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SUSTAINABLE STRATEGIES FOR RENEWED HOPE IN FOOD SECURITY AND JOB CREATION IN NIGERIA

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University of Abuja, Nigeria
21-25 October, 2024

EDITORS
A.A. **Oyerinde**, L.D.N. **Nnadozie**, A.I. **Aderolu** & B.C. **Okoye**

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PREFACE

The 58th Annual Conference of the Agricultural Society of Nigeria (ASN) held from 21st to 25th October, 2024, at the University of Abuja, Nigeria, marked a significant milestone in the nation's quest for sustainable agricultural practices. With the theme ***"Sustainable Strategies for Renewed Hope in Food Security and Job Creation in Nigeria",*** the conference gathered experts, practitioners, policymakers, and stakeholders to share knowledge, discuss challenges, and proffer solutions for the advancement of Nigeria's agricultural sector.

This conference was convened at a time when the country faces growing concerns over food insecurity, unemployment, and the urgent need for economic diversification. With a focus on innovative solutions and long-term strategies, the discussions and presentations throughout the conference addressed pressing issues, including sustainable farming techniques, the role of technology in agriculture, youth engagement in agribusiness, and policy frameworks that can drive both food security and job creation.

The proceedings of this conference encapsulate the wealth of ideas, debates, and research findings that emerged over the course of the event. These contributions are a testament to the collective efforts of the agricultural community in Nigeria to foster resilience and progress in the face of an ever-evolving global landscape.

As we share the knowledge generated at this conference, it is our hope that these discussions will inspire actionable strategies, foster collaboration, and guide future policies that will propel Nigeria toward a future of food security, sustainable agricultural practices, and job creation for its citizens.

We express our deepest gratitude to all the speakers, panelists, attendees, and partners who made this conference a resounding success. Together, we are building a foundation for a renewed hope in Nigeria's agricultural future.

Prof. Chinedum Nwajiuba, *FASN*
Former Vice-Chancellor, Alex Ekwueme Federal University, Ndufu-Alaike, Ebonyi State Nigeria

An Address of the National President, Agricultural Society of Nigeria (ASN) **Professor Jude Mbanasor *FASN, FNAAE, FSM*** presented on the occasion of her 58th Annual Conference and General Business Meeting held at the University of Abuja Nigeria, 21-25 October 2024

PRESDIDENT'S ADDRESS

Before I commence the reading of this address, may I crave the indulgence of all of you for us to stand and observe a one-minute silence in honour of our fallen hero, Prof A.A. Njidda who died tragically in a car crash a few months ago. Before his painful exit, Prof Njidda was the first National Vice president of this August body. He was also the Dean, Faculty of Agriculture at the National Open University of Nigeria (NOUN). His death has diminished all of us and robbed us of the services of a vibrant and hardworking comradeand academic. I pray God to comfort his family in this period of grief. May his gentlesoul rest in peace.

I most heartily welcome all of you to the 58th Annual Conference of the Agricultural Society of Nigeria (ASN), holding at the Faculty of Agriculture, University of Abuja, right here in the capital city of the FCT. I welcome in a special way the Honorable Minister of Agriculture and Food Security, Alhaji Abubakar Kyari, for graciously accepting to deliver the keynote address at the conference. I also salute the Vice Chancellors and former Vice Chancellors in our midst, the lead speakers and others who are here to add value to this conference.

Last year, we were at Lafia in Nassarawa State, where the 57th Annual Conference produced spectacular results, which we are consolidating in this year's conference. I once more express our gratitude to the government and people of Nassarawa State for their warm hospitality. I also commend the Local Organising Committee, which did its best to provide the much-needed ambience for a successful conference.

I have no doubt that our Local Organising Committee for the 58th conference will surpass their predecessors. With the orderly way things have gone through so far and the unprecedented attendance at this year's conference, it is obvious that the LOC has been working very hard. I most sincerely commend the Chairman and members of the LOC, ABUJA 2024, for a job well done. I also thank everyone whose inputs have brought us this far.

Ladies and gentlemen, as you are already aware, the Agricultural Society of Nigeria was established in 1962, just two years after our country's independence. As an umbrella body of all practitioners involved in agricultural matters, ASN has a mandate to promote and foster understanding of both basic and applied agriculture science to enhance exchange and dissemination of knowledge in all areas of agricultural production. In the execution of this core mandate, we collaborate with national and international societies. Through conferences, symposia, lectures, Seminars and other means of communication, we have been gathering experts, professionals and farmers and industries and policy makers to examine the latest research findings and employthe same for the agricultural advancement of Nigeria. It is important to point out that our members are drawn from both the public and private sectors. You can also locate us at universities, research institutions, and everywhere you talk of agriculture.

Every year, at our annual conference, we pick a theme with its sub themes, which we dissect and come out with a framework for useful implementation of our recommendations. Last year, our theme was "***Strengthening Agriculture for Food and Nutrition Security, Market Development and Export in a Climate Change Environment".*** We generated quality papers which I believe were germane in tackling some of the challenges facing agriculture in Nigeria. We raised the alarm to the threatening issue of climate change. I am sure that the pattern ofthis year's rains and the attendant flooding have vindicated us.

Our theme for this year is "***Sustainable Strategies for Renewed Hope in Food Security and Job Creation in Nigeria"*. As usual, we have lined up more than 13 sub-themes from where ideas and recommendations would be generated for the overall good of Nigeria and her people. Experts are poised to present quality papers that will enrich our knowledge not only on the themes but the entire agriculture value chain.

As is our culture, this year's theme was carefully chosen to reflect the present realities inNigeria. While the theme aligns with the Federal Government's renewed hope agenda, including sustainable agricultural policy, we want to interrogate strategies necessary for the realization of food security and job creation in Nigeria. Our goal is to help the government and the Nigerian people conquer the present hunger in the country as well as enhance opportunities for ameliorating the pressure of unemployment among our youths. I advise our participants to pay rapt attention as our experts tackle these twin burning issues.

However, I must express my deepest regret that our policy makers for these numbers ofyears that we have been brainstorming on national issues have not deemed it necessary to work on our recommendations. This was one of the issues I raised last year. I am not aware that there has been any positive response from the government. But that would not deter us in our patriotic zeal to serve our country to the best of our knowledge and strength.

Another issue I raised last year is the reluctance of government to access and makeuse of the research findings of our research institutes scattered across the country. It is quite unfortunate that when our counterparts abroad are hero-worshipped because of how serious the government takes their research findings, some of our colleagues here are not happy because their works are not truly appreciated. It would be presumptuous of me to conclude that the government is not interested in what we are doing. But a littlemore interest by the government would encourage us to do more.

Related to this is the question of underfunding of research institutes in the country. While I acknowledge the financial challenges assailing government in funding the annual budget as a result of global economic meltdown, I plead that the affairs of the institutes be treated as a national emergency for the simple reason that Nigeria actually depends on agriculture for survival.

Accordingly, both the government and the organized private sector may do well to bail our research institutes from their present cash-strapped status. Some years back, our researchers came up with the finding that cassava was good for baking bread. After a half-hearted attempt by the government to enforce its implementation, it was brow beaten by industry users to dump that beautiful idea. Today, bread is almost unaffordable, especially to the downtrodden. My plea is that we should be taken more seriously by both the government and corporate organizations.

To all our members, I urge you not to be discouraged. I believe that our efforts will be recognized, if not today, certainly tomorrow. As part of that process of encouraging you, the National Executive Council has selected a few of you to be conferred with the Fellow of the Society. It is a call to duty, to defend the honour of the society, and to make a name for yourselves. Always know that as our ambassadors, all eyes are on you.

However, this address will not be complete if I fail to mention the devastating effect of insecurity on Nigerian farmers and how this has become a present danger and threat to the realization of food security in the country. Due to the activities of bandits and insurgents, millions of farmers have been chased out from their farms in many parts of Nigeria. Indeed, millions of them have become internally displaced persons in IDP camps. Those who ought to use and implement our research findings are nowhere to befound. What it means is that food security has been threatened.

As always, we are using this medium to appeal to governments at all levels to take the security of farmers seriously. We know for a fact that our security agencies are doing their best by taking the war to the doorsteps of the criminals, but until the farmers return to the farms and resume food production, our journey to the attainment of food security still remains very far.

Another matter that is impacting negatively on food security is the exchange rate of the Naira to other major foreign currencies. Although the federal government seems to be arresting the free fall of the Naira which hitherto resulted in the escalating cost of goods and services, there is also the need for it to do more to stabilize the exchange rate. We are aware of the nexus between the exchange rate and the GDP of a nation as they relate to imports and exports mechanism. Farmers are hardest hit because the machineries needed for mass production of food are imported, and with high exchange rate remain unaffordable. Whatever they produce is not even enough for local consumption. Ordinarily, the agricultural sector ought to be the largest employers of labour in Nigeria. Unfortunately, it is constrained by the twin challenges of insecurity andfluctuating exchange rate.

Accordingly, we have adopted this theme: ***Sustainable Strategies for Renewed Hope in Food Security and Job Creation in Nigeria*** as a means of gingering government to solve these twin challenges as a means of fast- tracking the process for the realization of food security and job creation in Nigeria. I believe our speakers at this conference will come out with the right framework neededto assist the government in delivering one of its core campaign promises

As we gather again this year for our annual conference, I wish to acknowledge the contributions of our founding fathers and past Executive Members towards the strengthening and sustenance of this August body which is as old as Nigeria itself. Our labour shall certainly never be in vain.

In line with that pledge, the National Executive Council has in the last one year digitalized all our operations, including registration and payment of dues at conferences. Meetings are now held virtually, same with other important engagements. We shall continue to do our best to give you top-notch services both now and in the future.

Once again, on behalf of the National Executive Council, I welcome all of you to this memorable conference. May God continue to grant us success in all our endeavours.

Professor Jude Mbanasor *FASN, FNAAE, FSM*
National President, Agricultural Society of Nigeria

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PROCEEDINGS

Comparative Assessment of the Growth and Yield of Cowpea (*Vigna Unguiculata)* Accession under Saline Condition

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Abstract
Salinity remains a threat to agricultural crop production, especially in cowpea production in many parts of the world. This research work was conducted to evaluate the impact of salt on the germination, growth and yield performance of cowpea in Lafia, Nigeria. Different NaCl concentrations (Control 0.25, 1.0 a 2.0g/L) were tested on the parameters as experimental treatments, while the control contained only water without any NaCl additive. Data were collected on germination, growth and yield performance of cowpeas under the salt stress, and were subjected to a Two-way analysis of variance, and the treatment means were compared using Duncan's New Multiple Range (DMR) Test at 5% (P>0.05) level of significance. The results obtained showed that the germination of cowpea seeds, growth and yield were highly affected by salinity at all levels of treatments when compared with the control. In conclusion, therefore, the results further confirmed the deterrent of salinity to cowpea production, especially in Lafia, Nigeria.
Keywords: Cowpea, accession, germination, salinity, growth, yield

INTRODUCTION

Cowpea (V*igna unguiculata* L. Walp.) has been widely cultivated in a range of ecologies especially in the savannah regions and in tropics and sub-tropics (Conrow, 2019). It is one of the most important food legume crops in the semi-arid tropics covering Asia, Africa, Southern Europe and Central America. Cowpea is also an important food crop in West and Central Africa. The high protein content of cowpea, ranging between 20 to 28% makes it an important supply to the diet of many African people. Cowpea also contributes to the soil nitrogen status through symbiotic N_2 fixation, thereby enhancing soil fertility (IITA Genebank 2018).

Salinity is one of the most serious factors limiting crop production, especially the sensitive ones (Saberi, *et al*., 2021). High soil salinity affects agricultural production in large proportions in the world territorial areas Munns (2002), Mshelmbula *et al*., 2016; Tianxiao *et al*., (2021) reported that salinity reduced the ability of plants to take up water, leading to growth reduction as well as metabolic changes similar to those caused by water stress. Similarly, Machado & Serralheiro, (2017) reported that high salt concentration in roots affects the growth and yield of many important crops. The salinity reduced the crop yield by upsetting the water and nutritional balance of the plant.

Salinity is a widespread environmental stress for crop plants in arid coastal regions of the world (Hussain *et al*., 2019). Due to increasing salt salinity, large areas of arable land are being removed from crop production every year. The use of saline irrigated water and the application of fertilizer are the main factors for increasing soil salinity (FAO 2021). Excess salinity in the soil water can decrease plant availability and can cause plant stress. High level of soil salinity can significantly inhibit seed germination and seedling growth, due to the combined effects of high osmotic potential and specific ion toxicity (FAO 2021). For cowpea, quite a number of reports have been reported on the effects of salinity on the growth of cowpea. Omomowo & Babalola (2021), stated that salinity levels adversely affected growth of cowpea, while testing 25 genotypes of cowpea at different salinity levels; Amador and Dieguez (2007), reported that the weight of sodium chloride pre-treated seeds of cowpea decreased significantly at increased salinity. Filho (2008), observed that lengths of the main roots and shoots of cowpea decreased to 23% and 44% respectively when treated with 100m sodium chloride.

Soil salinity, being the presence of high levels of salt in the soil, possing a serious threat to agricultural productivity in arid regions with intense soil evaporation (Katerji, *et al*., 2003). It is caused by shallow, saline groundwater and is one of the most serious environmental stresses that limits crop production worldwide (Katerji, *et al*., 2003). Soil salinity refers to the electrical conductivity of the saturated paste in the soil, and it is an important factor in proposed solutions in semiarid regions (Newton *et al*., 2015; Katerji, *et al*., 2003). The high content of exchangeable sodium negatively affects nutrient availability and increases soil pH, leading to reduced field productivity. To improve productivity and quality of economic crops, salinity and pH control are necessary (Newton *et al*., 2015). Measuring crop yields at increasing soil salinity can help distinguish salt tolerant and salt sensitive crops, and classification based on soil salinity distinguishes different groups of crops based on their salt tolerance (Katerji, *et al*., 2003). For instance, soil salinity is used to classify crops as salt tolerant, moderately salt sensitive, or salt sensitive (Katerji, *et al*., 2003). However, the behavior of crops under saline conditions is not fully explained by measuring crop yields at increasing salinity (Katerji, *et al*., 2003). Soil salinity can be either natural or induced (Katerji, *et al*., 2003). While salinity slightly increases with depth, regularly applied surplus water may contribute to the increase in salinity on a long-term basis (Katerji, *et al*., 2003). Hence, soil salinity is a growing problem that demands attention from cowpea farmers and researchers alike.

The effects of soil salinity on cowpea growth and yield of cowpea have not been thoroughly investigated. Cowpea is sensitive to salinity, and the negative effects of salt stress are most pronounced when it occurs during the vegetative stage (Ravelombola *et al*., 2018). Seed yield is reduced due to a decrease in seed number when exposed to salinity (Ravelombola *et al*., 2018). However, the sensitivity to salinity decreases as the plant matures (Ravelombola *et al*., 2018). Salinity stress significantly reduces vegetative growth during all three stages, but the effect is less pronounced when stress is imposed during the last two stages (Ravelombola *et al*., 2018). While salinity has little effect on the weight of individual seeds (Ravelombola *et al*., 2018), it has a significant impact on overall yield. Studies have shown that brown Sargassum muticum and red Jania rubens seaweed extracts can ameliorate the negative impacts of soil salinity on chickpea growth and yield (Abdel *et al*., 2017). Additionally, Sar and Jan extracts can improve growth and yield of chickpea plants through balanced ionic content and improved antioxidant defence (Abdel *et al*., 2017). Furthermore, a study conducted on chickpea plants exposed to long-term NaCl stress revealed metabolic activation and deactivation in roots and shoots through amino acid profiling (Abdel, *et al*., 2017). Overall, soil salinity has a significant impact on cowpea growth and yield, but solutions such as seaweed extracts and balanced ionic content can help mitigate these negative effects. (Abdel *et al*., 2017; Ravelombola *et al*., 2018; Abdel *et al*., 2017).

Because of the high economic contributions of cowpea to both human and livestock all over the world and particularly in Nigeria, there is need to know the salt tolerance of cowpea varieties grown especially in Nigeria. Hence, this research was therefore designed to evaluate the effects of salinity on the, growth and yield performance of cowpea varieties Nigeria.

Salinity is a significant environmental stress that adversely affects agricultural productivity, particularly in arid and semi-arid regions. However, the growth and yield performance of commonly grown cowpea varieties under saline conditions have not been thoroughly investigated. Therefore, there is a need to assess and compare the performance of different cowpea varieties under saline conditions to determine their salt tolerance and identify accessions with better growth and yield potential.

Cowpea being one of the most important food legume crops in the semi-arid tropics covering Asia, Africa, Southern Europe and Central America. Cowpea is also an important food crop in west and Central Africa. High protein content of cowpea, ranging between 20 to 28% makes it an important supply to the diet of many African people. Cowpea also contributes to the soil nitrogen status through symbiotic Nitrogen fixation, thereby enhancing soil fertility (IITA Genebank, 2018).

This study seeks to compare the salt tolerance and productivity of the cowpea accessions and to identify the accessions that exhibit superior growth and yield potential under salinity stress in lafia. Assess the growth characteristics of three cowpea accessions under saline conditions. Evaluate the yield of the selected cowpea accession under saline conditions. Identify cowpea varieties that exhibit better tolerance to salinity stress.

MATERIALS AND METHODS

Experimental Site

The study was carried out in the screen house of the teaching and research farm of the Faculty of Agriculture Federal University of Lafia, Nasarawa State (Latitude 08.28 N and Longitude 08.32 E).

Collection of Materials

Clean cowpea seeds (*Vigna unguiculata*) accession namely Tvu 398 Tvu 4609, and Tvu 4606 were obtained from (Genetic Resources Center IITA, PMB 56320, Oyo Road, Ide-oshe, Ibadan, Nigeria). Thereafter, the seeds were treated with Dress Force (20% imidacloprid, 20% metalaxyl-M, 20%Ws Tebuconazole), until it was ready for planting. The soil sample was collected at the Faculty of Agriculture Teaching and Research Farm of the Federal University of Lafia. Topsoil (0-15cm) was collected for use. The soil was sun-dried to constant weight, and thereafter, 5kg of soil was measured into polythene bags. These were perforated at the bottom. The bags were placed in the screen house at a spacing of 30cm x 30cm, as proposed by Okeleye *et al*. (1999). An analytical reagent Sodium Chloride (NaCl = 58.44) was obtained from a chemical store of the Department of Plant Science and Biotechnology, Federal University of Lafia

Experimental Design and Treatments
The trial is a pot experiment carried out under a controlled irrigation system in the screen house. The experiment was laid out in a split-plot Block Design. There were thirty-six combinations including control made of three liquidified salt dosages applied directly to the potted soil as presented in the table1 below. These were replicated three times.

Table 1: Treatments

Treatment	V1 (Tvu 398)	V2 (Tvu 4606)	V3 (Tvu 4609)
1g	1gV1	1g V2	1g V3
2g	2g V1	2g V2	2g V3
0.25g	0.25g V1	0.25g V2	0.25g V3
CONTROL	0g V1	0g V2	0g V3

Where: V1= Tvu 4609, V2= Tvu 4606 and V3= Tvu 398

Table 2: Field Layout

S/No	Rep 1	Rep 2	Rep 3
1	0.25gV3	0g V2	1gv1
2	0g V3	2g V1	2gv3
3	2g V1	1g V2	0gv1
4	0g V1	0.25g V2	0gv2
5	2g V3	0gV1	1gv3
6	1g V3	0.25g V3	2gv1
7	0.25g V2	2g V3	0gv3
8	1g V1	2g V2	1gv2
9	0g V2	1gv1	0.25gv3
10	2g V2	0gv3	0.25gv1
11	0.25g V1	1gv3	2gv2
12	1g V2	0.25gv1	0.25gv2

Method of Application
0.25g, 1.00g, 2.00g and 0g of sodium chloride were measured and diluted in one liter of tap water each. The mixture was stirred vigorously to ensure a total and complete dilution of the NaCl reagent. These were stored in bottles with screw cap top. Another portion of the tap water (1liter) without any additive was also measured and was used as control. All the treatments including the control (untreated) were replicated 3 times. These were labeled as 0.25g, 1.00g, 2.00g and 0g as the control. The soil filled pots (three replicates for each treatment), were spaced 15cm apart, within each row.

Four (4) seeds were randomly selected and sown in each of the polythene bags including the control portion. The seeds were maintained on a saline nutrient solution until they were fully mature.

Data Collection
Data were collected on the following parameters:
Number of Days to Seed Germination
Germination of the cowpea seeds sown in all the experimental pots were subsequently noted, until they were fully germinated.

Percentage (%) of Seed Germination
The percentage of the seeds germinated was calculated using the formula as shown:

$$\frac{n}{N} x\ 100$$

Where n = Number of seeds germinated, N = Total number of seeds planted = (4).

Number of Leaves per Plant
Number of leaves per plant after germination was continuously counted on weekly basis.

Plant Height
The height of the plants in all the experimental pots was measured with the aid of a ruler (30cm). This was done on weekly basis for ten (10) weeks.

Number of Days to First Flowering
The experiment was also noted for first flowering in all the plants between 7-10 weeks. The mean of the results was also calculated and recorded.

Number of Days to First Pod Formation
This is the number of days after planting, taken for the plants to produce its newest viable pod. This was subsequently noted, and recorded.

Number of days to first pod maturity
The number of days taken by each cowpea plant to produce its first matured pod was also noted and recorded.

Number of Pods per Plant
After harvest, the number of pods formed on each cowpea plant was counted.

Number of Seeds per Pod
Number of seeds in each pod was counted for every cowpea plant and recorded.

Data Analysis
Data collected were subjected to a two-way analysis of variance, and Duncan's New Multiple Range (DMR) Test was used to separate the mean differences at a 5% level of significance.

RESULTS AND DISCUSSION
Effect of Salinity on Germination of Cowpea
This table assesses how salinity affects the number of days to germination and the percentage of seeds germinated for three cowpea accessions: Tvu 398, Tvu 4609, and Tvu 4606. The data shows that Increasing salinity (NaCl concentration) delayed germination (i.e., took more days). Germination percentages decreased as salinity increased. At 0 g/l NaCl (control), germination was the fastest and highest, but with increased salt concentrations (up to 2.00 g/l), both parameters declined significantly.

Table 1: Effect of salinity on germination of cowpea.

Treatment [NaCl (g/l)]	No. of days to germination Tvu 398	% of seeds germinated Tvu 398	No. of days to germination Tvu 4609	% of seeds germinated Tvu 4609	No. of days to germination Tvu 4606	% of seeds germinated Tvu 4606
0 (control)	4.60[a]	5.00[a]	4.70[a]	4.33[a]	4.10[b]	4.00[a]
0.25	5.70[b]	5.00[a]	5.33[b]	4.67[b]	5.66[b]	6.00[b]
1.00	6.33[c]	7.00[b]	5.00[c]	7.00[c]	6.00[c]	7.31[c]
2.00	6.38[c]	7.34[c]	5.38[d]	8.20[d]	5.80[b]	7.70[d]
LSD	3.89	3.89	3.89	3.89	3.89	3.89

Values are means of three replicates. Means carrying the same superscripts is not significantly different from each other at P>0.05 probability level.

Effect of Salinity on the Number of Leaves per Plant

The number of leaves per plant for the three cowpea accessions (Tvu 398, Tvu 4609, and Tvu 4606) was analyzed. Salinity reduced the number of leaves, especially with higher NaCl concentrations. The control plants had the most leaves, whereas plants subjected to higher salinity (2.00 g/l NaCl) had the least.

Table 2: Effect of salinity (NaCl) on the Number of leaves per plant of three cowpea accessions.

Treatment [NaCl (g/l)]	**No. of leaves per plant** Tvu 398	**No. of leaves per plant** Tvu 4609	**No. of leaves per plant** Tvu 4606
0 (control)	41.33[b]	42.33[b]	40.33[b]
0.25	21.25[a]	23.25[a]	24.25[a]
1.00	18.00[a]	19.00[a]	18.00[a]
2.00	17.67[a]	19.67[a]	18.67[a]
LSD	**11.23**	**11.23**	**11.23**

Values are means of three replicates. Means carrying the same superscripts is not significantly different from each other at P>0.05 probability level.

Effect of Salinity on Plant Height

This table evaluates how salinity impacts the height of cowpea plants. The control plants were the tallest, with Tvu 4609 reaching 114.00 cm. Increased salinity led to a decrease in plant height across all accessions, with the largest reduction observed at 2.00 g/l NaCl.

Table 3: Effect of salinity (NaCl) on the Plant height of three cowpea accessions

Treatment [NaCl (g/l)]	**No. of leaves per plant Tvu 398 (cm)**	**No. of leaves per plant Tvu 4609 (cm)**	**No. of leaves per plant Tvu 4606 (cm)**
0 (control)	93.20[a]	114.00[b]	80.87[a]
0.25	73.75[b]	78.87[a]	73.25[a]
1.00	65.57[b]	76.87[a]	73.76[a]
2.00	53.25[b]	51.25[a]	65.57[a]
LSD	**33.49**	**33.49**	**33.49**

Values are means of three replicates. Means carrying the same superscripts is not significantly different from each other at P>0.05 probability level.

Effect of Salinity on Stem Girth

Stem girth (thickness) in millimetres was assessed under varying NaCl treatments. The control group exhibited the largest stem girth. As salinity increased, stem girth decreased significantly across all accessions.

Table 4: Effect of salinity (Nacl) on the Stem Girth of three cowpea accessions.

Treatment [NaCl (g/l)]	No. of leaves per plant Tvu 398 (mm)	No. of leaves per plant Tvu 4609 (mm)	No. of leaves per plant Tvu 4606 (mm)
0 (control)	15.43^{a}	14.80^{a}	18.70^{a}
0.25	12.50^{ab}	12.50^{b}	14.50^{b}
1.00	10.40^{cb}	11.40^{bc}	10.40^{bc}
2.00	10.50^{dcb}	11.50^{bdc}	12.50^{bdc}
LSD	**9.44**	**9.44**	**9.44**

Values are means of three replicates. Means carrying the same superscripts are not significantly different from each other at P>0.05 probability level.

Effect of Salinity on the Number of Days to Flowering

This table tracks the number of days until flowering for the cowpea accessions. Control plants flowered sooner (49–55 days). Increased salinity delayed flowering, with the longest time to flower occurring at 2.00 g/l NaCl for all accessions (63–65 days).

Table 5: Effect of salinity on the No. of days to flowering of cowpea.

Treatment [NaCl (g/l)]	No. of days to flowering Tvu 398	No. of days to flowering Tvu 4609	No. of days to flowering Tvu 4606
0 (control)	49^{a}	55^{a}	45^{a}
0.25	58^{ab}	58^{ab}	58^{ab}
1.00	56^{ab}	59^{ab}	58^{ab}
2.00	63^{b}	65^{b}	65^{b}
LSD	**24.23**	**24.23**	**24.23**

Values are means of three replicates. Means carrying the same superscripts are not significantly different from each other at P>0.05 probability level.

Effect of Salinity on the Number of Days to First Pod Formation

The impact of salinity on the days to the formation of the first pod is shown. The control plants formed pods earlier (around 60–69 days), while plants exposed to higher salinity took longer, with delays seen at 2.00 g/l NaCl.

Table 6: Effect of salinity on the No. of days to 1st pod formation of cowpea.

Treatment [NaCl (g/l)]	No. of days to 1st pod formation Tvu 398	No. of days to 1st pod formation Tvu 4609	No. of days to 1st pod formation Tvu 4606
0 (control)	69.01^{b}	68.90^{a}	60.77^{a}
0.25	70.12^{a}	62.23^{a}	60.35^{a}
1.00	71.30^{a}	74.75^{a}	70.75^{a}
2.00	74.44^{a}	74.33^{a}	70.33^{a}
LSD	**58.11**	**58.11**	**58.11**

Values are means of three replicates. Means carrying the same superscripts are not significantly different from each other at P>0.05 probability level.

Effect of Salinity on the Number of Days to First Pod Maturity

The number of days until the first pod matures was recorded. Control plants matured faster. Salinity delayed pod maturity, with the longest delays observed at 1.00 and 2.00 g/l NaCl.

Table 7: Effect of salinity on the No. of days to 1st pod maturity of cowpea

Treatment [NaCl (g/l)]	No. of days to No. of pods per plant Tvu 398	No. of days to No. of pods per plant Tvu 4609	No. of days to No. of pods per plant Tvu 4606
0 (control)	57.01^{b}	60.70^{a}	68.77^{a}
0.25	70.12^{a}	62.23^{a}	60.35^{a}
1.00	71.30^{a}	74.75^{a}	70.75^{a}
2.00	74.44^{a}	74.33^{a}	70.33^{a}
LSD	**51.98**	**51.98**	**51.98**

Values are means of three replicates. Means carrying the same superscripts are not significantly different from each other at P>0.05 probability level.

Effect of Salinity on the Number of Pods per Plant

This table looks at how salinity affects the number of pods per plant. Control plants produced the most pods (about 6.71–6.82 per plant). Higher salinity drastically reduced pod numbers, with the lowest counts (around 2–3 pods per plant) occurring at 2.00 g/l NaCl.

Table 8: Effect of salinity on the No of Pod per plant of cowpea accession.

Treatment [NaCl (g/l)]	No. of days to No. of pods per plant Tvu 398	No. of days to No. of pods per plant Tvu 4609	No. of days to No. of pods per plant Tvu 4606
0 (control)	6.71^{b}	6.40^{b}	6.82^{b}
0.25	6.33^{b}	5.60^{b}	6.01^{b}
1.00	4.20^{b}	3.00^{a}	3.12^{a}
2.00	3.45^{a}	2.37^{a}	2.03^{a}
LSD	**2.01**	**2.01**	**2.01**

Values are means of three replicates. Means carrying the same superscripts are not significantly different from each other at P>0.05 probability level.

Table 1: Germination under Salinity Salinity delayed germination and reduced the percentage of germinated seeds in cowpea. Control plants had the highest germination rates, while plants exposed to 2.00 g/l NaCl showed significant reductions. Similar studies confirm that high salinity hinders water uptake, delaying germination (Nikolić, et al., 2023). Compared to studies by Mu, et al. (2023), the effect on cowpea was particularly severe at higher concentrations.

Table 2: Number of Leaves Salinity reduced the number of leaves per plant, with the most pronounced effect at 2.00 g/l NaCl. This reduction is consistent with findings by Ashraf and Harris (2021), who linked reduced leaf growth to osmotic stress caused by high salt concentrations, which limits nutrient availability and water absorption.

Table 3: Plant Height Height decreased with rising salinity levels. Tvu 4609, the tallest accession, experienced the steepest decline. This trend aligns with Silva, & Santos, (2024), who demonstrated that salinity stunts growth by disrupting water balance, ultimately reducing cell expansion.

Table 4: Stem Girth Stem girth was significantly affected by salinity, with control plants showing the thickest stems. This is consistent with the findings of Athar and Ashraf, (2009), who noted that salinity stress decreases stem girth due to hindered nutrient translocation.

Table 5: Flowering Delay Higher salinity delayed flowering. Similar studies by Mishra, et al. (2021) found that salt stress disrupts the plant's hormonal balance, delaying flowering by affecting the transport of essential nutrients like potassium and calcium.

Table 6: Pod Formation Salinity delayed pod formation, especially at 2.00 g/l NaCl, supporting Jayawardhane, et al. (2021), who demonstrated similar delays in pod initiation under saline conditions due to impaired reproductive growth.

Table 7: Pod Maturity Pod maturity was delayed by increasing salinity. The findings agree with research by Bilal, et al. (2024), who showed that salinity prolongs pod maturation by reducing photosynthesis and nutrient allocation to reproductive structures.
Table 8: Pod Number Pod number was significantly reduced under high salinity. Control plants produced the most pods, while plants at 2.00 g/l NaCl had the least. This aligns with the findings of Atta, et al. (2023), who reported that salinity decreases pod formation due to physiological stress and reduced carbon fixation during photosynthesis.

Conclusion

The results from all tables show that increasing salinity has detrimental effects on cowpea's growth, development, and yield. These findings align with several recent studies highlighting the negative impacts of salinity on crop performance. However, differences in magnitude between accessions suggest genetic variability in salinity tolerance, which could be explored further to develop salt-resistant cowpea varieties.

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Appendix

Plate 2: Experimental Layout

Plate 1: Preparation of Sodium solvent concentration

Plate 3: Experimental layout

Plate 5: Growth of cowpea varieties at 4 weeks after planting.

Plate 6: Growth of cowpea at 6 weeks after planting.

Plate 7: Growth of cowpea at 8weeks after planting.

	
Plate 8: showing the pod at week 8.	Plate 9: showing the stress on the plant leaf at week 7.

Impact of Fodder Development Innovation Project on Livestock Productivity and Farmers Livelihood in Participating State of Nigeria

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Abstract
The Study of Impact of Fodder Development Innovation Project on Livestock Productivity and Farmers Livelihood in Participating State of Nigeria. Tools of analysis are descriptive, inferential statistics, Tobit Regression Analysis and propensity score matching was used. The participants, 77.6% are male, highlighting a significant predominance of male farmers who have actively participated in the FDIP. The positive coefficient of 0.364 for participants, significant at the 5% level. The result reveals that, the ATT for average weight gain is highly significant, with values around 380, indicating a substantial increase in livestock weight gain due to FDIP The result as presented in the Average Treatment Effect on the Treated (ATT) for farmers' income is significant at the 1% level across all methods. The ATT values range from approximately 19,024 to 20,171, indicating a substantial positive impact of FDIP on farmers' income. The study Recommended that low level of veterinary extension hence the need to produced extension bulletin in Ajami for the farmers because majority of them have not had a formal education, but can read and write Arabic this will bridge the gap in knowledge and improve technology.
Keywords: fodder, Ruminant Livestock production.

INTRODUCTION

Livestock has been kept as a source of investment, insurance against disaster and also for cultural purposes. Mixed farming systems (where crops and animals are integrated on the same farm) form the backbone of small-scale agriculture. Livestock in these systems not only provide 90% of the milk, 77% of the ruminant meat, 47% of pork and poultry meat, and 31% of eggs, but also fill an important economic and ecological niche throughout. Li et al., (2008).

Ruminant livestock, such as cattle, sheep and goats, tend to be dependent directly on the land. Their production systems therefore are largely determined by agro-ecology and land-use. Production systems for monogastric species such as pigs and chickens depend more on consumer demand and the level of capital investment, FAO, (2021).
Farmers' livelihood is composed of the activities that generate the means of household survival and longer-term well-being. Livelihood may be divided into natural resources based activities (e.g. collection and gathering, cultivation, livestock-keeping, weaving) and non-natural resource based activities (e.g. trade, services, remittances. Ellis, (2000).

MATERIALS AND METHODS

Data were analyzed using both descriptive and inferential statistics. Descriptive statistics involved the measures of central tendency such as mean, frequency distribution, percentages and standard deviation were used, and propensity score matching (PSM) was used to determine the impact of participation in FDIP on weight gain, income and level of living of Livestock farmers. the Tobit model were chosen because it has an advantage over other discrete models (LPM, Logistic, and Probit) in that; it reveals both the probability of access and level of participation The Tobit model assumes latent unobservable Y_i which linear y depends on X_i via a parameter vector β and a normally distributed error term U_i captures the random influence of this relation. The model for the regression is thus expressed:

$$Y_i^* = \beta_0 + \beta_i X_i + U_i \quad (2)$$
$$Y_i = Y_i^* \text{ if } \beta_0 + \beta_i X_i + U_i > 0 \quad (3)$$
$$Y_i = 0 \text{ if } \beta_0 + \beta_i X_i + U_i < 0 \quad (4)$$

(Adopted from Oladimeji, 2014).

RESULTS AND DISCUSSION

Sex distribution among the fodder farmers

The results show that, among the non-participants, approximately 60% are male, indicating a majority of male farmers who have not actively engaged with the FDIP. Gender disparities in access to and utilisation of agricultural innovations and projects. Among the participants, 77.6% are male, highlighting a significant predominance of male farmers who have actively participated in the FDIP. This suggests that gender disparities in participation, male farmers still constitute the majority of project beneficiaries. This finding underscores the importance of considering gender-specific needs and constraints in project design and implementation to ensure equitable participation and impact across different segments of the farming population. The study aligns with the findings of Okwoche et al. (2012), which reported a male dominance (70.77%) among sorghum farmers in Benue State, Nigeria, further contextualising the gender dynamics observed in the FDIP.

Table 1: Sex distribution among fodder farmers

	Non-participants		Participants	
Sex	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Female	84	40.4	51	22.4
Male	124	59.6	177	77.6
Total	208	100.00	228	100.00

Age distribution of fodder Farmers

The results in the table of age revealed that the 31–40-year age group has the highest proportion of both participants (42.5%) and non-participants (42.3%). This suggests a strong presence of young, potentially active farmers in the programme area. The slightly higher average age of participants (41.8 years) compared to non-participants (40.6 years) further reinforces this trend. This aligns with previous research findings from Okwoche (2012), and Asogwa *et al*. (2012), which also reported a high representation of young farmers in agricultural contexts. However, a slight decline in participation is observed among the 41-50-year-old age group, where there's a higher proportion of non-participants (27.9%) compared to participants (27.6%).

Table 2: Age distribution of fodder farmers

	Non-participants		Participants	
Age	**Frequency**	**Percentage**	**Frequency**	**Percentage**
20 -30 years	19	9.1	23	10.1
31 - 40 years	88	42.3	97	42.5
41 - 50 years	58	27.9	63	27.6
51 - 60 years	30	14.4	40	17.5
61 - 69 years	13	6.2	5	2.2
Total	208	100.00	228	100.00
Mean	40.6			41.8
Standard dev.	8.2			9.3

Impact of fodder development innovation project on output (average weight gain and milk yield)

The result revealed that, the ATT for average weight gain is highly significant, with values around 380, indicating a substantial increase in livestock weight gain due to FDIP. The T-values, all above 28, reinforce the significance and robustness of these findings. This substantial increase underscores the importance of better fodder quality and feeding practices introduced by the FDIP. Weight gain is a critical factor for livestock farmers, influencing both market value and income potential. Similar improvements have been reported by the FAO (2010), which noted that enhanced feeding practices led to substantial gains in livestock weight.

Table 3: Estimating the impact of FDIP on average weight gain

Parameters	Nearest neighour	Radius	Kernel	Stratification
ATT	384.742***	377.122***	380.776***	383.652***
SE	13.058	13.22	13.174	12.416
Treated	221	201	221	221
Control	125	208	211	259
T-value	29.464	28.527	28.904	30.9

Note: *** represent significant at 1% level of probability

Impact of fodder development innovation project on farmers' income

The Average Treatment Effect on the Treated (ATT) for farmers' income is significant at the 1% level across all methods (Nearest neighbour, Radius, Kernel, and Stratification). The ATT values range from approximately 19,024 to 20,171, indicating a substantial positive impact of FDIP on farmers' income. The T-values, all above 8, confirm the statistical significance of these results. The increase in farmers' income suggests that the FDIP has effectively enhanced their economic status by improving livestock productivity and market access. Increased income levels can be attributed to better livestock management practices, higher milk yields, and increased weight gain of livestock, which improve market prices and sales. This finding is consistent with previous studies, such as Bedi et al. (2016), which reported that agricultural interventions that improve productivity directly contribute to higher income levels for farmers.

Table 4: Estimating the impact of FDIP on farmers' income

Parameters	Nearest neighour	Radius	Kernel	Stratification
ATT	20171.9***	19709.5***	19312.7***	19024.5***
SE	2296.9	1690.4	1841.5	1518.7
Treated	221	201	221	221
Control	125	208	211	259
T-value	8.782	11.659	10.488	12.527

Note: *** represent significant at 1% level of probability

Impact of fodder development innovation project on farmers' level of living

The result shown that, the ATT for farmers' level of living is also significant at 1%, with values ranging from approximately 13,245 to 14,392, demonstrating a significant positive impact of FDIP. The T-values, all above 9, reinforce the robustness and significance of these findings. This improvement in the level of living can be interpreted as better housing, nutrition, education, and overall well-being due to increased income and better livelihood outcomes. Enhanced living standards are a direct result of improved economic stability and productivity. These results align with the findings of the World Bank (2013), which highlighted that agricultural development projects lead to substantial improvements in the living standards of rural populations.

Table 5: Estimating the impact of FDIP on farmers' level of living

Parameters	Nearest neighour	Radius	Kernel	Stratification
ATT	14392.308	14041.4	13676.5	13245.008
SE	1425.145	1414.32	1340.37	1292.223
Treated	221	201	221	221
Control	125	208	211	259
T-value	10.099	9.928	10.204	10.25

Note: *** represent significant at 1% level of probability

CONCLUSION

Based on the findings from the study, it can be concluded that participation in the activities of FDIP significantly affected positively on the herd size, income, livelihood and participation among farmers using all the matching algorithm estimated. Similarly, the average treatment effect is significant at 1 % for all matching algorithm except in herd size and Income where it is significant at 5% in nearness neighbors, kernel, and stratification with a varying t-values. So, the project has indeed been effective in the areas under study

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Assessing the Effectiveness of Dried Poultry Manure as a Natural Fertilizer on the Growth and Biomass Production of *Amaranthus cruentus* (Spinach) in the Humid Climate of Jos Plateau, Nigeria

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Abstract

A field experiment was conducted at the Crop Production experimental field of Federal College of Land Resources Technology Kuru-Jos during the wet season of 2023 and 2024 to evaluate different rates of poultry manure applications on the growth of Amaranthus cruentus. The objective was to determine optimal application rate of dried poultry manure (DPM) as a sustainable fertilizer option for enhancing the productivity of leafy vegetables such as Amaranth. The study comprises six poultry manure rates (0.0, 1.5, 3.0, 4.5, 6.0 and 7.5 t/ha) replicated in three blocks and fitted in a randomized complete block design. Growth data assessed were plant height, no. leaf, stem girth as well as crop biomass taken at 4 and 6 weeks after planting (WAP). Data generated were subjected to analysis of variance and the least significance difference (LSD) was used to ascertain significant differences in treatments. All the application rates showed significant differences compared with the control treatment. Increased rates of poultry manure resulted in enhanced Amaranth growth rate, biomass and yield. 6 tons per hectare applications of poultry manure showed economic and profitable Amaranthus cruentus crop production.

INTRODUCTION

Amarathus cruentus, a versatile crop with high nutritional value is an important vegetable crop grown in Nigeria mostly for its leafy materials used in preparing dishes such as soup, stew, salad and porridge (Afolayan and Jimoh, 2020). The leafy vegetable contains protein enriched with essential amino acid lacking in cereal and tubers. According to Shippers *et al.,*(2000), Amaranth leaf is more superior to lettuce and contain high level of carotene and micronutrients such as Na, Cu, Mn and Cl.

In the search for suitable and organic farming practices the use of natural fertilizer has gained significant attention. Dried poultry manure (PM) is one such natural fertilizer that has proven effective in enhancing soil fertility and promoting crop growth. This study aims to assess the effectiveness of dried PM on the growth and biomass production of A. cruentus commonly known as spinach in the humid climate of Jos Plateau, Nigeria

The increasing demand for sustainable agricultural practices has led to a surge in research on organic fertilizers as alternatives to inorganic fertilizers (Singh et al., 20022). Poultry manure, rich in N, P and K (Saeed et al., 2018) has been identified as valuable natural fertilizer (Ogunwale et al., (2020). Amaranth, a nutrient-demanding crop, is an excellent candidate for evaluating the efficacy of organic fertilizers. Previous studies have demonstrated that application of poultry manure can improve soil structure, increase soil microbial activity and enhance nutrient availability, leading to improved crop yields (Ibie et al., 2019; Ogunleye et al., 2016; Oyedele et al.,2020). However the optimum application rate of PM for A, cruentus in the specific climatic conditions of Jos Plateau has not been extensively studied. This study aims to investigate the impact of dried poultry manure on the growth and biomass production of A. cruentus, providing valuable insights into sustainable agricultural practices.

MATERIALS AND METHODS

The study was conducted at the Crop Production experimental field of Federal College of Land Resources Technology, Kuru located in Jos South local Government Area of Plateau State, Nigeria. The area is characterized by a humid climate with moderate to high rainfall and cool temperature, ideal for the growth of A. *cruentus*. The field experiment was carried out during the wet season of 2022. The experimental field was prepared by clearing the vegetation, ploughed and harrowed to create fine seed bed. The field was then divided into plots measuring 2m x 2m each, with 50cm separating each plots.

The experiment was designed as a randomized complete block design (RCBD) with three replicates. Dried PM was applied to the plots at the specific rates two weeks before planting to allow for proper decomposition and nutrient release of the manure which was incorporated into the soil to a depth of 10cm to ensure uniform distribution. The treatments consisted of six different rates of dried PM; 0.0, 1.5, 3.0, 4.5, 6.0 and 7.5 t/h. Each treatment was assigned randomly within each block at the time of land preparation. 10g of A. cruentus seeds mixed with 100g of fine sand were drilled along the rows 20cm apart into the prepared plots. Thinning was done two weeks after planting (WAP) to maintain uniform plant to plant stand. Growth data (Plant Height, No. leaves, Stem girth) were collected at 4 and 6 WAP. To obtain Biomass yield, 10 plants were carefully uprooted and roots were washed off sand under running water at 6 WAP and weighed,

Data collected were subjected to analysis of variance (ANOVA) and where the treatment showed differences, least significant difference (LSD) test was used to compare treatment means.

RESULTS AND DISCUSSION

There were significant differences in growth parameters across treatment means (table 1) at 4 and 6 WAP compared with the control treatment. The highest increase in growth characters was the application of 7.5 tons per hectare DPM at 4 and 6 WAP. The biomass yield (figure 1) also followed the same trend as the growth parameters which increased as the DPM rates increases.

Study by Olarinwaju et al (2020) found treating A. cruentus with varying rates of PM from 0-10 tons per ha improved both vegetative growth and yield. Furthermore, PM improves soil structure aeration and moisture retention all of which are critical for the healthy growth of A, cruentus (Khan, et al. 2021). An enhanced microbial activity associated with organic manure application contributes to improved nutrient availability to the plant fostering better growth and development (Ravindranaath and Narayanasamy, 2021). In terms of yield, several studies have documented positive outcomes from the application of PM to Amaratus. Ikhuoria et al (2022) reported that the fresh biomass yield of Amaratus cruentus increased significantly with the application of PM up to 8 tons per ha. According to the study the yield improvements were attributed to increase nutrients uptake due to high organic material content found in PM. From economic perspective using PM can reduce the pressure on forex exchange request for inorganic fertilizer importation.

In conclusion the applications of Dried Poultry Manure significantly enhance the growth and biomass yield of *Amarantus cruentus*.

Table 1: Effects of poultry manure on A. Cruentus plant heights, No. leaves & Stem girth

	Plant Height (cm)		No. Leaves		Stem girth (cm)	
Treatment	4 WAP	6 WAP	4 WAP	6 WAP	4WAP	6 WAP
0.0t/ha	0.5	5.1	5.1	8.9	0.2	1.0
1.5t/ha	3.2	11.8	7.4	10.7	0.7	1.2
3.0t/ha	6.5	21.1	8.2	12.3	1.2	1.5
4,5t/ha	10.3	23.6	8.8	11.3	1.2	1.8
6.0t/ha	15.4	38.3	10.4	15.1	1.6	2.3
7.5t/ha	20.9	51.3	11.2	23.4	1.9	2.8
LSD	0.29	0.82	0.32	0.31	2.05	0.06

Table 2: Effects of poultry manure on A. Cruentus biomass yield (tons) at 4 & 6 weeks after planting.

Treatment	Biomass yield (tons per hectare)	
	4 WAP	6 WAP
0.0t/ha	2.1	3.9
1.5t/ha	4.7	5.7
3.0t/ha	5.1	7.4
4,5t/ha	6.8	8.3
6.0t/ha	9.4	10.1
7.5t/ha	10.2	11.4
LSD	1.32	1.51

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Bacteriological Status of Fishing Gears and Crafts in Asa River, Ilorin Kwara State Nigeria

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Abstract

This study focused on the bacterial status of freshly operated fishing gears and crafts in Asa River, Ilorin Kwara State. A total of 7 samples comprised of 5 gears (monofilament gillnet, multifilament gillnet, gura trap, cast net, hook and line), alongside 2 crafts (planked and dugout canoes) were taken per landing site of four (Aliara, Apata, Dam and Waterfall) that were purposefully selected among other landing sites due to their activeness in fishing activities. This formed a factorial experiment of 7 by 4, which summed up to 28 samples. Sterile scissors and knife were respectively used to cut 1g sample of each freshly used gear (at the knotted points) and crafts (were scraped from the deck side) in sterile cellophane nylon, after which they were transported to the laboratory for bacterial analysis and the obtained results were statistically analyzed using Analysis of Variance (ANOVA). Means were separated with a t-test at a probability less than or equal to 5% ($p \leq 0.05$). Results indicated the presence of five (5) bacteria isolates with an occurrence rate of 90% Pseudomonas aeruginosa, 55% Escherichia coli,equivalent to 50% of Bacillus subtilis and Shigella flexxneri and the least of 35% Staphylococcus aureus from both gears and crafts samples. Higher bacterial loads of no significant difference ($P \leq 0.05$) (5.98 ± 0.14^{a} $X10^{6}$CFU/ml in planked and 5.90 ± 0.07^{a} $X10^{6}$CFU/ml dugout) were observed in the respective planked and dugout canoes made of Khaya ivorensis and Afzelia afzelii woods as compared to synthetic gears. There were no significant differences ($P \leq 0.05$) ($X10^{6}$CFU/ml) in the isolated bacteria of monofilament (5.82 ± 0.14^{a}), multifilament (5.13 ± 0.12^{a}), cast net (4.65 ± 0.24^{ab}) and hooks and line (4.25 ± 0.74^{ab}), but with overall least significant ($p \leq 0.05$) bacteria of1.08 ± 0.13^{e} obtained in gura trap among others. The isolated bacterial ($X\ 10^{6}$CFU/ml) in gears and crafts of Waterfall (5.82 ± 0.14^{a}) and Apata (5.56 ± 0.10^{a}) fishing sites were not significantly different ($p \leq 0.05$) from each other but were significantly higher ($p \leq 0.05$) than the equivalent bacteria obtained in the samples collected at Dam (3.81 ± 0.16^{b}) and Aliara (3.69 ± 0.13^{b}) fishing sites. It is noteworthy that plant-based crafts; mainly planked and dugout canoes harbored more bacteria than synthetic gears in a river and this could serve as an awareness to fishermen that bacterial infection on the catches is possible through invaded fishing gears and crafts. Gura trap identified with the least bacterial organisms was due to the polished nature of the used cone for its construction which reduced rottenness to some extent.

Keywords: Bacteriological, Fishing Gears, Crafts, Asa River, Ilorin, Kwara State

INTRODUCTION

Fishing activities constitute the traditional occupation of individuals and communities leaving around these water bodies such as lakes, streams, rivers and oceans (Adewumi *et al.,* 2016). Basically, Fish production is either by capture fisheries, artisanal fish farming (fish farming) or by importation (Adewumi *et al.,* 2016). Capture fisheries involve the harvesting of naturally existing stocks of wild fish. This can be done either by small scale/artisanal fishers or by industrial/commercial trawlers. In artisanal fisheries, production is achieved by individual or by small groups by the use of labour-intensive gears and crafts (Anene *et al.,* 2020). Several studies have been conducted on the microbiological status of fishing gears and crafts, revealing the presence of various pathogenic and spoilage microorganisms (Grimaldo *et al.,* 2020).

These days, fishing gear made of synthetic netting fibers are widely used in both artisanal and industrial sub-sectors of the capture fisheries. Fishing crafts also known as fishing vessel includes any vessel of whatever description, design, or size, and in whatever way propelled, that is used for fishing by any person or persons (FDF, 2017). Some of the common bacterial species found on these surfaces include *Staphylococcus aureus, Escherichia coli,* and *Salmonella spp*. (Anene *et al.,* 2020). Studies have also investigated the microbial status of fishing gears and crafts, using various methods such as culture-based techniques, molecular methods, and next-generation sequencing. For example, a study by Kim *et al.* (2015) examined the microbial communities on different types of fishing gears using pyro sequencing, and found that the microbial composition varied depending on the gear type and location.

MATERIALS AND METHODS

Study area: Asa river originates in Oyo State, South West, Nigeria and flows to South-North through Ilorin, the capital of Kwara State, Nigeria, forming a dividing boundary between the eastern and the western parts of the city. The study was carried out along the Asa river segment which spans 6.2km and flows northwards through the Ilorin Metropolis. According to a study conducted by Odeyemi-Bello *et al.*, (2015), the Asa River Ilorin has a total length of about 100 km and a catchment area of 1,270 km². It is a highly dynamic river system that experiences seasonal fluctuations in water flow, as the river swells during the rainy season (May to October) and recedes during the dry season (November to April).

Four (4) landing sites which included Aliara, Apata, Dam and Waterfall were purposively selected from Asa river based on the intense fishing activities in the areas. One sample each of freshly used gears (monofilament gill net, multifilament gill net, gura traps, hook and lines and cast net) were cut at the knotted points with sterile scissors whereas, the crafts (planked and dug-out canoes) were scrapped at the deck regions with sterile knife from each of the four aforementioned landing sites. Thus, this indicated a 7 x 4 factorial experiment which summed up to twenty-eight (28) samples that were immediately transported in 28 sterile polythene nylons kept in an ice pack to reduce microbial activities to the microbiology laboratory, University of Ilorin where they were bacteriologically analyzed under aseptic conditions (Abdulsalami, 2017). Afterward, the laboratory’s result was subjected to Analysis of Variance (ANOVA). Means were separated with t-test at probability less than 5% ($P \leqq 0.05$)

RESULTS AND DISCUSSION

Table 1 presents five (5) different bacterial isolates of *Pseudomonas aeruginosa, Escherichia coli*, *Bacillus subtilis, Shigella flexxneri* and *Staphylococcus aureus* that were identified from freshly operated fishing gears and crafts in Asa river. Five bacteria isolated in the freshly operated gears and crafts of Asa river was probably due to their improper storage and maintenance by the fishermen. This concurs with Abdulsalami *et al.* (2017), that *Bacillus subtilis, Pseudomonas flourescens, Aeromonas hydrophilia, Proteus spp, Escherichia coli, Micrococci spp* and *Staphylococcus saprophyticus* on the fishing gears and crafts are mostly centered to negligence and improper care by the fisherfolks.

Table 1: Bacterial isolates of freshly operated fishing gears and crafts in Asa river

Locations & isolates from gears & crafts	Samples of gears and crafts in Asa river Mono	Multi	Gura	Cast	Hook&line	Planked	Dugout
Waterfall							
A	+	+	+	+	+	-	+
B	+	+	+	+	-	+	+
C	+	+	-	+	+	+	-
D	+	+	-	-	-	+	+
E	-	-	+	+	-	+	+
Apata							
A	+	+	+	-	+	-	+
B	+	+	-	+	+	-	+
C	+	-	+	+	-	+	+
D	+	+	+	+	-	-	+
E	+	-	+	-	+	+	+
Dam							
A	+	+	+	+	+	+	-
B	+	-	+	+	-	+	+
C	+	+	-	-	+	+	+
D	+	-	+	+	+	-	+
E	+	+	+	+	-	+	-
Aliara							
A	+	+	+	+	+	-	+
B	+	+	+	-	+	+	+
C	+	+	+	+	-	+	-
D	-	+	+	+	+	+	+
E	+	+	+	+	-	+	+

KEY: A- *Pseudomonas aeruginosa;* B- *Escherichia coli;* C- *Bacillus subtilis;* D- *Shigella flexxneri;* E- *Staphylococcus aureus*; + = Present; - = Absent

Overall bacteria isolates from samples of freshly used gears and crafts in four (4) different fishing locations of Asa river is represented in Table 2. The mean bacteria isolates (X 10^6CFU/ml) of sampled gears and crafts in Waterfall (5.82 ± 0.14^a) and Apata (5.56 ± 0.10^a) fishing sites were not significantly different ($p \leqq 0.05$) from each other and were significantly higher ($P \leqq 0.05$) than the equivalent mean bacteria obtained in the samples collected at Dam (3.81 ± 0.16^b) and Aliara (3.69 ± 0.13^b) fishing sites. This implies that bacterial invasion is evident in the gears and crafts used in almost all the fishing sites across Asa river, mainly because the impacts of any implement are relative to its effort, efficiency and frequency of use in the fishing business, although, there are case-specific exceptions to this generalization, whereby indiscriminate use of the river and pollution may affect the strength of these devices (Abdulsalami *et al.,* 2017).

Table 2: Overall bacterial isolates from samples of freshly operated gears and crafts in Asa river

Landing Sites	Mean+SE	Lower	Upper	t-statistics	p-value
Aliara	3.69 ± 0.13^{b}	3.40	3.98	28.89	0.000
Apata	5.56 ± 0.10^{a}	5.33	5.79	54.96	0.000
Dam	3.81 ± 0.16^{b}	3.45	4.16	24.49	0.000
Waterfall	5.82 ± 0.14^{a}	5.50	6.13	41.61	0.000

Hint: a-e are ANOVA superscripts, mean values or figures with the same superscripts along the rows are not significantly different from one other at $P \leq 0.05$

Generally, monofilament, multifilament, planked and dugout canoes were the most invaded gears and crafts with bacterial organisms among other variables which were cast net, hooks and lines and gura trap, and in the respective fishing villages of Waterfall, Apata, Dam and Aliara (Table 3). The respective monofilament, multifilament, planked and dugout canoes in Waterfall and Apata fishing sites had equivalent higher significant ($P \leqq 0.05$) bacterial loads of (5.82 ± 0.14^{a}) (5.56 ± 0.10^{a}), (5.13 ± 0.12^{a}) (4.34 ± 0.17^{ab}), (5.98 ± 0.14^{a}) (5.52 ± 0.14^{a}) and (5.90 ± 0.07^{a}) (4.29 ± 0.06^{ab}) as compared to equivalent lower significant ($P \leqq 0.05$) bacterial loads obtained in monofilaments (3.81 ± 0.16^{bc}) (2.69 ± 0.13^{bc}), multifilaments (3.42 ± 0.12^{bc}) (2.35 ± 0.17^{c}), planked (4.65 ± 0.14^{b}) (4.20 ± 0.14^{b}) and dugout canoes (4.00 ± 0.12^{b}) (3.52 ± 0.04^{c}) of Dam and Aliara fishing sites. Contrarily, cast nets (4.65 ± 0.24^{ab}**)** **(**4.09 ± 0.10^{b}) and line of the hooks (4.25 ± 0.74^{ab}) (4.06 ± 0.10^{bc}) in Waterfall and Apata fishing sites had no significant difference in their isolated bacteria which were quantitatively higher than those obtained in the same cast net (3.23 ± 0.14^{c}) (2.29 ± 0.21^{cd}) and lines of hooks (3.01 ± 0.18^{c}) (2.09 ± 0.13^{d}) in Dam and Aliara fishing sites. All in all, gura traps used across the four locations had the least equivalent significant ($P \leqq 0.05$) bacterial loads (Table 3). Planked and dugout canoes were more invaded with bacteria than the synthetic made gears mainly because bacteria can degrade wood that produce extracellular enzymes which has the potential of breaking down the woody cell wall. Additionally, synthetic nature of any operating gears does not guaranty rot profness or that they will be totally unaffected when immerse in water for prolong period which conforms with findings of Abdulsalami *et al., (*2014) and Abdulsalami *et al. (*2017), that strong resistance wear and tear of synthetic gears are not subjected to its bacterial resistance.

Table 3: Mean bacterial isolates from freshly operated fishing gears and crafts of Asa river

Fishing gears	Mean bacterial isolates of gears and crafts at different locations and crafs			
	Waterfall	Apata	Dam	Aliara
GEARS				
Monofilament	5.82 ± 0.14^{a}	5.56 ± 0.10^{a}	3.81 ± 0.16^{bc}	2.69 ± 0.13^{bc}
Multifilament	5.13 ± 0.12^{a}	4.34 ± 0.17^{ab}	3.42 ± 0.12^{bc}	2.35 ± 0.17^{c}
Cast net	4.65 ± 0.24^{ab}	4.09 ± 0.10^{b}	3.23 ± 0.14^{c}	2.29 ± 0.21^{cd}
Hooks and lines	4.25 ± 0.74^{ab}	4.06 ± 0.10^{bc}	3.01 ± 0.18^{c}	2.09 ± 0.13^{d}
Gura trap	2.12 ± 0.14^{d}	2.00 ± 0.10^{de}	1.73 ± 0.16^{e}	1.08 ± 0.13^{e}
CRAFTS				
Planked canoe	5.98 ± 0.14^{a}	5.52 ± 0.14^{a}	4.65 ± 0.14^{b}	4.20 ± 0.14^{b}
Dugout canoe	5.90 ± 0.07^{a}	4.29 ± 0.06^{ab}	4.00 ± 0.12^{b}	3.52 ± 0.04^{c}

Table 4 presents the occurrence rate of bacterial organisms in the fishing gears and crafts of Asa River, of which *Pseudomonas aeruginosa* was the most dominant with 90% invasion, 55% *Escherichia coli*, equivalent 50% of *Bacillus subtilis* and *Shigella flexxneri* and with the least of 35% *Staphylococcus aureus* observed (Table 4). High prevalent of *Pseudomonas aeruginosa* in gears and crafts of Asa river among others was due to its ability to be distributed throughout different habitats in the world. Ahaneku and Animashaun (2015) worked on water quality index and fishing tools in river Asa, Ilorin and they reported seven (7) bacteria and five (5) fungal isolates which they said *Pseudomonas aeruginosa* and *Aspergillus niger* were the most predominant among the isolated bacteria and fungi respectively.

Table 4: Occurrence rate of bacterial organisms in the fishing gears and crafts of Asa river

Bacteria Isolates	Number of Isolates (cfu/ml)	Percentage of Isolates
Pseudomonas aeruginosa	18	90
Escherichia coli	11	55
Bacillus subtilis	10	50
Shigella flexxneri	10	50
Staphylococcus aureus	7	35

CONCLUSION AND RECOMMENDATIONS

Pseudomonas aeruginosa was the most prevalent bacteria isolate in gears and crafts of Asa river among the respective orders of *Escherichia coli*, *Bacillus subtilis, Shigella flexxneri* and *Staphylococcus aureus*. Plant-based crafts; mainly planked and dugout canoes harbored more bacteria than the synthetic gears and this could serve as an awareness to fishermen that bacterial infection on the catches is possible through invaded fishing gears and crafts. Synthetic nature of any gears does not guaranty its rot profness in water, invulnerability to bacteria attack or that they will be totally unaffected when immerse in water for prolong period. Life span of individual gear or craft is majorly determined by its natural or chemical components, R-tex, frequency of use, maintenance and storage culture. In the same vein, gill nets, being monofilament or multifilament is the most efficient and commonly used gear in open waters by many indigenous fishermen and this features make it to be irresistible to many bacterial organisms than the respective cast nets, hooks and line and gura trap in Asa river. Operating gears and crafts in different landing sites of Asa river are vulnerable to bacterial attack due to their proneness to common environmental impacts in the open river as well as negligence of the concerned authorities to ensure proper testing of these implements before operating by the fisherfolks.

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Effect of Nitrogen Application on Root Rot Disease of Selected Cassava (*Manihot esculenta* Crantz) Varieties in a Moist Savanna

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Abstract

Cassava (Manihot esculenta Crantz) is one of the most important root crops in Nigeria; where it is widely cultivated for its calories and usage as raw material for other value-added products. Cassava root rot disease (CRRD) is a widespread and economically significant disease in tropical Africa, contributing substantial yield loss. The screening for resistant varieties to CRRD is therefore imperative to militate against the loss attributed to CRRD. Fifteen pro-vitamin A cassava varieties were investigated for their resistance to root rot disease in this study. The trial was laid as a split plot in randomized complete block design (with two nitrogen (N) rates of 0 and 100 kg/ha) in three replications. The trial was established for two consecutive seasons (2018 and 2019). Variety IBA 980581 had the highest incidence of CRRD (6.39% and 3.99%) in 2018 and 2019 planting seasons, respectively; with percentage disease severity index of 3.62 and 1.99, respectively. IBA 070539 appeared resistant to CRRD, with and without N fertilizer application in both seasons. From our study, N application, influenced the spread and severity of CRRD in pro-vitamin A cassava varieties. Aspergillus species were the most prevalent pathogen associated with infected cassava, while other pathogens included Fusarium, Lasiodiplodia, Botrytis and Rhizopus. Fourteen pro-vitamin A varieties appeared tolerant to CRRD, while IBA 070539 expressed the best performance against CRRD and could be further investigated for the presence of resistant genes, as well as antimicrobial metabolites.

Keywords: Cassava, root-rot, Pro-vitamin A, resistance, Nitrogen

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a high-yielding staple crop that is globally regarded as a 21st-century crop for all categories of farmers. Cultivation of cassava in Nigeria significantly contributes to gross domestic production and food security, especially, through its postharvest value addition for different categories of food products and cattle feed (Adedire *et al*., 2021). Biofortification of crop aims to improve nutrient density of agricultural products through biotechnological approach or conventional breeding without depleting any desirable component of the produce (Hritik *et al*., 2024). This phenomenon is not only targeted at food security but to also address hidden hunger associated with micronutrient deficiencies. Precision agriculture, through biofortification of cassava, is gaining more traction in Nigeria and across the globe.

Cassava biofortification has been adopted as a means of improving essential elements, such as vitamin A, to boost the quality of food materials generated from cassava (Ossai *et al*., 2024).

Many developing countries contend with various problems that militate against the production of cassava. The challenges are classified as either abiotic or biotic influences. Biotic factors usually include microbial and insect pest, while abiotic factors are often associated with nutrient (especially, nitrogen) deficiency. Cassava root rot diseases, caused by mycopathogens, have been reported to cause significant yield loss, accounting for over 50% pre- and postharvest losses of this economically significant crop (Thepbandit *et al*., 2024). Root rot disease in cassava is largely managed using different combination of chemicals, some of which are applied on a prophylactic basis and indiscriminately (Maywald *et al*., 2023). Such practice exacerbate the accumulation of cytotoxic residue in the environment and negatively influencing human, animal and plant health.

Application of nitrogen fertilizers, to mitigate the effect of abiotic stress, has also been associated with contradictory outcomes in crop production, these include increased proliferation and virulence of pathogen, induction of disease tolerance or resistance, alteration of soil ecology and improved yield (Cai *et al.*, 2021). It is therefore imperative to establish the interplay among nitrogen application, root rot incidence and rot severity in provitamin-A cassava varieties. This research seeks to identify root rot-resistant provitamin-A cassava variety and establish the relationship between nitrogen application and cassava susceptibility.

MATERIALS AND METHODS

The trial was laid as a split plot in randomised complete block design (with two nitrogen (N) rates of 0 and 100 kg/ha from urea fertilizer as main plots and 15 variety as sub plots) with three replications. All the plots received basal doses of 60 kg/ha P and K (from SSP: Single Super Phosphate and MOP: Muriate of Potash). The trial was established for two consecutive seasons (2018 and 2019) at the Ibadan station of the Institute of Agricultural Research and Training (IAR&T), Nigeria; and the roots were harvested at 12 months after planting from an area of 20 m^2. Plot size was 5 m x 5 m and cassava was planted at 1m x 1m spacing. Provitamin-A cassava genotypes used included 980518, IBA090090, I920326, I070539, IBA083724, NRO7022, 92132, IBA070593, L070337, I11421, I011797, IBA120008, 070337, I011371, I011368 and IBA980505.

Disease incidence and severity index

Postharvest symptom observed on the field included root rot, tissue discolouration and signs of depolymerisation. Disease incidence was assessed using the formula: $\frac{n}{N} \times 100$. Where n = number of symptomatic roots, N = total number of sampled plants. Percentage rot severity was assessed according to the method of Adedire *et al.* (2021).

Isolation of pathogens from infected cassava samples

Symptomatic portions of cassava root tissue samples (5 mm section) were surface-sterilised with 2% sodium hypochlorite solution for 30 seconds, rinsed thrice with sterile distilled water and drained on sterile blotting paper. Prepared samples were inoculated on Potato Dextrose Agar (PDA), incubated at 30ºC for 7 days. Mycopathogens were also isolated from leaf samples of plants associated with CRRD and identified (Thepbandit *et al*., 2024).

Pathogenicity test using cassava root
Root rot-associated microbial strains were subjected to pathogenicity assessment on healthy cassava roots using the tissue disc displacement assay (Hohenfeld *et al*., 2024). A tissue disc (5 mm) was removed from surface-sterilised, healthy cassava root, replaced with mycelial disc of each test fungus and kept moist for 10 days.

Data analysis
Data collected on disease parameters were compared using DSTAAT and means were separated with Duncan's Multiple Range Test (DMRT). Effect of variety was also determined using SAS (version 25.0) software.

RESULTS AND DISCUSSION
Cassava root rot disease was identified in 14 out of 15 cassava genotypes. Symptoms associated with infected roots included tissue depolymerisation and discolouration. Some infected root samples also generated offensive odour, possibly associated with microbial degradation, characteristic of cassava rot. Although, compared with reported susceptibility of cassava to CRRD (da Silva *et al*., 2024), incidence and severity of root rot associated with the genotypes were low and as such, the pro-vitamin A cassava variety were regarded as tolerant.

Cassava root rot disease incidence and severity index in the 2018 season raged from 0.00% - 6.39% and 0.00% - 3.62%, respectively; while in the subsequent season, CRRD incidence ranged from 0.00% to 3.99% (Table 1). Highest disease occurrence was observed in genotype 980581 in both seasons, with incidence of 6.39% and 3.99%, and disease severity index values of 3.62% and 1.99% in 2018 and 2019 seasons, respectively. This was followed by genotype IBA-980505 with incidence of 3.31% in 2018 and 3.44% in 2019. Pro-vitamin A cassava genotype I-070539 showed no symptom of CRRD, both in 2018 and 19 seasons. This observations are essential to genotype selection because CRRD in susceptible cultivars cause significant losses in root quality and overall yield of cassava. This is particularly pressing in countries that largely depend on agriculture-related activities for their income (Thepbandit *et al*., 2024). Ntui *et al.* (2023) discussed introgression of resistance factors from tropical Manihot species through improvement-breeding into native cultivars, as well as strategies to prevent resistance breakdown in cassava genotypes. Recent studies in cassava transcriptome analysis using RNA-Seq, differential gene expression studies and gene silencing have revealed candidate genes responsible for CRRD (Hohenfeld *et al*., 2024). Some of these factors include MLP-like protein 31 and the peroxidase A2-like gene, while other candidate genes would include inductive transcript receptors for vertical resistance.

Influence of nitrogen application on susceptibility of pro-vitamin A cassava genotypes to CRRD was also observed (Table 1). In 2018, nitrogen application significantly exacerbated the susceptibility status of 980581, IBA-083724, 982132, NR-070220, I-070337 and I-011371 to CRRD. In the subsequent season (2019), application of urea fertilizer increased CCRD incidence in 980581, IBA-083724, NR-070220, I-011797, IBA-120008 and I-011371. In both seasons (2018 and 2019) nitrogen application induced CRRD in IBA-083724, NR-070220 and I-011797 cassava genotypes. Conversely, fertilizer application reduced CRRD severity in I-920326, however, the disease suppression was not significant. Mycopathogens associated with CRRD isolated from infected cassava genotypes included *Aspergillus*, *Fusarium, Lasiodiplodia*, *Botrytis and Rhizopus* species*,* with *Aspergillus* (Figure 1) being the most predominant species.

Aspergillus flavus and *A. niger* caused a dry rot with grey and dark green discoloration of affected root tissues. In a similar study, Cai *et al*. (2021) reported the significant influence of fertilizer on rhizospheric fungal community of cassava. This affected cassava performance and the proliferation of pathogens around the root of host plant.

Table 1: Incidence and severity of root rot disease in cassava genotypes

Pro-Vitamin A cassava Variety	**Nitrogen application**	**2018 season**		**2019 season**	
		Incidence (%)	**DSI (%)**	**Incidence (%)**	**DSI (%)**
980581	+	**6.39a**	**3.62a**	**3.99a**	**1.99b**
	-	4.04b	2.90ab	1.60cd	0.62c
IBA-090090	+	1.61cd	0.48cd	1.13cd	0.23c
	-	0.96de	0.74cd	0.95de	0.76c
I-920326	+	0.26de	0.05d	0.00e	0.00c
	-	0.65de	0.43cd	0.86de	0.39c
I-070539	+	**0.00e**	**0.00d**	**0.00e**	**0.00c**
	-	**0.00e**	**0.00d**	**0.00e**	**0.00c**
IBA-083724	+	1.48cd	0.23cd	1.17cd	0.24c
	-	**0.00e**	**0.00d**	**0.00e**	**0.00c**
NR-070220	+	2.30bc	1.08cd	1.89bcd	0.81c
	-	**0.00e**	**0.00d**	**0.00e**	**0.00c**
982132	+	0.31cd	0.06d	0.99de	0.27c
	-	0.00e	0.00d	0.43de	0.09c
1BA-070593	+	0.19de	0.36cd	0.64de	0.26c
	-	1.51cd	0.49cd	1.63cd	0.65c
I-070337	+	1.07cd	0.36cd	0.92de	0.29c
	-	0.00e	0.00d	0.37de	0.07c
I-011412	+	1.26cd	0.26cd	1.13cd	0.23c
	-	1.20cd	0.24cd	0.89de	0.18c
I-011797	+	0.84de	0.27cd	1.38cd	0.38c
	-	**0.00e**	**0.00d**	**0.00e**	**0.00c**
IBA-120008	+	0.94de	0.15cd	1.78cd	0.32
	-	**0.00e**	**0.00d**	**0.00e**	**0.00c**
I-011371	+	2.14bc	1.12cd	2.22bc	0.73c
	-	**0.00e**	**0.00d**	**0.00e**	**0.00c**
I-011368	+	0.00e	0.00d	0.49de	0.23c
	-	0.00e	0.00d	0.15de	0.03c
IBA-980505	+	**3.31b**	**1.61bc**	**3.44ab**	**1.74b**
	-	2.74bc	1.62bc	1.87bcd	2.86a

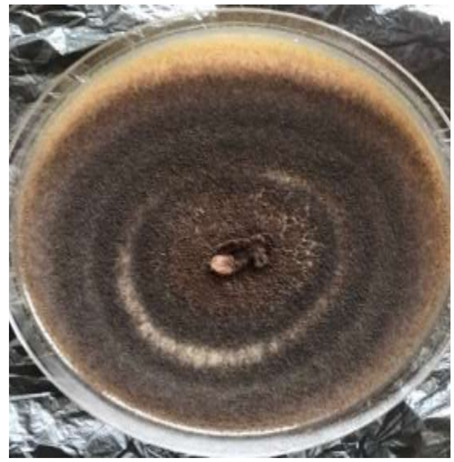
+: 100 kg/ha nitrogen application; -: without nitrogen application; DSI: Disease severity index. Mean values with similar letter(s) along the column are not significantly different at 5 % level of probability by Duncan Multiple Range Test (DMRT).

However, contrary to the observations of our study, reports have attributed substantial improvement in the health of modernties of crops to the application of chemical fertilizers, especially, in the management of mycopathogens (Maywald *et al*., 2023; Csihon *et al*., 2024). Therefore, the pathosystem of individual cassava genotype should to be screened to establish their response to fertilizer application. This will inform appropriate recommendations for fertilization, particularly, in a CRRD-endemic field.

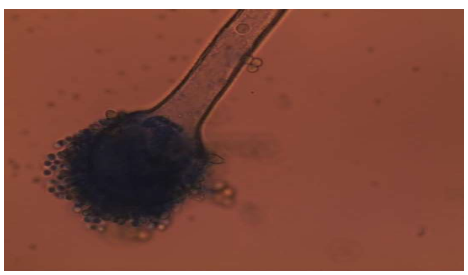
CONCLUSION AND RECOMMENDATIONS

Biofortification of cassava with vitamin-A aims to address both food insecurity and hidden hunger. Unfortunately, CRRD and low soil nitrogen pose significant threat to cassava farms, leading to yield loss in cassava-producing nations. Selection for resistance or tolerance in cassava genotypes is therefore imperative. Hence, this study investigated the susceptibility of 15 pro-vitamin A cassava genotypes to CRRD, as influenced by nitrogen application on an endemic plot. Fourteen genotypes were tolerant to CCRD, 980581 expressed the highest incidence, while I-070539 showed no root rot symptom in both 2018 and 2019 seasons. Consequently, 980581 should be further investigated for active or passive resistance factors, mechanisms of activation against rot pathogens and subsequently recommended by IAR&T as either CRRD-resistant or tolerant cassava genotype.

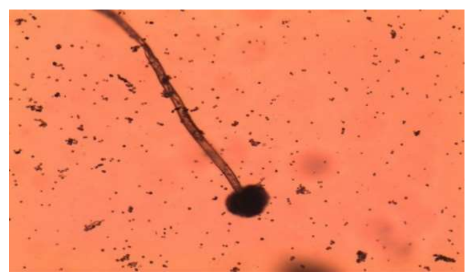
Culture of *Aspergillus flavus*



Culture of *Aspergillus niger*



Conidiophore of *Aspergillus flavus* (× 400)



Conidiophore of *Aspergillus niger* (× 400)

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Appraisal of Approaches for Rural Development Adopted by Selected Non-Governmental Organizations in Plateau State, North Central, Nigeria

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Abstract

This paper examines the approaches adopted by selected agencies in the delivery of rural development programs in rural communities of Plateau State, Nigeria. The specific objectives were to: comparatively determine the major activities of the organizations as development agencies; identify the major target groups of the organizations; determine the sources of funding for the organization's programs, and; determine the methods/approaches used for the delivery of the organization's programs. Data was obtained using a structured questionnaire and subjected to descriptive statistics like frequency distribution and percentages. Eighty (80) respondents comprising staff members of the respective agencies were chosen through purposive sampling technique from 4 Local Government Areas in the State. The organizations devoted considerable efforts in agricultural, health, community development, human resource development, trading, technology and industrial promotion programmes. The target groups of the organizations were mostly farming communities and associations, women, children and youths. The organizations depended on grants from international institutions or national grants as their major sources of financing for their programmes. The organizations adopted several approaches but centered more on integrated rural development (ECWA-POD) and gender approaches (COWAN) to execute their programmes for rural development. It was therefore recommended that the organizations should consider self-sustainability plans and seek for alternative sources of steady funding rather than depend entirely on donor funds in the implementation of their rural development programs.

Keywords: Approaches, Donor agencies, Non-governmental Organizations, Rural Development

INTRODUCTION

The development sector has witnessed an influx of new players due to the perceived failure of government to address the issues of developing a fairer and more sustainable trend of agricultural and rural development. One of these participants is the Non-Governmental Organizations (NGOs). The term Non-Governmental Organizations (NGOs) refers to a wide range of organizations, from big charitable organizations to small self-help groups all of which work to raise the standard of living for their constituents. Several charitable organizations are committed to development efforts. NGOs refers to independent, relatively structured intermediate organizations that support rural groups and as a result, they have become an essential and strong framework for current societal engagement in government issues for development initiatives. (Owa, Wisdom and Egbara, 2017).

According to Abanyam and Mnorom (2020), NGOs have diverse origins, others emerged as charity programmes; some arose from popular change progressives that championed the rights of women, small-holder farmers, natives, religious institutions, environmental activist, trade association as well as other associations. While the great majority of NGOs were created in the 1970s and 1980s, some dates back to the 1950s, 1960s, and even earlier eras after the end of World War II, when the United Nations attempted to clearly differentiate between corporate groups and intergovernmental specialized agencies. In recent times, a significant decline in public employment opportunities for extension or change agents have made most specialists to have turned to NGOs as potential employers. The NGOs have been further empowered by the readiness of foreign aid organizations to fund their development initiatives (Akinloye and Banji, 2005).

Over the years, research work on non-governmental organizations' contributions to the development of rural communities in Nigeria has been extensively carried out. This study focused on the approaches adopted by selected Non-Governmental Organizations; Country Women Association of Nigeria (COWAN) and Evangelical Church of West Africa-People Oriented Development (ECWA-POD) in delivering their rural development programs in communities of North Central, Plateau State, Nigeria and it is against this background that the study was conceived. More specifically, this study:
i. identifies the major target groups of the organizations;
ii. determines the sources of funding for the organization's programs, and;
iii. determines methods/approaches used for the delivery of the organization's programs.

MATERIALS AND METHODS

Study Area

Plateau State, Nigeria served as the location of the research work. With an estimated population of 4.4 million inhabitants and a yearly increase of 3.0 percent, the State spans approximately 26,899 square kilometers. (National Bureau of Statistics, 2019). Plateau State is positioned between latitude 80^{o} 24' N and longitude 80^{o} 32' and 100^{o} 38' East. Jos Plateau, a region with a high concentration of mountains in the Northern part of the State, seems to be where the name of the state originated. The altitude varies from 1,200 meters (about 4000 feet) to a peak of 1,829 metres more than sea level around the Shere-hills region close to Jos. The state shares common boundaries with Benue State to the south, Taraba State to the east, Kaduna State to the north-west, Nasarawa State to the southwest, and Bauchi and Gombe states to the North East (City Population, 2023).

Sampling Techniques

The staff members of the two organizations- Country Women Association of Nigeria (COWAN) and Evangelical Church of West Africa-People Oriented Development (ECWA-POD)- in their respective operational locations make up the study's population. In the initial stage, four (4) local government areas (LGAs) were chosen using the purposive sample technique, taking into account the level of activity of these organizations in the designated LGAs. Bokkos, Jos-South, Kanke, and Pankshin local government areas are the selected local governments. Using a purposive sample technique, forty (40) NGO staff members from each organization were selected for the second stage based on staff availability in the operating locations. The organizations provided a list of their employees, which served as the study's sample frame. For ECWA-POD, eighteen (18) staff members were selected from Bokkos and twenty-two (22) staff members from Jos South local government areas respectively. For COWAN, fifteen (15) staff members were selected from Kanke and twenty-five (25) staff members were selected from Pankshin local government areas respectively. Lastly, a total of eighty (80) NGO staff were purposively selected to constitute the sample size of the study. Primary data were obtained with the aid of a structured questionnaire administered to the staff members of the NGOs. Data obtained from the study was processed using descriptive statistics like percentages and frequency counts.

RESULTS AND DISCUSSION

Major Programmes of the Organizations

According to the study, both groups have made significant contributions to rural development. A review of their operations offers' insight into how, in the case of ECWA-POD, delivery and service activities are combined with employment-generating activities; in contrast, COWAN has concentrated more on community empowerment and human resource development than on service delivery. According to the report, the majority of program activities led to improvements in self-reliance and technology transfer, community development, human resource development, health and hygiene, economic development, and behavioral changes. There was also the significance of sustainability and ecological protection. Their role has evolved from being only providers of services to include training, enhancing capacity, facilitating, and empowering communities.

Target Group of the Organizations

The results, shown in Table 1, show that most (60.0%) of the ECWA staff indicated that farmers associations and farming communities constitute their major target groups while (66.6%) of COWAN staff choose women, children and youth as the major target groups of the organization. This result agrees with Biersnchenk and Hoffmann (2006) which states that the usual target audiences covered by NGOs' provisions are the rural smallholder farmers, especially the more disadvantaged groups of women and children and the marginalized population. According to them, most non-governmental organizations consider the inclusion of women groups in their micro-credit programmes since they are perceived as having a good record of credit repayment and are also known to take full control of the overall developmental goals of children which include acquiring knowledge, well-being, etc.

Table 1. Target groups of the organization

	ECWA		COWAN	
Group	***f**	**%**	***f**	**%**
Faith based organizations	11	36.6	8	26.6
Underprivileged and physically challenged	11	36.6	7	23.3
Community based organizations	16	53.3	14	46.6
Farmers associations	18	60	16	53.3
Women, Children and Youth	10	33.3	20	66.6

Source: Field survey, 2019 *Multiple responses

Sources of Funding

Table 2 indicates that the major (60.0%) sources of funding for ECWA POD programmes are through international donations while COWAN also relies more (66.6%) on international donations to execute their rural development programs. Ngeh (2013) also reported that individual donations, grants from national or international organizations and membership fees are the main sources of revenue for non-governmental organizations. A considerable number of these organizations lack the necessary funds needed to execute beneficiary-related initiatives. As a result, they often consider raising funds from other sources.

Table 2: Sources of funding of the organization's programs

Sources	ECWA *f	%	COWAN *f	%
Individual donations	7	23.3	9	30.0
Public donations	8	26.6	10	33.3
International donations	18	60.0	20	66.6
Member subscriptions	5	16	7	23.3
Self-funding (Miscellaneous)	14	46.6	7	23.3
Government donations	6	20.0	12	40.0

Source: Field survey, 2019 *Multiple responses

Methods/Approaches used for Delivery of Programmes

The result in Table 4 reveals that both organizations employ several approaches in delivering their programmes, ECWA centering more (30.0%) on integrated rural development while COWAN adopts more (32.5%) of gender approaches for the delivery of its programmes. This result aligns with Achegbulu and Ujah (2006) who stated that rural development is better achieved through an integrated rural development approach and the bottom-up strategy which involves the holistic improvement of livelihoods of communities as well as mobilization of the community groups in the identification of felt needs of the rural communities, sourcing of project funds in conjunction with other stakeholders such as the government and NGOs.

Table 3. Approaches used for delivery of programmes by the organizations

Approach	ECWA *f	%	COWAN *f	%
Awareness Raising	3	7.5	6	15.0
Bottom-up Approach	6	15.0	3	7.5.0
Capacity Building	3	7.5	3	7.5.0
Self-help Development	6	15.0	2	5.0
Advocacy	6	15.0	4	10.3
Collaboration	3	7.5	3	7.5
Participatory Approaches	6	15.0	3	7.5
Gender Approach	5	12.5	13	32.5
Integrated Rural Development	12	30.0	7	17.5

Source: Field survey, 2019 *Multiple responses

CONCLUSION AND RECOMMENDATIONS

Rural development is the end result of interactions that revolve around material, technical, organizational, cultural, societal and financial components. Approaches and strategies adopted by organizations for rural development should be such that are capable of bringing about changes, mainly in the well-being of those belonging to the economically disadvantaged, neglected and underprivileged parts of the communities.

The study revealed that the target groups of the organizations constituted farming communities, organizations and the less privileged in the communities. The major sources of funding of the organization's activities were from donor agencies. The organizations adopted several approaches but centered more on integrated rural development (ECWA-POD) and gender approaches (COWAN) to execute their programmes for rural development. It was recommended that the organizations should consider self-sustainability plans and seek alternative sources of steady funds for their programmes rather than depend entirely on external sources of funding.

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Sweet Potato Seed System in Nigeria: An Appraisal

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Abstract

Sweet potato is an important food and nutrition security that is adapted to all agro-ecologies in Nigeria. As a result of its importance to the economy of rural and urban households, its production has increased over sixfold in the last two decades despite its low yield per unit area. One of the most important factors militating against high productivity is the use of poor planting materials by farmers. To ensure the delivery of high-quality seeds of improved varieties to farmers to increase productivity, there is a need to understand the current sweet potato seed system. This work, therefore, appraises the temporal development of the current seed system, the classes of seed that make up the seed system, and the extent of the seed certification.

INTRODUCTION

Sweet potato is an important food and nutrition security crop in most sub-Saharan African countries. It is a perennial crop that is cultivated as annual. In Nigeria, it is the 3rd largest root and tuber crop after cassava and yam. It is adapted to all agroecologies from the high rainforest belt of the south to the Sudan-Sahel region of the north with different intensities (Anderson et al, 2012). With about 4 million metric tonnes of fresh root produced in 2021, Nigeria is the 3rd largest producer of sweet potato in Africa after Malawi (7.44 million tonnes) and Tanzania (4.99 million tonnes) (FAOSTAT, 2022). Its production has increased over six-fold in the last two decades due largely to an increase in land area under cultivation as a result of its high productivity under short duration (3-5 months), resistance to many diseases and pests, low input requirement, high nutritive value (especially the orange- and purple-fleshed cultivars), and its adaptability to marginal growing conditions (e.g., drought and poor soil) (Oswald, et al., 2009). Its higher market price per kilogram compared to cassava has transformed it to increasingly important cash crop.

Despite its growing importance, productivity has remained low with root yield of <3 tons/ha (Ebem et al., 2021). This has remained so despite the release of new improved varieties that combine high yield potential with high nutritional values. One of the major constraints to high sweetpotato productivity is the use of poor seed quality, especially for varieties that are susceptible to the debilitating sweetpotato virus disease (SPVD) (Adeyonu et al., 2019). According to Stathers et al. (2018), more than 95% of planting materials used by farmers in sub-Sahara Africa are sourced from regrowths from the previous field after one or two rains, from other farmers, or from the local market. The consequence of the use of such seed is poor yield, which is as a result of the high viral load and pathogenic infections accumulated over the years in recycled sweetpotato vines. Sweetpotato virus disease has been reported to cause yield loss as high as 90-98% (Rajendran et al., 2017), whereas the use of virus-free planting material, especially in susceptible cultivars, can result in 30% yield gain (Fuglie et al., 1999). For high root productivity, therefore, the production and use of pathogen-free planting materials is a critical factor.

Sweetpotato seed system

A seed system comprises a set of activities from variety development through seed production and delivery to farmers (Ayenan et al., 2021). A typical seed system comprises the formal, semi-formal and informal systems. The National Agricultural Seed Council, Nigeria's seed regulatory and certification body also adopted this format across crops (Legg et al., 2022), The informal seed system is the traditional system that is characterized by the use of farmer-saved seed or uncertified seeds from other farmers and local sources (Teeken et al., 2018). The farmer is in full control of the variety to plant and the source of seed (FAO, 2016). It is the most dominant seed system in sweetpotato as it is in most other root and tuber crops in Nigeria.

The Semi-formal seed system is an intermediate system that taps the strength of community participation in seed production. Organized farmers, farmer cooperatives and individual seed producers are the drivers of this model. It is the current state of sweetpotato seed system in Nigeria where commercial seed producers called Decentralized Vine Multipliers (DVMs) that are organized into sweetpotato seed cooperatives are trained on EGS handling and conservation through the use of farm-gate net-tunnel technology and QDS production. The semi-formal seed system is an effective route to the formal seed system for many root and tuber crops including sweetpotato.

The formal seed system is a highly regulated and controlled system that leads to the production of certified seeds of improved varieties. In sweetpotato, the formal seed system encompasses the pre-basic, basic, and certified quality declared seed (QDS) (Stathers et al., 2018). The share of the semi-formal and formal seed systems in the total sweetpotato seed demand in Nigeria is extremely small, especially before the release of the first set of sweetpotato varieties in the early 2010s. However, with a shift in focus towards enhancing the production of high quality sweetpotato planting materials, especially with the finding that sweetpotato farmers in Nigeria are willing to buy high quality seeds (Adesina et al., 2017), the contribution of the semi-formal/formal seed system to sweetpotato seed demand in Nigeria has increased significantly, though still very low. The intention of UmudikeSeed, a private seed company to begin the production of sweetpotato EGS and QDS signals the shift towards full formal seed system.

The current sweetpotato seed system is presented in Figure 1. The National Root Crops Research Institute (NRCRI), Umudike is saddled with the responsibility of producing EGS for the seed system. This is so as EGS production is highly technical, requiring tissue culture approaches to eliminate viruses and other pathogens, and the invitro multiplication and hardening of clean plantlets to generate pre-basic seed. Pre-basic seed needs to be further multiplied in the screenhouse under strict conditions to generate basic seed that is sold to DVMs. The DVMs multiply EGS once in the field and sell to farmers as Quality Declared Seed (QDS).

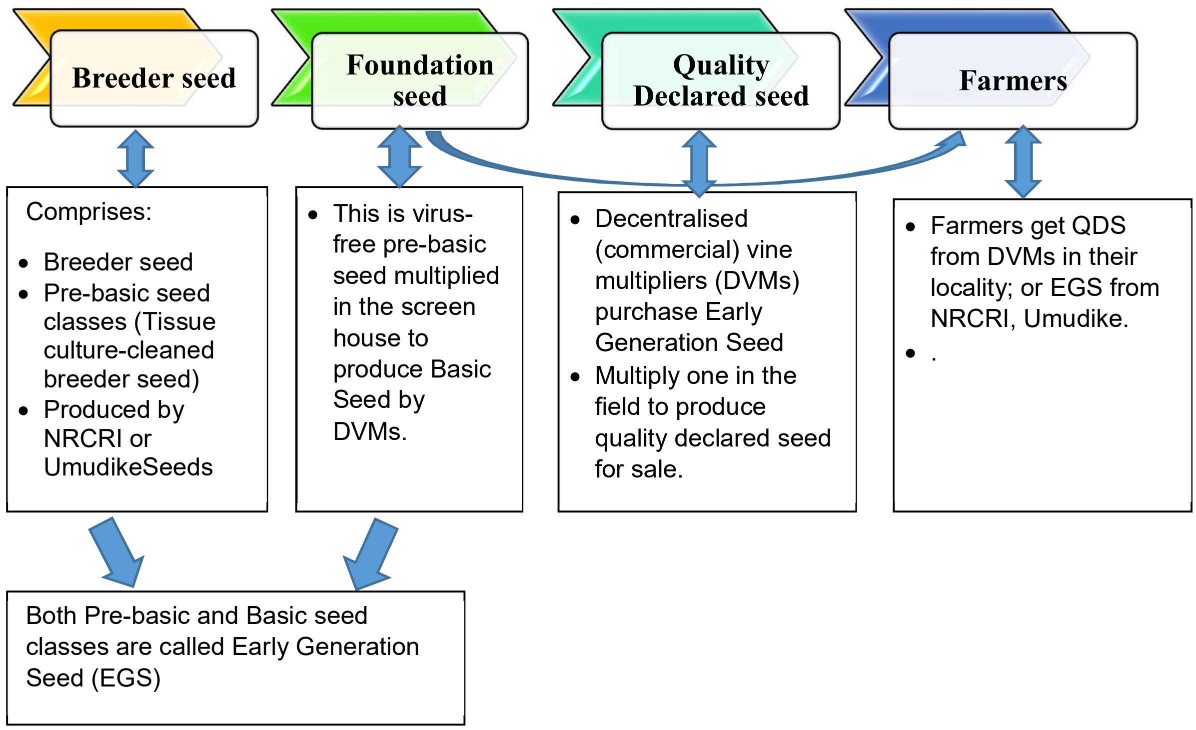

Figure 1: Diagrammatic representation of the current sweetpotato seed system.

Seed certification

Presently, the various seed classes are not certified, though conscious efforts are taken to ensure the production of virus-clean EGS upon which other seed classes depend. Virus indexing to check if the EGS is virus-clean is usually done using appropriate techniques. The current non-certification of sweetpotato seeds is due partly to the non-conclusion of the efforts to produce a NASC- approved Certification Protocol Manual, and partly due to the non-existence of trained NASC and community-based Certification Officers as done in cassava. *However, the use of EGS to produce QDS ensures that farmers have access to new varieties and their quality seeds that can significantly impact productivity and market access*.

Temporal development of the sweetpotato seed system in Nigeria

The development of the seed system begins with the release of improved varieties that leads to the production of breeder seeds/EGS of improved varieties from which other classes of seeds are produced. Summary of the temporal development of the sweetpotato seed system in Nigeria is presented in Figure 2.

The period of late 1970 to 2000s was the period when sweetpotato farmers sourced planting materials from previous years' fields, other farmers, or from other local sources. The system was characteristically informal. The planting materials were not certified, and seed purchase was not popular. Attempts at developing improved varieties were largely carried out by IITA, Ibadan, while the NRCRI, Umudike was involved only in adaptation trials of elite genotypes from IITA.

The period between 2000 and 2010 witnessed strong efforts at developing new improved sweetpotato varieties at the NRCRI, Umudike. Progeny populations from adapted and elite genotypes were developed and advanced with wide adaptation tests in important sweetpotato belts of the country. However, the informal seed system still dominated the sweetpotato system. The NRCRI, Umudike was field-multiplying and supplying seeds of selected improved genotypes to farmers that were willing to purchase seed. However, the seeds sold were neither virus-cleaned nor certified.

The period between 2011 and 2015 witnessed the official release of three improved varieties (Mother's Delight, King J and UMUSPO/2) by the NRCRI, Umudike in 2012 and 2013 under the Alliance for Green Revolution in Africa sweetpotato (AGRA) breeding grant. The availability of the newly released varieties galvanized a robust collaboration between the NRCRI, Umudike, CIP (International Potato Centre) and the Federal Government of Nigeria in 2015 which led to the commencement of the semi-formal sweetpotato seed system in Nigeria. By this system, CIP supported the NRCRI, Umudike with training in EGS production, in the supply of screen house equipment, and in the development of the DVMs in six states of the country. This period also ushered in the era of farmers actually purchasing high quality seeds. The subsequent years (2016-2023) consolidated the semi-formal seed system with series of trainings of farmers in sweetpotato seed production, handling and marketing, creating networks of DVMs that service local communities with quality vines for planting. This period also witnessed the continual release of new varieties into the seed system. The business decision of Umudike Seeds Limited to begin the production of EGS QDS in 2023 is a significant turning point in the sweetpotato seed system towards full formal system where well-labelled certified seeds of improved varieties will be available to farmers.

Late 1970s - 2000	2000 - 2010	2011 - 2015	2016 - 2023
• Sweetpotato seed system completely informal. • Breeding: Only selection of elite genotypes collected from IITA. • No onstation-based population development	• Informal seed system completely dominates • Onstation-based population development began. • No varietal release	• Three new varieties were released (2012 & 2013) • A semi-formal seed system began (EGS production began; DVM system initiated; DVMs trained. •	• Semi-formal seed system strengthened • Formal seed system emerging - Private seed company (UmudikeSeeds) involvement in EGS production emerging. • New variety released (2018).

Figure 2: Temporal appraisal of sweetpotato seed system in Nigeria.
IITA = International Institute for Tropical Agriculture

CONCLUSION AND RECOMMENDATIONS

The Nigerian sweetpotato seed system has grown over the years from the 1970s. It is still largely dominated by the informal system, but the semi-formal seed system's influence is growing rapidly. With the intention of UmudikeSeed to venture into the production of EGS and QDS, the emergence of the formal sweetpotato seed system is beginning. This emergence will be further strengthened with the official release of sweetpotato Seed Certification Protocol Manual, the training of NASC seed certification officers and local sweetpotato cooperative leaders on the use of the certification protocol, and the continuous release of end-user preferred sweetpotato varieties.

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Efficiency Analysis of Maize Producing Farms in Federal Capital Territory, Abuja, Nigeria

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Abstract
The study examined the efficiency of maize farms in Federal Capital Territory (FCT). The study determines the economic efficiency of maize farmers in the study area and identifies the problems faced by farmers in the study area. Primary data were used for the study. A multi-stage sampling technique was employed in the selection of respondent for the study. The primary data were obtained using structured questionnaires administered to 269 farmers. Descriptive statistics and stochastic frontier model were used for the analysis of data. The variance parameter of Sigma (δ^2) was 1.548 for the farmers and statistically significant at 1%, this indicates a good fit and correctness of the distributional form assumed for the composite error term. The gamma (γ) which is the proportion of deviation from frontier that is due to inefficiency estimate was 0.953 and was statistically significant at 1%; it shows the amount of variation resulting from the technical inefficiency of maize farmers. This means that more than 95% of the variation in the farmer's outputs respectively is due to differences in technical efficiency. Seed (1.166) was statistically significant at 1% for the farmers. This implies that an increase in seed will lead to an increase in the output of maize, the coefficient of labour was 0.004; it is positive but not significant. This implies that increasing labour will increase production but not significantly. The allocative efficiency scores were high as majority (70%) lie between 41 and 100%. The mean allocative efficiency of the farmers was 48%. This indicates that about 48% of the variations in the total cost of production of maize farmers were due to differences in their allocative efficiencies. Economic efficiency was calculated as the product of technical efficiency and allocative efficiency. Mean technical efficiency × Mean allocative efficiency = Economic efficiency. 0.71 × 0.482 = 0.342. The results show that the maize farmers in the study area were not economically efficient in producing maize though there is room for more improvement. Economic efficiency of 34% indicates that the farmers can still reduce input cost by 66%, while maintaining the same output, or they can increase output by 66% while still maintaining the same input cost and technology. The farmers ranked high cost of inputs such as fertilizers, agrochemicals and improved seeds as their 1st constraint. . Government should provide production inputs at subsidized rates to enable the farmers get them easily

Keywords: Maize, efficiency, economic efficiency, Constraints

INTRODUCTION

Akande, (as cited in Agbonika, 2013) said maize is a crop of great economic importance in Nigeria. Maize is a cereal crop grown for food, feed and industrial uses and it is the second most common cereal food crop after rice. Maize is widely cultivated throughout the world, and a greater amount of maize is produced each year than any other grain, in Nigeria it is produced largely in the Northern Guinea Savannah. There are several domestic markets for maize all over Nigeria and maize also filters into international markets such as Niger, Chad, Mali, Benin Republic and some other countries in the West African Sub region (Iken and Amusa, 2004). Maize is widely consumed as a stable food by poor rural and urban households: providing carbohydrate, vitamins, and relatively small amount of protein to human beings and livestock as well. Maize will continue to play a large and important role in Nigeria's food production (USAID, 2010). The total land planted to maize in Nigeria is above 2.5 million hectares with an estimated yield of about 1.4 metric tonnes per hectare but 16% increase in production occurred in 2021 giving 11.6 million tonnes of maize yearly, the highest in the last six (6) decades (Agbonika, 2013, USDA, 2021). According to Agbonika (2023) it is an essential diet that is consumed by a good number of families and homes. An average Nigerian consumes maize or its derivatives at least once a day. Several varieties have been introduced that give high yield and resistance to diseases.

Oladele (2005) opined that the efficiency of technologies generated and disseminated depend on the effective utilization by farmers. The steady growth of population has led to an increase in the demand for food and agricultural raw material (Owolabi *et al.,* 2012). Productive efficiency can be enhanced through developing and embracing advanced technologies and improving farmer's access to resources. The most widely used techniques in the prediction of productive efficiency level and its causal factor are stochastic frontier analysis (SFA) and data envelopment analysis (DEA). The Stochastic Frontier Analysis uses a parametric approach and it is extensively used in estimation of the technical efficiency of farm or production method with multiple inputs and one output, According to Onuk *et al*, 2010, Maize *(Zea mays)* is one of the main cereal crops of West Africa, and the most important cereal food crops in Nigeria. It comes after wheat and rice in terms of world importance. Maize has been of great importance in providing food for man, feed for livestock and raw materials for some agro-based industries.

Maize (Z*ea mays)* which is considered as one of the most abundant food crops in Nigeria. About 80% of maize is consumed by man and animals, while 20% is utilized in variety of industries processes for production of starch, oil high fructose, corn sweetener, and ethanol, cereal and alkaline. Maize farming serves as a significant source of income for many households that are into farming, obvious increase in its production has been noticed: 75 million tons recorded in 2018 in Africa which is 75 percent of global maize production also in Nigeria 10.1 million tons in 2014, 10.4 million tons in 2016, and 11.6 million tons in 2021. There is need to determine the efficiency of farmers involve in maize production and identify the constraint that they face, in order to recommend and proffer solution that helps in stability of increased production of maize in the study area.

METHODOLOGY

The study was conducted in Federal Capital Territory (FCT), Abuja. Abuja is located between latitudes $9^0 25'$and $9^0 21'$ north of the Equator and Longitudes $6^0 45'$ and $7^0 39'$ east of the Greenwich meridian. Abuja shares boundary with Kaduna State to the north, Niger State to the west, Nassarawa and Kogi States to the east and south respectively. It covers an area of 8,000 square kilometres with a population of about 1,405, 201 people (National Population Commission- 2006). Abuja comprises of six (6) constitutionally recognised area councils namely: Abaji, Bwari, Gwagwalada, Kuje, Kwali and Abuja Municipal. Gwagwalada Area Council has an area of 1,043 km² and a population of 157,770 at the 2006 census. Gwagwalada area council lies between latitude $07^0.57'$N and longitude $07^0.7'$E. Kuje area council comprises of 162 communities widely spread within a land mass of about 1,800 square kilometer and a population of over 420,000 at the 2006 census. The vegetation of these area councils combines the best features of the Southern tropical rain forest and Guinea savanna of the North (Aiyedun, 2003). This reflects the full transitional nature of the Area as between the Southern forest and Northern grassland which have the woods and shrubs respectively. A multi-stage sampling technique was used to select the maize farming household for this study. Firstly, Gwagwalada and Kuje Area Council were purposively selected due on the prevalence of the maize crop production activities in these areas. Secondly, list of registered maize farmers in these areas were gleaned from the farmers register. Lastly, simple random sampling was employed in selecting 10% of the sample frame (2690) to give a sample size of 269. Primary data were used in this study and the data were obtained through the use of well-structured questionnaire administered to household heads using enumerators. Descriptive statistics (This includes frequency count and percentages) and inferential statistics were employed in the analysis of data. Descriptive statistics was used to determine the constraints and stochastic frontier production function was used to determine the efficiency of maize farmers in the study and is expressed as:

$$Y = X_{it}\beta + e_{it} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.\dots (1)$$
$$e_{it} = v_{it} - u_{it} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (2)$$

The explicit form of the model is as shown in equation 4 as:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \mathrm{In} X_2 + \beta_3 \mathrm{In} X_3 + \beta_4 \ln X_4 + \beta_5 \mathrm{In} X_5 + v_{it} + u_{it} \dots (3)$$

Where:
Y = Output of maize (Kg)
X_1 = Farm size (ha)
X_2 = Quantity of seeds (Kg)
X_3 = Quantity of labour (man-days)
X_4 = Quantity of fertilizer (Kg)
X_5 = Quantity of agrochemicals (herbicides and insecticides used) (liters)
β_0 = Intercept
$\beta_1 - \beta_5$ = Coefficients for the associated independent variables
v_{it} = One sided component which captures deviation from frontier as a result of inefficiency of the farmers.
u_{it} = effect of random shocks outside the farmers control

The individual farmer's level of technical efficiency (TE_i) is then calculated as:

$$TE_i = \exp(-E[u_i/\in_i])\, i, \dots\dots\dots..n \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.(4)$$
Such that $0 \leq TE \leq 1$

The stochastic cost function which is the basis for estimating the allocative efficiency of the farms is specified as follows: The stochastic frontier cost function is defined by:

Cobb-Douglas stochastic frontier cost function

$$lnC = b_0 + \sum_{i=1}^{6} b_i lnP_i + \beta lnY_g + v + u \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (5)$$

$$lnC = b_0 + b_1 lnP_1 + b_2 lnP_2 + b_3 lnP_3 + b_4 lnP_4 + b_5 lnP_5 + b_6 lnP_6 + v + u \dots\dots\dots\dots\dots (6)$$

Where:
C = Total cost of maize production of i^{th} farming household (N)
P_1 = Cost of labour (N)
P_2 = Cost of seed (N)
P_3 = Cost of fertilizers used (N)
P_4 = Cost of agrochemicals (N)
P_5 = Cost of farm size (N)
P_6 = Cost of implements used (N)
b_0 = intercept
b_i = vector of cost parameter to be estimated
β = vector of output parameter to be estimated
v= random variability in the cost of production that cannot be influenced by the farmer.
u= the deviation from the cost frontier attributed to cost inefficiency.

RESULTS AND DISCUSSION
Table 1 shows the estimates of the parameters for the stochastic frontier production function and the variance parameters of the model. The variance parameter of Sigma (δ^2) was 1.548 for the farmers and statistically significant at 1%, this indicates a good fit and correctness of the distributional form assumed for the composite error term. The gamma (γ) which is the proportion of deviation from frontier that is due to inefficiency estimate was 0.953 and was statistically significant at 1%; it shows the amount of variation resulting from the technical inefficiency of early maize farmers. This means that more than 95% of the variation in the farmer's outputs respectively is due to differences in technical efficiency.

Farm size: The estimated coefficient for farm size (0.566) for the farmers was positive and statistically significant at 1%. This implies that a 1% increase in farm size will *ceteris paribus* lead to an increase of 0.566% in maize output.

Seed: The estimated coefficient for seed was positive and statistically significant at 1% for the farmers. This implies that an increase in seed will lead to an increase in the output of maize. The significance of seed quantity is due to the fact that seed determines to a large extent the output obtained. If correct seed rates and quality seeds are not used, output will be low even if other inputs are in abundance.

Labour: The coefficient of labour is 0.004; it is positive but not significant. This implies that increasing labour will increase production but not significantly. This is contrary to the findings of Adeoye *et al*. (2011) who reported coefficient of labour (0.10) positive and statistically significant at 1% level of probability among watermelon farmers in Oyo state of Nigeria.

Fertilizer: This was 0.638, positive and statistically significant at 1% for the maize farmers. This implies that an increase in fertilizer use will increase output for the farmers which is in line with the report of Onuk *et al,* (2010) Fertilizer is a major land augmenting input because it improves the quality of land by raising yields per hectare.

Table 1: Estimates of Technical Efficiency model for the maize farmers

Variable	Coefficient	Std Error	T-ratio
Constant (β_0)	5.911	0.470	12.57***
Farm size (β_1)	0.566	0.119	4.76***
Seed (β_2)	1.166	0.081	14.41***
Labour (β_3)	0.004	0.039	0.089
Fertilizer (β_4)	0.638	0.129	4.96***
Pesticides (β_5)	0.189	0.104	1.81*
Sigma squared	1.548	0.343	4.508***
Gamma	0.953	0.016	58.39***

*** P < 0.01, ** P < 0.05, * P < 0.1

The general distribution of the farmer's efficiency presented in Table 2 showed that majority (78%) of the farmers fall between technical efficiency positions of 61% and 100% with a minimum of 1% and a maximum of 91%. The implication of the result is that farmers in the study area had wide differences in their technical efficiency operation. The mean technical efficiency of the farmers was 71%. This implies that on the average, the respondents are able to obtain about 71% of potential output from a given mix of production inputs. Thus, in the short-run, there is a scope for increasing maize production by 29%, by adopting the technologies or techniques used by the most technical efficient farmers in maize production. Generally, a negative sign on a variable means that the variable reduces technical inefficiency, while a positive sign increases technical inefficiency.

Table 2: Frequency distribution of the technical efficiency of maize farmers

Technical efficiency range	Frequency	Percentage
0.01-0.20	12	7
0.21-0.40	6	3
0.41-0.60	25	12
0.61-0.80	112	53
0.81-1.00	57	25
Total	**212**	**100**
Mean	0.71	
Minimum	0.01	
Maximum	0.91	
SD	0.19	
CV (%)	26.55	

Table 3 contains the estimates of the parameters for the stochastic frontier cost function for allocative efficiency and the variance parameters of the model. The variance parameter of sigma (δ^2) was 2.191 and statistically significant at 1% level. The gamma estimate was 0.955 and statistically significant at 1% level of probability, meaning that 96% variation in the cost of production was due to differences in their allocative efficiencies. The mean allocative efficiency of the farmers was 48%. This indicates that about 48% of the variations in the total cost of production of early maize farmers were due to differences in their allocative efficiencies.

Seed: The estimated coefficient for seed (0.634) was positive and statistically significant at 1% level of probability, implying that cost of production increases by the value of the coefficient (0.634) as the quantity of the variable is increased by 1%. This finding agrees with Okoruwa & Ogundele (2006) who examined technical efficiency differentials in maize production technologies in Nigeria. They reported that the coefficient of seed was positive and significant for traditional technology and that increase in seed would increase output levels of maize farmers.

Farm size: The coefficient of farm size (0.159) was positive and statistically significant at 1% level meaning that cost of production increases by the value of the coefficient as the quantity of the variable is increased by 1%. This result agrees with the finding of Muhammad–Lawal *et al*. (2009) who worked on the technical efficiency of youth participating in agriculture programme in Ondo State, Nigeria. They reported that farm size was positive and significant and that increase in the farm size would increase output level of farmers.

Agrochemicals: The coefficient of agrochemical was 0.125 and statistically significant at 5% level of probability implying that the cost of production increases by the value of the coefficient as the quantity of the variable is increased by 5%. This finding agrees with the result of Amaza and Maurice (2005) who reported positive and significant coefficient of agrochemicals in rice-based production system in Nigeria.

Farm implements: The value of farm implements (0.089) was positive and statistically significant at 1% level of probability meaning the cost of production increases by the value of the variable as the quantity is increased by 1%. This agrees with several other studies such as Muhammad-Lawal *et al.* (2009) and Amaza and Maurice (2005) who reported that coefficient of farm implement was positive and significant and that increase in usage would result in increase in output levels in farm production.

Table 3: Maximum likelihood estimates of the stochastic frontier cost Function for maize producers

Variables	Coefficient	std error	t-ratios
In cost of seed	0.634	0.084	7.520***
Constant	4.198	0.950	4.421***
In cost of farm size	0.159	0.054	2.952***
In cost of agrochemicals	0.125	0.062	2.032**
In cost of fertilizer	-0.015	0.021	-0.681
In cost of labour	-0.053	0.059	-0.887
In cost of farm implements	0.089	0.026	3.447***
Sigma (δ2)	2.191	0.361	6.063***
Gamma (γ)	0.955	0.010	99.711***
Log likelihood	-60.48		
Mean allocative efficiency	0.254		

***, **,* implies significant levels at 1%, 5% and 10% respectively

The frequency distribution of allocative efficiencies is presented in Table 4.. The mean allocative efficiency of the farmers was 0.482, the maximum value was 0.977 and minimum was 0.095. This implies that if the average farmer in the study area was to achieve allocative efficiency of his most efficient counterpart, then the average farmer could realize 51% cost savings (1 – (0.482/0.977) x 100. The most inefficient farmer could realize cost savings of 90% (1 – 0.095/0.977) x 100 to become the most efficient farmer.

Table 4: Frequency distribution of allocative efficiency of maize farmers

Efficiency	Frequency	Percentage
0.01-0.20	56	26
0.21-0.40	8	4
0.41-0.60	130	61
0.61-0.80	8	4
0.81-1.00	10	5
Total	**212**	**100**
Mean	0.482	
Minimum	0.095	
Maximum	0.977	

Economic Efficiency of the Farmers

Economic efficiency was calculated as the product of technical efficiency and allocative efficiency. Mean technical efficiency × Mean allocative efficiency = Economic efficiency 0.71 × 0.482 = 0.342.

The results show that the maize farmers in the study area are not economically efficient in producing maize though there is room for more improvement. Economic efficiency of 34% indicates that the farmers can still reduce input cost by 66%, while maintaining the same output, or they can increase output by 66% while still maintaining the same input cost and technology. The allocative efficiency scores were high as majority (70%) lie between 41 and 100%. We therefore reject the null hypothesis, meaning that early maize variety adopters are economically inefficient.

Table 5: level of economic efficiency of maize farmers

Efficiency	Frequency	Percentage
0.01-0.20	15	7
0.21-0.40	120	57
0.41-0.60	65	30
0.61-0.80	2	1
0.81-1.00	10	5
Total	**212**	**100**
Mean	0.342	
Minimum	0.00095	
Maximum	0.889	

Constraints faced by farmers in maize production

Table 6 shows the distribution of farmers based on constraints faced in maize production and are discussed according to their ranking. These problems were affecting the profits they could realize.

High Cost of Inputs

The farmers ranked high cost of inputs such as fertilizers, agrochemicals and improved seeds as their 1st constraint. About 94% of the respondents identified this as a problem. Most of the farmers are forced to buy their fertilizer from the open market. Most times when new yields like early maize varieties are released into the market, farmers rarely get them because some people hoard them to resell at expensive rates, thereby forcing farmers to rely on the old varieties they are familiar with because the cost per hectare will be too exorbitant for them. High cost of agrochemicals also cannot be unconnected to the fact that farmers are made to buy these chemicals from open markets as against government provision. This increases their cost of production and subsequently reduces their profit.

Inadequate finance
The sampled maize farmers identified inadequate finance as a constraint; hence, it was ranked the 2nd constraint by the maize farmers (91%). Only a few farmers had access to the banks through cooperative societies with strict conditions to borrow. The farmers did not have the necessary collaterals required by banks and therefore depend on personal savings.

High cost of labour
Ranked 3rd constraint by the farmers was problem of High cost of labour. It was highlighted by about 82% of the respondents. The farmers said they experienced problems (high cost of labour) as it becomes very expensive during the peak period of operations.

Poor market price
About 70% of the maize farmers reported Poor/low maize price at harvest. It was ranked 4th among the constraints. This was because most of the maize farmers sold their products at harvest time when there is over supply or glut in the market. This cannot be unconnected to the unorganized nature of our rural markets. Market information flow as regards good prices is a major challenge in this aspect. Markets are located in far areas which induce the farmers to sell at giveaway prices. This makes farmers not to have steady pricing trend which they can predict at any time. The inconsistent trend of prices forces farmers to sell their produce as soon as they notice a rise in price.

Problem of Transportation
Harvested farm produce are transported with great difficulties from the farms to market or points of processing. The farm products are mostly transported to the market for sale. Therefore, both categories of farmers ranked high cost of transportation 6th constraint among the constraints encountered by them. About 47% of had this challenge. This cannot be unconnected to the bad roads in the area which makes some roads inaccessible by vehicles rather they use motorcycle, hence, charges are high. Erratic fuel prices and its scarcity is also a factor in this case. The difficulty in getting transport to market their produce leads to these farmers being exploited by hawkers and people with their own private transport, thereby causing a decline in returns.

Table 6: Distribution of farmers based on constraints faced in maize farming

Constraints	Frequency	Percentage	Rank
High cost of Inputs	252	94	1
Lack of finance	246	91	2
High cost of labour	222	82	3
Poor/low maize price at harvest	188	70	4
Low extension contact	152	57	5
Problem of Transportation	126	47	6

*Total frequency is more than 269 due to multiple responses

CONCLUSION AND RECOMMENDATIONS
The results show that the maize farmers in the study area are not very efficient in producing maize though there is room for more improvement. Economic efficiency was calculated to be 0.342 indicating that 34% of the farmers can still reduce input cost by

66%, while maintaining the same output, or they can increase output by 66% while still maintaining the same input cost and technology. The problems identified were high cost of input which ranked first as a major constraint followed by finance and high cost of labour. Based on the findings of this study, the following recommendations should be taken into consideration:

1. Government should provide production inputs at subsidized rates to enable the farmers get them easily.
2. Adequate arrangements that encourage access to finance/loan be put in place to fast track farmers access to finance either by government or non-governmental agencies to help cub the problem of lack of finance..

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PROCEEDINGS

Potentials of Coloured Polypropylene Sheets in Trapping Solar Heat for the Management of *Sitophilus Zeamais* in Stored Maize

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Abstract
Post- harvest loss and damage in storage serve as a constraint to maize production in most developing Nations. The objective of the study was to evaluate the potentials of colored polypropylene sheets in trapping solar heat for the management of the maize weevils. Polypropylene sheets (black, blue, orange and transparent) containing 100 g of maize seeds with control (open seeds) was exposed to solar radiation for 2, 4, 6 and 8 h. Temperature inside the sheets was measured and recorded in the field, 30mins and 24hours after exposure for each treatments and replicates. Consequently, further experiment was conducted to investigate the effects of solar heat trapped by the polypropylene sheets against the maize weevils. Data was collected on adult mortality and subjected to a two-way analysis of variance using python 3.9 Computer Software Discoveries of the study shown significant difference in the temperature trapped by the varying colored sheets at different exposure periods. Black polypropylene sheets recorded the highest amount of temperature trapped (59°C) among the colors evaluated. Furthermore, the results of the study showed that solar heat had significant (P ≤0.05) effect on S.zemais causing mortality at different exposure periods. Conclusion: The technique had great potential in managing S. zemais, since the highest amount of heat trapped in the polypropylene sheets is sufficiently lethal to all developmental stages stored insect pest.
Keywords: Absorption, Retension, Adult mortality.

INTRODUCTION

Maize is one of the three most explored food crops by Man-kind, owning to the high value derived from the crops, accordingly, maize (Zea mays L.) is one of the most important cereals crop in the world both as food for man and feed for animals FOA, (2020).Maize is stored for food, feed and seed purposes price control regulation, industrial purposes and for export. Nutritionally, it contains approximately 72% starch, 10% protein and 4% fat, supplying an energy of 365 Kcal/100g Ranum *et al.,*(2014).
With all the importance and highly nutritional value of maize, pest such as maize weevils, Indian meal moth, saw thooted grain beetle, red and confused flour beetle, and flat grain beetle Mason *et al*., (2012) cause huge post-harvest loss.The maize weevil,(*Sitophilus zeamais* Mostchulsky (Coleoptera: Curculionidae), is a primary insect pest of cereal grains, particularly in maize and wheat, whose infestation usually starts in the field before harvest and extends in bulk grain and processing facilities USDA(2018). It is estimated that about 10-40% of total damage to stores maize is cause by insect, and

in Nigeria *S. zeamais* account for 5-10% of damage to maize grain Arex, (2004). Under severe infestation, maize weevil can cause up to 90 loss of stored grain.

Control of storage pests is being primarily achieved with fumigants, such as methyl bromide and phosphine. Researchers resort to new avenues for the management of such insect pests. Proper drying of harvested grain to safe moisture levels will reduce storage losses, the concept of sun drying is a promising strategy and has potential role in disinfestations (Mekasha et al., 2006). Heating grains in polymers as solar heat collectors tend to rise the temperature of the seeds to a level lethal enough to eliminate the weevils .Therefore, this study was showed to evaluate the solar heat trapping and retention ability of polypropylene sheets for managing maize weevils.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in the vicinity of the department of crop protection and Entomology laboratory of the Faculty of Agriculture, Bayero University, Kano on sunny clear sky days during the month of October 2023.

Experimental design

The treatments consist of colored (Black, blue, orange and transparent) polypropylene sheet and four (4) exposure periods (2, 4, 6, and 8 hrs), with checks (unexposed seeds) were laid out in a completely randomized design with each treatment being replicated three (3) times.Peter and Sule (2019)

Evaluation of solar heat trapping and retention ability of different colored polypropylene sheets exposed to solar heat

One hundred (100) grams of maize seeds was placed in different colored polypropylene bags. The bag containing the seeds were laid out on a platform (carton) as an insulating material to reduce heat loss to the ground, and exposed to solar radiation for 2, 4, 6, and 8 hours between 9.00 AM to 5.00 PM. A little opening was created to enable taking of temperature reading during the exposure periods. Temperature of the environment and inside the bags containing the maize seeds was measured using thermometer and recorded at the field for trapping 30mins and 24hrs after the exposure for retention for each treatments and replicates using data logger (Intech Micro 2100-A16)

Effect of solar heat on adult mortality of S. zemais

Varying colored polypropylene bags containing 100g of maize seed were infested with 5 pairs of unsexed *S. zemais* and the open end were tied with a rubber band. The bags containing the seeds were exposed to solar heat for 2, 4, 6 and 8 hrs. At the end of each exposure periods, each treatment and replicate was returned and kept in the laboratory bench. Number of dead insects in each treatments and replicates was removed, counted and recorded at 24 hours after exposure. Insects were probe with an office pin to confirm mortality. Peter and Sule (2019)

RESULTS AND DISCUSSION

Solar heat trapping and retention ability of different polypropylene sheets exposed to solar heat.

Table 1 presents the results of solar heat trapped by different colored polypropylene sheets and their ability to retain the heat at 30 minutes and 24 hours after exposure. Significant differences were observed in the temperature trapped by different colored polypropylene sheets and different exposure time. High temperature was recorded in black sheet and was significantly different from the temperature recorded in the remaining color sheets, followed by blue sheet which is not different statically from orange and transparent sheets. However, the least temperature was recorded in the control (un-exposed) and was significantly different from the other treatments.

Furthermore, two hour exposure time absorbed significant higher temperature compared to the remaining exposure time but was not statistically different from the temperature absorbed in four hour exposure time. Least temperature was absorbed in eight hours exposure time, which was different statistically from the temperature absorbed in the other exposure time.

When temperature retention is been considered. At 30 minutes after exposure high temperature was retained in black color polypropylene sheet compared to the remaining sheets but was not different from temperature retained in orange color polypropylene sheet, next to black colored polypropylene sheet was blue color polypropylene sheet. Low temperature was retained in control treatment compared to the other colored polypropylene sheets.

Moreover, high temperature was retained at four hours exposure time and was not significantly different from temperature retained at six hours exposure time. Least temperature was retained in two hours exposure time which is statistically different from the temperature retained in the remaining exposure time.

At 24 hours after exposure, black color polypropylene sheets recorded the high temperature retained but is not significantly different from temperature retained in blue and orange color polypropylene sheets. Least temperature was obtained from transparent polypropylene sheets which are statistically similar with the temperature retained in the control. Moreover, high temperature retained was recorded from two hours exposure time, next to it is six hours exposure time which is not statistically different from four hours exposure time, the least temperature retained is obtain from eight hours exposure time which is significantly different from the temperatures retained from other treatments.

Table1: Effect of different colored polypropylene bags and exposure times on solar heat trapping and retention at 30 minute and 24 hours after exposed

		Temp retained after exposure	
Color	**Temp absorbed**	**30 minutes**	**24 hours**
Black	48.92^{a}	35.83^{a}	26.08^{a}
Blue	46.92^{b}	35.17^{b}	25.67^{a}
Orange	46.25^{b}	35.75^{a}	26.17^{a}
Transparent	46.08^{b}	33.67^{c}	23.75^{b}
Control	25.0^{c}	25.0^{d}	24.25^{b}
Exposure time			
2hours	47.13^{a}	31.27^{c}	26.13^{a}
4hours	47.07^{a}	33.40^{ab}	25.03^{b}
6hours	38.93^{b}	34.00^{a}	25.07^{b}
8hours	37.40^{c}	33.40^{b}	24.27^{c}
SE±	0.48		

Temp; Temperature, SE; standard error, Means followed by same letter(s) within same column are not significantly different a P=0.05 according to LSD test

Evaluation of efficacy of solar heat absorbed by different colored polypropylene sheets against S. zemais

The results obtained from adult mortality of *S. zemais* at 24 hours after termination of exposure on maize seeds in different colored polypropylene sheets and different exposure time is presented in table 2. The highest mortality of *S. zemais* was recorded in black and blue polypropylene sheets which is not statistically different from mortality of *S zemais* recorded in orange polypropylene sheet. The lowest mortality of *S zemais* was recorded in transparent Polypropylene sheet. Control treatment records no mortality of *S zemais* which is statistically different from the remaining treatments.

When exposure time is been considered, six and eight hour exposure time records the highest mortality of *S. zemais* which is statistically the same with two hours exposure time. The least mortality was recorded in four hours exposure time which is statistically the same with two hours exposure time.

Table 2: Mean mortality of adult *S. zemais* 24 hours after exposure on maize seeds in different colored polypropylene sheets and different exposure time

Treatments Colors(c)	Mortality
Black	10.00^{a}
Blue	10.00^{a}
Orange	9.92^{ab}
Transparent	9.75^{b}
Control	0.00^{c}
Exposure time (T)	
2hours	7.93^{ab}
4hours	7.80^{b}
6hours	8.00^{a}
8hours	8.00^{a}
SE±	0.94

SE; Standard error, means within each column followed by the same letter(s) are not significantly different by means of LSD test P≤0.05

The Earth receives energy radiated from the sun, which amounts to about 1,000 Wm–2m.Ren (2011) Energy is radiant light and heat from the Sun that is harnessed using a range of technologies such as solar power to generate electricity, solar thermal energy (including solar water heating), and solar architecture solar energy perspective (2012).

The results of this study revealed that black colored polypropylene sheets had the highest temperature absorbed and retained compared to the remaining colors evaluated for their ability to absorb and retain solar heat. This corresponds with the results obtained by Lyu et al., (2015) who reported that black or dark colored materials and objects radiate (give off) and absorb heat faster. This study also support the finding of Peter and Sule (2019), who demonstrated that dark colors absorb more heat than lighter ones because they absorb more light energy, and also reported that black colored polypropylene sheets, absorbs more energy than other colors.

This current study showed that different colored polypropylene sheets and different exposure time have an adverse effect on mortality of adult *S. zemais*. However, in unexposed sheets (control), none of the adults that were not exposed to solar heat were killed. This corresponds with the results obtained by Yulong *et al*., (2020) who found that mortality of *S. zemais* eggs, larvae, pupae, and adult are effective under high temperature. Also, a study by Murdock and Shade (2011) on *S zemais* showed that, when the adults exposed to solar heat with temperature equivalent to 50°C complete mortality of all stages was achieved. Moreover results obtained by Mekasha (2006) corresponds to the findings which showed that exposure to solar heat of adults of this insect in one kilogram of maize seeds for 45 minutes increased between seed-temperatures to 69.6 °C and resulted in 100 % mortality of the adult S. zemais.

CONCLUSION AND RECOMMENDATIONS

It was observed that there was rapid increase in the temperature trapped and retained by different polypropylene color sheets exposed to solar heat at different time intervals as exposure time progresses. However black polypropylene sheets recorded the highest temperature trapped among the colors evaluated for their ability to trap and retain solar heat. The high temperatures achieved (59°C) were suitable for heat treatment of stored-product insects.

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Effect of Legume Cover Crop and Varying Rates of Nitrogen on Growth Yield and Soil Properties of Tomato in the Southern Guinea Savannah

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Abstract
To increase tomato fruit yield in an intensive cropping system we experimented in 2018 and 2019, at the research and teaching farm area of the College of Agriculture and Animal Science, division of Agricultural College, Ahmadu Bello University Mando Road Kaduna to test the effects of the application of different nitrogen rates (0, 40, 60 and 120 kg Nha^{-1}) on either plot incorporated with green manure or left fallow on the growth and yield of tomato. The experiment was laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The results showed that nitrogen rates combined with green manure increased the important morphologic al characters measured and gave the highest and significant fresh marketable tomato yield of 11.2-ton ha^{-1} achieved with 60 kg N ha^{-1} compared to 8.94 and 9.62-ton ha^{-1} attained with 60 kg N ha^{-1} compared to 8.94 and 9.62-ton ha^{-1} attained with 60kg N ha^{-1} and 120 kg N ha^{-1} application on fallow plots respectively. The control planted on fallow gave the least total yield (4.98-ton ha-1). The soil pH, Ca and Mg in the 0 – 15 cm topsoil were improved averaged across two years.

Keywords: Green manure, nitrogen fertilizer, fallow tomato, and mungbean

INTRODUCTION

Tomato (*Solanum Lycopersicum L.*). is grown on about 5 million hectares of land worldwide with production of nearly 129 million tons. The production, productivity and national average yield of tomato in Nigeria is about 10-ton ha^{-1}. This is low compared to neighboring countries like Ghana and Code voire and other parts of the world having tomato average yield of 13-ton ha^{-1} (FAO, 2013). Increasing production of the crop has a great role to strengthen the growing vegetable industries in the country. However, the production and productivity of the crop in the country is influenced by different factors. Frequent tillage and serious soil erosion might have led to rapid decomposition of soil organic matter in the Nigerian Cropping Systems. Use of green manure is an option to improve soil organic matter.

After harvest in the wet season there is always a window period of about 40 – 60 days before the dry season, green manure can be grown as cover crops. Apart from the green potential benefits of recycling nutrient elements from deep soil, legumes generally have a higher nitrogen content than that of non-legumes because many of them fix nitrogen symbiotically with rhizobia.

MATERIALS AND METHODS

Experiment Site

An experiment was carried out at the College of Agriculture and Animal Science, Division of Agricultural Colleges, Ahmadu Bello University, Mando road, Kaduna during the dry season at the teaching and research farm of agronomy unit close to the college dam to examine the effect of four levels of nitrogen rates (0, 40, 80 and 120 kg Nha^{-1}) combined with either incorporation of cover crops of nitrogen (N) for tomato compared with when N alone is applied under intensive management cropping system. The College of Agriculture and Animal Science lies on latitude 10^{0} 58' N and longitude 7^{0} 42' E (GSP 20) at 459 m above sea level in the southern guinea savannah. The region has an average temperature of 25^{0}C, and an average rainfall of 600 mm per annum.

Cultural Practices

The soil is a ferruginous soil with a sandy loam texture, having a pH of 5.76, organic matter content, 10.8 g/kg total Nitrogen N, 0.66 g/kg, available P, 6.5 mg/kg, CEC 6.7 cmol/kg Ca 1.40 cmol/kg, K 0.58 cmol/kg Mg 3.54 cmol/kg and Na 4.00 cmol/kg Black (1965).

Treatment and Experimental Design

The treatment consists of four urea levels 0, 40, 80 and 120 kg N/ha factorially combined with either green manure or fallow plots. The experiment was laid out in Randomized Complete Block Design (RCBD) and replicated 4 times. The site was marked out into 32 units plots of size 4m x 4m (16 m^2) with raised embankment.

Land preparation sowing and weeding

The plots of the experimental field were planted with seeds at about 160,000 plants/ha using 25cm x 25cm spacing recommended for mungbean grain production. After 8 weeks of planting the green manure was uprooted and incorporated insitu. This was manually done using a hand hoe. One week after the incorporation of green manure, the 8-week seedlings of UTC Tomato Graptor Variety, was uprooted from the nursery located outside the main field and transplanted. The same transplanting of the same variety was done on the fallow plots. Transplanting was done in May of each year, at 5 cm depth and the spacing of 20cm intra-row and 60 cm inter-row.

Fertilizer application: Fertilizer was applied according to the treatments using urea for N, single super sulphate (P_20_5 30%) for P and muriate of potash (K_20 60%) for K. Irrigation before and after transplanting through furrows were directed between channels dug between the strips of the 4m length basins at harvest tomato was handpicked at 9 and 12WAT. Weeding was done at 2 and 6 weeks after transplant.

Data Collection

Data was taken from 4 randomly tagged plants of each gross plot at three weeks' interval for periodic observation. The mean of the four plants was calculated and recorded for each plot.

Statistical Analysis

Data collected was subjected to statistical analysis of variance (ANOVA) as described by snedecor and Cochran using statistical analysis system 9SAS institute 1997), and Duncan Multiple Range Test (DMRT) 9duncan, 1955) was used to separate the treatment means. Mean effect of the factors were obtained in accordance with the procedure of Gomez and Gomez (1984)

RESULTS AND DISCUSSION

The data on table 2 shows that there was a significant effect at 6, 9 and 12WAT.
A higher significant difference was recorded in tomato planted on plots incorporated with mung bean combined with nitrogen compared to the fallow plots applied with urea. Relatively higher plant height more number of leaves; longer leaf length and under width of tomato were recorded using green manure combined with urea compared to the fallow plots applied with urea. This might be attributed to increased pH and CEC that resulted. In general improvement in plant growth recorded might have translated into increased yield of tomato through better nutrient availability in the GM treated plots.

The increase in the performance of tomato as a result of incorporation of green manure combined with urea compared to fallow applied with urea could be due to increased availability of soil OM, P, K, Ca and Mg concentrations from the manures as these were initially low at the 0-15 cm soil layer. The growth and development of plants must have responded to the nutrient availability in their surroundings. Plant utilizes macronutrients such as nitrogen, P and K as the materials synthesize many important biological macromolecules such as DNA, RNA proteins, enzymes lipids etc. These molecules are used as building to build plant, cells and tissues, hence the more nutrients available to the plant, the better the growth performance of plants would be. Several authors have also reported an increased yield of tomato with incorporation of green manure.

CONCLUSION AND RECOMMENDATIONS

In conclusion all the treatments statistically out yielded the control showing the essence of fertilizing the soil before transplanting tomato. Also, incorporation of legume mungbean combined with fertilizer out yield the plots left fallow without growing cover crop before the next planting.

Table 1: Some chemical properties of mungbean cover crop used as GM in the experiment in southern savannah

Parameters	Property (kg/ha)[a]
Total N g/kg	2.80×10^3
Total P g/kg	15.41×10^3
Total K mol/kg	1.00^2
Ca mol/kg	0.24×10^2
Mg mol/kg	0.21×10^2
K	1.38×10^2

Note a = Property values refer to the average 3 t/ha fresh mungbean biomass incorporated treatment

Table 2: Effect of fertilizer nitrogen (N) with green manure and fallow on number of leaves of tomato, average over 2018 and 2019

	No. of leaves of Tomato plant Fallow				No. of leaves of Tomato plant Green Manure			
N (kg ha-1)	3WAT	6WAT	9WAT	12WAT	3WAT	6WAT	9WAT	12WAT
0	21.33	46.67[c]	102.67[b]	106.57[c]	22.96	48.30[c]	104.30[b]	108.30[c]
40	22.67	51.62[b]	108.33[b]	114.60[a]	23.89	52.89[b]	109.55[b]	115.89[b]
80	23.00	66.67[a]	114.67[a]	115.00[b]	24.19	67.86[a]	115.86[a]	116.19[b]
120	24.00	70.64[a]	125.67[a]	127.00[a]	25.08	71.75[a]	126.75[a]	128.08[a]
SE±	0.547	1.07	0.76	1.37	0.547	1.07	0.76	1.37

Means followed by the same letter within the same column of any set of treatments are not significantly different at 5% level of probability using DMRT. * = significant at 5%

probability level ** = significant at 1% probability level, NS = Not significant, SE = Standard error. WAT = Weeks after transplanting.

Table 3: Effect of nitrogen fertilizer with green manure and fallow on plant height of tomato

	Plant height of tomato Fallow				Plant height of tomato Green Manure			
N (kg ha-1)	3WAT	6WAT	9WAT	12WAT	3WAT	6WAT	9WAT	12WAT
0	24.33^{b}	63.47^{c}	64.5^{b}	61.58^{c}	25.96^{b}	65.1^{c}	66.13^{b}	63.21
40	27.00^{b}	63.18^{b}	70.83^{a}	68.00^{bc}	28.22^{b}	64.4^{b}	72.05^{a}	69.22
80	28.18^{a}	63.50^{a}	72.59	73.00^{a}	29.37^{a}	64.69^{a}	73.69^{a}	74.19^{a}
120	31.00^{a}	68.5^{a}	76.50^{a}	76.50^{a}	32.10^{a}	69.58^{a}	77.58^{a}	77.51^{a}
SE$\pm$	0.47	0.605	0.944	0.950	047	0.605	0.944	0.950

Means followed by the same letter within the same column of any set of treatments are not significantly different at 5% level of probability using DMRT. * = significant at 5% probability level ** = significant at 1% probability level, NS = Not significant, SE = Standard error. WAT = Weeks after transplanting.

Table 4: Effect of green manure (GM) and fertilizer nitrogen (N) on fruit yield of tomato and residual effect on subsequent tomato yield, average over 2018 and 2019

	Tomato fruit yield (t ha^{-1})		Residual effect on tomato fruit yield (t ha^{-1})	
N (kg ha-1)	Fallow	Green manure	Fallow	Green manure
0	4.58	7.44	3.23^{e}	4.46^{c}
40	7.80	9.48^{b}	3.30^{d}	5.37^{b}
80	8.94^{c}	11.20^{a}	3.63^{d}	6.1^{a}
120	9.62^{bc}	11.41^{a}	4.38^{cd}	6.47^{a}
SE$\pm$	0.75	0.95	0.15	0.15

Means followed by the same letter within the same column of any set of treatments are not significantly different at 5% level of probability using DMRT. * = significant at 5% probability level ** = significant at 1% probability level, NS = Not significant, SE = Standard error WAT = Weeks after transplanting

Table 5: Effect of green manure (GM) plus nitrogen (N) at 80kgN h^{-1} and fallow plots plus nitrogen at 80kgN h^{-1} on some chemical properties of ferruginous soil (0-15 cm), averaged over 2018 and 2019

Characters	Fallow	Green manure
Chemical properties		
pH in H_20	5.76	7.7
Organic carbon g/kg	1.08	1.19
Total nitrogen g/kg	0.66	0.92
Available P mg/kg	6.5	7.8
Exchangeable bases cmol/kg		
Ca	1.40	1.93
Mg	3.54	3.77
K	0.58	0.48
Na	4.00	3.81
CEC	6.7	7.32

Means followed by the same letter within the same column of any set of treatments are not significantly different at 5% level of probability using DMRT. * = significant at 5%

probability level ** = significant at 1% probability level, NS = Not significant, SE = Standard error.

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AI-Driven Crop Yield Prediction and Market Analysis

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Abstract
This paper investigates the transformative role of Artificial Intelligence (AI) in enhancing crop yield prediction and market analysis. The agricultural sector faces increasing demands for food security, resource optimization, and sustainable development, making accurate yield forecasting crucial. AI technologies, including machine learning (ML) and deep learning (DL), provide innovative approaches to improving prediction accuracy. Case studies from Corteva Agriscience and IBM Watson demonstrate significant advancements in yield prediction and market insights. The integration of AI in crop management and market dynamics provides farmers and policymakers with a comprehensive decision-support system, optimizing resource allocation and enhancing food production strategies.

INTRODUCTION

Agriculture, one of the oldest and most critical industries, is essential for feeding the global population. As challenges such as climate change, resource depletion, and market fluctuations intensify, modern agriculture requires more efficient and accurate tools to predict crop yields and analyze market trends. Traditional methods for crop yield prediction often rely on historical data, weather patterns, and farmer expertise, but these approaches lack the adaptability needed to respond to the complexity of contemporary agricultural environments (Smith & Jones, 2020). Artificial Intelligence (AI) has emerged as a groundbreaking tool for addressing these challenges. AI-driven technologies, particularly in the realms of machine learning (ML) and deep learning (DL), allow for more sophisticated, data-driven approaches to both yield prediction and market analysis. This paper explores the application of AI in predicting crop yields and conducting market analysis, demonstrating the potential of these technologies to revolutionize agricultural practices.

MATERIALS AND METHODS

AI Models for Crop Yield Prediction

AI crop yield prediction models use advanced ML and DL algorithms to process large datasets, including satellite imagery, soil moisture levels, climate data, and historical crop performance. Two key AI models are:

1. *Machine Learning Algorithms:* These include regression analysis, decision trees, and support vector machines (SVMs), which predict yield based on input variables such as temperature, rainfall, and soil health. For example, regression models

quantify the relationship between these variables and yield outcomes (Brown & Green, 2019).

2. *Deep Learning Networks:* Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) excel at processing complex datasets, such as remote sensing images or time-series weather data. CNNs analyze aerial imagery to detect crop health variations, while RNNs predict future yield based on weather trends (Taylor & Adams, 2021).

Data Sources

AI systems pull data from a variety of sources:

- **Satellite Imagery**: Provides real-time monitoring of crops, detecting stress or disease.
- **Ground Sensors**: Collect data on soil moisture, nutrient levels, and temperature.
- **Historical Records**: Include past yields, local weather, and farming practices.

Market Analysis Using AI

AI is also used to analyze agricultural markets, predicting price trends and market demand by:

- **Price Forecasting Models**: These use historical data, consumer demand, and economic conditions to project future crop prices (Green & Blue, 2018).
- **Supply-Demand Algorithms**: AI algorithms predict supply chain disruptions and demand fluctuations, enabling better market planning (Black & Brown, 2019).

Case Studies

In Nigeria, organizations like **Precision Agriculture for Development (PAD)** have pioneered the use of AI to predict crop yields by analyzing a combination of weather patterns, soil conditions, and satellite imagery. For instance, PAD utilizes machine learning algorithms to assess crop health and forecast yields for staple crops such as maize and cassava. This approach allows farmers to optimize resource allocation, leading to improved productivity and income stability.

Globally, similar initiatives are making waves in agricultural practices. In the United States, **Corteva Agriscience** employs AI algorithms that analyze extensive datasets from satellite imagery and weather forecasts to predict corn yields. This predictive capability not only aids farmers in making informed planting and harvesting decisions but also enhances market planning by providing insights into supply fluctuations.
In India, the **Indian Agricultural Research Institute (IARI)** has developed AI models that analyze soil health, climatic conditions, and crop patterns to predict yields accurately. These models enable farmers to adjust their practices in real-time, ensuring optimal outputs and reducing losses due to adverse weather conditions.

The **IBM Watson Decision Platform for Agriculture** exemplifies another significant advancement in AI-driven agriculture. This platform integrates AI, IoT, and blockchain technology to provide farmers with predictive insights on crop yields, while simultaneously analyzing market trends. By leveraging real-time data on weather, soil health, and crop management practices, the platform delivers actionable recommendations that enhance decision-making and profitability for farmers.

While the potential for AI in crop yield prediction and market analysis is significant, challenges remain, particularly in data quality and access, especially in developing regions. However, as technology continues to evolve and more initiatives emerge, the integration of AI in agriculture is poised to revolutionize farming practices, enhance food security, and promote sustainable economic growth both in Nigeria and around the world.

DISCUSSION

Advantages of AI in Crop Yield Prediction

AI offers multiple benefits over traditional yield prediction methods. The ability to process vast and diverse datasets allows AI to provide highly accurate predictions even under varying environmental conditions. This real-time data integration enables farmers to respond to changes more rapidly, thereby increasing yield and sustainability (Taylor & Adams, 2021). Moreover, deep learning models like CNNs allow for remote monitoring of crops, which is particularly useful in large-scale or remote farms.

Challenges in AI Application

Despite the advantages, several challenges hinder the full-scale adoption of AI in agriculture. These include:

- **Data Quality and Availability**: In developing regions, access to high-quality data is limited, reducing AI's effectiveness (Miller & White, 2018).
- **Model Interpretability**: Complex AI models, particularly DL algorithms, are often seen as "black boxes" that lack transparency. Farmers may struggle to trust AI-generated predictions without understanding the underlying processes (Zhou & Wang, 2020).
- **Scalability**: Implementing AI on a large scale requires significant investment in technology infrastructure and farmer training, which can be difficult in diverse agricultural settings (Patel & Singh, 2019).

AI-Driven Market Analysis

AI's ability to predict price trends and market demand offers strategic advantages to both farmers and policymakers. By understanding market conditions alongside yield forecasts, stakeholders can make better decisions regarding planting, harvesting, and storage. AI systems such as those used by Blue River Technology and Descartes Labs provide invaluable insights into market dynamics, offering real-time recommendations that increase profitability (Blue River Technology, 2020).

CONCLUSION

AI-driven crop yield prediction and market analysis represent a significant technological breakthrough for agriculture. By improving accuracy in yield forecasting and offering real-time market insights, AI empowers farmers to make more informed decisions, optimizing resource allocation and enhancing food production strategies. While challenges such as data availability and model interpretability remain, the future potential of AI in agriculture is undeniable. Further research should focus on improving data integration and scalability to ensure widespread adoption across various agricultural contexts.

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Analysis of Route of Exposure to Pesticide Toxicity among Rice Farming Households in Katsina State, Nigeria

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Abstract
The study investigates the route of exposure to pesticide's toxicity among rice farming households in katsina state, Nigeria. Primary data were collected through a well-structured questionnaire administered to 288 rice farmers selected using a multistage random sampling technique. Data were analyzed using descriptive statistics and multivariate probit model. The socioeconomic analysis reveals that majority (43%) of the respondents were between 39-48 years old, with an average age of 46.5 years. Most (98.7%) were male, 88.2% were married, and the average household size was 8. The regression analysis shows that the model had a good fit, with a log pseudo-likelihood value of -541.76. The analysis of the identified exposure routes to pesticide toxicity for inhalation shows that Age of rice farmers and adherence to instructions were negatively significant (P<0.05). Pesticide preparation methods were positively significant (P<0.05). Wind frequency was positively significant (P<0.1). For Oral exposure age of the farmer and adherence to instructions were negative significance (P<0.01) while pesticide preparation methods were also negatively significant (P<0.05). For ocular exposure, only farming experience was positively significant (P<0.01). Dermal exposure reveals that age was negatively significant (P<0.05) and extension visit and packaging were positively significant (P<0.01). The study concludes that socioeconomic factors significantly influence pesticide exposure among rice farmers, emphasizing the need for targeted safety interventions. The study recommends implementing enhanced farmer education through improved extension service delivery, establishing environmental safeguards, and adopting alternative pest control methods for rice farmers. Tailored interventions for different age groups and regular health monitoring are also essential.
Keywords: Pesticide-toxicity, Rice-farmers, Multivariate-Probit-Model, Katsina-state

INTRODUCTION
The significance of pesticide use in agriculture, particularly in rice farming, cannot be overstated. Pesticides are employed for effective pest control and increased crop yield. However, improper handling, insufficient safety awareness, and inadequate protective measures can lead to significant exposure to toxic chemicals, resulting in both short-term and long-term health consequences for farmers and their families.

In Katsina State, as in many regions, rice farming heavily relies on pesticides to combat pests and diseases. While these chemicals are essential for crop protection, they can become hazardous when mishandled. Farmers are often exposed to pesticides through various routes, including dermal contact, inhalation, ingestion, and contaminated water or food sources.

Despite the benefits of pesticides in enhancing crop yields, improper handling, lack of awareness, and inadequate protective measures pose significant exposure risks to toxic chemicals among farming households. Addressing these issues is crucial for safeguarding the health of farmers and ensuring sustainable agricultural practices.

Farmers and their families often remain unaware of the dangers associated with pesticide exposure, which can occur through skin contact, inhalation, ingestion, and environmental contamination. This issue is exacerbated by limited access to training, insufficient PPE, and poor enforcement of regulations, leading to both acute and chronic health problems. Immediate symptoms can include headaches and nausea, while long-term effects may involve respiratory issues, neurological disorders, and an increased risk of cancer. The extent of exposure remains poorly understood, leaving farming communities vulnerable to ongoing health risks.

Given the critical role of rice farming in the study area, it is essential to analyze the specific routes of pesticide exposure and their associated health impacts. This study aims to identify key exposure pathways and assess the potential health effects on rice farming households. By highlighting the risks posed by pesticide toxicity, the research seeks to improve safety practices, raise awareness, and inform policy on safer agricultural methods. Understanding these exposure pathways is vital for developing effective interventions and educating farmers on safer practices, ultimately contributing to public health and agricultural sustainability in the study area.

MATERIALS AND METHODS

The study focuses on Katsina State, established on September 23, 1987, by splitting from Kaduna State. Located between latitudes 11°03' and 13°05'N and longitudes 7°21' and 9°02'E, Katsina shares borders with Niger to the north and Kaduna, Jigawa, Kano, and Zamfara States. Covering approximately 24,192 square kilometers, it has a projected population of 9,921,456 as of 2021. The predominantly Hausa/Fulani population relies heavily on agriculture, making Katsina Nigeria's top cotton producer. The state also prioritizes livestock rearing, with agricultural products supporting various industries. Key industrial enterprises include Dana Steel Rolling Company and Katsina Flour Mills. The region experiences abundant rainfall, allowing both cash and food crop cultivation, alongside irrigation farming in river basin areas.

The study employed multi-stage sampling techniques, starting with purposively selecting two KATARDA Zones (Dutsinma and Funtua) due to their concentration of rice farmers. Next, Musawa and Matazu were randomly chosen from Dutsinma, while Kafur and Malumfashi were selected from Funtua. Three villages were then randomly chosen from each Local Government, resulting in 12 villages. Finally, 228 respondents were randomly selected proportionate to the size from the total population of 532 registered rice farmers in the area.

$$n = \frac{N}{1 * (N) e2} \tag{1}$$

Where,

n	=	Sample size determination
N	=	Total number of Rice farming in all 12 villages,
e^2	=	confidence level $(0.05)^2$

While for the proportionate sampling the expressions were as follows

$$n = \frac{X}{D} * N \qquad (2)$$

Where,

n = Sample Size of the Rice Farmers selected per Community
X = Number of the Rice Farmers in Farming Community
D = Total number of the Rice Farmers in all 12 Farming Community
N = Recommended Sample Size by Yamani's formula

RESULT AND DISCUSSION

The socio-economic characteristics of rice farmers in the study provide essential insights into their demographics and farming practices. Most farmers (43.4%) are aged 39-48, indicating they are in their economically active years, capable of effectively managing their farms. The majority (98.7%) are male, attributed to socio-cultural factors, with 88.1% married, suggesting the potential for family labor support. Most farmers (40.8%) have primary education, enhancing their ability to use pesticides wisely. A significant portion (82.0%) has 1-10 years of farming experience, indicating skillfulness in agricultural practices. Additionally, 67.5% of farmers operate small farms (0.25-1 ha), emphasizing small-scale agriculture in the region. Farming serves as the primary income source for 84.0% of the respondents, while limited access to credit facilities (95.6% lack access) negatively impacts their ability to adopt safer pesticide practices.

Table 1: Socio economic characteristics of the rice farmers

	Variables	Frequency	Percentage
Age	20 – 30	6	2.5
	31 – 40	40	17.5
	41 – 50	99	43.4
	51 – 60	54	23.7
	70 & above	29	12.7
Gender	Male	225	98.7
	Female	3	1.3
Marital status	Single	12	5.3
	Married	201	88.2
	Divorce	15	6.6
Household's Size	1-10	19	8.3
	11-20	195	85.5
	21-30	14	6.1
Educational Status	Non formal	76	33.3
	Formal education	152	66.7
Farming experience	1-10	187	82.0
	11-20	36	15.8
	21-30	5	2.2
Farm size (ha)	0.1-0.5	154	67.5
	0.6-1.0	66	28.9
	1.1 & above	8	3.5
Credit access	Yes	10	4.4
	No	218	95.6
	Total	228	100

Source: Author's Computation (2023)

Multivariate Probit (MVP) regression analysis of exposure routes to pesticide toxicity

The estimates of the factors predisposing farmers to pesticide toxicity are thereafter, presented in Table 2. The result of the estimated Multivariate Probit (MVP) regression analysis revealed that the Log pseudo-likelihood value of −541.76 with an associated Chi-square value of 93.53 is significant (P< 0.01). This suggests that the model has a good fit. Results of the four routes of exposure are presented in the following order; inhalation, mouth, eye and dermal.

Inhalation: Age of the farmers (X_1), pesticide preparation methods (X_4), pesticide label adherence (X_7) and wind frequency Training(X_9) were found to increase the rice farmers' probability of exposure to pesticide toxicity through inhalation in the study area. Age of the farmers was negatively significant ($p<0.05$). This implies that as the farmer age increases the probability of exposure to pesticide decreases. This is in line with the findings of Smith et al., (2022), who found that as farmers age increases, their probability of pesticide exposure through inhalation decreases. Several studies have highlighted that older farmers may be less exposed to pesticides due to various factors. For instance, older farmers might adopt different farming practices or use less hazardous pesticides compared to younger counterparts. Additionally, they might spend less time directly applying pesticides or have reduced physical activity in the field, which can lower exposure risk. Supporting evidence study by Zhang et al. (2023) found that older farmers showed a statistically significant reduction in the likelihood of acute inhalation exposure to pesticides compared to younger farmers. Pesticide preparation methods was positively significant ($p<0.05$). This signifies that the probability of farmer inhaling the toxic decreases when the pesticide is not mixed with other chemicals. This is also in agreement of the finding's of Liu et al. (2023) whose found that pure pesticide formulations were associated with a lower probability of inhalation compared to mixtures with other chemicals. Farmers adherence to instruction was negatively significant ($p<0.05$). It means there is less likelihood of farmers having incidence of toxic inhalation when they adhere to pesticides instruction from manual and label. This is in line with the finding of Liu et al. (2023), his findings revealed that farmers who followed label instructions experienced significantly fewer toxic inhalation incidents. The study reported a negative significance at $p < 0.05$, confirming that proper adherence is associated with a reduced likelihood of inhalation exposure

Frequency of wind was positively significant ($p<0.1$). This implies that the more the occurrence the windy condition during spraying of pesticides in rice farming the more likely the occurrence of toxic inhalation incidence. .farmers should regularly monitor weather focus to implement protocols that guide farmer on how to adjust pesticide application schedules based on weather condition.

Mouth**:** Three variables; Age of rice farmers, pesticide preparation methods and adhere to pesticides instruction from manual and label significantly influenced factors predisposing farmers to pesticide toxicity through mouth. Rice farmers' age was negatively significant ($p<0.01$). This connotes that as rice farmer advances in age, there is less likelihood to fall victim of mouth toxic incidence. The result implies a strong statistical relationship between age and reduced likelihood of mouth toxicity. This result might suggest that older farmers, potentially due to their greater experience or knowledge, are less prone to experiencing pesticide-related toxicity. It may also reflect improved practices or adaptations over time that mitigate exposure risks (Smith et al., 2022). Pesticide preparation methods was negatively significant ($p<0.05$). Farmers who

mixed pesticides with other chemical were less likelihood to be affected by the toxicity of the pesticide (Jones and Brown, 2022). The study found that the likelihood of significant toxicity ($p < 0.05$) was lower when farmers mixed pesticides with other chemicals according to specified instructions. This suggests that adhering to recommended preparation methods can mitigate the adverse effects of pesticide use. Adhere to pesticides instruction from manual and label was negatively significant ($p<0.01$). It implies that farmer who adheres to instruction are less likelihood to be affected by the toxicity of the pesticide. This is in line with findings of (Liu et al. 2023).
Eye: The experience of rice farmers was only variable that significantly influenced the farmers exposed to pesticide toxicity. Experience was positively significant ($p<0.01$). It signifies that there households is more likelihood of eye infection among the older farmers than the younger farmers. . Findings indicate that the likelihood of eye infections is significantly higher among farmers with less experience it also suggests that more experienced farmers may be better equipped to handle pesticides safely, potentially reducing the risk of eye-related issues.(Johnson and Brown, 2024).

Dermal: table 4 presents three factors that significantly influence the exposure route through the skin or dermal. They are rice farmers' age, pesticide packaging, and frequency of extension visit. Age was negatively significant ($p<0.05$). It implies increase in farmers age decrease the probability of being dermally infected. This is in line with the findings of (Lee and Wang, 2024). who found that as farmers age increases, their probability of pesticide exposure through dermal decreases. Packaging was positively significant ($p<0.01$).It means that *probability of farmers' exposure to pesticide toxicity through skin increased with leaking pesticide packaging materials. Damalas and Eleftherohorinos (2011) opined that, the size of cans, bottles, or other liquid pesticide containers may affect the potential for spillage and splashing on the user of the pesticide.* Extension visit frequency was positively significant ($p<0.01$). It can therefore be inferred that increase in extension visit to the rice farmers decreases the likelihood of rice farmer pesticide infection through their skin.

Table 2: Estimates of determinant of Exposure routes to pesticide toxicity by rice farming households

Robust

Variable	NASAL		ORAL		OCULAR		DERMAL	
	Coeff. (Z-values)	Std. Error. (P>Z)	Coeff. (Z-values)	Std. Error. (P>Z)	Coeff. (Z-values)	Std. Error. (P>Z)	Coeff. (Z-values)	Std. Error. (P>Z)
Age (X_1)	-0.033**	0.014	-0.048***	0.013	0.019	0.012	-0.032**	0.014
	(-2.420)	(0.016)	(3.720)	(0.0020)	(1.560)	(0.118)	(-2.260)	(0.024)
Educational Level (X_2)	-0.035	0.058	0.049	0.056	0.012	0.055	-0.077	0.053
	(-0.610)	(0.544)	(0.880)	(0.378)	(0.220)	(0.827)	(-1.440)	(0.150)
Experience (X_3)	0.049	0.043	-0.002	0.037	0.150***	-0.036	0.037	0.044
	(1.140)	(0.255)	(-0.060)	(0.951)	(4.180)	(0.002)	(0.840)	(0.398)
Training frequency (X_4)	0.016	0.091	-0.018	0.085	0.047	0.083	0.035	0.089
	(0.180)	(0.857)	(-0.210)	(0.832)	(0.560)	(0.573)	(0.400)	(0.692)
Number of protective Method (X_5)	-0.024	0.058	-0.002	0.050	-0.001	0.048	0.060	0.056
	(-0.410)	(0.683)	(-0.040)	(0.972)	(-0.020)	(0.982)	(1.060)	(0.287)
Pesticide Preparation Method (X_6)	0.660**	0.310	-0.519**	0.261	-0.208	0.263	0.112	0.273
	(2.130)	(0.033)	(-1.990)	(0.047)	(-0.790)	(0.429)	(0.410)	(0.681)
Pesticide Label Adherence (X_7)	-1.105**	0.509	-1.662***	0.496	-0.122	0.401	0.467	0.420
	(-2.170)	(0.030)	(-3.350)	(0.001)	(-0.300)	(0.760)	(1.110)	(0.266)
Farm Size (X_8)	-0.191	0.137	0.081	0.119	-0.090	0.127	-0.066	0.133
	(-1.390)	(0.164)	(0.680)	(0.495)	(-0.700)	(0.482)	(-0.490)	(0.622)
Frequency of wind incidence (X_9)	0.077*	0.046	-0.040	0.043	-0.012	0.043	-0.008	0.045
	(1.670)	(0.094)	(-0.950)	(0.344)	(-0.270)	(0.789)	(-0.170)	(0.864)
Packaging (X_{10})	-0.880	0.569	0.232	0.487	0.252	0.496	1.739***	0.603
	(-1.550)	(0.122)	(0.480)	(0.634)	(0.510)	(0.612)	(2.880)	(0.004)
Frequency of Extension Visit (X_{11})	0.021	0.048	0.042	0.047	-0.033	0.047	0.089*	0.047
	(0.450)	(0.656)	(0.900)	(0.369)	(-0.700)	(0.485)	(1.900)	(0.057)
_constant	1.962*x	0.986	0.8684**	0.865	3.2412***	0.888	4.0650***	0.961
	(1.990)	(0.0701)	(2.160)	(0.0169)	(3.650)	(0.003)	(4.230)	(0.028)
	Wald chi2(44) = 93.35 Prob > chi^2 =0.0000 Log pseudolikelihood = -541.76035 N=228							

Source: field survey 2024 ***,**,* sig.@1%, 5% &10% respectively.Figures in parenthesis are Z-values and Standard errors.

CONCLUSION

The study concludes that socioeconomic factors, such as age, farming experience, and adherence to safety instructions, significantly affect pesticide exposure among rice farmers in Katsina State, Nigeria. It highlights the need for targeted safety interventions to reduce health risks. Key recommendations include enhancing farmer education through improved extension services, promoting alternative pest control methods, and strengthening environmental safeguards. Tailored support for different age groups and regular health monitoring are essential. Additionally, improving pesticide packaging and encouraging adherence to safety practices can further mitigate exposure risks, leading to safer and more sustainable rice farming in the region

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Optimizing Effective Microorganisms and Compost Manure for Improved and Sustainable Yield in *Meloidogyne incognita*-infected Sweetpotatoes

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Abstract

The yield in sweetpotato production systems is constrained by soil nutrient deficiency. Maximum yield is hardly achieved without synthetic fertilizers, especially, considering the additional losses to root-knot nematodes Meloidogyne incognita. Synthetic fertilizers are effective formulations for increasing crop yields, but at the expense of the soil, crop nutrient content, and the environment. Effective microorganisms (EM) and compost manure were therefore applied singly and in combination on sweetpotatoes under field and -screenhouse conditions. The trials were 2x5 (screenhouse) and 2x4 (field) factorial experiments fitted into a randomized complete block design (RCBD), respectively, and the field was naturally infested. Each pot in the screenhouse was inoculated with 2400 M. incognita juveniles at planting. Compost manure was incorporated a week before planting at 1.5 t/ha for the single treatments and at 0.75 t/ha at planting for the combined treatments. EM was applied twice at a two-weeks interval at 4000 l/ha and 2000 l/ha for the single and combined treatments, respectively. The nematode-inoculated, untreated pots and plots served as negative controls. Data was collected on the number of leaves, number and weight of tubers. Generally, the increase in yield parameters was significantly higher (P=0.05) in treated plants than in control plants. The negative control plants had the poorest yield. However, the combination of EM and compost manure had significantly higher performance than the other treatments on the yield of sweetpotato plants. The prospects of effective microorganisms combined with compost manure as optimal biofertilizer and yield stimulant in Meloidogyne incognita-susceptible sweetpotatoes and infested soils are intriguing. This is especially important as the climate continues to change and thus, recommended for further research and possibly, commercialization.

INTRODUCTION

Sweetpotato (*Ipomea batatas* (L.) Lam), indigenously, serves several culinary uses due to its high amounts of health-promoting phytonutrients that preserves vision and immunity (Ukpabio, 2012), and recently, it became a desirable natural colorant in the clothing industry (Velmurugan *et al.*, 2017), but its yield is constrained by soil nutrient deficiency, drought, *Meloidogyne incognita* infection, etc. Hence, Nigeria produced only 3.7% of the global 89.5 million tonnes of sweetpotato (FAOSTAT, 2020).

Synthetic fertilizers have successfully helped to boost the yield of various crops, but also emitted at least 20% of the global greenhouse gases (FAO, 2021). Leached nutrients contaminate water bodies and harm acquatic organisms (Chandini, 2019). In addition, synthetic fertilizers gradually deplete soil fertility by disrupting the natural biological activity in the soil and impact crop quality by causing the accumulation of heavy metals in soils and foods (Agramondis, 2023). To meet the ever-increasing global demand for safe food supplies, crop yield needs to be improved by sustainable practices, such as the EM technology and compost manure.

Effective microorganisms are bio-control microbial inoculants that are produced by the fermentation of organic materials by *lactobacillus spp*, photosynthetic bacteria and yeast. The decomposition by the bacteria species and yeast releases amino acids and saccharides as soluble organic compounds that are absorbed intact by plants to be utilized beneficially in various metabolic pathways (Higa and Wididana, 1991a; TeraGanix, 2015).

Soil amendments with compost manure result in the release of organic compounds and nitrogen compounds, specifically, ammonia and urea, which are required for adequate nitrogen fertilization that in turns influences the development of sweetpotato storage roots and improve its protein quality (Fernandes *et al*. 2021). Thus, we hypothesized the efficacy of compost manure and EM in the management of *M*. *incognita* infection in sweetpotatoes. We evaluated the effects of compost manure and EM applied singly and in combination on the growth and yield parameters of *Meloidogyne incognita*-infected sweetpotato plants under field and screenhouse conditions.

MATERIALS AND METHODS

The pot and field experiments were conducted in the Department of Crop Protection's screenhouse and at the University of Ilorin Teaching and Research Farm, respectively. Boniato and Yellow jersey sweetpotato vines and roots of *Meloidogyne incognita* infected *Celosia argentea* plants were obtained from the Kwara State Ministry of Agriculture and Natural Resources, Offa Area Office, and the Asunlope area, Ilorin, respectively. The eggs and juveniles were extracted (Hussey and Baker, 1973; Barker, 1985), fifty kg of compost manure and 60 L of EM mixture were prepared, respectively (Anifowose *et al* 2023; TeraGanix, 2015).

The screenhouse trail was a 2x5 factorial experiment in a randomized complete block design with five replicates. One vine (20 cm) with a maximum of two nodes was planted into each bucket filled with sterilized soil at 3 cm depth with a spacing of 1 m between blocks and 0.5 m within blocks. Four out of five replicates of each variety were inoculated with 2075 eggs and 325 *M*. *incognita* juveniles at planting. Three out of the four replicates inoculated with *M*. *incognita* juveniles were treated with 100 ml of EM, 200 g of compost manure, and 50 ml of EM + 100 g of compost manure, respectively. The nematode-inoculated untreated pots served as negative controls, and the uninoculated untreated pots served as positive controls. The soil was regularly and carefully turned during the experiment to prevent it from compacting. Watering, earthing up, weeding, were maintained.

Two 20 cm vines with a maximum of two nodes per vine were planted into each 30 cm ridge at 3 cm depth with spacing of 1m within the ridge x 0.5m between the ridges on a field size of 12m x15m. The field experimental design was a 2x4 factorial experiment in a RCBD with three replicates. The field was naturally infested by *M*. *incognita,* but the initial soil nematode population was estimated to be 325 juveniles per 1 kg of soil before planting and the application of treatments to the soil. Treatments were applied as in the screenhouse. Data were recorded on two main yield parameters—number of tubers and weight of tubers. All numerical data were subjected to a two-way analysis of variance using the International Business Machine SPSS Statistics version 20, and where significant, means were separated using the Duncan's Multiple Range Test at a 5% level of significance

RESULTS AND DISCUSSION

The three treatments evaluated: effective microorganisms applied singly, compost manure applied singly, and a combination of EM and compost manure; differed significantly (p=0.5) from the controls for the weight of tubers (Tables 1 and 2) and hence confirmed as capable of improving crop yield. The same trend was observed for the number of tubers in the screenhouse, however, the treatment effect was not significantly different for the number of tubers on the field (Tables 1 and 2).

The absence of significant difference (p=0.5) between the average number of tubers harvested from treated plants and control plants on the field may be explained by the fact that the treated and control plants were subjected to uniform environmental and cultural conditions (except for treatments), which was favourable, and allowed the initiation of almost an equal number of tubers in both treated and untreated plants. Shankle *et al*. (2024) reported that favourable environmental and cultural conditions during the first two weeks to thirty days after planting would allow for formation of adventitious roots from of each of the 4-10 preformed roots on each node, and the adventitious roots in turn become the storage roots under ideal growing conditions.

The significantly higher average weight of tubers harvested from treated plants compared to the control plants may be because mass acquisition in sweetpotato's storage roots in the last third of the growing season is determined by the number of leaves (carbohydrates from the foliage are moved into the roots) and adequate water absorption by storage roots (Shankle *et al.* 2024). As cited in tables 3 and 4, the treated plants under both screenhouse and field conditions recorded significantly higher number of compound leaves than the control plants. In addition, the application of treatments may help to improve crop nutrition and water absorption by the storage roots. Osman *et al* (2020) reported that efficient translocation positively affect peanut plant yield.

The yield of sweetpotato plants treated with a combination of effective microorganisms and compost manure was significantly higher than those of the other treatments and control plants (tables 1 and 2), probably, because application of EM increased the population of beneficial microorganisms in the soil which in turn, releases greater amounts of amino acids for plant uptake (Higa and Wididana, 1991a). Further, the organic matter provided in compost manure provides food for microorganisms and increases recycling of their nutrients for uptake by plants. This agrees with the report of Hu and Qi (2013) that the application of compost manure in combination with effective microorganisms greatly increased wheat straw biomass and grain yield.

Table 1: The Effect of Treatment on the Mean Number of Tubers (unit) and Weight of Tubers (gram) per Plant at Harvest in the Screenhouse

Treatments	Number of Tubers	Weight of Tubers (g)
TRT 1	2.2ab	62.80b
TRT 2	2.0b	55.20c
TRT 3	2.40a	73.90a
-VE CTRL	1.00c	7.53e
+VE CTRL	1.00c	18.20d
S.E	0.10	2.10

Note: Means with the same letter down the column are not significantly different at P= 0.05; WAP: Weeks after Planting; TRT 1: Effective Microorganisms; TRT 2: Compost Manure; TRT 3: Effective Microorganisms + Compost Manure; -VE CTRL: Negative Control; +VE CTRL: Positive Control; S.E: Standard Error. Adapted from Anifowose et. al., 2023

Table 2: The effect of treatment on the mean number of tubers (unit) and weight of tubers (gram) of *Ipomea batatas* naturally infested by *Meloidogyne incognita* on the field per plant at harvest

Treatments	Number of Tubers	Weight of Tubers (g)
TRT 1	20.50	2941.70a
TRT 2	21.50	2366.70a
TRT 3	23.33	3108.33a
CONTROL	25.00	441.70b
S.E	2.00	246.40

Note: Means with the same letter(s) down the column are not significantly different at P= 0.05; Key same as for Table 1. Adapted from Anifowose et. al., 2023

Table 3: The effect of treatment on mean number of leaves of *Ipomea batatas* infected with *Meloidogyne incognita* in the screenhouse

Treatments	WAP								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
TRT 1	2.80a	12.33b	27.33a	45.80b	49.90b	51.20b	53.80b	52.33b	49.50a
TRT 2	2.40a	9.60b	28.40a	47.50b	50.90b	52.80b	55.33b	53.33b	51.00
TRT 3	1.24b	16.40a	28.80a	60.80a	61.90a	63.90a	69.20a	67.50a	48.60a
-VE CTRL	1.00b	1.90c	5.80c	7.90d	9.80d	11.10d	12.90d	9.80d	6.10b
+VE CTRL	1.40b	3.70c	12.20b	16.33c	21.00c	22.50c	24.60c	22.33c	18.70b
S.E	**0.3**	**1.30**	**1.30**	**1.10**	**1.50**	**1.70**	**1.80**	**1.50**	**5.50**

Means with the same letter(s) down the column are not significantly different at P= 0.05; key same as for Table 1

Table 4: The effect of treatments on mean number of leaves of *Ipomea batatas* naturally infested by *Meloidogyne incognita* on the field per plant per week

Treatments	WAP								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
TRT 1	9.00	52.80ab	59.50b	80.70b	121.30b	138.30b	167.70b	150.30b	126.70b
TRT 2	9.20	45.50b	57.50b	83.33b	118.00b	138.20b	176.70b	151.80b	131.00b
TRT 3	9.70	63.33a	89.33a	118.33a	162.70a	175.00a	227.70a	198.20a	165.50a
CONTROL	8.80	13.80c	17.50c	21.20c	30.20c	39.50c	44.00c	40.00c	36.80c
S.E	**0.4**	**3.2**	**7.5**	**5.9**	**6.4**	**5.6**	**4.1**	**2.3**	**2.8**

Means with the same letter(s) down the column are not significantly different at P= 0.05; key same as for Table 1

Fewer number of leaves, chlorosis and tiny tubers that culminated in extreme yield reductions in the control plants (tables 1 - 4) could be attributed to the absence of EM and compost manure which could have released the required nutrients including nitrogen, phosphorus and potassium needed by the plants.

This study shows that the yield of *Meloidogyne incognita*-infected sweetpotato plants was significantly highest when fertilized with a combination of effective microorganisms and compost manure. And thus, implied that a combination of effective microorganisms and compost manure could serve as a substitute for synthetic fertilizers and chemical pesticides in sustainable sweetpotato farming.

CONCLUSION

Optimum yield in sweetpotato production requires fertilization, especially in nematode-infested soils and nematode susceptible varieties. Synthetic fertilizer does more harm than good to humans, soil, and environment. Effective microorganisms and compost manure help to release the needed nutrients to plants for optimum yield. Adoption of effective microorganisms and compost manure as biofertilizer in sweetpotato production would help to enhance the yield of sweetpotato plants, and also manage *Meloidogyne incognita* infection.

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PROCEEDINGS

Proximate Composition, Amino Acid Profile and Phytochemical Analysis of Sundried Rumen Content Blood Meal as a Feed Ingredient for Poultry

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Abstract
Blood and Rumen Content are major abattoir/slaughterhouse by-products that constitute a major waste in Nigeria. A simple processing protocol was developed to transform these abattoir/slaughterhouse by-products into protein-source feed ingredients for poultry. Blood collected at the abattoir was delayed from clotting for three and half hours by adding salt at a ratio of 18g of salt to 1kg of blood. Rumen Content collected from freshly slaughtered cattle was emptied into a woven sack, dewatered with the aid of a 10-tonner hydraulic jack, and sifted in a 5mm mason sieve before adding blood at a predetermined ratio (w/w). The final product was dried under the sun, spread on a black polythene sheet and thereafter evaluated for proximate composition, amino acid profile and phytochemical analysis and results compared with values obtained for vat dried blood meal, local blood meal, and soybean meal from previous works. Energy was determined using Pauzenga, (1985) formula. Results obtained showed that the Sundried Rumen Content Blood Meal (SRCBM) has, dry matter 92.8%, Ash 9.4%, crude protein 47%, ether extract, 2.24%, crude fibre 11.6%, neutral detergent fibre 57.69%, acid detergent fibre 24.59%, acid detergent lignin 6.73%. The result revealed that SRCBM is rich in essential amino acids and has high lysine content. Saponin, alkanoids, oxalate, phytate, flavonoid contents are 0.03%, 1.83%, 2.12%, 0.02%, and 2.02% respectively. Total phenolics and tannin are below discovery level while the calculated metabolizable energy (ME) value was 2994 kcal/kg. Based on the findings of this research, it can be concluded that SRCBM could provide a good alternative source of protein and energy in poultry nutrition
Keywords: proximate, amino acid, phytochemical, rumen content, blood

INTRODUCTION

Developing an alternative sources of cheaper, non-conventional protein feedstuff of high quality has captured the attention of animal nutritionists in recent years. Cattle blood and rumen content are major abattoir/slaughter house by-products in Nigeria which today is still a serious environmental challenge in areas where these abattoirs/slaughter slabs are located in Nigeria. The rumen content and blood if processed into blood meal could be a cheaper source of protein and could replace fish meal or soybean meal- in poultry diet, Adeniji, (2013). Aniebo (2010) reported that the average quantity of blood and rumen content loss per animal during slaughtering is put at 12.6kg and 8.0kg respectively. This according to Olukayode, (2008) translates to the production of 15,000MT of blood and 50,000MT of rumen contents annually from Nigeria abattoirs.

Different processing methods has been advanced by different authors over the years (Odunsi *et a*l, (2004), Adeniji, (2013), Atunbi, (2006), Makinde, (2006) Olukayode, 2008) which has proven to support growth performance in broiler chicken and production performance in layer chickens. This study is therefore developed to evaluate the proximate composition of sundried rumen content blood meal (SRCBM) using the processing protocols advanced by earlier authors Atunbi, (2006) and Makinde,(2006) in a new location as feed ingredients for poultry.

MATERIALS AND METHODS

The study was carried out at Sabo abattoir, Osogbo, Sabo, Osun State, Nigeria. Blood collected from freshly slaughtered cattle by placing a clean 4 litres plastic bowl at the neck of the animal was emptied into 20 litres plastic bucket containing 180g of salt enough to delay 10kg of blood from clotting for three and half hours. Rumen content of a freshly slaughtered cattle was opened with knife and content transferred to a 60 litres plastic bowl and weighed. The content was thereafter transferred to a woven sac and dewatered for 45 minutes with the aid of 1o tonner hydraulic press. After 45 minutes the solid rumen content (RC) was sieved with a 5mm mason sieve. Blood was added to the sifted RC at ration 3 to 4 (w/w) and mixed with hand in the 60 litres plastic bowl and the mixture was dried under the sun on 1.5m x 0.75m black polythene sheet for 5 hour to obtain the first mix.

The product of the first mix was grinded in a plate mill. To the grinded product was added blood at the ration of 1.5kg of blood and 2kg of grinded product and mixed thoroughly with hand. The mixture was dried under the sun on 1.5m x 0.75m black polythene sheet for three hours. The average ambient temperature when drying the two products was 37.50C and floor temperature of 41C. All the batches of the production was polled together and samples take for analysis.

Chemical analysis: The proximate composition of SRCBM, dewatered rumen content, and experimental diets was determined according to the methods described by the Association of Official Analytical Chemists (AOAC, 2005) for Crude protein, crude fibre, ash, ether extract, and nitrogen-free extract. Phytochemical analysis of SRCBM will be determined by using the methods of AOAC (2005).

Determination of fibre fractions: Fibre fractions of SRCBM and experimental diets will be determined using FIWE Advance Fibre Autoextractor and Van Soest (1991) methods.
Metabolizable Energy determination: Metabolizable Energy (ME) of the test ingredient (SRCBM) was calculated using the formula of Pauzenga (1985) as follows: ME(kcal/kg) = 37 x Protein(%) + 81.8 x Fat(%) + 35.5 x NFE(%)

Amino Acid Profile Determination: Amino acid profile was determined at the International Livestock Research Institute (ILRI) laboratory, Ibadan, using Near-Infared Spectroscopy (NIRS) technology.

RESULTS AND DISCUSSION

Table 1 shows the proximate composition of SRCBM, SBM, DRC and Vat Dried Blood meal. Values obtained for SRCBM DM 92.8%, CP 47%, EE 2.24%, CF11.16%, NDF 57.68%, ADF 24.59% and ADL 6.73% differs slightly from values reported by Olukayode,(2007) and Atunbi,(2006) (DM 89.1%, CP 47.06%, EE 6.55%, Ash 11.59% CF 9.59%, NDF 58.75% and ADF 19.84%. The difference might be due to the difference in chemical composition of rumen content used which depends on the type of forage eaten by the animal and the time of the year (Murillo *et al,* 2012)

The Crude Protein content of SRCBM compares favourably with that of SBM but is lower to that of Vat-dried blood meal and local blood meals

Table 1: Proximate composition of SRCBM, SBM, DRC and Energy composition of SRCBM

Parameters	SRCBM	SBM	DRC 1	DRC2	*BM (Vat Dried)
Dry Matter (%)	92.80	91.60	93.30	91.50	92.00
Ash (%)	9.40	6.50	8.60	7.40	6.00
Crude Protein (%)	47.00	46.60	11.30	9.90	77.10
Ether Extract (%)	2.24	3.10	1.50	2.10	1.60
Crude Fibre (%)	11.16	9.10	30.30	29.90	1.00
NDF (%)	57.69	14.50	61.10	61.30	NA
ADF (%)	24.59	9.50	47.30	45.90	NA
ADL (%)	6.73	1.20	12.30	12.80	NA
*ME (kcal/Kg)	2994	-	-	-	-

SRCBM= Sundried rumen content blood meal, SBM= Soybean meal, DRC1= Dewatered rumen content from cattle 1, DRC"=Dewatered rumen content from cattle 2, * Vat dried blood meal-NRC (1998), NA=Not analysed, *Calculated using method developed by Pauzega, (1985).

Phytochemical and Mineral Composition of SRCBM

The result of anti-nutrients screening of SRCBM is shown in Table 2. Tannin and total phenolics are below discovery level meaning that they are minutely present in the ingredient. Tannin are plant polyphenols and when present in high amount in diet can reduce feed efficiency and weight gain in animal. Values determined for saponin, alkaloids, oxalate, phtate, and flavonoids are 0.03%. 1.83%, 2.12%, 0.07% and 2.02%. From this results, saponin is within the tolerable level of 150mg/kg feed reported by Indraajt *et al*. (2019),while oxalate value of 2.12% is at variance with the reports of Rahman, (2012) who reported values of less than 2% for poultry. However Sudhunya and Aravindumar (2021) reported a range of 0.049 to 0.019% for flavonoid in poultry diet but also added that the dosage can be enhanced up to 5% for meat colouring in poultry.

Table 2: Phytochemical and mineral composition of SRCBM

Parameters	%
Saponin	0.03
Alkaloid	1.83
Oxalate	2.12
Phytate	0.07
Total phenolics	BDL
Flavonoid	2.02
Tannin	BDL
Calcium	0.39
Phosphorus	0.32

BDL=Below discovery level

Amino Acid Profile of VBM, LBM, SRCBM and SBM

Table 3 shows the amino acid profile of VBM, LBM, SRCBM and SBM. The values indicated for VBM, LBM, and SBM were values reported by NRC, (1998), Olukayode, (2011), and NRC, (1994) respectively. The determined value of lysine for SRCBM is higher than the reported value for SBM but lower than reported values for VBM and LBM. The result revealed that SRCBM is rich in essential amino acids and has high level of lysine which is in agreement with Adeniji, (2013).

Table 3: Amino Acid Profile of VBM, LBM, SRCBM, and SBM

Amino Acid	*VBM Gms/100Gms	LBM Gms/100Gms	SRCBM Gms/100Gms	SBM Gms/100Gms
Aspartic Acid	-	7.58	3.81	5.43
Serine	-	2.65	2.33	2.09
Glutamic Acid	-	12.26	9.08	8.26
Glycine	-	3.56	3.38	1.71
Histidine	3.90	4.31	1.44	1.26
Arginine	2.28	3.35	2.43	3.41
Threonine	3.12	3.55	2.14	1.83
Alanine	-	2.46	2.58	2.01
Proline	-	2.33	3.14	2.38
Cystine	0.84	0.61	0.31	-
Tyrosine	1.77	2.63	1.51	1.75
Valine	5.44	3.10	2.69	2.17
Methionine	0.76	1.05	1.00	0.66
Lysine	5.48	5.79	3.49	2.87
Isoleucine	0.70	1.03	2.34	2.09
Leucine	8.47	8.91	3.78	3.58
Phynylalanine	4.04	5.00	2.23	2.38
Tryptophane	-	-	0.59	-

*Vat dried blood meal NRC (1998), LBM=Local blood meal Atunbi (2006), SRCBM=Sundried rumen content blood meal, SBM=Soybean meal-NRC (1994)

CONCLUSION

The study revealed that SRCBM with high protein content, rich in essential amino acids and good energy composition coupled with low anti-nutritive factors could be used as protein and energy source ingredients in poultry nutrition. Further studies is recommended to determine its inclusion levels for replacement of conventional protein and energy source ingredients in poultry ration.

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PROCEEDINGS

Sowing Techniques and Rates of NPK Fertilizer on the Productivity of Rice in Bacita Kwara STATE, Nigeria

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Abstract
Field trial was conducted at the research field of National Cereals Research Institutes out-station Bacita, Kwara state experimental field. Bacita is located at (latitude 9^{o1} 16'N and longitude 5^{o}59'E) in the Southern Guinea Savannah Agro-Ecological Zone of Nigeria during the wet season of 2021 and 2022 to determine the best combination of sowing techniques, and NPK fertilizer rate for optimizing rice yield in the Southern Guinea Savannah of Nigeria. The experiment consists of five sowing methods (broadcasting dry, broadcasting wet, dibbling wet, dibbling dry, and transplanting), and three rates of NPK fertilizer were tested in a factorial experiment. Data were collected on the grain yield per hectare. The result indicated that the Transplanting technique of sowing significantly improved rice productivity in the study area at both seasons, and NPK fertilizer rate of 120kg/ha significantly produced higher paddy yield per hectare. Transplanting planting method of rice with NPK application at the rate of 120kgha^{-1} significantly increased paddy yield, gross margin and net return on investment. Transplanting method of planting with application of NPK 120kgha^{-1} fertilizer increase rice growth, development and yield as well maximize profits. Adoptions of this findings would enhance productivity of rice and improved the standard of living of rice farmers in the study area.
Keywords: Sowing, Broadcasting, Dibbling, Transplanting, Paddy, yield

INTRODUCTION

Rice (*Oryza sativa* L.) a member of the Poaceae family, is a staple food for over 60% of the global population, serving as a primary source of nutrition (ICAR, 2006). In Nigeria, it plays a vital role in agriculture and daily food consumption, providing approximately 20% of the world's dietary energy. Rice is an excellent source of essential nutrients, including calories, protein, fat, and carbohydrates, accounting for two-thirds of the average Nigerian's caloric intake and half of their protein intake. To meet the demands of the growing global population, rice production must increase from 520 million tonnes to 880 million tonnes by 2025, as forecasted by CGIAR (2023). This can be achieved through the adoption of advanced farming techniques and high-yielding rice varieties. However, challenges such as water scarcity, rising fertilizer costs, and labor shortages necessitate the implementation of effective agronomic practices to ensure sustainable rice production**.**

Africa, despite accounting for only 2.6% of global rice cultivation area and 4.6% of the population, produces an average of 14.6 million tonnes of rice annually on 7.3 million hectares, as reported by AfricaRice (2022). West Africa dominates the continent's rice production, covering 56.5% of the land area, approximately 3.7 million hectares. In Nigeria, rice has become a staple food across all social classes, with demand surpassing other staples. The country's annual rice consumption is 5.4 million metric tons, worth over $9.2 billion. However, domestic production only reaches 2.3 million metric tons, resulting in a significant import deficit of 3.1 million metric tons. Nigerian farmers face substantial challenges in boosting productivity, including optimizing establishment methods, effective weed control, and fertilizer application, all of which significantly impact rice yields, as noted by Arouna *et al.* (2017).

In Nigeria, rice farmers employ various planting techniques, including broadcasting, dibbling on ridges, and random or row transplanting (Fukagawa and Ziska, 2019). While row transplanting is touted as a means to increase rice yields in lowland areas, it demands substantial water and labor resources. To address these challenges, direct seeding is now being advocated as a more efficient and labor-saving approach that conserves water (Kamai *et al.,* 2020).

In Nigeria, manual weeding is the traditional method, but it's no longer viable due to labor shortages and increasing costs. Moreover, distinguishing between rice seedlings and weeds, particularly grasses, is difficult during the early growth stage, making manual weeding ineffective. (Kamai *et al*., 2020). Therefore, herbicides are considered the most effective solution for weed control in direct-seeded rice (DSR) (Sanjoy *et al.,* 2019). Pre-emergence herbicide application is crucial for efficient weed management in DSR. However, selecting the right herbicide is essential for cost-effective weed suppression. Environmental factors, such as soil moisture, can impact herbicide efficacy and crop safety by affecting absorption, translocation, or metabolism. To boost rice production and meet the growing population's demands, it's essential to optimize rice planting methods, nitrogen rates, and herbicide application timing based on prevailing conditions. (Sanjoy *et al.,* 2019).

Despite the importance of optimizing rice production, there is a lack of knowledge on the best planting method and rates of NPK fertilizer application for achieving high paddy yields in this agro-ecological zone. This study aims to fill this knowledge gap by investigating the effects of different planting methods and NPK fertilizer application rates on rice productivity, with the goal of identifying the most effective practices for improving yields.

MATERIALS AND METHODS

Description of the Experimental Site

The experiment was conducted at the research field of National Cereals Research Institute out-station, Bacita, Kwara state. Bacita is located at (latitude 9^{o1} 16'N and longitude 5^{o}59'E) in the Southern Guinea Savannah Agro-ecological Zone of Nigeria. The experiment was carried out during the wet season of 2021 and 2022.

Treatments and Experimental Design

The trials were carried out in two years in the raining season. The experiment consisted of factorial combinations of five planting methods (dry-seeding broadcasting, wet-seeding broadcasting, dry-seeding dibbling, wet-seeding dibbling and row transplanting methods), and three level of NPK fertilizer rates (0kg/ha, 60kg/ha and 120kg/ha). The (15) treatments combinations with three replications were laid down factorial in a split-plot design with NPK fertilizer rate allocated to the main plot while sowing methods were designated to the sub-plot. The gross plot size was 9m^2 (3m x 3m) and net plot size was 4m^2 (2m x 2m).

Land Preparation
The experimental field was prepared according to standard procedures, involving ploughing, harrowing, leveling, and manual bounding. In both locations, nursery beds were created for sowing seeds and raising seedlings, which were later transplanted to the field.

Seed/Seedling
Direct seeding and broadcasting were done using both dry and pre-germinated seeds. A nursery was established for the seedlings, which were later transplanted at 14 days after establishment at a rate of 2 seedlings per hole. Both transplanting and direct seeding were done with a spacing of 20 x 20 cm. FARO 44 rice seed variety was used, with the following seeding rates: 25 kg/ha for transplanting, 50 kg/ha for direct seeding, and 60 kg/ha for broadcasting.

Fertilizer Application
A basal application of NPK 15:15:15 fertilizer was applied on the day of sowing or transplanting. The first topdressing with Urea was applied 3-4 weeks after sowing or transplanting, followed by a second topdressing with Urea 6-8 weeks after sowing or transplanting, according to the specified fertilizer rates for each treatment.

Disease and Pest control
Throughout the experimental period, there were no occurrences of pest or disease outbreaks. As a result, no pesticides were applied during the experiment.

Harvesting
The rice field was harvested when 80-85% of the panicles had turned yellow or brown, which occurred around 14-16 weeks after sowing (WAS). Harvesting was done using a rice sickle.

Threshing and Winnowing
Threshing was done manually using a drum on a tarpaulin. The seeds were then separated from the chaff through winnowing, a process that uses air to blow away the lighter chaff, leaving the heavier seeds behind.

Yield Parameters
In each plot, five hills were randomly selected and tagged for data collection, and the following parameters were recorded:

Grain Yield
Total grain at harvest was determined by weighing the grains from each net plot with a Mettler scale Model 1210 and the value obtained was converted to per hectare basis.

Statistical Analysis
Data analysis was performed using GENSTAT software (2008 edition). Analysis of Variance (ANOVA) was conducted using the General Linear Model Procedure. Least Significant Difference (LSD) was used to compare means at a 5% level of probability ($P \leq 0.05$)

RESULTS AND DISCUSSIONS

Table 1 shows the initial physical and chemical properties analysis of the soils at the experimental sites during the 2021 and 2022 (combined) cropping seasons. The results showed that the soil texture was predominantly sandy clay, with pH range of 7.3 across both years. The soils had a moderate organic carbon content of 1.8%, relatively low total nitrogen levels, moderate available phosphorus, and low exchangeable cation levels, consistent with the soil characteristics described by Peter *et al.* (2006).

Table 2 indicated the result on paddy yield per hectare, the results shows that transplanting method of planting significantly and consistently produced highest rice paddy yield in both years compared to other methods of sowing. These was consistent with findings by Kawure *et al*. (2023), emphasizing that transplanting and direct seed dibbling methods generally result in higher yields compared to seed drilling and broadcasting methods.

NPK fertilizer at 120kgha-^{1} significantly increased rice paddy yield per hectare in both years compared to the control and the other rate of application. This outcome was attributed to the adequate nutrient supply promoting rapid growth, efficient metabolic processes, and enhanced carbohydrate mobilization, which collectively facilitated robust cell division and elongation.

These findings align with previous studies by Schnier *et al.* (1990), who reported that higher nitrogen levels (120 and 150 kg/ha-^{1}) resulted in significantly increased yields in both wet-sown and transplanted rice.

The significant interactions between sowing methods and rates of NPK fertilizer on yield and yield components showed that transplanting method of sowing with 120kgha-^{1} of NPK fertilizer applied produced highest value for yield and yield attributes. These shows that crop requirements for these important nutrients were met at that rate. The findings of Peng *et al.* (1996) supported these results, showing comparable yield outputs between transplanted rice provided with nitrogen fertilizer and wet-drilled rice.

Table 4 showed the Economic analysis of rice production on different planting methods and NPK fertilizer rates in Bacita (pooled data for 2021 and 2022) on the paddy yield (t/ha) indicated that highest yield was obtained from P_5F_2 (6377.09 t/ha), with transplanting method of sowing with combination of 120kgha-^{1} compared to other methods of planting. The Gross returns (Naira₦ /ha) revealed that the highest gross returns were obtained from P_5F_2 (₦1,594,271.25/ha), the transplanting method of planting with 120Kgha-^{1} NPK fertilizer. The Total Variable Cost (TVC₦) showed that the TVC ranged from ₦331,800 to ₦411,500 across all treatments. The Gross Margin (Net returns ₦) indicated that the highest gross margin was obtained from P_5F_2 (₦1,182,771.25/ha) which is the transplanting methods with 120kgha-^{1} NPK fertilizer application.

CONCLUSION AND RECOMMENDATIONS

Transplanting method of planting resulted in significantly higher paddy yield compared to other methods of planting. Application of NPK fertilizer at the rate of 120kgha-^{1} produced significantly higher paddy yield compared to the control and other rates of application. Transplanting method of planting rice with NPK fertilizer application at 120kgha-^{1} gave higher paddy yield compared to the other methods of planting and NPK fertilizer combinations.

Transplanting of rice with NPK 120kgha-^{1} fertilizer (P_5H_2) resulted in significantly the highest grain yield, gross returns, and gross margin. The gross margin increased as the grain yield increased, indicating that the higher the yield, the higher the profit.

Transplanting method of planting improved the productivity of rice in the study area and is hereby recommended. NPK fertilizer at the rate of 120kgha-^{1} increased paddy yield and is recommended. Transplanting method of planting with application of NPK 120kgha-^{1} fertilizer increase rice growth, development and yield as well maximize profits. Adoptions of this findings would enhance productivity of rice and improved the standard of living of rice farmers in the study area.

Table 1: Physical and Chemical Properties of Soil in the Experimental Site for the both wet seasons

Properties	2021 and 2022 Combined
PH	7.3
O.C.%	1.82
O.M.%	3.12
N%	0.35
Avail P (ppm)	12.35
K	0.34
Na	0.21
Ca	3.56
Mg	2.86
EA	0.50
TEB	6.97
CEC	7.47
B.S.%	93%
Particle size analysis	
Sand %	78.6
Silt %	5.4
Clay %	16
Texture	Sandy loam

Table 2: Effects of Sowing Methods, Timing of Herbicides Application and NPK Fertilizer Rates on Grain Yield per Hectare in 2021 and 2022 at Bacita

	Yield (Kg/ha-1)	
Treatments	Bacita	Bacita
Sowing Methods (S)		
Broadcast dry	3185.31c	2945.69d
Broadcast wet	3270.69d	2988.61c
Dibbling dry	3194.58c	4507.78b
Dibbling wet	3623.61ab	4813.89a
Transplanting	3940.56a	4912.78a
SE±	90.76	122.82
NPK Fertilizer Kg ha^{-1} (F)		
0	2759.60c	3056.33c
60	3615.67b	4373.92b
120	4187.58a	4791.00a
SE±	70.30	95.13
Interactions		
S x F	**	**

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. [1]Weeks after sowing; [2]not significant difference at 5% level of probability

Table 3: Interaction Effect of Sowing Methods x NPK Fertilizer (F) Application Rates on Rice Grain Yield per Hectare at Bacita in 2021 and 2022

	Rates of NPK Fertilizer (Kg/ha-1)					
Sowing Methods	Bacita 2021 0	60	120	Bacita2022 0	60	120
Broadcast dry	3262.92g	4411.67c	2737.50j	2062.50k	2493.75j	4280.83e
Broadcast wet	2321.67j	3013.75i	5535.42b	2757.92i	3333.33h	2874.58
Dibbling dry	3088.75h	3508.33f	3076.67h	2516.67j	3940.00f	4666.67d
Dibbling wet	3410.08fg	3533.75f	3092.08h	3554.17g	5012.50c	5875.00b
Transplanting	1714.58k	3610.83e	6496.25a	4390.42e	4090.00e	6257.92a
SE (±)	65.3			52.1		

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. [1]Weeks after sowing; [2]not significant difference at 5% level of probability.

Table 4: Economic analysis of rice production on different planting methods and NPK fertilizer rates in Bacita 2021 and 2022 Combined

Treatment combinations	Grain yield t/ha	Gross returns Naira (₦)/ha	Total Variable Cost (TVC)	Gross Margin (₦)
P_1F_0	2662.71	665,667.5	331,800	333,867.5
P_2F_0	2539.80	634948.76	336,800	298148.76
P_3F_0	2802.71	700,677.50	336,800	363,877.5
P_4F_0	3452.50	763125.00	336,800	426325.00
P_5F_0	3482.13	870,531.20	346,800	523,731.25
P_1F_1	3452.71	863177.5	351,800	511,377.50
P_2F_1	3173154	793385.0	351,800	441585.00
P_3F_1	3724.17|	931041.25	361,800	569,241.25
P_4F_1	4273.13	1068281.25	361,800	706,451.25
P_5F_1	3850.42	962603.75	386,500	576,103.75
P_1F_2	3509.165	877291.25	391,500	485,791.25
P_2F_2	4205.00	1051250	391,500	659750.00
P_3F_2	3871.67	967917.5	401.500	566417.50
P_4F_2	4483.54	1120885	401,500	719,385.00
P_5F_2	6377.09	1,594,271.25	411,500	1,182,771.25

NB: P_1 =Broadcasting dry, P_2=Broadcasting wet, P_3=Dibbling dry, P_4=Dibbling wet, P_5=Transplanting,
F_0 = OKgha-^{1} NPK Fertilizer, F_1=60Kgha-^{1}NPK Fertilizer, F_2=120Kgha-^{1}NPK Fertilizer

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Evaluating the Actionability and Barriers to Adopting Climate-Smart Agricultural Practices Recommended through Digital Advisory Services among Smallholder Farmers in Savannah Belt, Nigeria

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Abstract
This study investigated the actionability and barriers to adopting the climate-smart agriculture practices recommended through the digital advisory services in Savannah Belt, Nigeria. The study employed a combination of both qualitative and quantitative research methods, analysing primary and secondary data to provide a comprehensive understanding of the adoption barriers. The findings revealed that the mobile phone-based extension model satisfactorily covered climate-smart agricultural topics. Research further revealed that lack of resources, inability to access credit facilities, insufficient time, and lack of finance to hire help are major barriers to the adoption of climate-smart initiatives. The study concludes that Nigeria's traditional agricultural system is open to innovations that can enhance farm productivity, improve access to opportunities, and uplift the livelihoods of smallholder farmers. It recommends redesigning the country's extension services and agricultural products to address farmers' diverse and complex needs, particularly regarding access to information, capital, and inputs, especially in the face of climate change.
Keywords: Adoption, CSA practices, digital advisory services, smallholder farmers, Savannah Belt, Nigeria

INTRODUCTION

The impacts of global climate change on food systems are expected to be far-reaching, complex, and highly variable across regions and over time. These changes will significantly affect agricultural yields, food prices, supply chain reliability, food quality, and food safety, particularly in developing countries like Nigeria, where socioeconomic conditions amplify the vulnerabilities of smallholder farmers (Sonja, Bruce, & John, 2012). Smallholder farmers, with limited resources and capacity to invest in adaptive technologies and institutions, are especially susceptible to the growing risks posed by climate change. While climate-smart agricultural practices (CSA) offer potential synergies for improving food security and building resilience, the adoption of these practices faces significant barriers. Climate-adaptive interventions, such as agricultural intensification, reduction in food waste, and improved extension services, need careful management to ensure the equitable distribution of their costs and benefits. In Nigeria, a significant challenge in this regard is the inadequate ratio of extension agents to farmers.

According to the National Agricultural Extension and Research Liaison Services (NAERLS), one extension agent is often tasked with supporting as many as 5,000 to 10,000 farmers, rendering the system inefficient in helping smallholder farmers reach their maximum production potential and meet growing food demands (NAERLS, 2015; Richard et al., 2020). The limitations of traditional extension services underscore the importance of exploring alternative models for delivering agricultural advisory services. Mobile phone penetration in Nigeria stands at 94%, with 30% of the population using smartphones and 70% using brick and feature phones (Adepetun, 2016). This presents a unique opportunity to leverage digital platforms for delivering agricultural extension and advisory services to smallholder farmers. With the widespread use of mobile phones, digital advisory services can offer a scalable and accessible alternative to the traditional, in-person extension model, which is increasingly unsustainable due to the limited availability of extension agents. Digital platforms have the potential to bridge the gap between extension services and farmers by providing timely and relevant information on CSA, which is critical for enhancing resilience and productivity in the face of climate change.

However, despite the promise of mobile-based agricultural advisory services, several barriers hinder the adoption of climate-smart practices among smallholder farmers in Nigeria's Savannah Belt. These barriers might include limited digital literacy, inadequate access to capital for implementing recommended practices, cultural factors, and the availability of infrastructure to support digital solutions in rural areas. Understanding these barriers is essential for designing effective interventions that can improve the adoption of CSA practices and, ultimately, enhance the livelihoods of smallholder farmers. Therefore, this study aims to evaluate the farmers' perception of the practicality and barriers to adopting the climate-smart agricultural practices recommended through the mobile phone platform. We aimed to generate insights that can inform policies and programs supporting farmers' resilience and adaptation to climate change. By addressing these challenges, the study hopes to contribute to building a more resilient and sustainable agricultural system in Nigeria, capable of withstanding the growing risks of climate change.

MATERIALS AND METHODS

Study Design

The study was conducted in the Savanna Belt agroecological zones of Nigeria, utilising a multistage sampling procedure to select participants. Seven northern states—Kebbi, Sokoto, Zamfara, Katsina, Jigawa, Yobe, and Borno—were purposively selected in the first stage. These states were chosen because they were beneficiaries of the Climate Change Adaptation and Agribusiness Support Program (CASP), which ran from 2013 to 2021 and the Rural Poor Stimulus Facility (RPSF) from 2020 to 2022. In the second stage, 85 local government areas were randomly selected across the seven states. The third stage involved the purposive selection of 2,050 smallholder farmers in various value chains, including rice, maize, tomato, pepper, and onions. These farmers were selected based on data provided by the Federal Ministry of Agriculture and Rural Development (FMARD) and Precision Agriculture for Development (PAD), as they were also beneficiaries of the CASP. Finally, random sampling was used to select 708 smallholder farmers for the study.

Data collection

The study utilised both quantitative and qualitative data collection methods to achieve a well-rounded understanding of the barriers to adopting the climate-smart agriculture practices recommended through digital advisory services. Quantitative data were collected through structured questionnaires, which included questions on the economic variables that are attributable to the digital agricultural advisory provided to them by the RPSF intervention. Qualitative data were gathered through interviews and unstructured questionnaires. These sessions were designed to elicit and gather in-depth insights, opinions, or narratives about their experiences and challenges with adopting climate-smart agriculture practices.

Analytical tools

In this study, descriptive statistics were used to achieve the research objectives. Specifically, pie charts were employed to analyse 12 agronomic themes across five crop value chains—rice, tomato, pepper, maize, and onions—featured in the digital advisory project. Furthermore, bar charts were utilised to assess the barriers to adopting climate-smart agricultural recommendations. The 15 similar responses collected were grouped into four key barriers for clearer interpretation.

RESULTS AND DISCUSSION

Descriptive Statistics

Digital Agronomic Contents Disseminated to the Farmers

A total of 708 farmers were surveyed for their perception of the practicality and barriers to adopting 12 specific climate-smart agronomic recommendations covered across the five-crop value chain; rice, tomato, pepper, maize, and onions.. Agronomic topics related to these 5 crops were explored to develop and disseminate 42 digital advisory messages to the farmers. Overall, sustainable fertiliser application, land preparation and time of planting, and disease management had five (5) topics each. Whereas control of pests in stored maize, *Tuta absoluta* (Tomato Ebola), and fall armyworm management were crop value chain-specific recommendations with only 1 topic each. Other themes such as water management, use of improved seeds, harvest and postharvest practices, nursery establishment and weed management had 4 advisory messages each to various crops. The study assessed farmers' perceptions of the actionability of the climate-smart recommendations (see Figure 1), with 58% of respondents (413 out of 708) indicating that they found the digital agronomic content highly actionable. Additionally, 213 farmers (30%) rated the recommendations as moderately actionable, stating that resource availability would influence their implementation. However, an aggregated 3% of respondents found the messages either not actionable or minimally actionable, while 5.8% (41 farmers) remained neutral, indicating uncertainty about adopting the recommendations even with adequate resources. The study further uncovered that, notably, 96% of these farmers self-reported actively applying at least one of the digital agronomic advice, aligning closely with the combined 96.8% who viewed the advice as neutral, moderately actionable, or highly actionable. This is similar to the work of Kassem, Shabana, Ghoneim, and Alotaibi (2020) who analysed the perception of farmers on the content and quality of agronomic advice received through mobile-based extension services in Egypt.

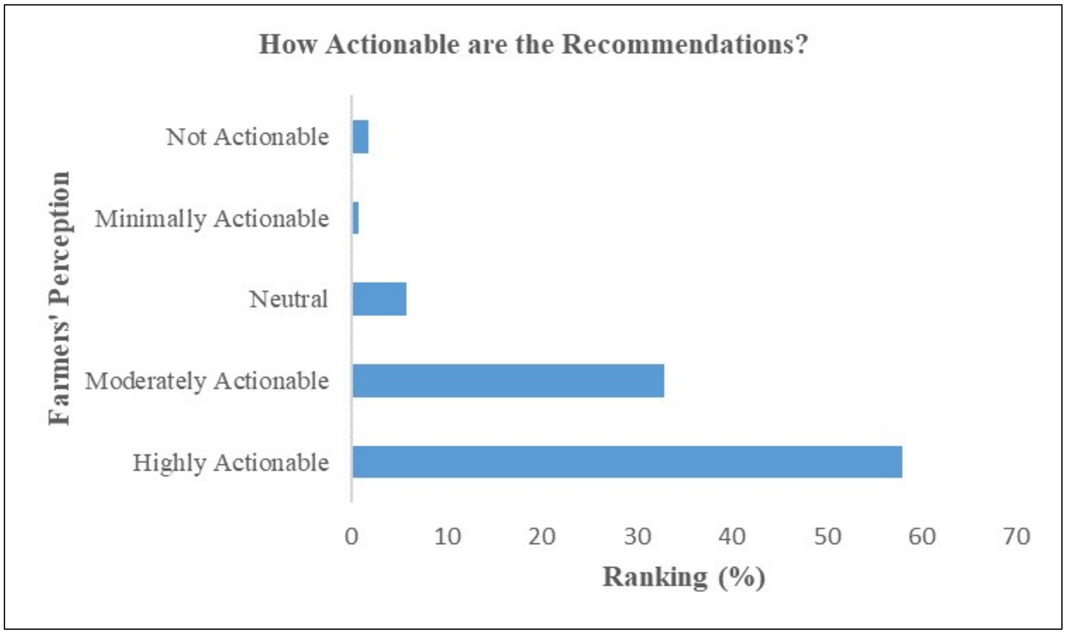

Figure 1: Farmers' Ranking of the Actionability of the Advisory Contents

Barriers to Adoption of the Recommended Climate-smart Agriculture Practices

The barriers to adopting climate-smart agricultural practices recommended through digital advisory services generated over 15 related and unrelated responses. For clarity purposes, the responses were grouped into four (4) barriers as shown in Figure 2 below. The results show that 75% of surveyed farmers cited a lack of financial resources as a key barrier, as recommendations like using improved seed varieties, irrigation farming, and integrated pest and disease management require substantial financial investment. Despite the potential business benefits, most smallholder farmers lack the financial capacity to fully adopt these practices, aligning with Zerssa et al. (2021), who identified economic constraints, such as low income and limited finances, as significant barriers to climate-smart agriculture. Additionally, 13% of respondents pointed to factors like insufficient access to chemical fertilizer alternatives, difficulty sourcing quality inputs, insufficient access to arable farmland, and unpredictable weather events as barriers, reflecting the importance of these elements in successfully implementing and sustaining recommended practices. This is consistent with Khidir (2020), who highlighted that resource availability, including farmland and labour, plays a critical role in adopting mobile phone-based agricultural services. Furthermore, 7% of farmers indicated that limited access to credit facilities impedes adoption, as financial constraints prevent investments in necessary inputs and technologies, which aligns with the findings of Nandini and Venkataramana (2024), who noted that insufficient financial resources, such as credit, is a barrier to adopting climate-smart technologies.

Finally, 5% of respondents indicated that limited time to work on the field and the inability to hire farm labour were also major barriers. This might be because farmers often need more support to integrate new practices into their existing schedules. When resources and assistance are limited, it becomes challenging for them to commit to new practices, leading to a reliance on traditional methods that may not be as effective in mitigating climate impacts. This corroborates the findings of Olooto, Abdulrahman, and Bello (2022) who indicated that one of the major personal constraints that hinder the adoption of climate-smart agriculture is the demand or insufficient time

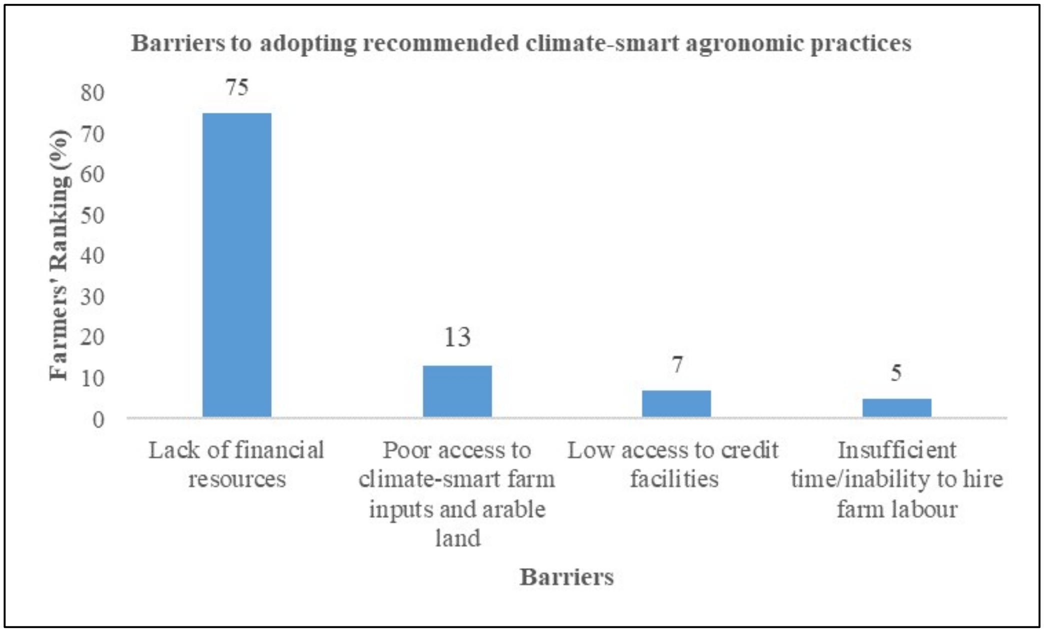

Figure 2: Barriers to Adopting Climate-smart Agronomic Practices

CONCLUSION AND RECOMMENDATIONS

The study examines the barriers to adopting climate-smart agricultural practices recommended via digital advisory services in Nigeria's Savannah Belt, using both quantitative and qualitative data. Key barriers include limited financial resources, restricted access to credit, lack of time to implement new practices, inability to hire labour, and challenges like inadequate access to alternative fertilizers, difficulty sourcing quality inputs, poor access to arable land, and unpredictable weather patterns. Financial limitations are the primary barrier to adopting extension messages. Therefore, it is recommended that an integrated framework to enhance resource-constrained farmers gain adequate access to capital and inputs should be embedded into extension services.

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Preliminary Investigation of Amino Acid Quality of Sun-dried Locust (*Schistocerca gregaria*) for Potential Use in Fish Feed

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Abstract
This study carried out a preliminary investigation of Amino Acid quality of Sun-Dried locust (Schistocerca gregaria). The amino acid profile values g/100g protein of locust (Schistocerca gregaria) were Arginine (7.42); Histidine (4.15); Isoleucine (4.11), Leucine (5.91); Lysine (5.90); Methionine (2.31); Phyenlalanine (4.46); Threonine (4.02); Valine (3.77); Aspartic acid (9.37); Serine (5.00); Glutamic acid (15.36); Proline (3.78); Glycine (4.80); Alanine (5.11); Cystine (1.66) and Tyrosine (3.06). The amino acid profile of locust compared favourably (g/100g protein) with fishmeal. People and animals often consume locusts but usually not enough to significantly reduce the population levels over large areas. Fishmeal as fish feed ingredient has become expensive and scarce, and its use in fish feed formulation is not cost effective, since feed presently accounts for about 80% of production cost due to fuel subsidy removal in Nigeria and consequent economic decline. Therefore, concerted efforts have been directed towards discovering unconventional, cheaper, readily available and highly digestible alternative sources of feedstuff for fish. Considering the high amino acid profile (balanced amino acid composition) of locust its potential for inclusion as alternative source to conventional protein sources in the diets of man and his livestock with particular reference to fish could be explored. Locust meal will not require fortification with any amino acids because of its balanced amino acid composition and the values obtained are within the National Research Council (NRC) minimum recommended amino acids levels in fish feed.
Keywords: Amino Acid, Fish Feed, Investigation, Quality, Sun-Dried Locust (Schistocerca gregaria)

INTRODUCTION

The nutrient quality of feed ingredients is one of the major pre-requisite for the production of good quality feeds aside from availability, cost and season. The basic nutrient that cannot be compromised in the choice of ingredient for feed formulation and preparation is protein (Zeitler et al., 1984). Feedstuffs like maize, sorghum, soya beans, groundnut and fishmeal were previously used in preparing fish feed/pellets. However, the scarcity of these plant sources and competition from other sectors for such conventional crops for livestock and human consumption as well as industrial use makes them expensive and placed them far beyond the reach of fish farmers or producers of aqua-feed (Langia, Maulub, Hasimunad, Kapula and Tjipute, 2024).

The prevalent economic down-turn in Nigeria due to the removal of fuel subsidy has further escalated the cost of the conventional feedstuffs even beyond the reach of man for personal consumption let alone livestock. Fishmeal, the main fish feed ingredient which is known to contain complete essential amino acid (EAA) profile that is required to meet the protein requirements of most fish species for growth and tissue development has also become expensive and scarce. Hence, its use in fish feed formulation is no longer cost effective since feed presently accounts for about 80% of production cost. Therefore, concerted efforts have been directed towards discovering unconventional, cheaper, readily available and highly digestible alternative protein sources of feedstuff for fish (Aderolu, Lawal, Awobajo, Olaniyan and Bello, 2018).

In Nigeria one of the alternative sources that have been extensively explored for possible use as ingredient in fish feed formulation are non-conventional animal protein sources (Balogun and Abdullahi, 2023). The non-conventional feedstuff of animal origin such as locust, grasshopper, earthworm, garden snail,termite and tadpole, live maggot, earthworm, crayfish waste, toad and housefly larvae are high quality feed ingredients which could compare to certain extent with the conventional types (Balogun and Abdullahi, 2023; Michael and Kolapo, 2017; Sogbesan and Ugwumba, 2008; Nnaji and Okoye, 2004; Madu and Ufodike, 2003; Falaye, 1992; Idoniboye-obu and Ayinla, 1991; Annune, 1990; Spinelli, 1980. They are cheaper by virtue of the fact that there is no competition for human consumption (Gabriel et al., 2007). The only problem with these feedstuffs is their unavailability in large commercial quantities for the sustenance of the aquaculture industry in most parts of Africa, Nigeria inclusive (Adeleke, Robertson-Andersson, Moodley and Taylor, 2020; Gabriel et al., 2007).

The desert locust *Schistocerca gregaria* are agricultural pests collected by people in several countries for food using large nets and other means. Locusts are usually stir fried and eaten (FAO, 2004). In Nigeria they are sold at markets in various parts of northern Nigeria. Locust invades these regions at a particular season of the year (FAO,2004). They are part of a large group of insects commonly called grasshoppers which have hind legs for jumping. Locust belongs to the family Acrididae. Locusts differ from grasshopper in that they have the ability to change their behavior and habits and migrate over long distances. They are usually restricted to the semi-arid and arid deserts in Africa, the East and South- West Asia that receive less than 200mm of rain annually. This is an area of 16 million square kilometer consisting about 30 countries (FAO, 2004). And during plaques the out break extends to about 29 million sq km and 60 countries (Martínez et al., 2017; FAO, 2004).

During out breaks a desert locust has potential to damage the livelihood of the people in the area and its surrounding environs. The activities of locust could be referred to as lethal cocktail, a situation that could be characterized as catastrophic. It is not only humans that risk going hungry, animals are also affected thus the livelihoods of nomadic pastoralist are also threatened leaving them desperately short of grazing land for their animals. Locust swarms can vary from one square kilometer to several hundred square kilometers. There can be at least 40 million and sometimes as many as 80 million locust adults in each square kilometer of swarm. Desert locusts usually fly with the wind at a speed of about 16–19km/h, thus depending on wind swarms travel 5-130km or more in a day. Solitary desert locust adults usually fly at night while gregarious adults fly during the day (Babmann, Hahn, Rebl, Wenzel, Hildebrand, Verleih and Palm, 2023; FAO, 2004).

In South Africa, Ledger (1987) suggested that serious consideration be given to attempting harvest of the brown locust, *Locustana pardalina* (walker) as human and animal food (as indigenous people have done for centuries) in order to eliminate or reduce the use of insecticides on the pest. The idea was however dismissed as impracticable by agricultural officials. Nevertheless, local officials in Thailand launched a campaign to combine grasshopper harvest and sale with pest control when conventional control procedures proved unsuccessful (Maulu et al., 2021; Deforliart, 1989).

According to FAO (2004) locusts are rich in protein. About 62% of the dry weight of desert locust consists of protein (>50), fats and the remainder are inorganic constituents (Si, Cu, Fe, Mn, Na, Mg, K, Ca, Ti, Ni, P and S). The protein contents of grasshoppers 30 – 37% CP; (Nnaji and Okoye, 2004) are comparable to that of locust. Sutton (1988) stated that locusts have approximately 24% crude protein. Banjo *et al.* (2006) reported that *Zonocerus variegatus* has CP 26.8; EE 3.80; Ash 1.20; CF 2.40; DM 92.18; M 2.61; NFE 63.2; Vitamin A (Ug/100g) 6.82; Vitamin B2 (mg/100g) 0.07; Vitamin C (mg/100) 8.64; Ca (mg/100g) 42.16; P (mg/100g) 131.2; Mg (mg/100g) 8.21.

In Japan, processed grasshoppers are the most commercially available. The widely eaten imago (the grasshopper, oxyya velox F.) is preserved by boiling in soy sauce. The product appears as a luxury item in supermarkets throughout the country, including Tokyo. (Dadebo, Degsera and Tekle-Giorgis, 2014; Mitsushashi, 1984) Locusts are used by various African groups consistently as food. The locust individuals are gathered in the early day before they are active then boiled before being cleaned and salted. Even the legs are used by grinding and combining them with peanut butter and salt. Locusts are also becoming a food item in South Korea where rice farmers are beginning to gather and sell them to supplement their income from rice production (Encyclopedia Smithsonian, 1980). In Nigeria they are consumed in the arid savannah and Northern parts that are prone to locust infestation. The adult state of variegated grasshopper *Zonocerus variegates* (Linn) (Order – Orthopthera: Family – Pyrgomorphidae) which have large dry season population in southwestern Nigeria is reported eaten in Akoko area of Ondo state (Fasoranti and Ajiboye, 1993).

People and birds often eat locusts but usually not enough to significantly reduce population levels over large areas. Considering its high protein contents (>50%), its potential for inclusion as protein source in animal feed with particular reference to fish could be explored. The use of locust meal could thus be economical and advantageous if incorporated in fish feeds without compromising growth and feeds conversion. All fish species require the 10 essential amino acids namely arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. Feed stuff deficient in any of the 10 essential amino acids cause depressed appetite and consequently depressed growth rate of fish (Kemigabo et al., 2018; Khan et al., 2009; Ayinla, 1988; Ayinla and Bekibele, 1992). This study therefore carried out a preliminary investigation of the Amino acid quality of Sun-Dried Locust (*Schistocerca gregaria*) for potential use in Fish Feed

MATERIALS AND METHODS

Sample Collection

The Sun-Dried locust (*Schistocerca gregaria*) were purchased from a local market in Birnin Kebbi, Sokoto State, Nigeria. *Clarias gariepinus* (Teugels) used for this study were obtained from a homogenous source in a standardized hatchery, Mairuwa fish farm, along Funtua-Gusau road, Katsina State.

Sample Preparation

The locust samples were sorted out to remove dirt's, stones and other forms of impurity. The locust samples were further dried in open air for Seven (7) days. The fish were cleaned and eviscerated.

Biochemical Analysis

The samples were taken to the central laboratory of the National Research Institute for Chemical Technology (NARICT), Basawa, Zaria, Nigeria for determination of amino acid profile.

Determination of Amino Acid Profile

The same procedure of amino acid determination was applied to the locust and fish samples in triplicate. The amino acid profile of the sample was determined by using the method described by Spackman *et al.* (1958). Five grams (5g) of the sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Technicon Sequential Multi-Sample Amino Acid Analyzer (TSM)-1model DNA 0209 as indicated in the manual of Technicon Instrument Company (1973).

Defatting sample: Three (3.0g) grams of dried sample was weighed into the extraction thimble and the fat was extracted with chloroform/methanol (2:1 mixture) using soxhlet extraction apparatus as described by AOAC (1980). The extraction lasted for 15 hours.
Hydrolysis of the sample: Two (2.0g) grams of the defatted sample was weighed into a glass ampoule. Seven milliliters (7ml) of 6 NHCl was added and oxygen was expelled by passing nitrogen into the ampoule (this was to avoid possible oxidation of some amino acids during hydrolysis). The glass ampoule was then sealed with Bunsen burner flame and placed in an oven preset at 105ºC ±5ºC for 22hours. The ampoule was allowed to cool before broken open at the tip and the content was filtered to remove the humins. The filtrate was then evaporated to dryness at 40±2ºC under vacuum in a rotary evaporator. The residue was dissolved with 5ml of acetate buffer (pH 2.0) and stored in plastic specimen bottles at 2±ºC in a freezer.

Loading of the hydrolysate into the TSM Analyzer (DNA 0209): Five to ten (5–10) microlitres of the hydrolysate was loaded. This was dispensed into the cartridge of the analyzer. The TSM analyzer is designed to separate and analyze free acidic, neutral and basic amino acids of the hydolysate. The analysis lasted for 76 minutes.

***Method of calculating Amino Acid values from the chromatogram peaks*:** The net height of each peak produced by the chart recorder of TSM (each representing an amino acid) was measured. The half-height of the peak on the chart was found and the width of the peak on the half height was measured and recorded. Approximate area of each peak was then obtained by multiplying the height with the width at half height.

The norleucine equivalent (NE) for each amino acid in the standard mixture was calculated using the formula:

$$\mathrm{NE} = \frac{\text{Area of Norleucine peak}}{\textit{Area of each amino acid}}$$

A constant S was calculated for each amino acid in the standard mixture:
Sstd = NEstd × Mol. Weight × μMMAstd

Finally, the amount of each amino acid present in the sample was calculated in g/16gN or g/100g protein using the following formula:

Concentration (g/100g protein) = NH × W@ $\frac{NH}{2}$ × Sstd × C

$$\text{Where C} = \frac{\text{Dilution} \times 16}{Sample\ \text{Wt(g)}x\ N\%\ x10\ x\ Vol.Loaded}\ \text{NH x W (nleu}$$

Where,

NH = Net height

W = Width @ half height

nleu = Norleucine

Technicon TSM-1 Model DNA 0209 had the capacity to analyse the following Amino Acids on g/100g protein basis: - Lysine, Histidine, Arginine, Aspartic Acid, Threonine, Serine, Glutamic acid, Proline, Glycine, Alanine, Cystine, Valine, Methionine, Isoleucine, Leucine, Tyrosine, Phenylalanine.

Table 1: Amino Acid Composition/ Amino Acid Profile (g/100g Protein) of Sun-dried Locust

EAA	Locust	Fish Meal
Arginine	7.42	6.13
Histidine	4.15	2.65
Isoleucine	4.11	3.68
Leucine	5.91	7.02
Lysine	5.90	7.83
Methionine	2.31	2.87
Phenylalanine	4.46	4.54
Threonine	4.02	4.58
Tryptophan		
Valine	3.77	5.05
Aspartic acid	9.37	9.49
Serine	5.00	4.67
Glutamic Acid	15.36	14.50
Proline	3.78	4.37
Glycine	4.80	7.05
Alanine	5.11	6.58
Cystine	1.66	0.92
Tyrosine	3.06	3.49

Table 2: Recommended Nutrient/ Amino Acids Levels in fish feed

Nutrients (Amino Acid)	Minimum Recommended Levels % of diet
Arginine	1.5
Histidine	0.7
Isoleucine	0.9
Leucine	1.4
Lycine	1.8
Methionine + Cystine	1.0
Phenlalamine + Tyrosine	1.8
Threonine	0.8
Trytophane	0.2
Valine	1.2

Source: NRC (1993)

RESULTS AND DISCUSSION

The result of the amino acid determination (Amino acid profile) in Table 1 shows that locust (*Schistocerca gregaria*) contained all the essential amino acids with the exception of tryptophan. The results of these findings (Table 2) indicated minimal loss of available amino acids with particular reference to methionine and lysine, the values were within the National Research Council (NRC, 1993) minimum recommended nutrient levels in fish feed for optimal growth.

However, the acid hydrolysis involved in the amino acids profile determination through the use of Technicon Sequential Multisample Amino Acid Analyzer (TSM)-1 model DAN 0209 resulted in the destruction of all tryptophan and considerable amount of cysteine and methionine present in the locust sample. The methionine + cysteine values of locust (3.97) compares favourably well with that of fishmeal (3.79). the lysine values of the locust (5.90) was lower but compares favourably with fish meal (7.83). The arginine, histidine, isoleucine, serine, glutamic acid and cystine values were higher than that of fish meal.

CONCLUSION AND RECOMMENDATIONS

The search for alternative protein sources to fishmeal has become of paramount importance to the aquaculture enterprises because of the growing concern on the future availability of fishmeal for incorporation into fish feed. The complete amino acids composition g/100g protein of Locust (*Schistocerca gregaria*) makes it a good nutritious fish feed ingredient that can potentially replace fishmeal either fully or partially in fish feed formulation particularly in circumstances where fishmeal is scarce and expensive.

Lysine and methionine are very crucial in fish feed formulation because they are the first limiting amino acids in most commercial feedstuffs particularly those of plant origin and thus fish meals from such sources may need to be fortified with commercial supplements of lysine and methionine. However, locust meals will not require fortification with any amino acids because its amino acids composition is complete/balanced and the values are within the National Research Council (NRC, 1993) recommended nutrient (amino acids) levels in fish feed.

It is recommended that locust be subjected to further research on anti-nutritional factors to determine if they are present in locust and subsequently determine the best processing methods that will enhance their efficiency of utilization, growth performance and good health regime in fish, thereby reducing cost of production and maximizing profit.

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Agronomic Performance of Extra-early Provitamin a-Enriched Quality Protein Maize Inbreds

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Abstract
Utilization of extra-early maturing Provitamin A quality protein maize (PVA-QPM) cultivars could reduce malnourishment and enhance food security, especially in the resource-poor communities of the Southern Guinea savannah agroecology. This study was to identify extra-early maturing PVA-QPM inbred lines of superior grain yield and other agronomic traits. Ten extra-early PVA-QPM inbreds and two extra-early open-pollinated varieties that served as checks were tested at the Lower Niger River Basin Development Authority, Ilorin, under rainfed conditions for two years. The combined analysis of variance showed marked differences among genotypes for grain yield, plant and ear height, days to anthesis, silking, anthesis-silking interval and ears per plant. Six extra-early PVA-QPM inbreds were highly prolific for grain yield and other agronomic traits compared with the two open-pollinated varietal checks. They could be introgressed to produce hybrids of drought escape, high grain yielding and quality nutrients adapted to the southern Guinea savannah agroecology of Nigeria. These inbreds will eventually improve food security and lessen malnutrition, especially among the resource-poor in the southern Guinea savannah region.
Keywords: Grain yield, plant height, soil textural class, food security, malnutrition

INTRODUCTION
Millions of people worldwide, particularly the rural poor-resource, feed on conventional maize deficient in the vital nutrients of provitamin A (PVA), tryptophan and lysine amino acids (Bello, 2017, Bitew *et al.,* 2024). These are causing food insecurity and malnourishment in the region. Vitamin A is a micronutrient required to enhance immune systems and revitalize the eyesight of humans. Unfortunately, the body of humans cannot synthesize it. Normal-endosperm maize contains insufficient tryptophan and lysine content amino acids of around 0.46 compared to quality protein maize (QPM) with around 0.73 (Bitew *et al.,* 2024). Consumption of maize deficient in these two essential amino acids without supplementary protein source for a balanced diet among infants can lead to decreased child growth like Kwashiorkor, immune system reduction and death (Ige *et al.,* 2023). The availability of drought-tolerant extra-early maturing maize cultivars that can withstand the effect of the short rainy season on the grain-filling stage and well fitted as drought escape is crucial for cultivation in the southern Guinea

savannah region (Bello *et al.,* 2019). This study was to identify extra-early maturing PVA-QPM inbred lines for high grain yield.

MATERIALS AND METHODS

The test sites and genetic materials used

We obtained ten extra-early maturing PVA-QPM inbreds from the International Institute of Tropical Agriculture (IITA) Ibadan. Two extra-early maturing open-pollinated varieties recommended by IITA for drought-prone areas in Northern Nigeria served as controls.

Field evaluations

The experiments were conducted in the rainfed growing season at the Lower Niger River Basin Development Authority, Ilorin, on 15th July 2022 and 17th July 2023. The Nitrogen, Phosphorus, and Potassium (NPK at 20: 10: 10) fertilizers were applied to both managed trials at 60 kg/ha each of N, P, and K at planting. Additionally, 60 kg/ha of urea was applied two weeks after planting. Each row plot was 4 m long with spacing of 0.75 m between rows and 0.40 m within rows, constituting an experimental unit. The density of 66,666 plants per hectare was achieved by planting three seeds per hill and later thinning them to two plants per stand. The layout of the trials in each cropping year was in a randomized complete block design (RCBD). Weed control was achieved by applying pre-and post-emergence herbicides (Atrazine and 2-4D) at 7 litres per hectare, followed by manual weeding.

Data collection

Data was collected on days to anthesis, days to silking, anthesis-silking interval, plant height, ear height, plant aspect, ear aspect, number of ears per plant and grain yield.

Statistical analyses

Data from the trials were analyzed using the PROC GLM model of SAS (SAS Institute, 2018). Combined ANOVA across years were computed. Pertinent means were separated using the least significant difference to quantify the variations among each mean character. The percentage coefficient of variation (PCV) separates the different summations and means was used with the standard error (S.E).

RESULTS AND DISCUSSION

Combined analysis of variance

The combined analysis of variance revealed significant differences among the different genotypes for various characteristics of the studied traits (Table 1). The ANOVA results showed significant differences in grain yield among the evaluated maize genotypes, indicating that some genotypes are more productive than others, which can be critical for selecting high-yielding varieties, especially under varying environmental conditions. There was significant variation in plant height across different treatments. The implication is that taller plants may have the advantages of light capture and overall biomass, but excessive height could also lead to lodging. Understanding these differences necessitates choosing varieties that balance height with stability (Sheidu and Igyuve 2023). The differences in ear height were significant, indicating that **e**ar height is crucial for harvest efficiency and can influence yield. Varieties with optimal ear height may be more suitable for mechanized harvesting. There were significant differences in days to anthesis and silking. These two traits are essential for understanding the timing of flowering, which can affect pollination success and yield. Early-maturing varieties may be preferable in regions with shorter growing seasons. The ASI showed significant variation among genotypes, which denotes that a shorter ASI is generally favourable, as it indicates better synchronization between pollen shed and silk emergence, leading to improved kernel set and grain yield. The differences in the number of ears per plant were significant, as it connotes that this trait is directly linked to yield potential. Genotypes with a high ear per plant number can contribute to greater grain yield. Thus, it shows that the maize inbred lines used in the study exhibited significant variability, contributing to diverse genotype outcomes (Fekadu *et al.,* 2024). It also suggests that the genetic frequencies of the maize inbred lines for these traits were widely dispersed across the two years of rainfed cropping, potentially leading to the identification of different inbreds for improvement and the emergence of new genes, thus expanding and diversifying the genetic diversity of adapted genotypes (Alam *et al.,* 2022). It could ultimately help maintain genetic gains in breeding programs. The heritable differences could be leveraged in selection processes in crop improvement programs (Bello and Olawuyi, 2015, Bello, 2017). However, the lack of significant differences observed for plant and ear aspects suggests that the genetic makeup of the inbreds was uniform for these traits. The non-significant mean squares for the year and the interaction between genotype and years indicate that the performance of the inbreds was consistent across the two growing years. These differences could enhance the studied traits in maize through selection. This finding is consistent with previous studies (Bello, 2017, Bello *et al.,* 2019, Ige *et al.,* 2023). Recurrent selection breeding methods could improve genotypes within these ten inbreds.

Table 1. Combined ANOVA mean squares of PVA-QPM inbred lines for agronomic traits evaluated across 2 years in rainfed seasons

Source of variation	Df	Grain yield (t ha^{-1})	Days to anthesis	Days to silking	Anthesis silking interval	Plant height	Ear height	Plant aspect	Ear aspect	Ears per plant
Year	1	6.00	7.54	6.11	9.01	8.55	10.22	7.54	9.00	8.23
Rep (Year)	6	10.54	9.60	11.67	9.11	10.17	12.01	9.22	11.32	9.88
Genotypes	9	98.67**	62.09*	66.11*	91.23**	57.60*	66.55*	39.31	25.11	87.60*
Genotypes × Year	9	31.67	11.01	25.77	41.22	13.07	34.66	17.88	31.11	14.55
Pool error	30	89.33	78.51	67.00	88.3434	92.34	12.82	19.33	67.32	29.39
% CV		11.8	16.7	19.9	12.2	15.7	9.8	11.5	10.9	13.4

** and * significant at 0.01 and probability levels, respectively.

The mean performance indicates substantial variation in grain yield among the evaluated maize inbred lines, ranging from 2.71 to 4.1 t ha^{-1} (Table 2). Six inbreds (TZEEIORQ 32, TZEEIORQ 41, TZEEIORQ 49, TZEEIORQ 52, TZEEIORQ 57, and TZEEIORQ 25) demonstrated superior grain yield, averaging 3.67 t ha-1, which was an 11% increase compared to the two open-pollinated varietal controls. Among these, TZEEIORQ 25 stood out with a yield of 4.01 t ha-1, showing a 17% advantage over the best open-pollinated varietal check (SAMMAZ 48). For plant and ear aspects, the performance across the two years was moderate, with the two varietal checks demonstrating outstanding performance compared to TZEEIORQ 5, which showed the highest score with advantages of 32% and 29%, respectively. Additionally, TZEEIORQ 25 exhibited superior plant and ear heights, with percentage increases of 7% and 16%, respectively, relative to TZEEIORQ 49, which had the lowest height. All inbreds and checks had only one ear per plant. There was a significant difference for days to anthesis, silking, and anthesis-silking intervals. TZEEIORQ 62 was the earliest for anthesis and silking, with the lowest anthesis-silking interval. This inbred could potentially be used to develop maize cultivars with earliness to anthesis and silking.

Table 2. Genotypic means of PVA-QPM inbred lines for agronomic traits evaluated across 2 years in rainfed seasons

Genotypes	Days to anthesis	Days to silking	Anthesis silking interval (No)	Plant height (cm)	Ear height (cm)	Plant aspect (No)	Ear aspect (No)	Number of ears per plant	Grain yield (t ha^{-1})
TZEEIORQ 32	63.7	66.8	3.1	139.2	60.7	2.33	2.33	1	3.68
TZEEIORQ 41	61.6	64.6	3.0	137.1	61.1	2.74	2.52	1	3.54
TZEEIORQ 49	60.8	62.7	1.9	129.8	51.7	2.61	2.77	1	3.33
TZEEIORQ 54	57.9	59.7	2.8	136.4	59.9	2.92	2.42	1	3.39
TZEEIORQ 52	62.5	65.6	3.1	139.2	60.4	2.53	2.56	1	3.55
TZEEIORQ 5	56.9	58.8	1.9	131.7	61.1	2.99	2.89	1	2.71
TZEEIORQ 57	60.4	63.1	2.7	130.5	58.7	2.82	2.85	1	3.70
TZEEIORQ 61	61.2	64.3	3.1	138.0	59.3	2.90	2.19	1	3.41
TZEEIORQ 62	59.4	61.2	1.8	132.6	61.2	2.81	2.30	1	3.51
TZEEIORQ 25	63.8	66.7	3.2	140.1	61.6	2.97	2.12	1	4.01
Varietal Control									
SAMMAZ 32	59.6	62.3	2.7	132.7	56.7	2.01	2.07	1	3.21
SAMMAZ48	60.4	62.3	2.9	133.0	57.9	2.02	2.12	1	3.33
Mean	60.6	63.2	2.7	136.03	59.2	2.64	2.43	1	3.45
Range	6.9	7.1	1.4	10.3	9.9	0.98	0.82	0	1.3
LSD (0.05)	3.13	0.69	1.89	0.57	6.67	0.99	4.23	19.11	34.67*
CV%	10.14	8.11	6.23	9.16	11.12	10.56	7.09	20.45	15.78
SE±	25.69	1..67	13.00	18.23	12.89	9.62	4.74	10.23	14.76

CONCLUSION

The combined analysis of variance showed marked differences among genotypes for grain yield, plant and ear height, days to anthesis, silking, anthesis-silking interval and ears per plant. Six extra-early PVA-QPM inbreds were highly prolific for grain yield and other agronomic traits compared with the two open-pollinated varietal checks. They could be introgressed to produce hybrids of drought escape, high grain yielding and quality nutrients adapted to the southern Guinea savannah agroecology of Nigeria. These inbreds will eventually improve food security and lessen malnutrition, especially among the resource-poor in the southern Guinea savannah region.

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Evaluation of Integrated Pest Management Strategies for Sustainable Management of Tomato Insect Pests: A Review

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Abstract
Tomato production is significantly infested by various insect pests, leading to crop damage and yield losses. Our conventional pest control practices rely heavily on chemical insecticides that cause concern over environmental pollution, pest resurgence, and health risks. Integrated Pest Management (IPM) offers an alternative by combining various control methods for sustainable long-term pest suppression. However, limited data exists on the effectiveness of specific IPM strategies for controlling key tomato pests in the context of different cultivars. This review aimed to evaluate the efficacy of various IPM strategies in managing pest populations and enhancing the sustainability of tomato production. Field trials conducted across research were reviewed, comparing the effectiveness of four approaches; cultural practices, biological control, judicious chemical control and Combination of all three IPM approaches. Pest population dynamics, crop damage assessments and yield parameters were reviewed. Results from the review indicate significant reductions in pest abundance and increased yield in the integrated IPM strategy compared to other strategies and uncontrolled trials. The integrated IPM plots also showed the lowest levels of crop damage - 3.5% pest incidence and the highest fruit yield - 228 kg per plot. These findings suggest that a comprehensive IPM approach can effectively suppress pest populations and enhance tomato yield. Further analysis should focus on developing specific IPM strategies, the economic viability of each IPM strategy and the long-term impact on pest resistance development.

Keywords: Integrated Pest Management (IPM), Tomato, Pests, Sustainable agriculture.

INTRODUCTION

Tomato (*Solanum lycopersicum*) is one of the most economically important vegetable crops worldwide, contributing significantly to global food security and agricultural economies. Tomato production is significantly hampered by various insect pests, leading to yield losses and economic burdens for farmers (Benhura *et al*., 2018). Common pests include insect herbivores such as aphids (e.g., *Myzus persicae*), whiteflies (e.g., *Bemisia tabaci*), and tomato fruitworms (e.g., *Helicoverpa armigera*); pathogens such as bacterial wilt (*Ralstonia solanacearum*) and tomato mosaic virus (ToMV); and weeds such as nutsedges (e.g., *Cyperus* spp.) and pigweeds (e.g., *Amaranthus* spp.). Whiteflies, *Bemisia tabaci* (Gennadius); Thrips, *Thrips tabaci* (Lindeman); Aphids, *Aphis gossypii* (Glover); and Tomato fruitworm, *Helicoverpa armigera*, Tomato leaf miner, *Tuta absoluta* are some of the most important insect pests that attack tomato. These pests can reduce yield, affect fruit quality, and increase production costs, making effective pest management crucial for sustainable tomato production. Conventional pest control practices heavily rely on chemical insecticides, raising concerns about environmental pollution, pest resurgence, and human health risks (Bajwa *et al*., 2014). In response to these challenges, Integrated Pest Management (IPM) has emerged as a holistic approach to pest control that emphasizes the integration of multiple strategies to minimize pesticide use while maintaining or enhancing crop productivity. Integrated pest management (IPM) offers a sustainable alternative by combining various control methods for long-term pest suppression (Liu *et al*., 2020). It integrates multiple pest management strategies, including cultural practices, biological control, mechanical control, and judicious chemical control, to create a holistic and ecologically sound approach to pest management. By combining these strategies in a coordinated and strategic manner, IPM aims to suppress pest populations, reduce pest damage, and minimize environmental impacts. Additionally, IPM emphasizes the importance of monitoring pest populations, implementing preventative measures, and utilizing thresholds for intervention to ensure effective and targeted pest management. However, the efficacy of IPM strategies may vary depending on factors such as local pest pressure, crop cultivars, and environmental conditions. Therefore, it is essential to evaluate the performance of IPM strategies under different contexts to identify the most effective approaches for sustainable pest management. Extensive research supports the efficacy of IPM in managing various agricultural pests (Lamichhane *et al.*, 2018). This review aims to evaluate Integrated Pest Management (IPM) strategies for the sustainable management of tomato pests. By conducting a comprehensive study, the efficacy of IPM strategies in controlling key pests of tomato crops is assessed while minimizing environmental impacts and maintaining crop productivity, by identifying the most effective IPM strategies for managing tomato pests in these cultivars, with implications for sustainable tomato production worldwide.

REVIEW METHOD

Numerous studies have demonstrated the effectiveness of IPM strategies in managing tomato pests while minimizing environmental impacts. The methodology used in preparing this article was the collection of information from different search sites like Google, Google Scholar, academia, springer etc., and research articles published in various national and international journals. Integrated pest management (IPM) is based on the principles of prevention, monitoring, and control, aiming to minimize pest damage while minimizing risks to human health and the environment. This review evaluates the efficacy of various IPM strategies in managing pest populations and enhancing the sustainability of tomato production, focusing on the key components of IPM.

1. **Cultural practices**: Crop rotation, intercropping, and sanitation to disrupt pest life cycles and reduce pest pressure.
2. **Biological control**: Introduction of natural enemies such as parasitoids, predators, and pathogens to suppress pest populations.
3. **Judicious chemical control**: judicious use of pesticides, employing selective and reduced-risk products, and applying them only when necessary and in accordance with IPM principles.
4. **Combination Treatment**: Integration of multiple IPM strategies to maximize pest suppression and minimize pesticide use.

RESULTS AND DISCUSSION

Cultural Practices

The cultural method of pest control is one of the oldest and most effective methods deployed for pest control by farmers in their crop fields. These methods promote natural pest control by making the environment less favourable for their growth and enhancing the competing ability of the crops grown (Hill, 1987). Practices such as crop rotation, healthy crop growth, altered timing of cropping, and different crop combinations that come under cultural control are solely related to crop ecology (Bajwa and Kogan, 2004). Prevention, avoidance and suppression are the 3 main categories under cultural control of pests which enhance crop competing ability against pests as well as create a favorable environment for pest natural enemies and less suitable conditions for pest outbreaks (Bajwa and Kogan, 2004). Some cultural practices include healthy crop, sowing date and altered timings, soil and fertilizer management, tillage, planting density, mulching, irrigation/water management, intercropping, trap crops and crop rotation.In an experiment by Afreen *et al.,* (2017), the number of whitefly and fruit borer in tomato cultivation based on different planting dates and mechanical support were evaluated. The lowest whitefly population was recorded in tomato planted from October 10 to November 25. As the planting date, advances whitefly population increased while the fruit yield decreased (Borah and Bordoloi, 1998). In another experiment by Saunyama and Knapp (2003) in Zimbabwe, the effect of pruning and trellising of tomato on the incidence of red spider mite was assessed. Unpruned and untrellised plots had 37.7 and 30.2 mites per leaf respectively, while pruned and trellised plots had 4.6 and 17.3 mites per leaf respectively. This indicated that pruning and trellising of tomatoes in this study was effective in controlling the population of red spider mite.

Diakalia *et al* (2018) studied the effect of plant diversification on pest abundance and tomato yields in Burkina Faso. The results showed that plots where tomato was alone (without association) are those where *B. tabaci* (whiteflies) and *H. armigera* (caterpillars) most develop and as quickly as possible. The lowest infestation level was obtained in the tomato associated to basil. Low infestation was also observed in tomato plots associated with onion. Results shows a clear relation between the diversification of plants in the same plot and a depressed development of the pest populations (Diakalia *et al*., 2018). Several authors (Rhino *et al.,* 2014; Khafagy, 2015) reported that aromatic plants contain volatile compounds that can disrupt the development of the pest and promote the growth of the host plant. Umeh *et al* (2002) reported from their survey that intercropping tomato with crops such as cereals tubers and other vegetables reduced infestation in some areas in Nigeria. 8.4% of farmers in the survey used cultural methods such as roguing and application of wood ash to against insect pests such as grasshoppers, tomato fruit borer, whitefly and aphids, while 50% applied both synthetic pesticides and cultural control. Togni *et al* (2018) reported that the combined effect of intercropping and sprinkler irrigation made tomato plants less suitable for whitefly *Bemisia tabaci* establishment. Integrating tomato–coriander intercropping and sprinkler irrigation can help manage *B. tabaci* in organic tomato crops. In a study by Maerere *et al* (2010), aphids infested tomato plants in all cultural practices tested but at variable levels of intensity. Tomatoes which either received the fertilizer treatment, mulch or were intercropped with either cowpea or spider plants were infested the most compared to other treatments. This is contrary to results reported from other studies which suggest that intercrops which are infested by similar insect pests as the main crop may help lure the pest away from the main crop (Cook *et al.,* 2007). However, the IPM and mulch treatments of Maerere *et al* (2010) were equally effective against thrips, aphids and bollworms. The efficiency of the mulch treatment in reducing pest numbers is enhanced by reduced weed occurrence in mulched plots.

Biological Control

Biological control agents, including parasitoids, predators, and entomopathogenic fungi, contribute to the suppression of pest population. This highlights the importance of conserving and augmenting natural enemies in agroecosystems to enhance pest control efficacy and reduce reliance on chemical pesticides.

In a study by Aynalem *et al* (2022) to evaluate the effectiveness of single and combination treatments of entomopathogens; *Beauveria bassiana*, *Metarhizium anisopliae*, *Bacillus thuringeinsis*, and an insecticide against tomato leaf miner, *Tuta absoluta* under greenhouse and field condition, results showed significant leaf and fruit damage reduction in all the treatments. *B. bassiana*-AAUB03, *M. anisopliae*-AAUM78, and *B. thuringiensis*-AAUF6 showed the highest leaf (93.4%, 89.7% and 90.1%) and fruit (93.5%, 94.4% and 95%) protection under greenhouse condition. The combined treatments improved leaf protection efficacy up to 95.3% under field condition. All the entomopathogens did not cause any adverse effect on the growth of tomato rather improved shoot length, shoot branching, leaf and fruit numbers (Aynalem *et al*., 2022). Ndaruhutse *et al* (2021) evaluated the effectiveness of some commercial bio-pesticides (two isolates of *Trichoderma*, *Trichoderma* Sp1 and *Trichoderma* Sp2) and antagonistic synthetic pesticides, in managing pests of tomato over two cropping cycles under field conditions. Commercial bio-pesticides were more effective in reducing populations of insects compared to the antagonistic synthetic pesticides, having reductions of up to 73% of white flies (*Bemisia tabaci)* and 65% of tomato leaf miner *(Tuta absoluta)*. The synthetic pesticides reduced the populations by up to 32% and 25% in white flies and tomato leaf miner respectively.

Husin (2017) investigated the efficacy of some commercial EPNs against different stages of tomato leaf miner*, Tuta absoluta* (larvae, pupae and adults) in Petri dish, leaf and soil bioassays. Results showed high adult and larval mortality of the tomato leaf miner using *Steinernema feltiae*, *Steinernema carpocapsae* and *Heterorhabditis bacteriophora* in dish and leaf bioassays in optimum conditions (> 90 % RH). *S. feltiae* was the most virulent species, followed by *S. carpocapsae* then *H. bacteriophora*. Larval susceptibility increased throughout larval development. In soil*, S. feltiae* and *S. carpocapsae* were significantly more virulent than *H. bacteriophora* against fourth larval instar when they drop to pupate in the soil and against adults when they are emerging from pupae (Figure 1).

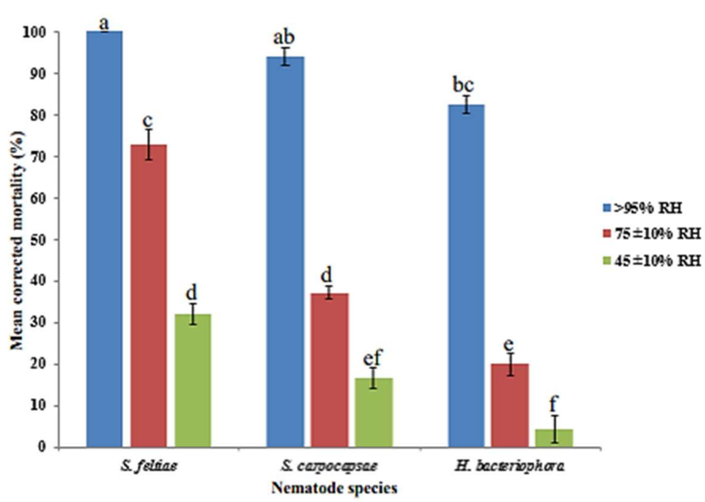

Figure 1: Mean corrected mortality of 4th larval instar of *T. absoluta* 48 h after application of three EPNs (60 ± 6 IJs cm-2) in water at three different RH values and 25 ± 0.5 °C (Husin, 2017).

Chemical Control and Reduced-Risk Pesticides

While chemical control was integrated into IPM program, it is used judiciously and in combination with other control methods to minimize environmental impact and pesticide resistance development. Reduced-risk pesticides with low toxicity to non-target organisms and short residual activity are employed, to minimize negative effects on beneficial insects and the environment. Targeted pesticide applications, timed according to pest thresholds and biological control agent compatibility, can effectively suppress pest populations while minimizing pesticide residues in the environment and on harvested fruits. However, some of the chemical insecticides in used in Nigeria in tomato cultivation includes Cypermethrin (Dragon), Deltamethrin (Delta force), Pyrethroid (Lara force), Imidacloprid (Imiforce), Imidacloprid (Quick action), Permethrin (Attack) e.t.c. (Ogwo, 2021).

Wade *et al* (2020) examined the efficacy of different pesticides against major insects of tomato - whitefly, aphid, leaf miner and fruit borer. The results revealed that *Beauveria bassiana* @ 5 ml lit-1 was the best treatment which was recorded minimum (3.28) mean whitefly population, treatment *Lecanicillium lecanii* @ 5ml lit-1 was the best treatment for aphid, which recorded minimum (1.47) mean population. Emamectin benzoate 05 SG @ 0.002 per cent was found most effective treatment for leaf miner and fruit borer, which recorded lowest per cent leaf miner infestation (11.71%) and 13.10 per cent and 11.81 per cent on number and weight basis, while Azadirachtin 1% EC @ 0.002 per cent was noticed effective against fruit borer damage which recorded 15.40 per cent on number and 13.86 per cent on weight basis. In a study by Maerere *et al* (2010), the low aphid incidence in tomato fields was due to the farmers' practice as a result of the routine insecticide spraying having direct contact effect on aphids.

Khan *et al* (2023) assessed the effect of different synthetic insecticides against tomato leaf miner (*Tuta absoluta*). The insecticides used were Lambda cyhlothrin 2.5% EC, Flanicamid 50% WG, Acetamiprid 20 SP and Imidacloprid 25% WP, sprayed twice at 20 days interval. The lowest percent damage of tomato leaf miner infestation was recorded in Lambda cyhalothrin treated plot (10.96%), followed by Imidacloprid (13.76%) which was statistically similar with Flanicamid 50% WG (14.64%) and Acetamiprid (14.93%) respectively, while highest damage was reported from check plot (30.79%). Nawakht *et al* (2019) tested a number of environmentally safer pest management options and safer insecticides were against tomato fruitworm in open field tomato. The results showed a varying degree of fruit damage caused by tomato fruitworm in different treatments on different dates (Figure 2). Although all the tested materials reduced fruit damage to some extent, the damage observed in the treatments with emamectin benzoate and spinosad was lower than in the control plot, suggesting the effectiveness of these insecticides for the control of tomato fruitworm.

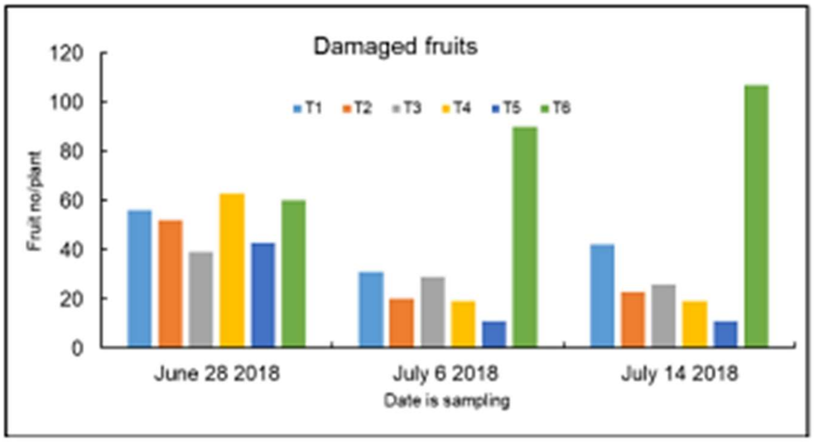

Figure 2: Number of damaged fruits in 6 treatments of safer insecticides were against tomato fruitworm (Khan *et al*., 2023). Where T1= Emamectin benzoate, T2= Spinosad, T3= Fenvalerate (Belt SC 480), T4= Cypermethrin, T5= Metaguard (bio-agent), T6= Control, No intervention.

Integrated Pest Management (IPM) Strategies

The results of this review demonstrate the effectiveness of integrated pest management (IPM) strategies in controlling tomato pests while minimizing pesticide use and environmental impact. By combining cultural practices, biological control, and judicious chemical control, we can achieve significant reductions in pest populations and damage levels compared to conventional pesticide-based approaches.

In a study by Fuad *et al* (2019), a survey was done on the impact of IPM adoption on tomato cultivation. Their results showed that the average infestation of insects was found significantly lower in the fields of IPM adopters than IPM non-adopter, and average frequency of chemical use in season was also significantly lower in the fields of IPM adopter (2.14) than IPM non-adopter (3.44). Moacyr *et al* (2005) reported from their study that the number of insecticide applications in their tomato cultivation study was 65.6% lower with the IPM system (8.5 applications) than with the calendar system (25 applications). Thus, the pests were efficiently controlled with IPM at lower costs. IPM was more efficient with a similar production and 65.6% less pesticide applications than in the calendar. Picanço *et al* (2007) reported that IPM was more efficient at controlling pests of tomato in their study than the calendar-system and proved to be effective at reducing the number of parathion-methyl and abamectin applications by 3.8- and 2.9-fold.

Reddy and Tangtrakulwanich (2014) reported from their study that plots treated with the IPM package (PSO, BotaniGard, neem, and DiPel) at 15, 30, 45 and 60 days after transplant, the number of *Tetranychus marianae*-infested leaves (red spider mite) and the number of mites per leaf were both significantly lower than in plots treated with carbaryl, malathion, or control plots. Significantly lower fruit damage by tomato fruitworm *Helicoverpa armigera* was recorded in plots treated with the IPM package compared to the carbaryl or malathion treated plots and to both controls. In a study by Aynalem *et al* (2022) to evaluate the effectiveness of single and combination treatments of entomopathogens; *Beauveria bassiana*, *Metarhizium anisopliae*, *Bacillus thuringeinsis*, and Tutan36%SC (insecticide with active ingredient of Chlorphenapyr 36%SC) against tomato leaf miner, *Tuta absoluta* under greenhouse and field condition, when the entomopathogens were combined with half or quarter reduced concentrations of Tutan36% SC, it showed 94.4% of pest protection.

Table 1: Pest incidence and Damage levels in tomato cultivation (Benhura *et al.,* 2018)

IPM Treatment	Pest Incidence (%)	Damage Levels (Scale 0-5)
Cultural Practices	10.2	2.1
Biological Control	5.8	1.5
Chemical Control	15.6	3.2
Integrated IPM	3.5	1.0

Yield and Productivity

Fuad *et al* (2019) reported that the marketable yield of tomatoes was found significantly higher in the fields of IPM adopters (51.34 t/ha) than in the fields of IPM non-adopters (42.24 t/ha). Gajanana *et al* (2006) reviewed the adoption of IPM technology in tomatoes using African marigold as a trap crop, root dipping of seedlings in Imidacloprid, soil application of neem/pongamia cake, spraying of botanicals like Pongamia soap and biopesticide like *Ha NPV* @ 250 LE/ha insect management. The adoption of IPM assessed in terms of yield, returns and cost, revealed a definite positive economic impact of adoption of IPM technology on tomato farms. The yield was higher on IPM (65.35 t/ha) than on non-IPM (44.72 t/ha) farms. Moacyr *et al* (2005) reported from their study that tomato plants cultivated under the calendar treatment (spraying twice weekly with fungicides and insecticides) and IPM systems presented similar production, with 28 and 30 ton/ha respectively, while a decrease of 73% in production was found in the control, with the production of only 7.7 ton/ha. This indicated that the use of IPM in tomato cultivation produced an even better result than the use of synthetic pesticides alone. Picanço *et al* (2007) recorded higher tomato yields in the calendar-based and IPM crop production systems, with 55.05 ± 3.91 and 61.21 ± 4.23 ton/ha, respectively. This reveals that the IPM tomato production system in their study produced a higher yield than the calendar-based production system and control. Reddy and Tangtrakulwanich (2014) reported marketable tomato yields from the plots managed with the IPM package that were significantly greater than those in chemical treatments and control. Saunyama and Knapp (2003) in Zimbabwe reported the highest tomato yield in pruned and tresilled tomatoes (179.0), followed by tresilling only (163.0), pruning only (126.0) and control (112.0). Afreen *et al.,* (2017) reported that fruit yield per hectare of tomato showed significant differences for different planting dates and mechanical support. Yield and yield components were found lowest when seedlings were transplanted early, which was primarily due to high infestation of fruit borer. According to Maerere *et al* (2010), the highest marketable yields were recorded with chemical control, which was attributed to the regular control of insects and diseases through regular pesticide sprays.

Table 2: Average and Total yield of tomato under different IPM treatments (Benhura et al., 2018)

IPM Treatment	Average Yield per Plant (kg)	Total Yield per Plot (kg)
Cultural Practices	2.5	150
Biological Control	3.2	192
Chemical Control	2.0	120
Integrated IPM	3.8	228

CONCLUSION AND RECOMMENDATIONS

In conclusion, Insect pests pose a significant threat to tomato production, and while conventional chemical control methods offer short-term solutions, their long-term sustainability is questionable. This review demonstrates the effectiveness of integrated pest management (IPM) strategies for sustainable management of tomato pests. Integrated pest management (IPM) offers a sustainable approach to managing tomato pests sustainably, emphasizing the integration of multiple strategies to minimize pesticide use while maintaining or enhancing crop productivity. By combining cultural practices, biological control, mechanical control, and judicious chemical control, IPM can effectively suppress pest populations while minimizing environmental impacts. The findings underscore the importance of adopting IPM approaches in tomato production to enhance crop resilience, protect natural resources, and promote agricultural sustainability. Further research and extension efforts are needed to promote widespread IPM adoption and address challenges to its implementation, ensuring the long-term sustainability of tomato production worldwide.

Despite its many benefits, IPM implementation faces several challenges and limitations. These include the complexity of pest interactions, the need for specialized knowledge and skills, and the reluctance of some farmers to adopt new practices. Additionally, IPM may require initial investments in infrastructure, training, and monitoring equipment, which can be barriers for resource-limited farmers. Furthermore, the effectiveness of IPM can vary depending on local conditions, crop species, and pest dynamics, highlighting the need for site-specific approaches and ongoing research and extension efforts. The following are my recommendations:

- Future research should focus on further optimizing and refining IPM strategies for specific tomato cultivars and pest complexes.
- Long-term studies are needed to assess the sustainability and resilience of IPM systems under changing environmental conditions and pest pressures.
- Site-specific research approaches on the effectiveness of IPM strategies.
- Outreach and extension efforts are essential to promote IPM adoption among farmers and facilitate knowledge transfer and technology transfer.

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Determinants of Use of ICT among Poultry Feed Retailers in Abia State

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Abstract
The study assessed the determinants of the use of ICT among Poultry Feed Retailers in Abia State, Nigeria. The objective of the study is to estimate the determinants of the use of ICT among poultry feed retailers in the study area. A multi-stage sampling technique was used in selecting 84 Retailers for the study. Data collected using a well-structured questionnaire administered to the respondents were analyzed using ordinary least square regression (OLS). Among the 12 estimated variables at the retailers' level, 5 variables were found to be significant, thus; the coefficients for educational qualification, location, capital invested, membership of cooperation, and access to credit were significant at 5%, 5%.10%,10% and 5% level of significant respectively. The study therefore calls for investment in ICT infrastructure and providing training on ICT use, formation of cooperatives including digital platforms for member's interactions, marketing and sales to address the needs and improve the overall performance of the poultry feed marketing industry in the study area and beyond.
Keywords: ICT, Poultry, Feed, Retailers

INTRODUCTION

The term ICT (Information and communications Technology) is the use of computing and telecommunication technologies, systems and tools to facilitate the way information is created, collected, processed, transmitted and stored (Rouse 2023). It includes computing technologies like servers, laptop computers and software applications, as well as the wired and wireless communication technologies that support telephones, the Internet, the Internet of Things (IoT) and the metaverse. According to Ajayi (2009), ICT is a technical means of collecting (to enter/collect), utilizing (process/analyze), and conveying (output/transmit) information. Megha (2021) noted that ICT is a technology that supports information-related activities such as data collection, processing, storage and presentation. Poultry production occupies a very strategic place in both the social and economic sectors of Nigeria (Okonkwo, 2013).

In line with the growth in ICT usage in business, Nigeria's poultry production has grown steadily in recent times, despite the myriad of challenges faced. Rabobank (2017) reported that Nigeria alongside Ghana, Côte d'Ivoire and Benin in West Africa showed the most potential for poultry sector development, in terms of increasing local demand and the incentives available, both fiscal and non-fiscal. This may be a result of the ever-growing population, an expanding middle class and an improving rural economy; demand for meat has increased over the years (NABC, 2020). Poultry production offers a very fast and healthy approach to meeting the growing demand for animal protein. Its offer of the highest turnover rate and quick returns to investment outlay in livestock enterprises has made it unique (, Adeyemo and Onikoyi, 2012 Anosike *et al.,* 2018, Ogunyemi and Orowole, 2020). With government protection for local producers against unfair international competition, the Nigerian poultry industry is likely to maintain a positive trajectory. Thus, numerous new investments are appearing in the poultry value chain including poultry feed manufacturing and marketing. Marketing consists of business-related activities that seek to anticipate demand and help in developing and making the goods and services available to the satisfaction of the consumers or users, at a profit to the organization (Anyanwu, 2000). Marketing involves transferring goods from the producers to the consumers in the right place, form and time. The quality of poultry feed available for use by farmers depends on how marketing systems for feed function in terms of cost and returns for the various operations involved (Emenyonu and Nkemka, 2013) piloted by the marketers. Hence the level of use of ICT tools and its effects by these marketers will go a long way to determine their performance in terms of productivity, profitability and efficiency in the marketing system. ICT usage is arguably one of the most important tools for doubling the productivity of agribusiness, and agribusiness entrepreneurs need to be encouraged to use ICT wisely to ensure its effectiveness. Given the importance of examining the performance of a system, this study will explore data to examine the effect of ICT on the performance of poultry feed marketers in Abia State.

METHODOLOGY

StudyArea

This study was carried out in Abia State of Nigeria. Abia State with Umuahia as its capital has seventeen (17) Local Government Areas, three senatorial zones namely, Abia South, Abia Central and Abia North and many communities. The State has a population density of 580 persons per square kilometre and a population of 3,727,300 persons (NPC, 2010). It lies between latitude4°45' and 06°07' N and longitude 07°00' and 08°10' East of the equator (Abia ADP, 2005). The climate is tropical and humid with minimal rainfall ranges of 2000mm to 2500 mm. The State is one of the rainforest zones which support livestock production such as Chickens (local chickens, broilers, and layers), turkeys, geese, ducks, guinea fowls and pigeons.

Sampling Technique

Multi-stage sampling procedures involving random, purposive and proportionate techniques were employed in the selection of the samples. In the first stage, 6 Local Government Areas were randomly selected from the 17 LGAs in the state. In the second stage, two communities were purposively selected from each of the 6 LGAs based on the intensity of poultry feed farming and marketing, giving a total of 12 communities. The third stage one popular market was purposively sampled also based on the intensity of poultry feed marketing. Fourthly, the study will involve a proportionate selection of 7 poultry feed retailers from each of the twelve markets selected to have a total of 84 respondents for the study.

Data Collection and Analysis

Ordinary least square regression model (OLS) was used to estimate Determinants of the use of ICT among poultry feed Retailers in the study area.

Model Specification

This model is specified explicitly as:

OLS Multiple Regression Model

$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + ei$..Where; Y= mean level of use of ICT, X_1= age of the marketer (years), X_2= educational background (years), X_3= Marital status (Married = 1 otherwise = 0), X_4= location of the market (dummy variable; 1=Local, 0=Urban), X_5= number of employees, X_6= sex (dummy variable; 1=male, 0=female), X_7= marketing experience (years), X_8= capital invested (Naira), X_9 = diversity of product mix (dummy variable; 1=yes, 0=no), X_{10}= high concentration of industrial activity in the area (dummy variable; 1=yes, 0=no), X_{11} = annual Revenue (Naira),ui= error term

RESULTS AND DISCUSSION

Determinants of use of ICT among poultry feed Retailers

The result of the findings in Table 4.1 showed the OLS regression estimates of socio-demographic determinants of the use of ICT among poultry feed retailers in the State. Among the four functional forms estimated, the linear was also chosen as the lead equation based on a high R^2 value, number of significant factors and agreement with a priori expectations. The R^2 value of 0.5783 showed that 57.83% of the variability in the degree of using ICT tools for poultry feed marketing (retailers) was explained by the independent variables. Among the 12 estimated variables at the retailer level, 5 variables were found to be significant, thus; the coefficients for educational qualification, location, capital invested, membership of cooperation, and access to credit.

Years of Education (Retailer)

The coefficient for years of education (0.2814) had a direct relationship with level of use f ICT tools among the poultry feed retailers at 5% level of probability in the study area. This implied that with an increase in years of education, there is a probability that the level of use of ICT will increase by 0.2814% level. Education however enhances the skill and ability of marketers to access and utilize market information better as well ICT, which may in turn reduce marketing costs and make it more profitable to participate in the market. This was in agreement with the findings of Sigei *et al.,* (2014) who noted that education has a positive effect on market participation and the use of ICT.

Location (Retailer)

The coefficient for location of the market (0.1428) also was found to have a negative relationship with the level of use of ICT tools among the retailers of poultry feed at 5% level of probability. Interestingly, this implied that those who are operating at urban market tend to increase the use of ICT at retailing than their counterparts at rural markets. The negative relationship at retailing level was not expected probably since most of the retailers operate at rural settings than urban. Katengeza *et al.,* (2011) elaborated that famers who stay further away from local (rural) markets are more likely to use ICT (mobile phones) for agricultural marketing in order to enhance their access to markets.

Capital Invested (Retailer)

The coefficient for capital invested in the business (7.86) had a direct relationship with level of use of ICT among the retailers of poultry feed marketers in the study area at 10% level of probability. This indicated that retailers who invested huge in the business are probably to employ ICT in marketing their feeds.

Membership of cooperation (Retailer)

Interestingly, the coefficient for membership of cooperation had a positive sign and significant at 10% level of probability, indicating that increase in membership of cooperation will increase ICT use among retailers of poultry feed in the study area. As retailers come together in group, they access and share production information in the areas of interest among themselves and questions are cleared and confusion put to the end. Among other things, Oluwaseun and Trudy, 2018) suggested that information and knowledge about marketing innovations (marketing information) spread more quickly within a cooperative compared with individual, and this enhances confidence about innovative practices and helps facilitate a more efficient marketing strategies, implementation and application.More so, it is expected that such organization serves as a bolster for its members in accessing bulk goods that could boost their marketing and revenue following Adamu *et al.,* (2015). Gertler (2001) further explained that co-operatives association was a practical tool for collaboration, collective action and they build and reinforce community, stabilize regional economies and provide a favourable climate for further investment and marketing. Co-operatives is capable of reducing spatial inequality and promote equitable sharing of the cost and benefits of development. It can promote economic democracy and the empowerment of marginalized groups- a hallmark of sustainable development and a precondition for shared responsibility (Agenyour, 2014).

Access to credit (Retailer)

The results of the finding also found coefficient for access to credit (5.05) significant and positively related with the use of ICT among retailers in the study area. This is also expected as increase in access to credit will lead to increase in ICT use to increase efficiency of return to service and possibly pay back the credit.

Table 1: OLS Regression Estimates of Determinant of use of ICT among Retailers of poultry feed marketers in the study area

Variables	Measurement	Parameter	Linear+	Exponential	Double Log	Semi-Log
Age	Years	X_1	-0.1426 (-1.61)	-0.1325 (-1.83)*	-0.6543 (-1.44)	-0.6598 (-1.16)
Educational qualification	Years	X_2	**0.2814** **(3.26)****	0.1751 (2.48)*	0.6091 (2.10)*	0.9860 (2.72)*
Marital status	Dummy(Married =1, others =0)	X_3	0.1091 (0.86)	0.0421 (0.41)	0.0860 (0.57)	0.1938 (1.02)
Sex	Dummy(Male=1, Female =0)	X_4	0.2122 (0.22)	00822 (1.02)	0.0302 (0.26)	-0.0652 (-0.45)
Location of the market	Dummy(Rural =1, Urban =0)	X_5	**-0.1428** **(-2.53)****	-0.1045 (-1.36)	-0.1566 (-1.37)	-0.1981 (-1.38)
Number of employee	Number	X_6	0.0745 (0.70)	0.0142 (0.16)	0.0853 (0.47)	0.2180 (0.95)
Marketing experience	Years	X_7	-0.0049 (-0.16)	-0.0072 (-0.29)	-0.1421 (-0.43)	-0.0211 (-0.51)
Capital invested	Naira	X_8	**7.86e-08** **(2.16)***	5.58e-08 (1.87)*	0.1174 (1.62)	0.1804 (1.98)*
Diversity of product mix	Dummy(Yes=1, No =0)	X_9	-0.0922 (-0.79)	-0.0885 (-0.92)	-0.1352 (-1.00)	-0.2188 (-1.30)
Monthly income	Naira	X_{10}	-2.91e-07 (-1.03)	-2.65e-07 (-1.15)	-0.1451 (-1.91)*	-0.1822 (-1.91)*
Membership of cooperation	Dummy(Yes=1, No =0)	X_{11}	**0.7226** **(2.05)***	0.4656 (1.61)		
Access to Credit	Dummy(Yes=1, No =0)	X_{12}	**1.2452** **(5.05)*****	0.7005 (3.46)**	0.7647 (2.48)*	1.2762 (3.30)**
Constant		B_o	1.3028 (3.13)**	0.5182 (1.52)	2.5897 (1.27)	3.0797 (1.20)
F-cal			6.40	4.79	3.34	5.25
R-squared			0.5783	0.5066	0.5556	0.5724
Adj R-squared			0.4979	0.4008	0.4103	0.4911

Source: Field survey, 2023. Figures in parenthesis represents t – values, ***, ** and * are Significant at 1%, 5% and 10% respectively

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Agricultural Extension Strategies and Farmers' Socioeconomic Characteristics in Soil Management Practice in Ikom local Government Area of Cross River State, Nigeria

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Abstract
This study assessed the socioeconomic characteristics, agricultural extension strategies and soil management practice used in Ikom Local Government Area of Cross River State, Nigeria. The objectives of the study were to; ascertained socioeconomic characteristics of the respondents in the study area, identify the agricultural extension strategies currently employed in the study area, and ascertain the soil management practice used in the study area. The population of the study comprised all crop farmers in Ikom Local Government Area of Cross River State. Primary data was used with the aid of a structured questionnaire. The sample size was obtained using purposive and proportionate sampling technique to select 120 respondents. Data obtained were analyzed using descriptive statistical tools such as frequency count, percentage and mean. Data obtained were analysed using descriptive statistical tools such as mean, percentage and frequency. The findings of the study showed that majority (52.5%) of the respondents were female while 47.5% were males. Larger proportion (35.0%) were in the age category of 31-40 years. Majority (47.5%) were married, majority (52.5%) had secondary education, majority (50.0%) had household size of 1-5 members, larger proportion (36.7%) had 11-15 years of farming experience, and most (43.3%) had monthly income of above ₦25,000. The study revealed that majority (64.2%) of the respondents identified the use of mobile phone-based extension as the agricultural extension strategy available for promoting soil management practice in the study area. Furthermore, the study showed that Crop Rotation ($\bar{X}$= 3.79) was the soil management practices mostly adopted in the study area. while Water/Erosion Management ($\bar{X}$= 2.28) was least practiced. The study recommended that government should implement targeted training programs to encourage the adoption of effective soil management practices such as crop rotation, while also addressing the lower adoption rates of practices like water/erosion management.

INTRODUCTION

In Nigeria, agriculture remains the foundation of the rural economy and plays a crucial role in the national economy, offering significant opportunities for entrepreneurship, particularly at the subsistence level. In 2005, agriculture contributed 41.67% to the gross domestic product (GDP) (CBN, 2006), marking a shift from the pre-independence era when it was the sole driver of the nation's economy. The country's food production heavily relies on staple food production by rural farmers, which serves as the main driver of their socioeconomic development activities. However, many educated youths tend to pursue careers in fields like engineering and accounting, while uneducated youths resort to low-paying jobs in construction sites and transportation services (such as motorcycle riding or operating commercial vehicles) to escape the economic hardships faced by farmers. This situation can be attributed to the country's economy, which is predominantly reliant on revenues from oil. Extension, as defined by Akinsorotan (2002), is an informal educational process aimed at rural communities and is crucial for enhancing the efficiency of farm families, production, and overall living standards. Extension services focus on helping farmers help themselves by analyzing their problems, stimulating innovations, identifying opportunities, providing advisory services, and promoting improved agricultural technologies (Effiong and Aboh, (2024); Nkang and Effiong, (2015); Ijioma*, et al.,* (2024)). However, food production in Nigeria is struggling to keep up with the growing population due to factors such as low budget allocations to agriculture by state and federal governments, logistical challenges in planning and implementing extension systems, and issues related to human resource development and management succession. Additionally, the sector faces challenges related to inaccurate weather forecasts, farmers' limited access to agricultural inputs and credit services, and a lack of validated and up-to-date information on existing technologies. The federal government's Agricultural Transformation Agenda has not been followed by sustained policy reforms and sufficient private-sector investments. The percentage of food-insecure households has increased from 18% in 1996 to 40% in 2005, and Nigeria ranks 80th out of 105 countries in the Economist Intelligence Unit's Global Food Security Index (el-Kurebe, (2012); Etim, and Effiong, (2022); Etim, *et al.,* (2022); and Effiong*, et al*., (2016).

RESEARCH METHODOLOGY

Ikom is a Local Government Area in Cross River State, Nigeria. Its headquarters are in the town of Ikom in the east of the area on the Cross River. It lies between latitude 5°57′40″ N and longitude 8°42′39″ E. It has an area of 1,961 km2 (757 sq mi) and had a population of 162,383 according to the 2006 census. The population of this study comprise all crop farmers in Ikom local government area of Cross River State. Primary data was obtained through the use of structured questionnaire. The study adopted a purposive sampling technique to select six (6) cells from the eleven (11) cells that make up Ikom block based on the intensity of agricultural production in the area which has a comparative advantage in many crops such as yam tubers, Cassava, Cocoa, among others, and a proportionate sampling of 20% of arable crops farmers from the cells giving a total of 120 respondents. Data was analyzed using descriptive statistics. Socioeconomic characteristics such as; sex, age, income, level of education, among others was measured using frequency count and percentage. Agricultural extension strategies currently employed for promoting soil management practice in the study area such as; Farmer Field Schools (FFS), Mobile Phone-Based Extension, and Participatory Rural Appraisal (PRA), among others, were measured using binomial regression and displayed on a table with frequency count and percentage. Soil management practices adopted in the study area was measured with variables such as; Conservation Tillage, Crop rotation and Organic matter amendment, among others, using a 4 point Likert type of scale which were; Always, Sometimes, Rarely and Not at all, which were coded as; 4, 3, 2, and 1, respectively

RESULTS AND DISCUSSION

Socio-economic distribution of respondents

Table 1 presents the percentage distribution of the respondent’s socio-economic characteristics.

Table 1: Distribution of the respondents based on socio-economic characteristics

Variables	Frequency	Percentage (%)
Sex		
Male	57	47.5
Female	63	52.5
Total	120	100.0
Age		
Below20	14	11.7
20-30	39	32.5
31-40	42	35.0
Above 40	25	20.8
Total	120	100.0
Marital Status		
Single	53	44.2
Married	57	47.5
Divorce	1	.8
Widowed	9	7.5
Total	120	100.0
Educational level		
No formal education	10	8.3
Primary	32	26.7
Secondary	63	52.5
Tertiary	15	12.5
Total	120	100.0
Household size		
1-5	60	50.0
6-10	57	47.5
Above10	3	2.5
Total	120	100.0
Farming experience		
1-5years	14	11.7
6-10years	39	32.5
11-15years	44	36.7
Above 15years	23	19.2
Total	120	100.0
Income		
Below 5000	27	22.5
5100-10000	14	11.7
10100-25000	27	22.5
Above 25000	52	43.3
Total	120	100.0

Source: Field survey data, 2024

The result shows that majority (52.5%) of the respondents were female while 47.5% were males. Majority (35.0%) were in the age category of 31-40years while others were 32.5%, 20.8%, 11.7% for the age categories of 20-30, above 40, and below 20 respectively. Majority (47.5%) were married, most (44.2%) were single while only 7.5% were widowed and 0.8% were divorced. Majority (52.5%) had secondary education, 26.7% had primary education, whereas 12.5% and 8.3% had tertiary and no formal education respectively. Majority (50.0%) had household size of 1-5 members, 47.5% had household size of 6-10 members while 2.5% had household size above 10 members. Majority (36.7%) had 11-15 years of farming experience, 32.5 had 6-10 year experience, 19.2% had above 15 years experiences while 11.7% had 1-5 year experience. Majority (43.3%) had monthly income of above ₦25,000 while others

(22.5%, 22.5%, 11.7%) had income of 10100-25,000, below 5000 and 5100-10000 respectively.

Agricultural extension strategies currently employed for promoting soil management practice

The distribution of respondents based on agricultural extension strategies currently available for promoting soil management practice in the study area is presented in Table 2.

Table 2: Distribution of respondents based on agricultural extension strategies currently available for promoting soil management practice in the study area

	Agricultural extension strategies	Yes	Percentage (%)	No	Percentage (%)
1	Farmer Field Schools (FFS)	48	40.0	72	60.0
2	Mobile Phone-Based Extension	77	64.2	43	35.8
3	Participatory Rural Appraisal (PRA)	46	38.3	74	61.7
4	Farmer-to-Farmer Extension Programs	52	43.3	68	56.7
5	Radio and Television Extension	75	62.5	45	37.5
6	Demonstration plots	73	60.8	47	39.2
7	Training workshops and seminar	71	59.2	49	40.8

Source: Field survey data, 2024

The result shows that majority (64.2%) of the respondents identified the use of mobile phone-based extension as the agricultural extension strategy currently available for promoting soil management practice in the study area. This was followed by radio and television extension (62.5%), demonstration plots (60.8%), training workshops and seminar (59.2%), farmer to farmer extension programs (52%), farmer field school (40.0%) and participatory rural appraisal (38.3%). The implication of this result is that mobile phone based extension is the most available extension strategy in the study area. The reason for this is likely due to the cost of transportation of extension agents to location of farmers in the study area. This study is in line with the study byAker and Mbiti, (2015) who opined that with the widespread availability of mobile phones, mobile-based agricultural extension services have gained popularity. These services provide farmers with agricultural information, weather updates, market prices, and other relevant data through text messages or voice calls. The study further shows that mobile phone-based extension services can improve farmers' access to information and decision-making.

Soil management practices adopted

Table 3: Distribution of respondents' based on soil management practices adopted in the study area

	Soil management	Always	Sometimes	Rarely	Not at all	Mean	Rank
1	Conservation Tillage	41(164)	77(234)	2(4)	-	3.35*	2
2	Crop Rotation	96(384)	23(69)	1(2)	-	3.79*	1
3	Organic Matter Amendment	45(180)	42(126)	30(60)	3	3.08*	3
4	Nutrient Management	25(100)	27(81)	35(70)	33	2.36	4
5	Water/Erosion Management	20(80)	35(105)	21(44)	44	2.28	5

Source: Field survey data, 2024 * = Soil management practices mostly adopted

The result in Table 3 showed the distribution of respondents based on soil management practices adopted in the study area. The study revealed that Crop Rotation ($\overline{X}$= 3.79), Conservation Tillage ($\overline{X}$= 3.35)and Organic Matter Amendment ($\overline{X}$= 3.08) were the soil management practices mostly adopted in the study area. However, Nutrient Management ($\overline{X}$= 2.36) and Water/Erosion Management ($\overline{X}$= 2.28) were rarely adopted. This implies that Crop Rotation was the major soil management practices mostly adopted and Water/Erosion Managementwas least practiced in the study area.. Lal, (2019) found that farmers adopts conservation tillage practices aim to minimize soil disturbance and maintain crop residues on the soil surface.

CONCLUSION

Agricultural extension strategies and farmers' socioeconomic characteristics in soil management practice is a critical aspect of agricultural production, as it directly affects crop growth, yield, and overall farm sustainability and agricultural extension services aim at promoting sustainable soil management practices among rural farmers. The findings of the study showed that majority of the respondents were female. A larger proportion were in the age category of 31-40 years, married, with secondary education, household size of 1-5 members, 11-15 years of farming experience, and monthly income of above ₦25,000. Majority of the respondents identified the use of mobile phone-based extension as the agricultural extension strategy currently available for promoting soil management practice in the study area. Soil management practices adopted in the study area were; Crop Rotation, Conservation Tillageand organic matter amendment.

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An Assessment of Physical Characteristics of Soil Derived from Basement Complex and Sandstone Parent Materials in Bauchi State, Nigeria

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INTRODUCTION

Soil consists of mineral particles and organic matter separated by pores filled with water or air. The content and the size distribution of pores depend on the size of the soil particles. The larger the pores, the fewer there are of them. Moreover, the wetter the soils, the more of its pores are filled with water. Due to meteorological climatic conditions, soil moisture levels vary from year to year (Hsiao *et al*., 2007). In drought conditions, no-tillage technology allows for preserving higher soil moisture content at 0–10 cm. Therefore, it is considered a means of preserving soil moisture (Feizienė *et al*., 2009). Soil air permeability depends mainly on large soil pores, total soil porosity, and the internal geometry of pores. Soil water retention is a key hydraulic property of soil, regulating soil functions and strongly influencing soil productivity (Laird *et al*., 2010). Soil pore characteristics are important for a large range of essential soil water and gas transport mechanisms as well as soil mechanical properties, such as soil friability ((Munkholm *et al*., 2012). The objective of this work was to determine the quantitative relationship among moisture content, storage capacity, water filled pore space and porosity with respect to soil derived from basement complex and sandstone for optimum agricultural production in Bauchi State.

MATERIALS AND METHODS

Bauchi State occupies a total land area of 49,119km^2 representing about 5.3% of Nigeria's total land mass and is located between latitudes 9^0 30^1 and 12^0 30^1 North and longitudes 8^0 45^1 and $11^0$0' East. The state is bordered by seven states; Kano and Jigawa to the north, Taraba and Plateau to the south, Gombe and Yobe to the east and Kaduna to the West.

Sampling Technique

The samples were taken from four different locations within a local government area. One local government area was used per rock formation. A total of 36 samples were used in each location given rise to 288 undisturbed samples

Field Procedure

The collection of soil sample was done starting from the upper layer (0 – 20cm). The excavation of the soil to allow for taking of soil samples was carried out by the use of digger while shovel was used to move out the soil particles. After the excavation of the pit to 1m, a measuring tape was used to measure the depth at which the samples were taken (0 – 20cm, 20 – 40cm and 40 – 60cm) depth. The undisturbed samples were collected using sampling rings while the disturbed samples were taken using a hand trowel into polythene bags. All the samples collected were labeled and the same procedure was used in collecting the samples from all locations and depths. Materials used in the field were Cutlass, Digger, Shovel, Meter rule, Sampling rings, Auger, Polythene bags, Hammer, Global Positioning System (GPS), Rubber ban, Piece of cloth.

Laboratory Procedure

Particle Size Determination

Soil samples were air-dried and served through a 2mm mesh. Particle size analysis was carried out by hydrometer method (Juo, 1979) using sodium hexametaphosphate as the dispersant.

Determination of Soil Hydraulic Properties.

Moisture content at field capacity

Moisture content at field capacity was determined by the formula mass of water at 0.33bar/mass of oven dried soil at 0.33bar x 100% (Anderson and Ingram, 1993)

Moisture content at permanent wilting point

Moisture content at permanent wilting point was determined by the formula: mass of water at 15bar/mass of oven dried soil at 15bar x 100% (Anderson and Ingram, 1993)

Available soil moisture in the soil

Available moisture in the soil was the difference between the soil moisture obtained on mass at field capacity and permanent wilting point (Israelson and Hanson, 1962).

Water filled pore space

Water filled pore space of the soil is the ratio of volumetric moisture content to porosity multiply by 100 (British Columbia Ministry of Agriculture, Food and Fisheries, 2002).

Storage capacity of the soil

Storage capacity of the soil is the difference between the total pore space (porosity) and available water on mass basis (British Columbia Ministry of Agriculture, Food and Fisheries, 2002).

Porosity

Porosity was determined using the formula; 1 – bulk density/2.65. The default value of 2.65 is used as a rule of thumb based on the average bulk density of rock without pore space (British Columbia Ministry of Agriculture, Food and Fisheries, 2002).

RESULTS AND DISCUSSION

Table 1 above showed that Alkaleri LGA study area is loamy sand while Bauchi LGA study area is sandy clay loam. The result of this study as presented in Table 2 below (soil physical parameters of soil of Alkaleri Local Government Area) and Table 3 (soil physical parameters of soil of Bauchi Local Government Area) below indicated that available moisture content was significantly ($p < 0.05$) higher in soil derived from sandstone compared to those derived from basement complex parent materials. This result is supported by work of O'Geen (2013) who reported that loamy textured soils (loams, sandy loams, silt loams, silts, clay loams, sandy clay loams and silty clay loams) have the highest Plant Available Water (PAW), because these textural classes give rise to a wide range of pore size distribution that results in an ideal combination of meso- and micro-porosity. Also from the analysis, storage capacity (SC) was significantly ($p < 0.05$) higher in soil of basement complex origin compared to soil of sandstone origin. This result is in agreement with the work of O'Geen, (2013) who reported that fine textured soils have the highest total water storage capacity due to large porosity values, but a significant fraction of water is held too strongly (strong matric forces/low, negative water potentials) for plant uptake. Soil depth and rock fragment content also affect water holding capacity because bedrock and rock fragments are assumed to be unable to hold plant available water and/or accommodate plant roots. The result of water filled pore spaces (WFS) was also subjected to analysis of variance (fully nested) and it showed a significant ($p < 0.05$) difference with soil derived from sandstone having higher water in filled pore space compared to soil derived from basement complex parent materials.

CONCLUSION

Fine textured soils have the highest total water storage capacity due to large porosity values, but a significant fraction of water is held too strongly (strong matrix forces/low, negative water potentials) for plant uptake. This is the case of soil derived from basement complex parent material in Bauchi State which has high storage capacity but small water filled space. This research is crucial for sustainable land management and agricultural practices in the region.

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Table 1: Particle Size Distribution of Soils of the Study Area

Location	Depth (cm)	%passing through 2mm sieve	Total sand 0.02-2mm	Silt (0.002-0.02mm)	Clay (<0.002mm)	Texture class
Alkaleri(AK)	0-20	92.00	75.04	14.56	10.40	Loamy sand
	20-40	94.50	77.60	10.44	11.96	Loamy sand
	40-60	93.10	79.60	10.44	9.96	Loamy sand
Gargawu(GG)	0-20	98.30	77,60	7.44	10.96	Loamy sand
	20-40	95.50	75.04	12.56	10.96	Loamy sand
	40-60	94.20	79.60	14.44	11.40	Loamy sand
Gar (GR)	0 – 20	93.50	73.60	12.16	14.24	Loamy sand
	20 -40	95.40	69.60	16.16	14.24	Loamy sand
	40-60	94.80	75.04	12.00	12.96	Loamy sand
Yankari	0-20	94.20	73.60	12.16	14.24	Loamy sand
Road(YR)	20-40	95.60	75.04	12.56	10.96	Loamy sand
	40-60	97.53	74.80	11.32	13.88	Loamy sand
Birshe Fulani(BF)	0-20	81.50	55.60	13.44	30.96	Sandy clay loam
	20-40	77.40	57.60	9.44	32.96	Sandy clay loam
	40-60	79.60	53.60	17.44	28.96	Sandy clay loam
Gubi (GB)	0-20	88.80	56.60	25.44	18.96	Sandy clay loam
	20-40	77.10	54.24	22.80	22.96	Sandy clay loam
	40-60	43.20	58.24	16.80	24.95	Sandy clay loam
M Lanman (ML)	0-20	79.33	56.24	19.52	24.24	Sandy clay loam
	20-40	76.21	52.60	21.44	26.24	Sandy clay loam
Dindima River	40-60	77.01	53.60	17.44	28.96	Sandy clay loam
(DR)	0-20	81.32	56.24	21.52	22.24	Sandy clay loam
	20-40	73.38	55.60	23.44	20.96	Sandy clay loam
	40-60	67.42	60.60	17.44	21.96	Sandy clay loam

Table 2: Soil Physical Parameters of Soil of Sandstone origin (Alkaleri LGA) in Bauchi State

Sample No	Soil Depth	Bulk Density	FC water(%)	PWP water (%)	Available Water(%)	Volume water(%)	Porosity (%)	water in filled pore space (%)	Storage capacity (mm/dc of soil)
AK (I)	0-20cm	1.57	15.10	32.50	17.40	24.20	0.41 or 41%	59%	23.6
AK (II)	20-40cm	1.48	17.10	34.30	17.20	22.50	0.44 or 44%	51%	26.8
AK (III)	40-60cm	1.53	18.20	37.00	18.80	28.80	0.42 or 42%	68%	23.2
GG(I)	0-20cm	1.55	18.30	31.40	13.10	20.30	0.42 or 42%	48%	28.9
GG(II)	20-40cm	1.52	19.20	35.90	19.70	29.90	0.43 or 43%	71%	23.3
GG(III)	40-60cm	1.45	23.50	38.50	15.00	21.80	0.45 or 45%	48%	30.0
GR (I)	0 – 200cm	1.36	16.60	29.60	13.00	17.68	0.49 or 49%	36%	46.0
GR (II)	20 – 40cm	1.14	20.00	34.60	14.60	16.64	0.56 or 56%	30%	53.0
GR (III)	40 – 60cm	1.17	22.00	34.90	12.90	15.09	0.56 or 56%	27%	53.0
YR (I)	0 – 20cm	1.20	15.00	33.20	18.20	21.84	0.54 or 54%	40%	51.2
YR (II)	20 – 40cm	1.20	18.00	33.20	15.20	18.24	0.54 or 54%	34%	49.9
YR (II)	40 – 60cm	1.20	17.00	31.60	14.60	17.52	0.54 or 54%	32%	51.6

FC = Field Capacity, PWP = Permanent Wilting Point

Table 3: Soil Physical Parameters of Soil of Basement Complex Origin (Bauchi LGA) in Bauchi State

Sample No	Soil Depth	Bulk Density	FC (water%)	PWP (water%)	Available water(%)	Volume water(g/cm^3)	Porosity (%)	water in filled pore space (%)	Storage Capacity (mm/dc of soil)
BF(I)	0-20cm	1.37	15.50	22.70	7.20	9.90	0.48 or 48%	21%	40.8
BF(II)	20-40cm	1.23	24.40	37.80	13.40	16.50	0.54 or 54%	31%	40.6
BF(III)	40-60cm	1.24	25.60	32.50	6.90	8.60	0.53 or 53%	16%	46.1
GB(I)	0-20cm	1.42	15.20	19.50	4.30	6.10	0.46 or 46%	13%	41.7
GB(II)	20-40cm	1.52	26.80	31.40	4.60	7.00	0.43 or 43%	16%	38.4
GB(III)	40-60cm	1.51	23.00	29.50	6.50	9.80	0.43 or 43%	23%	36.5
ML(I)	0-20cm	1.20	14.50	20.20	5.70	6.84	0.55 or 55%	12%	49.3
ML(II)	20-40cm	1.21	19.80	27.50	7.70	9.32	0.54 or 54%	17%	46.3
ML (III)	40 – 60cm	1.30	18.70	23.80	5.10	6.63	0.51 or 51%	13%	45.9
DR(I)	0-20cm	1.20	14.70	19.00	4.30	5.16	0.55 or 55%	9%	50.7
DR(II)	20-40cm	1.43	14.50	18.00	3.50	5.01	0.46 or 46%	11%	42.5
DR(III)	40 – 60cm	1.31	18.50	23.40	4.90	6.42	0.51 or 51%	13%	46.1

Source: Field work 2019. FC = Field Capacity, PWP = Permanent Wilting Poin

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Effects of Forest Plant Leaves (*Gliricidia sepium* and *Leucaena leucocephela)* on the Growth and Reproductive Performance of *Archachatina marginata*

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Abstract
Effects of Gliricidia sepium and Leucaena leucocephela on growth and reproductive performance of snail (Archachatina marginata) was investigated in this study. The snails were treated in accordance with: T_1 (control, compounded ration without leaf), T_2 (compounded ration with 10% Gliricidia leaves) and T_3 (compounded ration with 10% Leucaena leaves) within the period of 8 weeks. Forty five (45) Archachatina marginata were sourced and assessed for growth performance characteristics which included: feed intake, growth rate and weight gain, likewise, the reproductive performance based on compounded feed ration contained crude protein of 16.6% and metabolically energy of 2500 kcal/kg was also determined. The outcome of the results shows that there is significant difference in the parameters assessed on the Archachatina marginata after the stipulated period of 8 weeks. It was revealed that highest weight gained of the snails were 29.45g, 34.31g, and 23.21g for T_1, T_2, and T_3 respectively. It was also revealed that T_2 had the highest reproductive performance of 8.59 g, while T_1 and T_3 failed to lay eggs. Based on the results obtained, Archachatina marginata were significantly influenced with the addition of Gliricidia leaves in their compounded feed ration for maximum growth and reproductive performance. In order to encourage massive production of affordable Archachatina marginata for food consumption, Gliricidia sepium leaves can be adopted as addition in the feeding ration for snails.

Keywords: Archachatina maginata, Growth, Feed, Reproductive, Snails, Farmers.

INTRODUCTION

The African giant snail, scientifically known as *Achatina achatina* and *Achatina ficula*, is one of the largest terrestrial snails in the world. African giant land snails is one of the micro livestock that could serve as ready source of inexpensive meat among the human population especially in the humid tropics where snails thrive widely (Ajayi *et al*., 2008). African giant land snails are widely distributed in the moist forest belt of West Africa (Ghana, Nigeria, Cameroon, Republic of Benin, Togo, Liberia, Sierra Leone and Côte d'Ivoire, etc) and they are gathered from the forest during the wet season (CADEV. 2006). Snail farming has become an important economic activity in Nigeria in recent times in a renewed trust to increased animal protein production (Ugwuowo and Ani, 2011). Snail farming is environment friendly and can be done with little skill and cash (Akinnusi, 2004). Conventional feeds of snail comprise breadfruits, waterleaf, pawpaw leaf and fruit, sweet orange, mango fruit, ripe fruit of plantain and banana, and other feeds of plant origin (Isikwenu 2015) but the biology and plant food preferences of African giant snail have been thoroughly studied and in the recent times the introduction of compounded rations into the nutrition of domesticated snails with a view to provide steady snail food supply especially during dry season for consistent snail farming as well as providing rations for optimal snail growth has stimulated increase interest toward the rearing of domesticated snails in Nigeria (Ejidike, 2016). According to the research conducted by Olayiwola *et al* (2013) on evaluation of growth performance and nutrition digestibility of *Achatina fulica* snail fed with a diet supplemented with *Gliricidia sepium* leaves, the findings indicated a marked improvement in weight gain and feed conversion ratio compared to the control group, highlighting the plant's potential as a valuable feed component.

Similarly, Adu *et al*., (2016) investigated the effects of *Leucaena leucocephala* leaf meal on the growth performance and reproductive traits of African giant snails. The study reported enhanced growth rates, improved shell development, and increased egg production in snails fed with *Leucaen*a supplemented diet. The high protein content and palatability of *Leucaena* were identified as key factors contributing to these positive outcomes. *Gliricidia sepium* and *Leucaena leucocephala* are leguminous plants renowned for their high protein content and nutritional value. These plants are widely used in animal feed due to their rich content of essential amino acids, vitamins and minerals. Optimizing snail nutrition through innovative feed formulations is crucial for enhancing their growth rates, reproductive success and overall health. Incorporating high protein and nutrient-rich plant such as *Gliricidia sepium* and *Leucaena leucocephala* into snail feed ration is an emerging practice that over the years has shown promising benefits (Aina et al., 2016; Adejumo et al, 2015). Therefore, the incorporation of *Gliricidia sepium* and *Leucaena leucocephala* leaf meal in the diet of growing snails may be of help in meeting the nutritional and growth performance of snails as well as enhance their reproduction. This study was therefore conducted to determine the effects of *Gliricidia sepium* and *leucaena leucocephela* on the growth and reproductive performance of snail.

MATERIALS AND METHODS

Study Location

Ibadan is located in the South-Western area of Nigeria; it's about 128 kilometers inland northeast of Lagos and 530 kilometers southwest of Abuja, the Federal capital of the country. Ibadan is made up of largely Yoruba speaking peoples. It is reputed to be the largest indigenous city in Nigeria with a total area of 3,080 sq. kilometers. The total population of the five local government areas in the municipality is 1,889,776 while that of the outlying communities is 1,413,081 (OSGN, 2024). The urban extent density in Ibadan as at 2013 was 60 people per hectare, decreasing at an average annual rate of -0.1% since 2000. The urban extent density in 2000 was 61persons per hectare, increasing at an average annual rate of 0.4% since 1984 when the urban extent density was 58 persons per hectare. The current metro area population of Ibadan in 2022 is 3,756,000 a 2.9% increase since 2021 which was 3,649,000 (UN, 2022). There are eleven (11) local government areas in Ibadan Metropolitan area consisting of five urban local governments in the city: Ibadan North East, Ibadan South East, Ibadan South West, Ibadan North West and Ibadan North local government.

Ibadan has a tropical wet and dry climate with a lengthy wet season and relatively constant temperatures throughout the year. Ibadan's wet season runs from March through October, though August seems somewhat of a lull in precipitation. The mean total rainfall for Ibadan is approximately 1,230 millimeter or 48 inches, falling over about 123 days. There are two peaks for rainfall, June and September. The mean daily temperature is 26.46°C or 70.63°F, the mean minimum temperature is 21.42°C or 70.56°F and the relative humidity is 74.55% (BCM, 2022). The research study was carried out behind the goat unit of the Federal College of Forestry, Ibadan of coordinate 7°23'48.14221"N and 3 °51'46.92874"E (Wikidata.org)

Materials
Wooden cage, *Gliricidia* leaves, *Leucaena* leaves, compounded rations, rich loamy soil, water, bucket and bowl, foam, broom, forty-five growing snails (*Archachatina maginata*), concrete feeder.

Experimental layout and Design
Forty-five growing snails of *Archachatina marginata* species bought from Oje market at Ibadan, Oyo-state, Nigeria were randomly allocated. 15 snails per treatment and each treatment were replicates three times with 5 snails per replicate. Thus, the treatments were labeled; T1,T2 and T3. The snails were fed with compounded feed ration containing 10% *Gliricidia* and *Leucaena* leaves (T2 and T3). The 3 rations were listed in Table 1 below; date was collected after the period of 8 weeks and analyzed using completely randomized design (CRD). Duncan Multiple Range Test (DMRT) was adopted to separate the mean values owning to level of significance in analysis of variance (ANOVA). The treatment variables are as follows: Treatment 1: Control, compounded ration without leaf, Treatment 2: compounded with 10% *Gliricidia* leaves and Treatment 3: Compounded ration with 10% *Leucaena* leaves.

Management
Feeds were given to snails daily and this is based on 5% of their body weight (Amusan and Omidiji, 1999). The rearing unit was regularly moistened for easy burrowing into the soil. Mucus and feaces was regularly removed by scraping the top soil daily. New soil was replaces every two weeks and the surroundings were weeded to avoid ants. Left over feed was collected, weighed and recorded, also fresh feed were weighed and recorded before given to the snails.

Table 1: Experimental Rations

Ingredients (%)	T 1 (%)	T 2 (%)	T 3 (%)
Maize	35.5	33.1	33.1
Wheat bran	24.7	24.7	30.7
Palm kernel cake	26.8	25.4	20.8
Fish meal	1.5	3.0	3.0
Soya	3.0	-	-
Groundnut cake	4.7	-	-
Bone meal	3.6	3.6	3.6
Premise	0.1	0.1	0.1
Methionine	0.1	0.1	0.1
Lysine	0.1	0.1	0.1
Gliricidia leaves	-	10	-
Leucaena leaves	-	-	10

Table 2: Proximate composition of Gliricidia and Leucaena leaves

Composition	Gliricidia leaves (%)	Leucaena leaves (%)
Crude protein	24.81	29.10
Crude fiber	24.06	8.91
Metabolizable energy of 2500kcal/kg	29.20	19.60

Source: (Adeyemo, 2002).

The three experimental diets had a crude protein of 16.6% and a metabolizable energy of 2500kcal/kg

The proximate analysis in Table 2 revealed that *Leucaena* leaves has higher level of protein compared to *Gliricidia* leaves, though both are high in protein and could be used in animal feed to replace convectional protein sources which are expensive due to the competition for their use by man, animals and industries. The average feed intake was obtained by adding the total feed intake and dividing by the number of weeks for carrying out the experiment within the period of 8 weeks. The feed intake recorded ranged between (10.03g), (12.80g) and (8.03g) for T_1, T_2 and T_3 respectively with this period of 8 weeks (Table 3). This revealed that the addition of *Gliricidia* leaves to the ration in T_2 improved the feed intake unlike the very low value obtained in T_3; this might be due to an anti-nutritional toxic component in *Leucaena* leaves which has been found to cause complications in farm animals. The toxic component in *Leucaena* leaves is known as MIMOSINE (Kehinde, 1990). The result of the analysis shows that there is significant difference in the mean values of feed intake at 5% probability level. The relationship in average growth rate is illustrated in Figure 1 below. The graph shows that the order of growth rate with T_2 had the best performance, followed by T_1 and T_3.

RESULTS AND DISCUSSION

Table 3: The feed Intake per week

Week	T1 (g)	T2 (g)	T3 (g)
1	4.90	9.30	4.50
2	7.70	13.30	3.40
3	8.10	8.40	6.30
4	9.90	11.30	7.70
5	10.50	12.80	9.10
6	11.70	14.20	9.90
7	13.00	15.70	10.70
8	14,40	17.50	12.60
Mean	**10.03**	**12.80**	**8.03**

Table 4: Reproduction Rate of Snail on the Treatments

Week	T1 (g)	T2 (g)	T3 (g)
1	-	3.50	-
2	-	5.42	-
3	-	6.00	-
4	-	7.55	-
5	-	9.10	-
6	-	10.21	-
7	-	12.45	-
8	-	14.50	-
Mean		**8.59**	

Table 4 shows that the treatment (T_1) and (T_2) had no effect on the reproductive performance of the snails for the period of 8 weeks. Treatments (T_2) had the highest reproductive performance of (8.59g) while (T_1) and (T_3) had failed to lay eggs. The research work revealed that snails need more *Gliricidia* leaves in their compounded feed ration for maximum growth and reproductive performance.

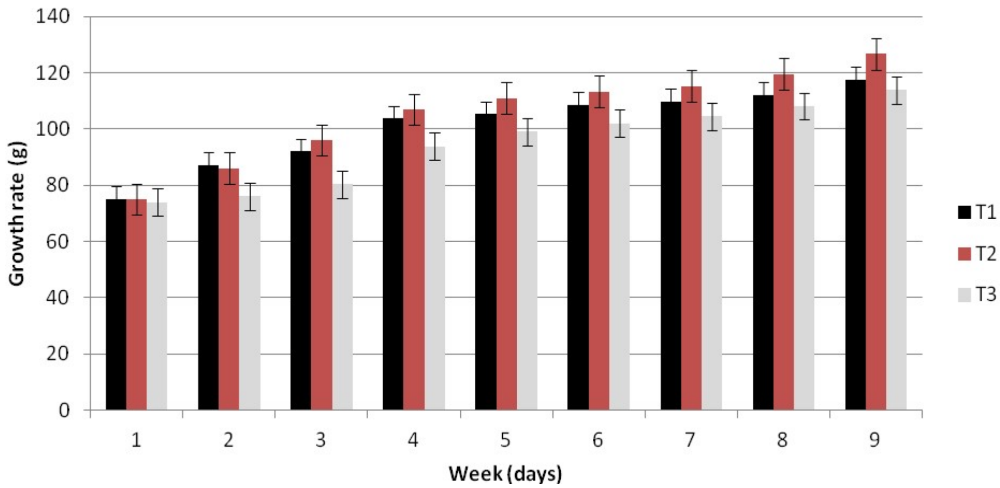

Figure 1: Growth rate of snails on treatments on treatment

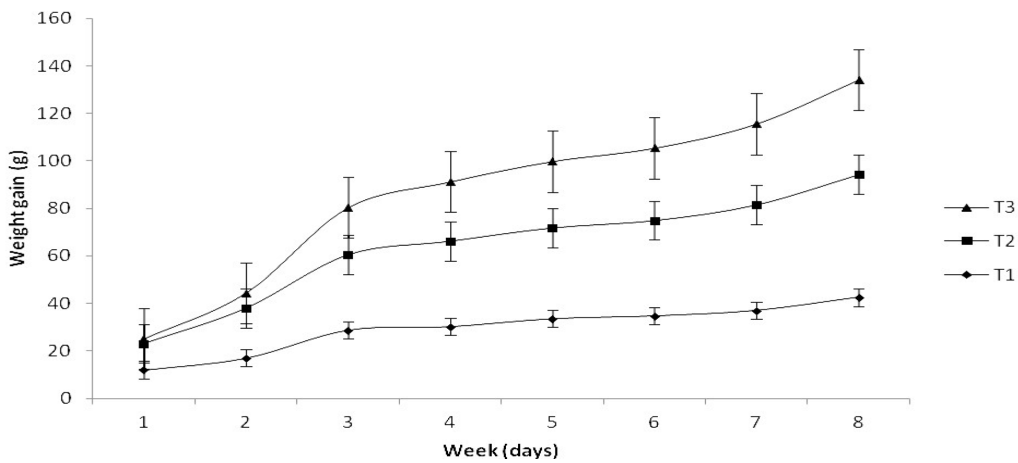

Figure 2:Weight gain of snails

It was discovered that there was increase in the growth of ths snails as the week progressed from week 1 to wek 8. The outcome of feed intake at the end of the period of 8 weeks when compared to the growth pattern, weight gain and reproductive performance of snails was such that T_1 had consumed an average feed intake of 10.03g, T_2 had 12.80g and T_3 had 8.03g respectively, this immensely contributed to their growth rate as illustrated in Fig 1 above where T2 had the highest growth rate followed by T1 and T3 (Fig.1). But it was clearly observed in Fig 2 that the feed intake of snails had better response on T3 as the snails here had highest weight gain followed by T2 and T3.This implied that snails responded better in terms of body weight when they are fed with ration combined with Leucaena leaves. As presented in Table 4, it shows that feed intake of the snails responded best on T2 as the snails fed with compouded ration combined with Gliricidia leaves had the best reproductive output while the snails in T1 and T3 respectively failed to produce eggs. This implies that T2 gives the best output in terms reproduction, therefore it should be adopted by those interested in snail farming business while those interested in consumption of snail meat could adopt T3 for optimum result. This result negates the findings of Jimoh and Akinola (2020), who fed African giant snail with roughage (unripe pawpaw and watermelon peel) and concentrate feed (Dietary treatments containing groundnut cake as protein feedstuff) with leaf meal (Dried Moringa oleifera leaf meal, Gliricidia sepium leaf meal and Leucaena leucocephela leaf meal) -inclusive diets. It was recorded that Snails fed with Leucaena leucocephala-inclusive diet had better egg production, fertility, hatchability, and juvenile snails which was as a result of the nutrients present in all the three diets combined.

CONCLUSION AND RECOMMENDATIONS

Leucaena and *Gliricidia* leaves used in this research at 10% level incorporated into compounded ration to feed snails were successfully completed after 8 weeks. Feed intake was significantly improved by adding *Gliricidia* leaves to Treatment 2 while *Leucaena* leaves in Treatment 3 depressed the feed intake. Also, growth rate and body weight were best in T_2 but not significantly affected. Incorporation of *Gliricidia* leaves in T_2 also enhanced the reproduction time performance through production and hatching of their eggs while those in T_1 and T_3 failed to lay their eggs.

A major aspect in animal husbandry is feeding and this constitute about 50 – 70% of the cost of production, hence the need to look for an alternative feed ingredients that are not hazardous and without adverse effect on snails are essential. Based on the result of this research, it can therefore be recommended to snail farmers to supplement convectional ration of their feeding with *Gliricidia* leaves in order to reduce the cost of production and maximize their profit.

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Knowledge and Information Needs of Maize Farmers on Aflatoxin Management Strategies in Oyun Local Government Area, Kwara State, Nigeria

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Abstract

Aflatoxin contamination poses a serious threat to maize production, diminishing crop quality and yield and also endangering the health of consumers and livestock. This study assessed the knowledge and information needs of maize farmers on aflatoxin management strategies in Oyun Local Government Area, Kwara State, Nigeria. A two-stage sampling technique was used in selecting one hundred and twenty respondents for the study. Data were obtained using structured questionnaire. Frequencies, percentages, means and standard deviation were used to analyse the data. The demographic analysis of the respondents shows that their mean age was 48.2 years, and they were mainly males (74.2%) with an average of 12.6 years' experience in maize farming. The respondents (45.0%) had moderate knowledge level. The respondents had highest information needs on identification of contamination sources ($\bar{x}$=1.18). The study concluded that farmers still need to be equipped with requisite knowledge and information to combat aflatoxin. It was recommended that more awareness creation on aflatoxin management through training of farmers should be emphasised as with most food safety issues.

Keywords: Aflatoxin, Food Security, Knowledge, Information Needs, Management Strategies

INTRODUCTION

Maize is one of the most important staple crops globally, serving as a crucial food source and economic commodity in many regions, particularly in sub-Saharan Africa. In Nigeria, maize is not only a major source of calories for millions of people but also a vital ingredient for livestock feed and industrial raw materials (Olabanji et al., 2021a). However, the potential of maize as a food security crop is threatened by several factors, one of which is aflatoxin contamination.

Aflatoxins are toxic substances produced by certain strains of Aspergillus fungi, predominantly Aspergillus flavus and Aspergillus parasiticus, that grow on maize and other crops under favorable conditions such as warm temperatures and high humidity (Kachapulula et al., 2017). These toxins are hazardous to both human and animal health, causing diseases like liver cancer, immune system suppression, and stunted growth in children (Kamala et al., 2018). Furthermore, aflatoxin contamination can reduce the economic value of maize by limiting its use in local and international markets, where stringent safety regulations often apply. Aflatoxin contamination is a major problem in Nigeria and other tropical countries, where climatic conditions favor the growth of these fungi. Poor post-harvest handling, improper storage practices, and lack of awareness among farmers significantly increase the risk of aflatoxin contamination in maize (Brancalion and Holl, 2020). As a result, there is a growing need for effective management strategies to mitigate aflatoxin risks in maize production.

Despite the increasing threat posed by aflatoxins, many maize farmers have limited knowledge about the contamination process and are often unaware of the management strategies that can be employed to reduce it. According to Olabanji et al (2021b), the adoption of good management practices is often hindered by the lack of adequate information dissemination and the farmers' access to accurate and timely knowledge. Understanding the knowledge gaps and information needs of maize farmers on aflatoxin management strategies is essential for designing effective extension services and agricultural training programs that could ensure that farmers are equipped with the necessary skills and information to implement preventive measures, thereby reducing aflatoxin contamination in maize. It is against this background that the present study was designed to assess the knowledge and information needs of maize farmers regarding aflatoxin management strategies in Oyun Local Government Area of Kwara State, Nigeria.

Objectives of the study

The specific objectives of the study were to;

i. describe the socioeconomic characteristics of the respondents in the study area
ii. examine the knowledge level of the farmers on aflatoxins’ management strategies and
iii. identify the information needs of the farmers on aflatoxin management strategies.

METHODOLOGY

The study was conducted in Oyun Local Government Area of Kwara State. Oyun is among the sixteen Local Government Area in Kwara State, Nigeria located in the Guinea savanna vegetation belt. Its headquarters are in Ilemona township. It has an area of 476 km^2 and a population of 138,363 with an annual population change of 2.6% (NBS population projection, 2022). The latitude is 8° 10' 6" North and longitude 4° 39' 8" East. The major towns in Oyun LGA are Erin-ile, Ijagbo, Ikotun, Ojoku, Ipee, Aho-Igbada, Ojoku and Ilemona. It is divided into eleven political wards for administrative purposes. The land is good for farming and manufacturing businesses. The population for the study comprises all farmers cultivating maize in Oyun Local Government Area. A two-stage sampling procedure was used in selecting one hundred and twenty respondents for the study. In the first stage six communities were randomly selected. In the second stage, twenty farming households were systematically selected for the study, i.e every 4th household. The household member with the most active role in postharvest handling was interviewed in each house. Data for the study was collected through the use of interview schedule. The socioeconomic characteristics of the respondents were determined using frequency counts and percentages. To determine the knowledge level of the farmers on aflatoxin management strategies, twenty-one knowledge-based questions on various aspects of the management practices were asked. The respondents were made to respond “true” or “false” to the questions. Each time a respondent indicated a correct answer; a score of 1 was given, wrong answers were scored 0. A respondent can have a maximum score of 21 and minimum of 0. Each of the respondents were categorized based on their scores into high knowledge for 15-21 correct responses, moderate knowledge for 8-14 correct responses, and low knowledge for 1-7 correct responses. To identify the information needs, respondents were asked to select from a list of aflatoxin management strategies using a three-point Likert-type scale of highly needed (2), moderately needed (1), and not needed (0). The scale measured as $X = \Sigma x / n$ Where, X = Likert value, Σ = summation, n = total respondents / sample size was used to form the basis for deciding the level of information need of each strategy. Thus, the decision rule holds that $X = (2 + 1 + 0) / 3 = 1.0$ so, strategies > 1.0 were considered the ones they needed while those < 1.0 were considered otherwise. Descriptive statistical tools of frequency distribution, percentages, mean counts and standard deviations were used to achieve objectives one to three.

RESULTS AND DISCUSSION

Socioeconomic characteristics of the Respondents

Data in Table 1 shows that most of the respondents (74.2%) were males while 25.8% were females. This indicates male dominance in farming activities due to the tedious nature of farming practices and the primary involvement of women in other activities like processing and trading of the farm produce. This may also be attributed to the tenure nature of land allocation system where female right to land ownership is limited (Olabanji et al., 2021a). A notable proportion of the respondents (48.3%) fall within 41-60 years age category with a mean age of 48.2 years. This is an indication that most of the famers in the study area are in the middle aged which may be due to declining number of youths involvement in farming activities. Also, majority (79.2%) of the farmers were married while 17.5% were single. By this it is obvious that most of the farmers have responsibilities to discharge in their homes which may limit the time allocation to proper aflatoxin management practices. About 38.3% of the respondents had secondary school education. This implies that the farmers have the ability to acquire knowledge when information is made available. Olabanji et al (2020) found out that exposure of farmers to education will increased the farmer’s ability to adopt change. Based on the years of experience, majority of the farmers (37.5%) had between 10-20years of experience in farming activities with an average of 12.6 years. In addition, an average of 3.6 acres are allocated to maize on farms of the respondents. This shows that most of them are small scale farmers. This inference was drawn based on the criteria set by Olayinde et al as cited by Ogunjimi and Farinde (2012) that all farmers who operate on land less than 10 hectares are small-scale farmers.

Table 1: Distribution of the Socioeconomic characteristics of the respondents

Variable	Frequencies	Percentages	Mean
Sex			
Male	89	74.2	
Female	31	25.8	
Age			
Below 20 years	09	7.5	
20-40	42	35.0	48.2 years
41-60	58	48.3	
Above 61	11	9.2	
Marital status			
Single	21	17.5	
Married	95	79.2	
Widowed	04	3.3	
Educational Level			
No Formal Education	32	26.7	
Primary Education	34	28.3	
Secondary Education	46	38.3	
Post-Secondary Education	08	6.7	
Years of farming experience			
Less than 10 years	30	25.0	
10-20 years	45	37.5	
21-30 years	26	21.7	12.6 years
Above 31 years	19	15.8	
Size of land allocated to Maize			
Less than 1 acre	18	15.0	
1-5 acres	87	72.5	3.6 acre
6-10 acres	11	9.2	
More than 11 acres	04	3.3	
Contact with extension agents (annually)			
Less than 5 times	102	85.0	
5-10 times	17	14.2	2 times
More than 10 times	01	0.8	

Source: Field Survey, 2024

Farmers' knowledge on aflatoxin management strategies

The result obtained from answers to the knowledge test shows that 45.0% of the respondents had moderate knowledge of aflatoxin management strategies, 35.8% had high knowledge, while 19.2% had low knowledge of the listed strategies. The moderate to high knowledge level of the respondents may probably be due to their relatively high farming experience. High knowledge is an important criterion in the adoption of effective practices.

Table 2: Distribution of the farmers according to their knowledge on aflatoxin management strategies (AMS)

Level of knowledge on AMS	Frequency (N=120)	Percentages (%)
High knowledge (15-21 scores)	43	35.8
Moderate knowledge (8-14 scores)	54	45.0
Low knowledge (1-7 scores)	23	19.2

Source: Computed from field data, 2024

Farmers' Information Needs on Aflatoxin Management Strategies

Data in Table 3 shows that identification of contamination sources (x̄=1.18), determination of moisture level (x̄=1.13) and proper drying methods (x̄=1.01) were selected as the highest information needed on aflatoxin management strategies. A critical factor in aflatoxin management is the timely and accurate identification of contamination. A farmers who cannot identify contamination sources, will not be able to apply appropriate interventions to prevent the spread.

Table 3: Distribution of the respondents based on their information needs on aflatoxin management strategies

Aflatoxin Management Strategies	HN	MN	NN	WMS	Std. Dev
Use of improved varieties that are resistant to diseases, drought-tolerant, and early maturing	38 (31.7)	40 (33.3)	42 (35.0)	0.97	1.089
Planting in a timely manner to avoid mid- and late-season drought	21 (17.5)	30 (25.0)	69 (57.5)	0.60	0.960
Identification of contamination	40 (33.3)	34 (28.3)	46 (38.4)	0.95	1.078
Identification of contamination sources	54 (45.0)	34 (28.3)	32 (26.7)	1.18	0.912
Proper drying techniques	43 (35.8)	35 (29.2)	42 (35.0)	1.01	1.010
Proper storage methods	40 (33.3)	37 (30.8)	43 (35.8)	0.98	1.106
Application of postharvest pesticides	28 (23.3)	37 (30.8)	55 (45.8)	0.78	1.009
Sorting damaged, moldy, shrunken, or otherwise nonconforming crops	32 (26.7)	34 (28.3)	54 (45.0)	0.82	0.897
Determination of moisture level	49 (40.8)	37 (30.8)	34 (28.3)	1.13	0.901

Source: Field Survey, 2024; Cut-Off Point = 1.00
HN = Highly Needed, MN = Moderately Needed, NN = Not Needed

CONCLUSION AND RECOMMENDATIONS

It was concluded that farmers in the study area need more information on aflatoxin management strategies, with particular emphasis on identification of contamination, moisture level determination, and proper postharvest techniques. It was recommended that more awareness creation on aflatoxin management through training of farmers should be emphasised as with most food safety issues.

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Profitability Analysis of Oil Palm Fruits Processing among Smallholder Processors in Kachia Local Government Area of Kaduna State

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Abstract
The study investigated the profitability of oil palm fruits processing among smallholder processors in Kachia Local Government Area of Kaduna State. A multistage sampling procedure involving purposive selection of palm oil producing district areas and a random selection of 60 smallholder palm oil processors was carried out in the study area. Information on the socio-economics of processors was collected. Most respondents are young (43 years) and active with considerable experience (10 years) in the enterprise. The study revealed that the enterprise is profitable in the study area with an average processor making an annual net returns of ₦3,615,860.00 and return on investment of (78.6%) which implies that for every one naira invested, a profit of 78 kobo is achieved by an average palm oil processor. The major constraint to oil palm fruits processing was reported by majority (28.13%) of respondents. The study recommends that oil palm fruits processors should form themselves into cooperatives associations in other to benefit from government and development organizations financial interventions.

Keywords: Profitability, Palm oil, Processors, Kachia.

INTRODUCTION

The potential of agriculture in Nigeria as a leading major exportable agricultural products; and as a significant contributor to the Nigeria's GDP and mainstay of her economy cannot be overstated. This stance was real way back from pre-colonial, colonial and first decades after independence. However, such earlier contribution and gains of agriculture has been nose driven from over 60 percent in the late 1960s, down to when the contribution of agriculture to GDP moved to 22.2% in 1980s (NBS, 2009). Currently, the contribution of agriculture to the country's overall GDP in real terms is 21.7% (NBS, 2023). However, owing to the renewed hope agenda of the current administration's resolve to make agriculture take its pride of place in Nigeria's economy again, indicates there are ample rooms for improvement.

Palm oil is extracted from the mesocarp of fruits of oil palm tree (*Elaeis guineensis Jacq).* Extracting of palm oil from fruits involves field processes include cutting `ripe fruit bunches from the palm tree and carrying the fresh fruit bunches and fallen loose fruits for processing; which involve stages like sterilisation, stripping, milling, processing, clarification and storage; (Badmus 1990). Palm oil is used in the manufacture of soap, and ointments; it is a chief chemical constituent of palmitic acid. Oil palm supplies palm oil and palm kernel oil which are derived from palm fruit and palm kernel respectively. FAO (2009) states that apart from fresh fruits bunches of palm fruits, other derive products from oil palm fruits includes palm kernel, palm wine, brooms, palm kernel oil, baskets and climbing ropes among other utility products.

Processing is the conversion of a commodity from its raw state to a more acceptable form. In the case of oil palm, it involves changing the fresh fruit bunches (FFB) to palm oil and other useful products. The oil winning process (value addition) in summary involves the reception of FFBs from the plantations, sterilizing and threshing of the bunches to free the palm fruit, mashing the fruit and pressing out the crude palm oil, which is further purified and dried for storage and export (Poku, 2002). After harvesting the FFBs, according to Anyaoha, Sakrabani, Patchigolla and Mouazen (2018), the palm fruits are processed into palm oil using either manual/traditional or mechanized/modern methods**.**

Owing to income growth and population surge, there is now increases in demand for palm oil. However, the challenging situation is the relatively low productivity of the oil palm sector in Nigeria making the country now a net importer of palm oil. Furthermore, the high transportation costs of moving goods from rural area to the urban area and to the international market makes exporting oil be in a competitive disadvantage position. The Nigeria's first goal is to make room for meeting the domestic demand for palm oil. Nigeria should seek to become competitive in export markets especially that the rapid devaluation of the naira cum poor naira's exchange rate could spur the exportation possibilities. This will generate more income and employment in Nigeria.

However, most of these smallholder palm oil processors in the study area process oil palm to get palm oil, kernel and fibre. This enterprise is labour intensive and its profitability depends not only on the harvest of the fruit branches harvested or purchased but on availability labour and how efficiently other associated resources are well utilized to achieved palm oil in sufficient quantity (Ukpabi 2004). The specific objectives of the study are to; determine socio-economic characteristics of smallholder processors; evaluate the profitability of palm oil processing; and to describe the constraint against palm oil processing in the study area.

MATERIALS AND METHODS

Kachia Local Government Area (LGA) of Kaduna State has an area of about 4632km^2 and a projected population of 895322 in 2023 from the population figure of 244,274 in 2006 (NPC, 2006). Kachia LGA is located between nlatitude 9^{0}33'N and 10^{0}11'N and longitudes 7^{0}10'E and 8^{0}08'E. The LGA has a total of 20 district namely Ankwa, Agunu, Kachia Awonn, Gumel, Ariko, Mazugu, Koro-tsoho, Doka, Bishimi, Katari south, Katari North, Kurmin Musa, Sabon sarki, Gidan tagwa and Jaba kogo. The people of the area are the diverse tribes such including, Kadara, Kuturmi, Jaba, Baju and Fulani. The vegetation of the area of the study is Guinea and with some area similar to rain forest vegetation. The major occupation of the inhabitants is farming. Majority of the farmers practice small scale agriculture. They grow arable crops with some forest products including oil palm Other occupation involved include, fishing, hunting, weaving, trading and many others. (Kaduna State Agricultural Development Programme, KADP, 2000). A multistage sampling technique was used to select the palm oil processors for the study. In the first stage 6 district which were known for oil palm production and palm oil processing were purposively selected for the study. The second stage involved the random selection of 10 farmers from each district giving a total of 60 palm oil processors enumerated in this study. The data were subject to Descriptive statistics, to analyse objective i and iii while farm budget technique was used to analyze objective ii of the study.

RESULTS AND DISCUSSION

Socio-economics of the sampled processors (Table 1) revealed a mean age of 43 years old, indicate that they are young and physically fit for the laborious processing work. Significant number of processors have formal primary (50%) and secondary (35%) education which plays an important role in palm oil processing operations aiding in the adoption of innovations that will improve oil palm fruits processing. An average size of palm plantation controlled per processors was 3.0 hectares. The average year of experience of processor in processing palm oil is 10 years. About 70% of processors acquired plantation through inheritance, meaning that most woodlot and oil palm owners are processors as well. The average household size of processors is 8 persons. Most processors are male (60%). The labour pattern used is such as family (54%) and hired (46%) labour.

The farm budget technique (Table 2) indicated a total gross margin of ₦7,016,360.00 mainly derived from palm oil (89.51) percent and oil sludge (7.41%). The total variable cost incurred was ₦3,400,500.00, in which the most variable cost item employed was the palm fruits (35.30%), which was gotten from own farm, purchased from other farmers or both. The next cost item was hired labour (27%) on harvesting and processing activities. The net return of ₦3,615,860.00 was achieved from the palm oil processing enterprise in the study area. The rate of return on investment was (0.79%); which implies on every one naira invested 79 kobo was gained.

The result in (Table 3) revealed that most respondents (28.13%) complaint of the problem of poor road infrastructures and inadequate vehicles necessary to facilitate movement of goods from processing shed to palm oil markets. Also, most (25%) of the smallholder farmers said lack of collateral hinders them from getting formal credits needed to increase the yield and quality of their products. Also, some (21.88%) respondents said inadequate infrastructure and some (18.75%) said storage facility compels most processors to sell off their palm oil at low prices and cannot take advantage of market competition. Lastly, some respondents (6.25%) complained of high cost of rent and acquiring land as key problem against their enterprise.

CONCLUSION

The study found that most oil palm fruits processors in the study area are young, fairly educated and well experienced enough to carry out a profitable enterprise. This is evidence in their annual net returns of ₦3,615,860.00 and return as to a naira invested (78.6%). The chief constraint was high transportation and inadequate vehicular infrastructure in transporting goods through rural to urban region. The study recommends that processors should form themselves into cooperative associations. They should approach government and development organizations to get financial help.

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Table 1: Socio-economic Characteristics of Palm Oil Processing Enterprise

Variables	Mean
Age	43
Education	35% (Primary education) 35% (Secondary education)
Size of farm	3.0Ha
Years of experience	10 years
Household size	8 persons

Source: Field survey data, 2024

Table 2: Average Cost and Return in Palm Oil Processing Enterprises

Items	Value (₦)	% Contribute in total cost
Returns		
Palm oil	6,280,000.00	89.51
Palm kernel (cracked)	124,240.00	1.77
Palm kernel (untracked)	92,120.00	1.31
Sludge	520,000.00	7.41
Total gross return	**7,016,360.00**	100%
Variable cost		
Palm fruits	1,200,500.00	35.30
Hired labour (harvesting & processing)	920,000.00	27.05
Extraction charges	450,000.00	13.23
Cracking charges	380,000.00	11.17
Other expenses (transport, water and firewood)	450,000.00	13.23
Total Variable Cost	**3,400,500.00**	100%
Rent (plantation)	520,000.00	43.55
Interest on borrowed capital	550,000.00	46.06
Depreciation on assets	124,000.00	10.38
Total Fixed Cost	**1,194,000.00**	100%
Total cost (TVC + TFC)	**4,594,500.00**	
Net return	**3,615,860.00**	
Return to naira	78.6%	
Benefit-Cost Ratio (BCR=TR/TC)	2	

Source: Field survey data, 2024

Table 3: Distribution of respondents according to constraints experienced

Educational level	Frequency	Percentage (%)
High transport cost	45	28.13
Inadequate storage facilities	30	18.75
Inadequate infrastructure	35	21.88
Inadequate finance	40	25.00
High cost of rent / land acquisition	10	6.25
Total	**160**	**100**

Source: Field survey data, 2024

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Gender Differentials in Labour Use among Coffee-producing Households in Kogi State Nigeria

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Abstract
Men and boys are mostly involved in the production of tree crops such as coffee while women and girls are involved in the marketing and processing of these crops. This study examined labour use across genders in coffee-producing households in Kogi State, Nigeria. Data from one hundred and twenty (120) coffee farming households were sourced using a well-structured questionnaire. Information on socio-economic characteristics, different activities in coffee production and costs of inputs used for coffee production was collected. Data were analysed using descriptive statistics and gross margin. The average age and household size were 60.8±16.1 and 7±5 persons, respectively. Most farmers (75.0%) were married, while 54.2% had primary education. In addition, nursery activity revealed boys and men (male gender) 41.7% and 20.8%, respectively, while girls and women 20.8% and 16.7%, were involved in this farming operation. Men were involved in the activities examined for coffee production in the study. Women were involved in all the activities except clearing, weeding, pruning, herbicide application and insecticide application. Boys and girls were also involved in nursery, harvesting, sorting, drying, packaging, marketing and transportation. Hence, for efficiency in coffee production, each gender should be empowered to participate in the farming operations to have a comparative advantage.

Keywords: Coffee, gender, activities, gross margin

INTRODUCTION

Coffee, one of the most consumed beverages in the world today is a tropical tree crop with African origins. The crop belongs to the Rubiaceae family and genus Coffea. According to Beenhouwer *et al*. (2015), the two most popular species of coffee across the globe are *Coffea Arabica* L. whose origin can be traced to Ethiopia and *Coffea canephora* A. which is commonly referred to as Coffee Robusta originates from Central to West Africa. According to Dube and Vargas (2013), coffee production is a highly labour-intensive activity implying that it is a source of employment for many, especially in Ethiopia and other producing areas in Africa. Smallholder farmers are responsible for over 90 per cent of the total coffee produced in Africa. According to FAO (2020), coffee is produced in thirty African countries including Nigeria. According to Alli *et al*. (2021), coffee production began in Nigeria around the early 19th century. Nigeria's Federal Department of Agriculture (FDA) noted that coffee had been imported there as early as 1920. The crop was, however, first grown earlier, as evidenced by export figures of 5.5 tons in 1896 and 25.2 tons in 1909, respectively (Alli *et al*., 2021). Coffee *liberica* and Coffee *Abeokuta*, which are native to Nigeria, were the most extensively cultivated species before the FDA introduced *C. canephora* (Robusta) and *C. arabica*. The farmers were exposed to other commercially significant *coffea* species in the 1930s as a result of the declining market for local coffee.90% and 4%, respectively, of coffee exports come from C. canephora (Robusta) and *C. arabica*. Labour plays a crucial role in coffee production, as it involves several stages that require human effort. The extent and nature of labour use in coffee production can vary depending on factors such as the type of coffee (Arabica or Robusta), the region where it is grown, and the level of technology and mechanization employed. According to Mohammed *et al.* (2013), activities in coffee production such as planting, maintenance, harvesting and drying are still very much labour-dependent in Nigeria. Hence, the role of labour in coffee production cannot be overstressed. Gender differentials in labour use in Nigeria, like in many other countries, reflect disparities in the types of work that men, boys, women and girls typically engage in, as well as differences in access to resources and opportunities. According to Aigbokie (2021), there exists a form of gender differential in many sectors of Nigeria and agriculture in particular, studies (Amadi *et al*. 2019; Asante *et al.* 2023) have identified the presence of gender differentials in rice and cassava production to mention a few. Given the labour-intensive nature of coffee production in Nigeria, there is a need to examine the existence of gender differentials in coffee production in Nigeria. This study therefore seeks to examine the use of information technologies among coffee-producing households in Kogi North Central Nigeria

Objectives

i. To determine the socio-economic characteristics of coffee-producing households in the study area.
ii. To determine gender use/ differentials among different activities in Coffee production
iii. To assess input used and costs for coffee production

METHODOLOGY

The study area is Kogi State in the North Central zone of Nigeria. Kogi State is a State known for its major production of coffee in Nigeria. The variety of coffee majorly produced in the State is Coffee robusta. Within the State, Ijumu Local Government Area (LGA) was purposively selected being a high coffee-producing LGA in the State. In the LGA, the Iyamoye community was also purposively selected for the study. A simple random sampling technique was used to select 130 coffee-farming households from the selected community. A structured questionnaire was used to collect information from the selected farming households and the data retrieved from the information collected were analysed with the use of simple descriptive statistics involving frequencies and percentages. One hundred and thirty well-structured questionnaires were distributed among coffee farming households. After sorting out for missing data, information from one hundred and twenty farmers was eventually used for the analysis.

RESULTS AND DISCUSSION

Table 1 presents the socio-economic characteristics of coffee-producing households in North Central Nigeria. The mean age of coffee farmers in the study area was 60.8±16.1. Sixty per cent of them are above 60 years old. This reveals that coffee farmers in the study area are old. This could limit their acceptance of improved technologies and techniques as they might prefer to stick to their old practices. Also, if young farmers are not introduced to coffee farming coffee production may go into extinction in the study area. Young farmers need to be supported with finance and inputs to enhance their interest in coffee production. Seventy-five per cent of the respondents are married.

Eighty-three per cent of the farmers have a primary educational level. Their educational level could help in their adoption of the latest farming techniques. The mean household size in the study area was 7 ±5 persons. Their medium household size could mean they are spending more money on running their families and less on inputs and farming activities. Eighty per cent of coffee farmers in Kogi state belonged to a socio-economic group. They belonged to groups such as town unions, cooperatives and the Coffee Farmers Association of Nigeria (CFAN). These socio-economic groups especially CFAN help farmers to get support and inputs from the government and Cocoa Research Institute of Nigeria. The majority (83.3%) of the farmers own their farms and cultivate ≤2 hectares. The majority of the coffee farmers are smallholder farmers. The mean years of experience is 28 ±10 years. The farmers have great experience in coffee production which is of great importance for their business. Sixty per cent of the farmers in the study area grow coffee with kola nuts. They practise mixed cropping to maximise the use of their farmland. The majority of the farmers grow coffee in Robusta. Half of the farmers get their planting material from fellow farmers and 80% of the farmers affirmed that coffee planting material is readily available for sale.

Table 1: Socioeconomic characteristics of Coffee-producing Households in North Central Nigeria

Variable	Freq	%
Age		
31-60	60	50.0
61-84	60	50.0
Mean 60.8±16.1		
Marital status		
Single	30	25.0
Married	90	75.0
Educational Level		
No formal education	20	16.67
Primary	100	83.3
Household size		
1-5	40	25.0
6-10	80	75.0
Mean 7 ±5		
Socio economic group		
Yes	100	80.0
Membership of Socio-economic association		
Non-member	20	16.7
Cooperative	30	25.0
Town Union	20	16.7
CFAN	50	41.6
Roles performed by the socio-economic group		
Financial assistance	60	50.0
Supply of inputs	50	41.7
Purchase of the farm output	10	8.3
Type farm ownership		
Own farm	100	83.3
Rented farm	20	16.7
Farm size		
≤2	100	83.3
2.1-5.0	20	16.7
> 5.0	0	0

Variable	Freq	%
Farming experience		
≤20	20	16.7
21-40	80	66.6
41-60	20	16.7
Mean 28 ±10		
Other crops grown with coffee		
Kolanut	60	60.0
Plantain	20	20.0
Maize	20	20.0
Cassava	20	20.0
Cropping system		
Coffee/arable	50	41.7
Coffee/tree crops	70	58.3
Variety of coffee planted		
Robusta	120	100.0
Source of planting material		
CRIN	30	25.0
ADP	30	25.0
Fellow farmers	60	50.0
Is the planting material available to buy?		
Yes	80	66.7
No	40	33.3

Source: Field Survey, 2022

Table 2 presents the gender use/ differentials among different activities in Coffee production. For nursery activity, table 2 revealed that the male gender (boys and men) 41.7 per cent and 20.8 per cent, respectively, while the female gender (girls and women) 20.8 per cent and 16.7 per cent, were involved in this farming operation. Furthermore, clearing activity showed 41.7 per cent and 50.0 per cent for both male gender and 8.3 per cent for adult women. Also, for transplanting activity 41.7 per cent of adult men and women and 8.3 per cent of boys and girls, respectively were engaged in this activity. One hundred per cent of the boys were involved in the weeding activity. For herbicide and insecticide application 100 per cent of men participated in each revealing that 41.7 per cent of girls, 37.5 per cent of women 12.5 per cent of men and 8.3% of boys were involved in this activity. In addition, 41.7 per cent of the female gender (girls and women) and 8.3 per cent of the male gender (boys and men), were involved in the drying activity of coffee production. Moreover, the result revealed that 41.7 per cent and 33.3 per cent of female’s gender (girls and women), 16.7 per cent and 8.3 per cent of male gender (boys and men) participate in packaging activity. Also, for marketing activity, 16.7 per cent of men, 8.3 per cent of boys, 58.3 per cent of women and 16.7% of girls were involved. Lastly, 16.7 per cent of boys, 8.3% of men, 41.7% of girls and 33.3% of women were in transportation activity.

Table 2: Gender use/ differentials among different activities in Coffee production

Activity	Who participated more			
	Boys	Men	Girls	Women
Nursery	50 (41.7)	25 (20.8)	25 (20.8)	20 (16.7)
Clearing	50 (41.7)	60 (50.0)		10 (8.3)
Transplanting	10 (8.3)	50 (41.7)	10 (8.3)	50 (41.7)
Weeding	70 (58.3)	50 (41.7)		
Pruning	40 (33.3)	40 (33.3)		
Herbicide Application		120 (100)		
Insecticides Application		120 (100)		
Sorting	10 (8.3)	15 (12.5)	50 (41.7)	45(37.5)
Drying	10 (8.3)	10 (8.3)	50 (41.7)	50 (41.7)
Packaging	20 (16.7)	10 (8.3)	50 (41.7)	40 (33.3)
Marketing	10 (8.3)	20 (16.7)	20 (16.7)	70 (58.3)
Transporting	20 (16.7)	10 (8.3)	50 (41.7)	40 (33.3)

Source: Field Survey, 2022 *% in Parenthesis

Table 3 presents the inputs used and costs for coffee production. The total cost expended on coffee seedlings was ₦4,500,000 and ₦1,836,000 was spent on herbicides. For insecticides ₦240,000 was spent, ₦720,000 on labour, ₦827,400 on basins, ₦420,000 on cutlass, ₦234,000 on fuel and ₦320,000 on transportation, respectively. The Total Variable Cost was ₦9,097,400 and the average cost per farmer per annum was ₦75,812.

Table 3: Inputs used and costs for coffee production

Input	Quantity	Unit Cost (₦)	Total Cost (₦)
Coffee Seedlings	30000	150	4500000
Average cost per farmer			37,500
Herbicides (Lt)	1020	1800	1836000
Average cost per farmer			1530
Insecticides (Lt)	20	12000	240000
Average cost per farmer			2000
Labour (No of person)	360	2000	720000
Average cost per farmer			6000
Basins (No)	240	3500	827400
Average cost per farmer			6895
Cutlass	360	1000/1500	420000
Average cost per farmer			3500
Fuel (Lt)	1200	180/270	234000
Average cost per farmer			1950
Transportation	20	16000	320000
Average cost per farmer			2667

Source: Field Survey, 2022

***Total variable cost** = ₦9097400* ***Total variable cost per farmer** = ₦75812*

CONCLUSION AND RECOMMENDATIONS

Men were involved in all the activities examined for coffee production in the study area except weeding. Women were involved in all the activities except clearing, weeding, pruning, herbicide application and insecticide application. Boys and girls were in the nursery, harvesting, sorting, drying, packaging, marketing and transportation activities. The use of labour among boys and girls should be reduced to promote their well-being.

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AGRICULTURAL SOCIETY OF NIGERIA
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Evaluation of Cocoyam Accessions (*Xanthosoma saggittifolium)* for Selected Agronomic Traits and Response to Biotic Stresses in Umudike Rainforest Agro-Ecology of Southeastern Nigeria

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Abstract
Selection for vigour and high yield potential is useful in the rapid assessment of crops in efficient breeding programme using vegetative growth index (VGI). Based on this, a study was conducted at the National Root Crops Research Institute Umudike, Southeastern Nigeria with objectives to: select Xanthosoma species of cocoyam cultivars with high vigour, high yielding in terms of fresh number of corms+cormels, low ratio of corms to high number of cormels, and response of cultivars to major biotic stresses. The eight cultivars was laid out in a RCBD with three replications. Each seed weight of 50g was planted 1m within row and 1m between row in a plot size of 20m^2 and 1m between plots. Data were collected on: Number of fresh corms, number of fresh cormels, total number of fresh corms+cormels/ 1000 plants/ hectare, low ratio of corms to high number cormels, and response of cultivars to major biotic stresses. Data were analyzed with ANOVA. Means were separated using LSD at 5% Probability. Vigour and Biotic severity rating was on 1 to 9. Results indicated that cultivars selected were very vigorous (score 7 to 8) and had 1 to 2 corms/plant/1000 plants/ hectare. Cultivar with the highest number of fresh corms+cormels/ plot was NXs/AS/004. Cultivars with low ratio of corms to highest cormels were NXs/AS/001 and NXs/AS/007 respectively. Cultivars with score of 1.0 to 1.2 for Boboon virus, corm rot disease and Nematode infestation were regarded as immune/resistant to field diseases.

Keywords: Xanthosoma, vigour, corms+cormels, ratio and severity

INTRODUCTION

Okpul and Ivancic, (2003) argued that efficiency of Cocoyam breeding programme include selection of vigorous plants with an approach regarded as vegetative growth index (VGI) and is useful for the rapid assessment of *Xanthosoma saggitifolium* accessions with good yield potential under evaluation. TANSAO (1998) observed that when germplasm with high genetic diversity collections are being evaluated, the best heterotic accessions are selected for use as parents (Quero-Garc, 2006) for parental breeding stock. This approach had led to the development of families with broad genetic base and high heritable quantitative agronomic multigenic traits (Devi, 2013). Such variation indicated considerable heterozygosity in the parent cultivars (Sabor, 2004). *Xanthosoma species* of Cocoyam plants with corm root rot disease tolerance at different levels and at various stages can be obtained through evaluation and selection processes during population development (Jackson and Pelomo, 1980). During accessions evaluation, breeders can screen large cultivars and select resistant ones as parental stock (Ivancic, 2003). Resistant cultivars of corm-rot disease may have the potential of being susceptible if not properly evaluated and selected. Therefore, selection for corm-rot resistance should be conducted throughout the screening and evaluation process of parental selection.

Cocoyam in general is grown extensively under varied agro-climatic conditions and have genetic variation for agro-morphological traits. Natural selection for adaptation and local preferences have had effect on storage root traits, storage root size, vegetative growth, phenology, tuber yield (corm+cormel), number of corms and cormels per plant stand. Agueguia and Nzuetchueng (1984) noted this when they stated that the main driver behind cocoyam cultivation is the prevailing climatic factors and particularly tuber yield in form of corms+cormels. Cultivated cocoyam have been described as belonging to varied corms and cormels yield with different traits preferred in major cocoyam growing States of Nigeria.

Such traits as large corms and cormels, vegetative cover of the plant, phenology, plant architecture, tuber flesh colour and as well as resistant /tolerance to pests and diseases (NRCRI, 2018) are being used in selection in the breeding programmes according to the farmers' specific needs and consumers' preferences. Breeding objectives are sometimes be imposed by growers, consumers, marketers, processors and breeding programmes are compelled to go by it. However, there is the need to evaluate and select cocoyam cultivars producing enough corms and cormels for use as seeds for planting. This area has not been harnessed by cocoyam breeding programmes. The objectives of this study were to: select cocoyam cultivars with high vigour, high yielding in terms of fresh number of corms+cormels, low ratio of fresh corms to high number cormels, and resistant/tolerant to major biotic stresses.

MATERIALS AND METHODS

The experimental site: The field studies were conducted at the western farm of National Root Crops Research Institute (NRCRI) Umudike in the tropical rainforest zone of Nigeria lying between longitude 7^0 32" E and latitude 5^0 29" N of the equator on an elevation of 122 metres above sea level (Agrometerological station at NRCRI – Umudike 2022) with an annual rainfall of 1800mm to 2200mm. Average temperature ranges from between 25^0C and 35^0C and average sunshine hours of 5 hours daily. The area has dual rainfall pattern, with rainy season which starts at April to October while the dry season starts from November to March (NRCRI, Agrometerology, 2022). The soil is sandy clayey of the Ultisoils.

Land preparation and field layout*:* The land was slashed, ploughed, harrowed and ridged with tractor. The land area was demarcated into blocks and plots. The ridges were spaced 1m apart. The plot size was 20m^2 (5m by 4m) with 1m between plots. The eight cultivars of Tannia *Xanthosoma species* of cocoyam were laid out in a randomized complete block design with three replications. Each block contained 8 plots. The study was evaluated under rain-fed condition.

Planting and agronomic activities: The size of the planting material for the evaluation was 50g corm planted on a spacing of 100cm by 100cm on the crest of the ridges with one corm per planting hole at a planting depth of 10cm. This gave a plant population of

10,000 plants per hectare. Weed control was with the application of Primextra Gold immediately after land preparation and complemented with hand weeding until harvest. ***Data collection**:* Data collected included growth data such as vigour score every two months and averaged. Using the scale of 1 to 9. Where 1 is very low and 9 very vigorously.

***Evaluation of the Pathological response of the cocoyam genotypes for boboon* virus** on the above ground biomass at 4 weeks interval until harvest and below ground parts such as Corm soft rot and Nematodes at harvest. Disease assessment was carried out using 1-9 disease severity (DS) rating scale as suggested by Toker *et al*. (1999).

Where: 1 = Immune (No symptoms on plants), 2 = Highly Resistant (small tissue depression or spot/slightly wrinkle of leaves and green), 3 = Resistant (elongating spot)/slight wrinkle and green, 4 = Moderately Resistant (coalescent spot)/leaf mottle and green, 5 = Tolerant (stem girdling) leaf mottled with yellow patches, 6 = Moderately susceptible (stem breaking)/leaf clearing, plant malnourished, 7 = Susceptible (lesion growth downward from breaking point) mottled yellow with patches of green, 8 = Highly susceptible (whole plant nearly dead) /mottled yellowing and stunted and 9 = Highly susceptible (All plants dead)/ highly stunted with short internodes mottled and yellowing. ***Harvest*:** The clones were harvested exactly 12 months after planting when all the foliage have senescence and completely dried up. The yield component data collected were: Number of fresh corms, number of fresh cormels, total number of fresh corms+cormels per 1000 plants per hectare to calculate the yield potential per cultivar based on rural farmer measure.

***Statistical analysis*:** Data were analyzed with ANOVA. Means separated using LSD at 5% Probability. Biotic stresses were rated using severity rating of 1 to 9.

RESULTS AND DISCUSSION

***Plant vigour*:** The mean vigour score of the 8 cocoyam cultivars evaluated is presented in Table 1. The plant vigour is the growth performance of the cocoyam genotypes. According Degrass (2001) plant vigour are the important morphological traits, which indicate the growth and development of the cocoyam plants. However. The cocoyam genotypes significantly varied in their growth performance. The perusal of the data in Table 1 showed that at the plant vigour of different genotypes ranged between 5.0 and 8.5 respectively. The cultivar NXs/001 and NXs/003 registered the maximum vigour score of 8.0 respectively. The minimum vigour scored was obtained from NXs/007 with vigour score of 5.0 respectively. The variation in growth performance may be attributed to the crops' polyploid genetic nature as well as the distribution of rainfall pattern. High vegetative growth of some of the genotypes that performed above average could be regarded as evidence of the crop genetic potential for adaptability to the location. Also, the vigour assessment is an indication of the health of the clones and the likelihood that the genotypes will yield well. *Crops in intercropping with cocoyam in a mixed cropping scheme should be carefully selected considering the canopy cover and given enough spacing to avoid smothering effect of the cocoyam plant. Cocoyam genotypes with high vigour smother weeds and have the ability to produce high yield (Onwueme and Sinha, 1999).* However, factors which tend to lower vigour are small sett sizes, presence of pathogens in the planted corms or in the soil, long dormancy period of the corms and advanced environmental conditions such as prolonged dry period during germination.

Yield components of the cocoyam genotypes: The yield of the cocoyam cultivars as measured in number of fresh corms, number of fresh cormels, total number of fresh corms+cormels are presented in Table 1.

Number of corms per plant: There was no significant (p>0.05) variation in number of corms per plant. Although the number of corms per plant ranged from 1 among many cultivars had 1 to 2 corms with mean of 1.4 corms per plant stand per 1000 plants per hectare (Table 1). Corms in some Tannia species of *Xanthosoma* variety of cocoyam are the edible portion of the plant while in some they are edible as well as the planting material for Tannia cultivation. The corm is where the cormels are attached. The corms in some varieties are mainly for planting as they contained more of oxalic compounds which causes scratching of the tongues and throats when boiled and eaten as food. This phytochemicals in the corms of *Xanthosoma species* corms are for defensive mechanism against foraging wild animals.

Number of Cormels per plant: Number of cormels per cultivar varied significantly (p<.05) among the cocoyam cultivars and ranged from 6 to 13 with mean of 8.5 cormels per plant per 1000plants per hectare. The cultivar with the highest number of comels were NXs/004 with 13 number of cormels per plant per 1000plants per hectare, followed by NXs/AS/007 with 10 number of cormels per plant while the least was NXs/AS/003 with 4 number of comels per plant. High number of cormels per plant is an index of high yield and good quantity of food material for the household as well as planting materials for cultivating the crop (Godden, 1999). In the majority of the Tannia species of the *Xanthosoma* cocoyam, it is part of the edible portion of the crop.

Total number of corms+cormels: High significant (p<0.01) number of total corms+cormels was observed among the cocoyam cultivars of the Tannia plant per plot of 20m2, and per 1000plants per hectare. Mean total number of corms+cormels ranged from 5 (NXs/AS/003 to 15 NXs/AS/004 number of corms+cormels per plot of the cultivars evaluated. The grand mean number of corms+cormels was 9.9 per plot of 20m$^{2.}$ The total number of corms+cormels, made up the total yield of the cocoyam plant (IBPRI, 1999).

Ratio of corms to cormels per plant: The ratio of corms to cormels had significant (p<0.05) variation among the cocoyam cultivars evaluated and ranged from 1: 4 for NXs/AS/003 to as high as 1: 9 for NXs/AS/001 and NXs/AS/007 respectively (Table 1). The low ratio of corms to high cormels is an index of high yield in cultivars of Tannia of the cocoyam *Xanthosoma species* that produces cormels for planting or for food. Corms with high number of cormels per corm is an index of high yielding cultivars. The cocoyam farmers mainly measure the crop yield by the number of fresh corms, fresh cormels, and total number of fresh corms + cormels per 1000plants per hectare (Nwankwo and Bassey, 2013). However, Onwueme and Singh (1999) reported that cocoyam genotypes of the Taro cultivar begins new corm formation at about 3 months after planting and cormel formation follows afterwards especially in cultivars that produce large cormels. This indicated that fresh matter accumulation for the corms and cormels commenced three months after planting. This period of fresh matter accumulation and bulking coincides with periods of heavy rainfall distribution. That is why cocoyam of the Tannia cultivars require high amount of water for vigorous growth and for fresh matter accumulation and bulking. Corms and cormels with diameter less than 4cm is not marketable. Large corms and cormels is a good index for cocoyam fresh market and material for planting. Breeding for this trait will enable the farmer capitalize on this strength to increase his competitiveness in the fresh cocoyam global and domestic market (Godden, 1999). The industrialist will be able to join the starch industries. This will boost the economy by generating more income and improve the livelihood of all the stakeholders in the cocoyam value chain. Cocoyam (Taro and Tannia) corms and cormels are edible and are usually cooked by boiling, roasted, baked, steamed or fried and used as a starchy vegetable and supplemental food consumed by over 400 millions of people globally. In addition to sustaining food security in domestic market, it also brings export earnings and employer of labour for both men, women and youths (Nwankwo and Bassey, 2013).

Pathogenic response of the cocoyam clonal genotypes: The Pathogenic response of the Tannia of the Xanthosoma species of cocoyam to boboon virus disease is presented in Table 2.

The analysis of the cocoyam cultivars to the response to the Boboon Virus Disease complex (BVD) attack indicated significant cultivar response to Boboon Virus Disease complex (BVD) infection. Most of the cocoyam cultivars were immune to the viral infection with the score of 1.0, while others were resistant to the virus attack with score of 2.2 within the location. Overall BVD pressure was maximum at score of 2.2 with mean score of 1.3. The significant variation may be attributed to the distinct genetic constitution of the cultivars and their performance in the given set of climatic and edaphic conditions. Recent research has shown that sweet potato yield can be increased by as much as 30 to 40% without additional fertilizer, pesticide, or genetic improvement by using a procedure that eliminates viral diseases from planting materials (Laurie and Niederwieser, 2004). These procedure included evaluation and selection of BVD resistant cultivars and improving the environment where the crop is growing through addition of nutrients to enrich the soil and pests control. Other methods is the development of virus-free species of cocoyam genotypes that are immune and resistant to Boboon virus disease through genetic recombination. These genotypes would be able to develop into healthy plants and are able to extend to all cocoyam growing regions and the benefits could be realized into billions of Naira. This development would considerably reduce the country's reliance on cereal imports for food and livestock feed.

Corm rot disease: The mean score rating of corm rot was 1.0, the range of the attack was from 1.0 to 3.0. The disease severity rating on the cultivar NXs/AS/004 was 3.0. The severity rating of the corm rot disease indicated that the cultivar was highly susceptible. The cultivar with such specific trait of susceptibility to corm rot disease had the potential of spreading the disease and were not selected. The corm soft-rot disease that attack the corms and cormels of the cocoyam genotypes were scored based on the severity of the disease of the cocoyam cultivar. The lowest severity score was 1.0 while the highest severity score was 3.0 with grand score mean of 1.3. The grand mean score of 1.3 indicated that significant number of the cultivars were not highly affected with corm- rot disease.

Nematodes: The study also showed that all the genotypes were not affected by nematodes. This was observed from the stresses field infestation of nematodes with the score of 1.0.

However, cocoyam cultivars resistant to environmental stresses such as virus diseases and corm rot disease will be more attractive to farmers. This will promote food security. This will also enhance the financial condition of the farmers through commercialization of disease free cocoyam produce. Cocoyam cultivars resistant to pests and diseases reduces the financial burdens of purchasing chemicals for disease control. This will equally minimizes crop failure and higher yields enabling the farmers to generate more income to improve their livelihood (Boudjeko, 2005).

CONCLUSION AND RECOMMENDATIONS

Many cultivars of the cocoyam accessions selected were very vigorous (score 7 to 8) and had 1 to 2 corms per plant per 1000 plants per hectare. The cultivars selected produced the highest number of corms+cormels per plot was NXs/AS/004 and were selected for commercial production. Also selected for low ratio of corms to high cormels were NXs/AS/001 and NXs/AS/007 respectively.They produced the major domestic consumption part of *Xanthosoma species* of cocoyam plant since it contains no Oxalic compounds that causes acridity or scratchy substances when boiled and eaten. Cultivars selected were immune/resistant to disease with score of 1.0 to 1.2 in the case of Boboon virus disease, corm rot disease and Nematode infestation. This showed that high significant number of the cultivars indicated resistant to the major diseases attacking the species of the cocoyam plant in the field.

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Table 1: Mean number of fresh corms, number of fresh cormels, total number of fresh corms+cormels, per 1000plants per hectare

S/no.	Cultivar ID	Plant vigour (Score 1 to 9)	No. of corms (per plant)	No. of cormels (per plant)	Total number of corms+ cormels (per plot)	Ratio of corm to cormels
1	NXs/AS/005 (Ariagaocha)	7.0	1	6	7	6
2	NXs/AS/007 (Nsukka Dwarf)	5.0	2	10	12	5
3	NXs/AS/002 (Purple fleshed)	6.0	2	9	11	5
4	NXs/AS/006 (Ndunga)	5.0	1	8	9	8
5	NXs/AS/001 (Edeocha)	8.0	1	9	10	9
6	NXs/AS/003 (Yellow fleshed)	8.0	1	4	5	4
7	NXs/AS/ 008 (Uzuakoli red)	7.0	1	9	10	9
8	NXs/AS/004 (Nkwocha soft)	7.0	2	13	15	7
	Mean	7.5	**1.4**	**8.5**	**9.9**	**1:4 -1:9**
	Range	5.0-8.0	**1-2^{ns}**	**6-13***	**5-15****	**5-9****

Table 2: The mean response of the Cocoyam cultivars of *Xanthosoma species* to biotic stresses of cocoyam evaluated in the field

S/no.	Cultivar ID	Boboon Virus Disease complex severity score (1 to 9)	Nematodes severity score (1 to 9)	Corm rot severity score (1 to 9)
1	NXs/AS/005 (Ariagaocha)	1.0	1.0	1.0
2	NXs/AS/007 (Nsukka Dwarf)	1.0	1.0	1.0
3	NXs/AS/002 (Purple fleshed)	2.1	1.0	1.0
4	NXs/AS/006 (Ndunga)	1.0	1.0	1.0
5	NXs/AS/001 (Edeocha)	1.0	1.0	1.0
6	NXs/AS/003 (Yellow fleshed)	1.0	1.0	1.0
7	NXs/AS/ 008 (Uzuakoli red)	1.0	1.0	1.0
8	NXs/AS/004 (Nkwocha soft)	2.2	1.0	3.0
	Mean	**1.3**	**1.0**	**1.3**
	Range	**1.0-2.2**	**1.0-1.0**	**1.0-3.0**

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Analyzing the Setbacks to Sustainable Vegetable Marketing in the Northern Zone, Taraba State, Nigeria

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Abstract
The study analyzed the setbacks to sustainable vegetable marketing in Taraba State, Nigeria. The specific objectives of the study were to describe the socio- economic characteristics, examine the factors influencing the marketing margin and identify the constraints associated with it. Multistage and random sampling procedures were employed in selecting 110 vegetable marketers for the study. The analytical tools employed were descriptive statistics and multiple regression analysis. Results revealed that 60% of the vegetable marketers were female with about 66.36% married and within the active age. The mean marketing experience was estimated at 8 years and majority, 89.09% of the marketers had access to market information with 85.45% using personal savings as their initial marketing capital. The value of the coefficient of determination, (R^2) of 0.8864 indicates that 88.64% of the variation in the marketing margin of the marketers was explained by the variables used in the model. The major constraints identified were price fluctuation, 89.09% and perish ability, 72.73%. It was recommended that high level of sensitization on good storage systems, all season production and provision of infrastructural facilities be made to curtail the menace identified in the study area.
Keywords: Socio-economic menace, vegetable marketers, Taraba State

INTRODUCTION

In many regions of Africa, vegetables are among the most significant and commonly grown food and income-generating crops, according to Okunlola (2009). Both small-scale farmers and large-scale businesses cultivate them extensively. They can provide a high yield per unit of land and, as a result, produce a high income for vegetable growers. According to Agbugba et al. (2013), it amounts to 500,000 to 600,000 tonnes annually in West Africa. Vegetable output in Nigeria is huge, with some estimates for annual production citing mind-boggling numbers. Vegetable marketing is so complicated and difficult due to its unique qualities, which include perishability, seasonality, and the need for uniformity (Adebisi-Adelani et al., 2011).

The vegetables have historically received less marketing attention since they are seen as minor crops compared to cash and main crops (Thompson and Agbugba, 2013). However, it is crucial to remember that vegetable marketing is one of the most lucrative but risky agribusinesses due to their high perishability, price, and yield variations, as well as their unique features, combined with changing consumer demand that could lead to increased uncertainty faced by the marketers (Adebisi-Adelani et al., 2011). In light of this, concerns about the effectiveness of vegetable marketing have been present over time. As more people express interest in starting vegetable businesses, particularly as market intermediaries and help with distribution, vegetable marketing is gradually growing. The activity will guarantee a ready market for the goods as well as a reliable source of income for vegetable marketers.

Review of Related Literature

In order to make products from producers available to consumers in the form they desire, at the location they desire, and for a price that is agreeable to both the producers and consumers for effecting a change of possession, Arene (2016) asserts that agricultural marketing encompasses all those physical, legal, and economic services. Agricultural marketing, according to Olukosi et al. (2005), Kohls and Uhl (1998), is the execution of all commercial operations engaged in the flow of commodities and services from the point of starting agricultural production until they are in the hands of the final consumer. This covers the assembly, handling, storage, transportation, processing, wholesale, retail, and export of agricultural commodities, as well as ancillary support services like market information, the creation of grades and standards, the trade in agricultural commodities, financing, and price risk management, as well as the institutions involved in carrying out the aforementioned tasks.

However, socio-economic factors play important roles in marketing and have been studied by various academics. Marketing of agricultural products, such as fruits and vegetables, has historically been a job preference for women and young people in many parts of Nigeria. In their study on the marketing analysis of a few vegetables in Port Harcourt Metropolis, Rivers State, Ikechi and Ayman (2018) discovered that the majority (77.8%) of vegetable marketers were women. While Bakari and Usman (2013) found that the majority (53.33%) of respondents were women and that 58.67% of all respondents were married in the Yola-North and South local government districts of Adamawa state, Nigeria. This suggests that marketing for vegetables is a job that can be done by both men and women, albeit women tend to dominate the industry. It was found by Okonkwo et al. (2020) in the South-South zone of Nigeria, that the mean age of respondents was 38.7 years in the region; age also plays a crucial part in marketing since it aids marketers in carrying out laborious and demanding job. The less physically fit a businessperson is as they age, the more they will need to rely on hired help or agents to carry out their tasks.

According to Arua et al. (2020), another socioeconomic feature trait that affects agricultural marketing is the marital status variable, which is significant in household decision-making and confers responsibility on an individual. In their study, they came to the conclusion that most vegetable marketers in Port Harcourt (55%) were married. In a similar vein, Ibrahim et al. (2020) stated that education and experience are real tools for picking up fresh perspectives and abilities that have a favourable impact on the scope of an enterprise's revenue and profit. In addition, Joyce et al. (2020) reported that 42.8% of the marketers had 6 to 10 years of marketing experience in the Mubi Metropolitan region of Adamawa State, Nigeria. Due to business strategies and networking established over time, marketers who stay with a company for a longer period of time are better prepared to explore business prospects. Ikechi et al. (2018) study on household size found that households with 1-3 people made up the highest percentage (40%) of all households, followed by households with 4-6 people (32%) and 7-9 people (13%), and households with >9 people (5%). This suggests that the majority of marketers had larger households, indicating that these households had more people living in them and required more labor for family care as well as more mouths to feed.

Agricultural marketing, particularly the selling of vegetables, faces many difficulties. Numerous studies have been done that identify various barriers to the selling of vegetables in Nigeria. In their study on the effectiveness of vegetable marketing in peri-urban areas of Ogun State, Nigeria, Isitor et al. (2016) examined the challenges faced by vegetable marketers and found that the top three issues were vegetable spoilage, poor road networks, and insufficient access to capital. According to Bakari and Usman (2013), the two biggest issues facing vegetable traders in Yola's North and South Local Government Areas were inadequate capital and improper storage. In a related study by Ridwan et al. (2021) on Marketing analysis of vegetables in Enugu State, Nigeria, the major challenges faced by vegetable marketers included high shop rent, high transportation costs, low capital, price volatility, poor credit facilities, and a low supply of vegetables due to seasonal variation.

Statement of the Problem

Every home needs a source of vegetables. In addition to being consumed domestically, vegetables like tomatoes also generate foreign exchange for their producer nations through exportation (Haruna et al. 2012). The tomato's high perishability deters many farmers from entering large-scale production and current growers from expanding their scale of production. As a result, both fresh and processed tomato products are expensive and have low productivity. Similar to this, due to its perishable nature, seasonality, and bulkiness, Bulama et al. (2020) classified marketing of vegetables as a complex phenomenon. Agbugba et al. (2013) state that in order to handle the tonnes of vegetables that are produced, an effective marketing mechanism will be necessary. In general, among other known variables, vibrations from transport trucks navigating undulations and imperfections on the roadways are what cause damages and losses in fresh product (Ibeawuchi et al., 2015). These elements may lower the profit that marketers can realize. Despite the fact that vegetables require specialized marketing facilities, the government used to focus more on production than marketing, which led to low productivity in the processing industries and high costs for both fresh and processed goods. According to Bulama et al. (2020), the market infrastructure and systems of better storage infrastructure need to be taken into account to maintain a constant supply of vegetables throughout the year. Examining how produce is obtained and used to close the shortfall gap between supply and demand is crucial to be achieved. Additionally, vegetable marketing will have a huge impact on the rural sector, especially for households in Taraba State, who rely on it as a source of income and subsistence. Marketers of tomatoes, onions, and other vegetables will undoubtedly find the study's conclusions helpful in developing appropriate marketing strategies for their products while reducing marketing expenses. Therefore, in order to ensure that farmers and marketers get a high return on their capital investment, the study aimed at analyzing the key setbacks to marketing of some selected vegetables in Agricultural Zone I (Northern part of Taraba State.

Objective of the Study

The aim of the study was to analyze the setbacks to sustainable vegetable marketing in Northern part of Taraba State, Nigeria. The specific objectives of the study were to:

i. describe the socio- economic characteristics of vegetable marketers in the study area;
ii. examine the factors influencing vegetable marketing in the area; and
iii. identify the constraints associated with vegetable marketing.

MATERIALS AND METHODS

The study area

The study was conducted in Zing, Yorro and Jalingo Local Government Areas (LGAs) of Agricultural Zone I of Taraba State, Nigeria. Agricultural Zone I is made up of six LGAs namely; Jalingo, Ardo-Kola, Zing, Yorro, Lau and Karim-Lamido with their headquarters at Zing, see (Fig. 1). Yorro which happens to be one of the LGAs selected lies between latitude $8^0 53'$ North and longitude $11^0 33'$ East sharing borders with Lau to the North-west, it has a total population of 89,865people (NPC, 2006) census and a land area of 1,160Km^2 with Mika market as one of the major markets. Zing LGA lies between latitude $8^0 53'$ North and longitude $11^0 44'$ East, it has an area of 1,030Km^2 and a population of 127,363people (NPC, 2006) having its major market at Zing main market.

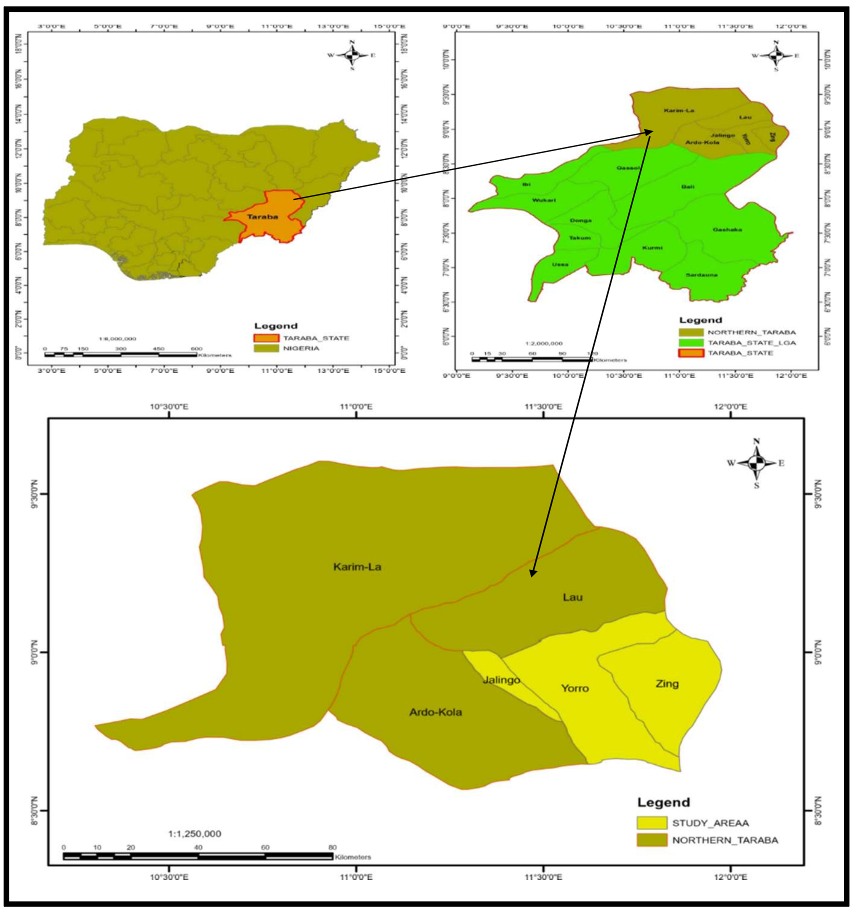

Figure 1: Map of Tararba State, Showing the Study area.
Source: Geography Department. Taraba State University, 2022

Agricultural zone 1

Sampling procedure and sample size
Multi-stage sampling procedure was employed for the study. According to Taraba State Agricultural Development Programme (TADP, 2016), there are four (4) operational zones in the state, namely: - Zone I, II, III and IV. Zone I comprise of Ardo-Kola, Jalingo, Lau, Karim-Lamido, Yorro and Zing LGAs with headquarters at Zing.

In the first stage, purposive sampling was used to select three out of five LGAs in Zone I because of the predominance production and marketing of the produce in the area. Secondly, Snowball sampling procedure enables us to identified major vegetable markets and marketers in the selected LGAs. The three major markets identified were Tashan Lau in Jaligo LGA, Zing town Market in Zing LGA and Mika market in Lau LGA. Thirdly, simple random sampling technique was used in selecting 110 marketers to form the sample size from the sample frame size of 155 marketers as clearly presented in Table I using Yamane (1967) formula as illustrated in equation 1.

Taro Yamane Formula.. $N = \frac{n}{1+n(r2)}$ (1)

Where: n = Sample size, N = Total population of vegetable marketers in the study area, r^2 = Confidence Interval (0.05)

Table1: Distribution of questionnaire administered in the study area

S/No	LGA	Markets	Population	Sampling size
1	Jalingo	Tashan Lau	75	52
2.	Yorro	Mika	34	23
3.	Zing	Zing	46	35
Total	3	3	155	110

Source: Field survey, 2022

Method of Data Collection
The targeted population for the study comprised of vegetable marketers in Agricultural Zone I of Taraba State, Nigeria**.** Data for this study were collected mainly from primary source. This was done manually through the administration of structured questionnaire to the respondents. Questionnaire administration was done by the researcher and some research assistants who were carefully selected and trained. Data collection was done in the month of August to October, 2022.

Analytical Techniques
The analytical tools that were used in analyzing the data collected include the followings: (a) descriptive statistics involved the use of central tendency such as means, percentages, and frequency distributions to describe the socio-economic characteristics of vegetable marketers, objective (i) and constraint associated with vegetable marketing, objectives (iii) and (b) Multiple regression analysis to estimate the factors influencing marketing margin of the marketers, objective (ii). The Economic, econometrics and statistical criteria were used in selecting best functional form among linear, semi log, double log and exponential functions. It is expressed explicitly as seen in equation 2:

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7) + e_i$ (2)

Where:
Y = Marketing Margin (₦)
X_1 = Sex (male=1 otherwise 0)
X_2= Age of the respondents (years)

X_3 = Educational level of the respondents (measured by number of years spent in school)
X_4 = Access to credit (access=1 otherwise 0)
X_5 = Selling Price (₦)
X_6 = Initial capital (₦)
X_7 = Marketing experience (years)
The functional forms that were tried in explicit form are shown in the following equations
Linear Function

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots \beta_7 X_7 + e_i \quad (3)$$

Exponential Function

$$LnY = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots \beta_7 X_7 + e_i \quad (4)$$

Semi-log Function

$$Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \cdots \beta_7 \ln \beta_7 + e_i \quad (5)$$

Double log function

$$LogY = b_0 + b_1 logX_1 + b_2 logX_2 + b_3 logX_3 + \ldots b_7 logX_7 + e_i \quad (6)$$

β_0=intercept
β_1-β_7=estimated parameters
e_i= error term

Explanation of variables

Dependent Variable (Marketing Margin): According to Arene (2003) and Ibrahim et al. (2020), the marketing margin is the difference between the prices paid by producers and consumers for an identical amount and quality of a given good. Among the independent variables are:

Sex is assessed in the model as a dummy variable with a value of 1 for male and 0 for female. It can refer to either of the two sexes (male or female). With expected positive (+) sign.
Age is the number of years that a person has been alive and actively involved in life (the activeness or strength input). This variable on marketing margin is predicted to have a negative relationship. As you get older, your business engagement becomes less active, and vice versa. Educational level**-** it is generally considered an important variable that could enable them have access to business information and technical know-how like credit and information on prices of vegetables. It is measured by number of years spent in school, with expected positive co-efficient.

Access to credit is one of the elements that might help marketers enhance their marketing margins. The capacity for corporate expansion may depend on its availability. This was measured using a dummy variable, with "Yes" denoting credit availability and "No" denoting a marketer's inability to obtain credit. The expected sign of the co-efficient is (+).

Experience in marketing is the duration of time spent in the industry. Most people, Ibrahim et al. (2020) agreed that experienced marketers would be more effective at carrying out the marketing activities and would therefore make more money. Years were used to measure it and the expected sign of the coefficient is positive (+). The researcher used the software E-views, version 10, to analyze the variables affecting the marketers' marketing margin.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents

The majority (60%) of respondents in Table 2 were female, indicating that women are primarily responsible for marketing vegetables in the Zone. This may be due to the widespread perception that women are more successful in marketing than men in terms of gaining favour with consumers and attracting them to their products. Similar results were attained by Ikechi and Ayman (2018) in their investigation of the marketing of particular vegetables in the Port Harcourt Metropolis of Rivers State, Nigeria, where the majority (77.8%) of vegetable marketers were women. Furthermore, it suggests that both men and women can participate in vegetable marketing; however, women are more likely to partake in this business.

Age is an important factor in marketing since it enables marketers to complete difficult tasks. As indicated in Table 2, the average age of vegetable marketers in the study area was assessed to be 39 years old, ranging from 19 to 62 years old. The distribution reveals that the majority of marketers (57.27%) were in the 19–40 age group, with only approximately 43 marketers being 41 years of age or older. This suggests that vegetable marketers were enthusiastic and young. This outcome is consistent with that of Okonkwo et al. (2020), who discovered that respondents' average ages in the South-South Zone of Nigeria were 38.7 years old. A businessperson's ability to physically carry out operations decreases with age, necessitating a greater reliance on hired labor or agents.

The socioeconomic factor of marital status affects household decision-making and bestows accountability on a person. The distribution of respondents' marital status revealed that the majority (66.36%) of them were married, which was consistent with the findings of Arua et al. (2020), who revealed in his study that the majority (55%) of vegetable marketers in Port Harcourt were married. On the other hand, the results showed that over 80% of the marketers attended one type of education or the other. This is in consonants with Ibrahim et al. (2020) who asserted that education is essential for the management and growth of any business. An individual's managerial abilities will be more effective when more literate than an individual that is illiterate.

The success and stability of any business depends on the skill and experience of the manager. Ibrahim *et. al*. (2020) opined that education and experience are veritable tools for acquiring new ideas and skills which reflect positively on the scope of enterprise’s income and profit. The distribution of marketing experience of the respondents in Table 2 showed that over 60 % had marketing experience above 6 years, with a mean of 8years. This result indicated that the marketers are well experienced in vegetable marketing as this may likely have a positive implication on the marketing efficiency. The longer marketers stay on a business, the better they would be equipped in exploring the business opportunities as a result of business tactics and networking developed over the years. This finding corroborate with the results of Joyce *et al*. (2020), on the analysis of fresh tomato retail marketing in Mubi metropolitan area Adamawa State, Nigeria that 42.8% of the marketers had 6 to10 years marketing experience.

Production companies, retailers, consumers, the government, and academic institutions all depend on market intelligence. According to the distribution of respondents depending on their access to market information, which is shown in Table 2, the majority of respondents (89.09%) had this access, while just a small percentage, 10.91%, did not. The inference is that marketers are more likely to make wise marketing decisions that would increase economic returns if they are up to speed with the most recent knowledge about the marketing system.

Table 2: Socio-economic characteristics of the respondents

Variables	Frequency n=110	Percentages (%)	Mean
Sex			
Male	44	40	
Female	66	60	
Age(years)			
≤20	8	7.27	
21-30	24	21.82	
31-40	31	28.18	39
41-50	27	24.55	
≥50	20	18.18	
Min =19			
Max = 62			
Marital status			
Single	22	20.00	
Married	73	66.36	
Divorced	5	4.55	
Widow	10	9.09	
Level of education			
No formal	15	13.64	
Primary	28	25.45	
Secondary	55	50.00	
Tertiary	12	10.91	
Experience(years)			
1-5	41	37.27	
6-10	46	41.82	
11-15	10	9.09	
16-20	7	6.36	8
≥21	6	5.46	
Market information			
Yes	98	89.09	
No	12	10.91	

Source: Field survey, 2022

Factors influencing marketing margin of vegetable marketers

The results as presented in Table 3 depicts the findings of the ordinary least square regression analysis conducted to look at the variables affecting vegetable marketers' marketing margin. Based on monetary, econometric, and statistical considerations, the lead equation was decided upon as the double log function that is equation 10. In all the explanatory variables, 6 out of the 7 explanatory variables included in the model had coefficients that were significant at various levels of significance and had the predicted co-efficient signs except age which had positive sign instead of negative. The factors that were analyzed includes: Sex (X_1), age (X_2), education (X_3), access to credit (X_4), selling price (X_5), initial capita (X_6), and marketing experience (X_7). The data fitted the model well, as shown by the coefficient of determination (R^2) value of 0.8864, which shows that 88.64% of the variation in the marketers' marketing margins can be accounted for by the model's variables. The value of the F-Statistics indicates that the entire model is likewise significant at the 1% level.

It was found that the sex of the marketers did not have any significance in the marketing margin of the business. On the age of the marketers, the calculated age coefficient of 0.234, which is statistically significant at the 5% level, even though contradicts the expected negative sign means that a rise in age will result in an increase in the marketers' marketing margin. This is to be expected because becoming older is likely to bring about a gain in the marketing process in terms of handling, packaging and bargaining with customers to attract more marketing margins. In addition, vegetable marketing requires less hard labour but more of experience, of course in improving the effectiveness of marketing initiatives. The findings agreed with Okonkwo et al. (2020) in the South-South Zone of Nigeria that age also plays a crucial part in marketing since it aids marketers in carrying out marketing functions.

The respondents' level of formal education had a positive coefficient and was significant at 5% level, suggests that the more educated they are the more marketing margin accrued in their businesses. It variably means a percent increases in the level of education increased marketing margin by 3 percent, which is impressive. This result is line with the assertion made by Ibrahim et al. (2020) who stated that education and experience are real tools for picking up fresh perspectives and abilities that have a favourable impact on the scope of an enterprise's revenue and profit. This is paramount to note that education is essential for the marketers to better understand and use the available information and techniques in increasing their profit margin.

Furthermore, increase in respondents' credit access would enable them acquire more modern facilities which will variably result in an increase in the marketers' marketing margin. According to Bulama et al. (2020), the market infrastructure and systems of better storage infrastructure need to be taken into account to maintain a constant supply of vegetables throughout the year. The results in Table 3 indicated that access to credit facilities positively increase the marketing margin of the marketers in the area. It also means that a percent increase in credit facilities will increase the vegetable marketing margin by 2 percent in the Zone which is commendable and encouraging if facilitated. According to the coefficient of selling price, a rise in the selling price of a marketer would result in an increase in the marketer's marketing margin. This implies that as the selling price rises by a percent, the marketing margin appreciably rises by 66 percent while all other variables remain constant. This result depicts to us that in all the variables’, selling mechanism is a key factor in determining the marketing margin in vegetable business. The results is in conformity with the findings of Ndaghu et al. (2010), who found that the structure and practices of vegetable selling in the Gombe State, Local Government Area of Kwadom Yalmatu Deba showed non-competitive pricing behavior and inequality in incomes among the merchants.

Initial capital is statistically significant at the 1% probability level and positively affected the marketing margin of marketers in the research area. This might be anticipated because marketers who invest a lot of money should have a bigger marketing margin because marketing activities benefit from economies of scale. On the other hand, the positive coefficient of marketing experience in vegetable marketing led to an increase in marketing margin. It shows that experience is statistically significant at 1% level and a percent increase in year of experience of the marketers will increase marketing margin by 26 percent keeping other variables constant. This indicates that more seasoned marketers generate better sales margins than less seasoned ones. In a similar vein, Ibrahim et al. (2020) stated that experience are real tools for picking up fresh perspectives and abilities that have a favourable impact on the scope of an enterprise's revenue and profit.

Table 3: Factors influencing the marketing margin of marketers

Variables	Coefficient	Standard error	t-ratios
Sex (x_1)	0.012	0.009	1.36
Age (x_2)	0.234	0.099	2.35**
Education (x_3)	0.032	0.013	2.50**
Access to credit (x_4)	0.024	0.011	2.22**
Selling price (x_5)	0.667	0.065	10.34***
Initial capital (x_6)	0.192	0.063	3.04***
Experience (x_7)	0.266	0.073	3.65***
Constant	-0.714	0.287	-2.49**

Source: Field survey, 2022
R-squared = 0.8864, Adj R-squared = 0.8786
F (7, 102) = 113.74***, Prob > F = 0.0000
***P<0.01 ** P<0.05 *P<0.10

Constraints associated with vegetable marketing

The results of constraints to vegetable marketing are as shown on Table 4. The results revealed that the most severe constraints to vegetable marketing were price fluctuation (89.09%) and perishability (72.73%) as they were ranked first and second respectively. Similar results were obtained by Oladejo and Oladiran (2014) in Oyo State Nigeria where 78.8% of tomato marketers faced the problem of rapid deterioration in tomato quality due to the perishable nature of tomato. The challenge of price fluctuation could be as a result of low production caused by problem of seasonality. This finding also agreed with that of Arua *et al*. (2020) in Onitsha Metropolis of Anambra State, that vegetable prices increase during the off season. It was also reported that the seasonal nature of tomato production is considered as bottlenecks which hampers all years round availability and causes fluctuation in prices of the product. Considering the inadequate storage facilities and high perishability, farmers are easily exploited by the wholesaler and are forced to sell their produce at low prices thereby earning low profit from the business.

Table 4: Constraints of vegetable marketing in the study area (n=110)

Constraints	Frequency n=100	Percentage (%)	Rank
Price fluctuation	98	89.09	1
Perishability (spoilage)	80	72.73	2
Inadequate credit facility	50	45.45	3
Inadequate storage facilities	45	40.91	4
Irregular supply	42	38.18	5
Seasonality	35	31.82	6
Low price of the commodity	21	19.09	7
Location not strategic enough	15	13.64	8
High cost of production	10	9.09	9
Inadequate market information	9	8.18	10
High marketing commission	6	5.45	11

Source: Field survey, 2022
Multiple response*

CONCLUSION AND RECOMMENDATIONS

The findings from the study showed that vegetable marketing was characterized with several menaces in Agricultural Zone I of Taraba State. Furthermore, it was revealed that the women dominated the business that was bedeviled by constraints which were predominantly price fluctuation and perishable (spoilage) nature of the produce.

Based on the findings of this study, the following recommendations were made

- Government should improve rural infrastructure (poor feeder roads) which would facilitate faster delivery of vegetables to reduce spoilage.
- There is need for marketers to be educated by the NGOs on efficient vegetable storage methods as this would reduce spoilage and economic losses.

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Factors Affecting the Utilization of Improved (*Taro*) Cocoyam Production Technologies among Farmers in Abia state, Nigeria

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Abstract
The study focused on factors affecting the use of improved Taro Cocoyam production technologies in Abia state. Specifically, the study ascertained cocoyam technologies that had been transferred to farmers; identified source (s) of information on cocoyam production technologies to farmers; assessed the level of utilization of cocoyam production technologies by farmers in the study area; and ascertained the socio-economic factors that significantly influence utilization of improved technologies on cocoyam production in Abia State, Nigeria. A multistage random sampling technique was used to select 90 taro (cocoyam) farmers. Objectives were achieved using simple descriptive statistics and an O L S multiple regression model Data were collected using a questionnaire. The results show that the main technology transferred). was a 25g set of cocoyam (80%), Time of planting (May -June) (68.89%), and Crop mixture (Arable Cropping) (64.44). The result of the use of cocoyam technologies revealed that a 25g set ($\bar{X}$= 2.878), use of mulching materials has a mean of ($\bar{X}$= 2.822); Time of planting (May -June) ($\bar{X}$= 2.8) and spacing (100cm × 50cm) ($\bar{X}$=2.6) have a high level of utilization of cocoyam techniques. OLS estimate on socio-economic factors influencing the use of improved cocoyam technology shows that a positive relationship exists between education attainment, farmer experience, household size and labour, there is an inverse relationship between Farm sizes of the farmers. The study therefore recommended that an awareness creation in the use of the various technologies by extension would be a necessary step towards increased cultivation and production of cocoyam.
Keywords: Utilization, improved cocoyam, Production technologies,

INTRODUCTION

Taro (Cocoyam) is grown in the tropical regions of the world especially in Africa, where it is cultivated for food (Food and Agricultural Organization, (FAO), 2015). the has improved the economic growth performance in Nigeria . The food crop which is mainly grown in the rural communities across Africa by subsistent farmers is highly valued among other tuber and root crops consumed among different households, the high cost of production is mainly due to the high labour requirement during cultivation amid the use of indigenous planting materials, application of total weed controls as well as limited value addition have led to a general decline of the cocoyam subsector (Boakye-Achampong, *et al*. 2017). Based on this the National Root Crop Research Institute (NRCRI) Umudike which had the national mandate to research root and tuber crops developed some processing technologies to reduce the perishability of the products and add value to these crops. The essence is to ensure that these crops can be put to wider use in the home, for income generation and probably for export purposes.

To this effect, groups and individuals all over Nigeria appreciated this development and requested to be trained in those technologies.

METHODOLOGY

The study was carried out in Abia State. Abia State is one of the 36 states of Nigeria and lies in the South-eastern of Nigeria with Ariaria international market, Aba as its capital and largest city. Aba was divided into two local government areas namely; Aba south and Aba North. Aba south is the main city centre and the heartbeat of Abia State, south-east Nigeria. Aba comprises many villages such as; Umuokpoji Aba, Eziukwu-Aba, Obuda-Aba, Aba Ukwu and other villages from Ohazu merged due to administrative convenience. A multi-stage random sampling technique was used to select 90 taro cocoyam farmers, used as respondents for the study. Data for this study were collected from primary sources. Objectives i, ii and iii were achieved using simple descriptive statistics while **iv** was tested using the O L S multiple regression the model.

Table 1: Level of Utilization of Cocoyam Farming Technologies

Technologies	Always	Sometimes	Never	Mean	Std. Dev.	Remark
25g sett of cocoyam	81	7	2	2.878	0.4786	Accepted
Time of planting (May - June)	75	12	3	2.800	0.3691	Accepted
Spacing adopted(100cm × 50cm)	58	28	4	2.600	0.3250	Accepted
Use of mulching materials	76	12	2	2.822	0.1763	Accepted
Fertilizer (NPK 20:10:10)	31	50	9	2.244	0.6237	Accepted
Planting depth (10 cm)	33	53	4	2.322	0.5574	Accepted
Pest control	18	61	11	2.078	0.5654	Accepted
Weed control	50	36	4	2.511	0.5853	Accepted
Crop mixture (Tree Cropping)	4	3	83	1.122	0.2881	Rejected
Crop mixture (Arable Cropping)	28	45	17	2.122	0.7004	Accepted
Use of manure	22	49	19	2.033	0.6779	Accepted
Side dressing application	5	12	73	1.244	0.5469	Rejected
Harvesting (8-12 months)	33	39	18	2.167	0.7382	Accepted
Grand mean				**2.226**		

Source: Field Survey, 2024. Decision mean ≥ 2.0

From the result eleven (11) of the variables in the table were accepted by the mean range used for decision which is 2.0 and above. 25g sett of cocoyam has on the average the highest mean ($\overline{X}$= 2.878) i.e., the farmers indicated strong agreement to the statement; this was followed by “Use of mulching materials has a mean of ($\bar{X}$= 2.822); this was followed by “Time of planting (May -June)” has mean of ($\bar{X}$= 2.8); this was followed by “Spacing adopted (100cm × 50cm)” ($\overline{X}$=2.6). Others are shown in the table. Also, from the table two items were rejected since they were less than 2.0, which were Crop mixture (Tree Cropping) and Side dressing application. Furthermore, the clustered mean was 2.226 which was accepted, this, therefore, implies that there is a high level of cocoyam storage techniques by farmers in the study area.

Table 2: Socio-economic factors influencing utilization of improved cocoyam technology

Variables	+Linear	Exponential	Semi log	Double log
Intercept	110083.6	5.599027	-19095.61	-1.925356
	(1.55)	(11.37)***	(-0.11)	(-8.41)**
Sex	0.0454642	3.28e-07	31092.77	0.0598499
	(1.10)	(1.14)	(5.20)***	(7.35)***
Age of the farmers	6805.75	0.5813647	1.247883	2.87e-06
	(1.43)	(17.55)	(1.58)	(2.67)***
Education attainment	0.097208	3.28e-07	42739.53	0.8308869
	(2.52)**	(1.23)	(1.58)	(22.56)***
Farmer experience	0.2402157	5.22e-06	49136.12	0.0954723
	(4.55)***	(14.23)***	(1.92)**	(2.74)***
Household size	0.4003172	3.02e-06	-2373.839	-0.0151381
	(2.65)***	(2.87)***	(-0.30)	(-1.38)
Farm size	-0.0898305	3.38e-07	-45090.88	-0.0202486
	(-3.01)***	(1.63)***	(-4.62)***	(-1.52)
Labour	90644.12	0.1732413	463944.8	0.9494328
	(72.76)***	(20.01)***	(44.60)***	(66.99)***
Access to credit	2568.89	0.031459	34058.04	0.0140612
	(0.91)	(1.60)*	(3.49)***	(1.06)
Extension contact	0.1027072	7.18e-07	9609.037	0.0149972
	(0.74)	(0.75)	(1.07)	(1.23)
R^2	0.724	0.612	0.711	0.691
R^{-2}	0.698	0.576	0.683	0.661
F-ratio	28.333***	17.015***	25.083***	22.808***

Source: field survey (2024) + lead equation, *** Significant at 1%, ** Significant at 5%, *significant at 10%.

Table 2 shows the results of ordinary least square regression (OLS) the models (linear, exponential, semi-log and double-log) were tried. the linear functional form was chosen as the lead equation. The R^2 value of 0.724 implies that the specified explanatory variables explained about 96.6% of the total variables in profit. The F-statistic of 28.333 which is statistically significant at 1% probability level, indicate that the equation has the goodness of fit Five out of nine variables significantly influenced the level of utilization of cocoyam farming technologies. The Table shows that a positive relationship exists between education, farming experience, household size and labour. This implies that as more of these variables are employed, there will be an increase in the utilization of cocoyam farming technologies. The result also shows that there is an inverse relationship between Farm size of the farmers. Education, farmers experience, household size. were positive and significantly influenced the level of utilization of cocoyam technologies at 5% and 1% level respectively. This showed that an increase in one year of education and years spent in farming increase the level of utilization some particular technologies for cocoyam farmers in the study area. The implication is that more years of formal education will help cocoyam farmers to increase their literacy level and this is an asset as the farmers would be exposed to many information sources and innovations such as improve farming technologies. This is in agreement with the findings of Okute (2017) where he reported that the educational level of farmers is expected to increase level utilization. The coefficient of household size was positive and significant at 5%. This implies that increase in the household size will lead to increase in level of utilization of cocoyam farming technologies. This connect with finding of Nzeakor *et al*., (2021) where they obtained a positive relationship between household size and level of utilization of new innovation. The coefficient of labour and farm size were positive and statistically significant at 1% level. This implies that an increase in number of workers in the farm, increases the level of utilization of cocoyam farming technologies. The plausible reason may be that more workers in the farm is significant enough to carry out major operation in the farm. Also, the result shows that an increase in the farm size will lead to decrease in level of utilization of cocoyam farming technologies in the area.

CONCLUSION AND RECOMMENDATIONS

Based on this finding it can be concluded that there is high level of utilization of cocoyam production technology in Abia State, Nigeria which is attributed to opulence of technical information on improved cocoyam production technology in the area among the cocoyam farmers studied. Also education attainment, farmer experience, household size, labour and farm size of the farmers has significant influence on level of utilization of cocoyam production technology by farmers in the study area.

The study recommends as follows:

i. Awareness creation in the use of the various technologies by extension would be a necessary step towards increased cultivation and production of cocoyam.
ii. The study also revealed that education and farming experience were positive. The result therefore calls for policies aimed at provision of free education ~~esp~~ecially to the girl – child and encourage those who are experience to study the production and increase utilization of cocoyam technologies.

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PROCEEDINGS

Effects of Varying Dietary Levels of *Moringa oleifera* and *Ocimum gratissimum* Leaf Meals on Faecal Oocyst and Egg Worm Counts of Cockerels and Egg-type Chickens

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Abstract
The effect of varying dietary levels of leaf meals of Moringa oleifera (MOLM), Ocimum gratissimum (OGLM) and their combinations (MOLM/OGLM) on faecal oocyst and egg worms count of cockerels and egg-type chickens was evaluated. Four hundred and five ISA strain layer birds from day old to 16th and 35th weeks were used. The experimental birds were allocated randomly to nine treatment groups. Each group comprised of 45 birds in a treatment with three replications of fifteen birds each. The leaf meal were incorporated at 0, 0.5 and 1.0% into the diets. Birds on the control (0%) treatment were given antibiotics, antihelminthics, coccidiostat, and vitamins when due. The experiment was laid out in a 3x3 factorial arrangement. Data were collected on faecal count and oocyst, egg worms count, and subjected to analysis of variance as in Completely Randomized Design (CRD). It was observed that birds on OGLM and MOLM/OGLM had the least faecal oocyst and egg worms count. Neither oocyst (0.00 epg) nor egg worms (0.00 epg) were found in the faeces of birds on 1.0% inclusion of OGLM and MOLM/OGLM.

Keywords: Egg-type chicken; cockerels; faecal-oocyst; egg-worm; Moringa oleifera; Ocimum gratissimum.

INTRODUCTION

Commercial poultry production has been the key to continuous and sustainable protein availability and supply to the human population. This had led to improvements in technologies in management operations. Therefore, the intensive system of operation is accepted the world over. However, the industry is confronted with the problem of diseases and antibiotic drug resistance.

Antibiotics have been used over decades in animal production with their attendant benefits such as improved growth rate, improved feed conversion and reduced mortality and morbidity in farm animals (1). The future and usage of these drugs have come under scrutiny in recent times due to residues left in meat, egg and other animal products and the increasingly reported cases of microbial resistance to these drugs in humans. The European Union banned their use due to the danger of drug residues in animal products and the health hazards to human health (2).

Apart from the deadly bacteria and viruses, parasitic diseases such as gastrointestinal infections are also a major threat requiring the use of various synthetic drugs. These invariably increase the cost of production and lead to low productivity.

Parasitic gastroenteritis includes but is not limited to helminth (worms) and protozoan (especially coccidia) infections. They inflict serious damage leading to great economic loss to poultry production. These parasites get into their guts through ingestion from contaminated soils, litter materials (especially for birds raised on the floor) or feed materials.

Coccidia infection affects all age groups in poultry causing poor feed conversion efficiency and death in most cases. They are difficult to eradicate completely due to their endemic nature, especially in the tropics. The problem is more serious when birds are raised on the floor in an intensive system due to splashing or leaking of water at drinking points and feeding areas, and because of the concentration of birds (3).

Among the most common helminth parasites of poultry in the tropics is *Ascaridia spp*. especially *Ascaridia galli*. They affect both young and adult birds. They seem to be one of the major threats in the intensive system especially where birds are raised on the floor since flies can carry worm eggs too (4). The eradication method remains the use of drugs which may be resisted by the organisms over time.

Reports have shown that some of the herbal preparations have hepato-protective characteristics, stimulate growth and improve liver functioning thereby leading to increased efficiency of feed utilization as well as higher profitability (7).

The phytochemicals in these plants have healing values which yield some positive actions in human and animals. Alkaloids, flavonoids, phenolic and tannins compounds are among the most essential of these phytochemicals (9;10).

Ocimum species (basil) and *Moringa oleifera* (Moringa) species are herbs of importance with great economic and medicinal value (15). *Tulsi (Ocimum sanctum)* leaf powder supplemented in broiler diet for 42 days at the rate of 1% was reported to have brought down the meat and blood cholesterol levels (11). According to (18) varying levels of inclusion of *Moringa oleifera* leaf meal in cassava chip-based diets fed to commercial egg-laying birds is possible with up to 10% inclusion without negative effects on egg quality parameters. The inclusion also had the benefit of enhanced acceptability.

This research, therefore, investigated the effects of varying levels of inclusion of *Moringa oleifera* (Moringa) and *Ocimum gratissimum* (Basil) leaf meals, singly and in combination on the population of oocyst and egg worms in feaces of cockerels and egg-type chickens fed with the leaf meals.

MATERIALS AND METHODS

The study was conducted at the Poultry Unit of the Directorate of University Farms (DUFARM), Federal University of Agriculture (FUNAAB), Abeokuta, Ogun State, Nigeria. This area lies in the interior part of the Southwestern region of Nigeria which is on latitude 7°15´N and longitude 3°26´E and an altitude of 76m above sea level as recorded by (19). It is a humid environment with; 1,037mm mean annual rainfall, 82% average relative humidity and 34.7°C average temperature. It is vegetation that interfaces between the tropical rainforest and derived savanna.

Collection and Identification of *M. oleifera* and *O. gratissimum*
The leaves of *M. oleifera* and *O. gratissimum* were harvested (March 2012 to June 2013) from established plantations at Camp, Alabata Road and Ajebo Road, in Abeokuta, Ogun state Nigeria. The farms were not close to manufacturing industries and highways therefore, the risks of dust and hydrocarbon contamination or deposits on the leaves were minimal. The two plants were taken to the herbaria of the Forest Research Institute of Nigeria (FRIN) in Ibadan, Oyo State, and the Department of Botany, College of Natural Science (COLNAS), Federal University of Agriculture Abeokuta (FUNAAB) for proper identification.

Processing of *M. oleifera and O. gratissimum Leaves*
The leaves of the two plants were separately dried for 3-5 days (sun drying) to reduce the antinutritional content and attain a constant weight. They were separately milled using a blender to give the leaf meals of particle size 2mm – 4mm.

Phytochemical analyses of *M. oleifera and O. gratissimum* leaf meals
The leaf meals of *M. oleifera* and *O. gratissimum* were analysed for some of their phytochemical contents at the Nigerian Institute of Science Laboratory Technology (NISLT) Samanda, Ibadan, Oyo state. Flavonoids, Phenolics, Saponins, and Tannins were the active constituents tested for.

At room temperature, 100 g of each of the leaf meals were separately soaked in 500 ml of distilled water in 1000 ml size clean and dry conical flasks for 72 hours. The contents were then filtered using Whatman No. 1 filter paper. The filtrates were evaporated to dryness gradually, then kept in distinct clean dry bottles and preserved at room temperature until required. The screening of the extracts was carried out for the presence of flavonoids, phenolics, saponins and tannins as described by (20) and (21).
Management of experimental birds.

“ISA” strains of day-old cockerels and egg-type chickens were gotten from a commercial hatchery (Avian Specialities Limited) in Ibadan, the capital of Oyo state Nigeria. 405 birds each of the cockerels and egg-type chickens were brooded for 4 weeks. On the 1^{first} day, the birds were vaccinated against Marek’s disease (MDi/o) and Newcastle disease (NCDVi/o). Gumboro disease vaccine was given by medication in their drinking water and fowl pox disease vaccine was given by a jab on the wing web in the third and sixth week respectively. In the first three days, an anti-stress drug (Vitalyte®) was given via drinking water to the control group. Also, an antibiotic (Keproceryl®) was given from the third to the seventh day and subsequently at 8 weeks intervals. Anticoccidial (Vazuril®) and antihelminth (Coccimet®) drugs were also administered to the control group only via drinking water. The birds on leaf meals were deprived of these prophylactic procedures.

A deep litter system was employed using wood shavings of 5 to 8cm at the chick’s phase and 15 to 20cm at the growing/adult phase as the bedding material. With adequate feeding, water and ventilation, the birds were nurtured to the 16^{th} and 35th weeks of age.
Experimental Layout.

The birds were randomly distributed into nine dietary treatment groups comprising three replicates per treatment. Each replicates had 15 birds which make up 45 birds per treatment. These replicates were raised in an open sided poultry pens measuring 3.12 x 1.15m each.

Experimental diets

The various inclusion levels of *Moringa oleifera* leaf meal (MOLM) and *Ocimum gratissimum* leaf meal (OGLM) replaced wheat offal in the experimental diets were as follows:

Treatment one; 0.0 percent inclusion of leaf meals (control diet).
Treatment two; 0.5 percent inclusion of *Moringa oleifera* leaf meal (0.5% MOLM).
Treatment three; 1.0 percent inclusion of *Moringa oleifera* leaf meal (1.0% MOLM)
Treatment four; 0.0 percent inclusion of leaf meals (control diet)
Treatment five; 0.5 percent inclusion of *Ocimum gratissimum* leaf meal (0.5% OGLM)
Treatment six; 1.0 percent inclusion of *Ocimum gratissimum* leaf meal (1.0% OGLM)
Treatment seven; 0.0 percent inclusion of leaf meals (control diet)
Treatment eight; 0.25 percent inclusion of *Moringa oleifera* leaf meal and 0.25 percent of *Ocimum gratissimum* leaf meal (0.25% MOLM and 0.25% OGLM)
Treatment nine; 0.5 percent inclusion of *Moringa oleifera* leaf meal and 0.5 percent of *Ocimum gratissimum* leaf meal (0.5% MOLM and 0.5% OGLM).

The experimental diets (%) for the starter and grower phases were shown in Tables 1 and 2, respectively, while the layer's diet was shown in Table three. Treatments one, four and seven were the control groups and they were the same in physical and analyzed composition. They were therefore represented by treatment 1 (0.0%) on the tables. The birds were fed a starter diet from day-old to 4th week, and a grower's diet from 4th to 16th weeks respectively. The layer's diet was fed from the 19th to the 35th week.

Table 1: Diets composition (%) for the starter phase

		MOLM		OGLM		MOLM/OGLM	
Ingredients	0.0%	0.5%	1.0%	0.5%	1.0%	0.50%	1.0%
Maize	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Fish meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Soybean meal	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Palm kernel meal	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Wheat offal	23.00	22.50	22.00	22.50	22.00	22.50	22.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Oyster shell	2.00	2.00	2.00	2.00	2.00	2.00	2.00
MOLM	0.00	0.50	1.00	0.00	0.00	0.25	0.50
OGLM	0.00	0.00	0.00	0.50	1.00	0.25	0.50
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
*Vit/mineral premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt (Nacl)	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100
Calculated analysis (%)							
Crude protein	19.61	19.66	19.70	19.59	19.57	19.62	19.63
Calcium	2.00	2.12	2.24	2.00	2.00	2.05	2.12
Phosphorus	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Energy (Kcal/Kg	2609.94	2600.69	2591.44	2600.69	2591.44	2600.69	2591.44

*Composition of Vitamin/Mineral Premix: vit. B_1 (1g); B_2 (6g); B_{12} (0.02g); BHT (5g); Biotin (0.05g); Ca-Pantothenate (15g); Choline chloride (250g); Co (0.4g); Cu (8g); E (30g); Fe (32g); Folic acid (1.5g); I (0.8g); K_3 (3g); Mn (64g); Nicotinic acid (30g); Se (0.16g); Zn (40g).MOLM/OGLM = *Moringa oleifera/Ocimum gratissimum* leaf meals

Table 2: Diets composition (%) for the grower phase

		MOLM		OGLM		MOLM/OGLM	
Ingredients	0.0%	0.5%	1.0%	0.5%	1.0%	0.5%	1.0%
Maize	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Soybean meal	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Wheat offal	31.00	30.50	30.00	30.50	30.00	30.50	30.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Oyster shell	2.00	2.00	2.00	2.00	2.00	2.00	2.00
MOLM	0.00	0.50	1.00	0.00	0.00	0.25	0.5
OGLM	0.00	0.00	0.00	0.50	1.00	0.25	0.5
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
*Vit/mineral premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt (Nacl)	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100
Calculateded analysis (%)							
Crude protein	15.90	15.99	15.95	15.88	15.86	15.91	15.92
Calcium	1.80	1.92	2.04	1.80	1.80	1.86	1.92
Phosphorus	0.60	0.60	0.60	0.60	0.56	0.54	0.63
Energy (Kcal/Kg)	2628.30	2619.05	2609.80	2619.05	2609.80	2619.00	2609.80

* Composition of Vitamin/Mineral Premix Vit. A (10 000 000iu); B_6 (1.30g); B_{12} (0.01g); Biotin (0.02g); D_3 (2 000 000iu); B_1 (1.30g) B_2 (4.00g); BHT (50.00g); D Calcium-Pantothenate, (1.30g); choline chloride (200.00g); Co (0.20g); Cu (5.00g); E (12 500iu); Fe (25.00g); Folic acid (0.05g); I (0.06g); K (1.30g); Mn (48.00g); Nicotinic acid (15.00g); Se (0.10g); Zn (45.00g). MOLM/OGLM = *Moringa oleifera*/*Ocimum gratissimum* leaf meals

Table 3: Experimental diets (%) for Laying phase (from 19 weeks)

		MOLM		OGLM		MOLM/OGLM	
Ingredients	0.0%	0.5%	1.0%	0.5%	1.0%	0.5%	1.0%
Maize	45.00	45.00	45.00	45.00	45.00	45.00	45.00
Soybean meal	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Palm kernel meal	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Wheat offal	15.00	14.50	14.00	14.50	14.00	14.50	14.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Oyster shell	7.00	7.00	7.00	7.00	7.00	7.00	7.00
MOLM	0.00	0.50	1.00	0.00	0.00	0.25	0.50
OGLM	0.00	0.00	0.00	0.50	1.00	0.25	0.50
Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt (Nacl)	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100
Determined analysis (%)							
Crude protein	17.26	17.32	17.39	17.23	17.21	17.28	17.30
Ether Extract	0.37	0.37	0.37	0.38	0.38	0.37	0.38
Crude fibre	0.50	0.50	0.51	0.49	0.49	0.50	0.50
Ash	0.23	0.23	0.23	0.24	0.25	0.23	0.24
Calcium	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Energy (Kcal/Kg)	2575.90	2566.65	2557.40	2566.65	2557.40	2566.65	2557.40

* Composition of Vitamin/Mineral Premix: Vits. A (10 000 000iu); B_{12} (10mg); BHT (5 000mg); Biotin (40mg); choline (275 000mg); Co (300mg); Cu (7 000mg); D_3 (2 000 000iu); D-Pantothenic acid (8 000mg); E (13 000iu); Fe (58 000mg); Folic acid (500mg); Riboflavin (5 000mg); Mn (48 000mg); I (60mg); Methionine (20 000mg); Nicotinic acid (28 000mg); Pyridoxine (1300mg); Thiamine (1300mg); Se (120mg); Zn (58 000mg). MOLM/OGLM = *Moringa oleifera*/*Ocimum gratissimum* leaf meals

Oocyst and egg worm counts

At week one (beginning of the experiment), week nine and week sixteen, faecal samples were taken each from 2 birds per replicate with sterilised swab sticks for oocyst and egg worm counts. The McMaster method was adopted in analyzing these samples at the parasitological laboratory, College of Veterinary Medicine, Federal University of Agriculture, Abeokuta as follows:

- 3.0g of faecal sample was weighed if diarrhoeic, 3 teaspoonful.
- The weighted sample was thoroughly broken up in 42ml of water in a plastic vessel with the aid of a homogenizer containing glass beads.
- It was emptied into a mesh sieve (fine) of aperture 100 x 100 to 1 sq inch).
- The filtrate was collected, agitated, and then filled up into a 15ml test tube.
- The tubes were then centrifuged at 2000 revolution/minute for two minutes.
- Next was pouring off the supernatant, then, the sediments were agitated, and tubes filled to initial level with flotation solution (salt/sugar).
- The tube was inverted simultaneously six times and then, the fluid was pipetted to fill both chambers of McMaster slide. Because of the quick rising of the eggs in the flotation fluid, no fluid was left in the pipette.
- Under each etched area, the number of eggs or larvae examined was multiplied by 100. If the chambers are two, it will be multiplied by 50, so as to calculate the number of eggs per gram of faeces (epg) thus:

A total volume of 45ml implies that 3g of faeces had been dissolved in 42ml of water. Therefore, 15ml implies that 1g had been dissolved, thus; under an etched area, the volume will be 0.15ml. Then the quantity of eggs was multiplied by 100, and if the number of chambers observed were two, it would be multiplied by 50 (22). The oocyst count was also carried out using this method.

Statistical Analysis

The experiment was arranged in a 3 x 3 factorial layout. Then, data generated were computed and subjected to analysis of variance (ANOVA) as in a completely randomized design (23). Significantly ($P<0.05$) different means were compared using Duncan's Multiple Range Test as contained in the same statistical package.

RESULTS AND DISCUSSION

Phytochemicals in M. Oleifera and O. gratissimum leaf meals

Table 4 shows some phytochemicals in *M. oleifera* and *O. gratissimum* leaf meals. Except for tannin that was relatively higher (1.20%) in MOLM than that of OGLM (0.36%), all other phytochemicals in OGLM were relatively higher than those in MOLM; Saponin; 0.52% in OGLM and 0.14% in MOLM, phenol; 1.23% in OGLM and 0.46% in MOLM, flavonoid; 2.19% in OGLM and 1.69% in MOLM.

Table 4: Phytochemicals of leaf meals of *M. oleifera and O. gratissimum* per 100g sample

Phytochemicals	*M. oleifera*	*O. gratissimum*
Tannin (%)	1.20	0.36
Saponin (%)	0.14	0.52
Phenol (%)	0.46	1.23
Flavonoids (%)	1.69	2.19

Graphical representation of the effects of varying dietary levels of *M. oleifera* and *O. gratissimum* leaf meals on faecal oocyst count of cockerels

Figure 1 presents the graphical representation of main effect of varying dietary levels of *M. oleifera* and *O. gratissimum* leaf meals on faecal oocyst count of cockerels. There were no oocyst in the faeces in week one. In week eight, there was a rise in faecal oocyst count with birds on MOLM having the highest value of 222.22 opg while birds on the inclusion of OGLM and MOLM/OGLM had the same value; 88.89 opg. At week sixteen, there was a decrease in the count, birds on the inclusion of MOLM still had the highest count of 161.11 opg; birds on OGLM had 61.11 opg while birds on the inclusion of MOLM/OGLM had the least count of 38.89 opg.

At various levels of leaf meal inclusion (Figure 2), birds on 0.5% MOLM had the highest count of 177.78 opg while birds on 1.0% inclusion of OGLM and MOLM/OGLM had the least count of 0.00 opg.

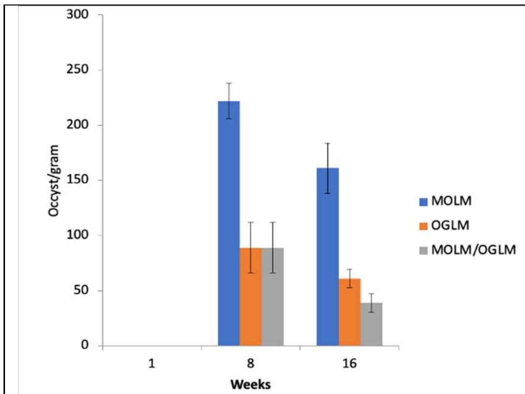

Figure 1: Effect of alternating dietary levels of MOLM and OGLM on faecal oocyst count of Cockerels

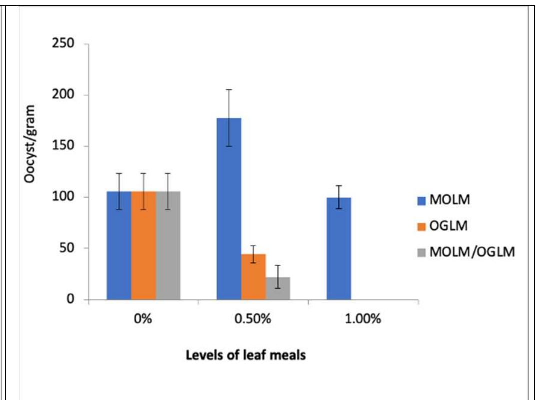

Figure 2: Effect of alternating dietary levels of MOLM and OGLM on faecal oocyst count of Cockerels

Graphical representation of the effect of varying dietary levels of *M. oleifera* and O. gratissimum leaf meals on faecal oocyst count of egg-type chickens

Figure 3 shows the bar chart representation of the effect of alternating dietary levels of *M. oleifera* and *O. gratissimum* leaf meals on faecal oocyst count of egg-type chickens. In week one, no oocyst was found. In week eight, there was high rise in oocyst count; 266.67 opg for birds on the inclusion of MOLM, 200.00 opg for birds on the inclusion of OGLM and 188.89 opg for birds on the inclusion of MOLM/OGLM. Oocysts count decreased sharply in week 16; 16.67 opg for birds on the inclusion of MOLM while it was 0.00 opg for birds on the inclusion of OGLM and MOLM/OGLM. In week 24, there was an increase in count, birds on the inclusion of MOLM had the highest count of 122.22 opg and the least 5.55 opg for birds on the inclusion of MOLM/OGLM. In week 32, there was an increase in oocyst count again with the highest 177.78 opg for birds on the inclusion of MOLM and the least 100.00 opg for birds on OGLM.

There was a decrease in oocyst count across the levels of the leaf meals (Figure 4). Birds on 0% inclusion of leaf meals had the highest oocyst count of 160.00 opg, while birds on 1.0% inclusion of OGLM and MOLM/OGLM had the least count of 0.00opg.

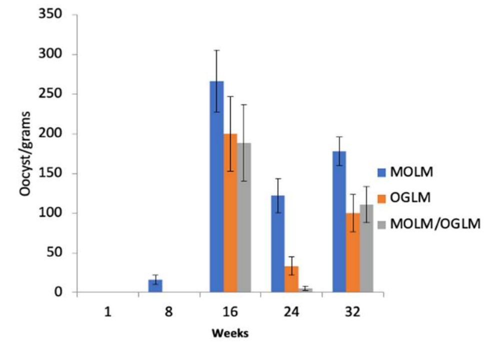

Figure 3: Effect of alternating dietary levels of MOLM and OGLM on faecal oocyst count of egg-type chickens

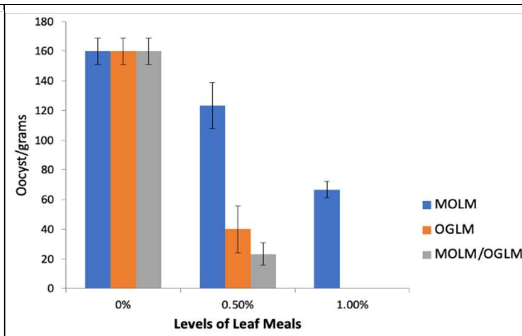

Figure 4: Effect of alternating dietary levels of MOLM and OGLM on faecal oocyst count of egg-type chickens

Graphical representation of the effect of varying dietary levels of *M. oleifera* and *O. gratissimum* leaf meals on faecal egg-worm count of cockerels

There were no egg-worms in the faeces of cockerels in week one (Figure 5). However, in week eight, there were egg worms (38.89 epg) in faeces of birds on MOLM which decreased to 27.78 epg in week sixteen. Birds on OGLM had the same egg-worm count in weeks eight and sixteen while egg-worm was not found in the faeces of birds on MOLM/OGLM.

At various levels of leaf meal inclusion (Figure 6), there were no egg-worms in the faeces of cockerels on 0% inclusion of leaf meal. At 0.5%, faecal egg-worm count was high (33.33 epg) for birds on inclusion of MOLM and low (11.11 epg) for birds on inclusion of OGLM while there was none (0.00 epg) for birds on inclusion of MOLM/OGLM. At 1.0%, only birds on inclusion of MOLM had egg-worms in their faeces (33.33 epg).

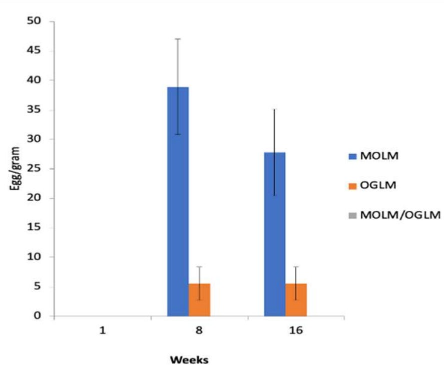

Figure 5: Effect of alternating dietary levels of MOLM and OGLM on faecal egg worm count of Cockerels

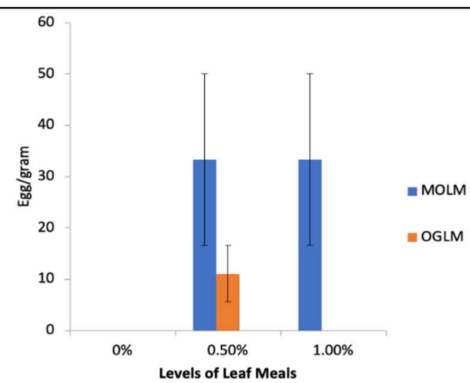

Figure 6: Effect of varying dietary levels of MOLM and OGLM on faecal egg worm count of Cockerels

Graphical representation of effect of varying dietary levels of *M. oleifera* and *O. gratissimum* leaf meal on faecal egg-worm count of egg-type chickens

The effect of alternating dietary levels of *M. oleifera* and *O. gratissimum* leaf meals on faecal egg-worm count of egg-type chicken was presented in Figure 7. There were no egg worms in faeces in week one. In week eight, only birds on MOLM had egg worms (11.11 epg) in their faeces. In week 16, there was a rise in faecal egg-worm count, it was decreasing across the leaf meals; 88.89 epg for birds on the inclusion of MOLM, 68.89 epg for birds on the inclusion of OGLM and 66.67 epg for birds on the inclusion of MOLM/OGLM. It decreased in week 24 to 16.67 epg for birds on the inclusion of MOLM, 5.56 epg for birds on the inclusion of OGLM and MOLM/OGLM. There was a rise again in faecal egg-worm count in week 32 with birds on the inclusion of MOLM having a count of 66.67 epg while for birds on the inclusion of OGLM and MOLM/OGLM had the same no of count; 44.44 epg.

At various levels of inclusion of the leaf meals (Figure 8), birds on 0% had the highest faecal egg-worm count of 66.67 epg while the least count of 0.00 epg was recorded at 1.0% for birds on the inclusion of OGLM and MOLM/OGLM.

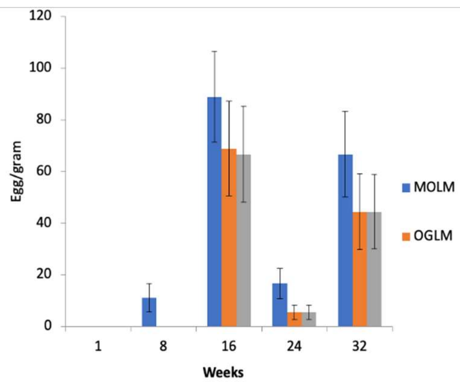

Figure 7: Effect of varying dietary levels of MOLM and OGLM on faecal egg-worm count of egg-type chickens

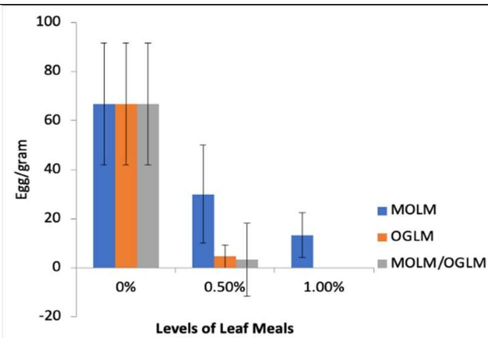

Figure 8: Effect of varying dietary levels of MOLM and OGLM on faecal egg-worm count of egg-type chickens

Nutrients, minerals and phytochemicals are among the good components of medicinal plants. The two leaf meals used in this experiment, *O. gratissimum* leaf meal (OGLM) and *M. oleifera* leaf meal (MOLM) contained phytochemicals as revealed by the phytochemical analysis of the leaf meals. Studies have shown that *O. gratissimum* contains tannin and steroids (12). Traditionally, tannins were believed to be an anti-nutritional factor. Discovery has now shown that they can be advantageous because, they have been effectively included in poultry feeds as additives, to manage diseases as well as to enhance good performance (24).

Saponins are a group of naturally occurring phytochemicals, though are heterogenous, they consist of fat-soluble steroidal glycosides (25). Currently, they are being investigated for their activities against fungi, bacteria, and protozoan (26; 27; 28; 29).
Moringa oleifera has been noted as a remarkable source of sulphur-containing amino acids methionine and cysteine, provitamin A, vitamins B, and C,and minerals (30). It also contains anti-nutritional factors (31;32; 33).
A significant rise in faecal oocyst count in week 8 for cockerels on 0% leaf meal (control) might be a signal that the leaf meals were capable of inhibiting the growth of oocysts

better than the control at this stage since the values were lower than the control. There was a report of milder faecal scores and improved body weight gain for naturally eimeria-infected broiler chickens treated with moringa extract (34). Also, (35) reported anticoccidial actions of *Ocimum gratissimum* leaf extract on avian coccidiosis. The decrease in count from week 8 may be attributed to the administration of coccidia drug to the control group. Birds on MOLM inclusion had more oocysts than birds on OGLM inclusion, while birds on inclusion of MOLM/OGLM had the least count with birds at 1.0% inclusion of MOLM/OGLM having no oocyst in their faeces. This is in line with the submission of (36) that the use of medicinal herbs as anticoccidial remedies is promising as an alternative solution to coccidiosis.

The results of the faecal egg-worm count obtained in this study revealed that there were no egg-worms in faeces of cockerels up to the seventh week. There were no egg worms in faeces of birds on MOLM/OGLM and those on 1.0% inclusion of OGLM. The decrease in faecal egg-worm count across the levels of the leaf meals might imply that the strength of the leaf meals in inhibiting the growth of helminths increased with an increase in the level of the leaf meals included. There was a report that *O. gratissimum* had nematicide activity (37), and (38) also reported that cold leaf infusions of *O. gratissimum* have been employed for the relief of haemorrhoids and stomach distress. The absence of egg worms in the faeces of cockerels in the control group may be a result of the administration of antihelmintic drug to the birds in this group.

CONCLUSION AND APPLICATIONS

- Built on the result of this study, it can be concluded that the two leaf meals used for this study; *Ocimum gratissimum* leaf meal (OGLM) and *Moringa oleifera* leaf meal (MOLM), both contain phytochemicals in varied quantities. Tannin in MOLM was higher than that in OGLM, Saponin in OGLM was higher than that in MOLM while flavonoids in OGLM was higher than in MOLM.
- There was a drastic reduction in faecal egg-worm count of both cockerels and egg-type chicken across the various levels of the leaf meals included, birds on 1.0% inclusion of OGLM and MOLMGLM had no egg-worms in their faeces. However, birds on MOLM recorded a high faecal egg worm count. Therefore, for a reduction in endo-parasite load (faecal oocyst and egg worms), OGLM or MOLM/OGLM may be included in the diet from day old at up to 1.0% (0.5%MOLM/0.5%OGLM)

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Assessment of Efficiency and Financial Performance of Modern Rice Mills in Western Agricultural Zone of Bauchi State, Nigeria

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Abstract
The study assessed efficiency and financial performance of modern rice mills in Western agricultural zone of Bauchi State. Multi-stage sampling procedure was used in selecting 31 modern rice mills and data were analyzed using descriptive statistics and budgetary models. The result revealed that the average purchase price of 100kg of paddy was ₦25,306.45 and the average selling price was ₦31,854.84. Rice recovery was grossly 50%. The average cost incurred in processing 100kg of paddy was ₦2,680.69. Value added and processing efficiency were ₦6,548.39 and 244.82% respectively. The financial viability analysis revealed an operating ratio, fixed ratio, gross ratio and capital turnover of 0.58, 0.07, 0.65 and 1.96 respectively. Inadequate working capital, high costs of paddy procurement and interruption in power supply were the major challenges affecting the performance of modern rice mills in the study area. Rice mills have a great effect as emerging technologies in crop processing and marketing. The study recommended that modern rice mills should form clusters so they could demand necessary facilities such as adequate electricity and water supply collectively from concerned service providers. Efforts should be made to introduce improved management practices in the running of rice mills to avoid unproductive overhead costs and ensure optimum performance.
Keywords: Assessment, Efficiency, Financial performance, Milling, Rice

INTRODUCTION

Rice is one of the major staple foods in Nigeria, consumed across all geopolitical zones and socio-economic classes. Rice consumption is increasing rapidly in Nigeria due to shift in consumer's preference towards rice, increasing population growth, increased income levels, and rapid urbanization. However, rice production falls short of demand despite the fact that Nigeria has the potentials to be self-sufficient in rice production owing to the fact that rice can be produced in all thirty-six (36) States and the FCT (Udemezue, 2018). This deficit over the years created market for imported rice to meet up with local demands and overtime and made Nigerian markets saturated with foreign rice. The country was at a time depending on rice importation of over 3 million tonnes annually, equivalent to over US$480 million in scarce foreign exchange (kamai et al., 2020). In 2015, federal government in a move to boost domestic production banned the importation of rice in Nigeria. This move has now placed a rise in the demand of locally produced rice and as a result increased local production is being clamored for every day. The quality and quantity of processed Nigerian rice available in the market and having the quality desired by consumers closes the rice import gap (Gabdo *et al.,* 2020).

Rice processors have a major role to play in the improvement of the quality of home grown rice and their efficiency can be considered as a key element in the development of home grown rice market (Nwachukwu *et al.,* 2020). Estimating efficiency is an essential issue in the use of scarce resources in production. This is so in the sense that it is the very first step to substantial resources savings (Balogun *et al.,* 2018). Financial performance measures a firm's ability to generate profits and is central investment to achieve business goal.

Objectives of the Study
The specific objectives of the study are to:
1. determine processing efficiency of modern rice mills in the study area;
2. evaluate the financial performance of modern rice mills; and
3. describe constraints affecting modern rice mills in the study area.

METHODOLOGY
Study Area
The study was carried out in western zone of Bauchi State, Nigeria. There are seven local government area in Western Zone of Bauchi, these include; Alkaleri, Bauchi, Bogoro, Dass, Kirfi, Tafawa Balewa and Toro. The zone is located in the North-Guinea Savannah part of the State on latitude $9^{0}30$ and longitude $8^{0}50$. The landmass is 24,270.701km^2 (Bauchi State Agricultural Development programme BSADP, 2018). The rainfall and temperature ranges between 600-1200 mm and 9.11^{0}C – 40.55^{0}C, respectively. The western zone has vast expanse of woodland savannah which is a mixture of several vegetation types. The area has two main seasons; the dry season, between November and March; and rainy season which is between April and October. The State has an estimated population of 4,476,465 (National Population Commission [NPC], 2018) in the study area with the total population of 7,057,045 in Bauchi State. Arable farming and livestock production are the main agricultural practice in the area.
Sampling Procedure and Sample Size.

The study used a multi-stage sampling technique. In the first stage, Western agricultural zone which consist of 7 Local Government Areas was selected from the three agricultural zones in Bauchi State. In the second stage, four Local Government Areas were purposively selected due to the availability of modern rice mills in the LGAs, viz; Bauchi, Bogoro, Dass and Toro. In the final stage, all modern rice mills were selected as the sample. Thus, a total of 31 modern rice mills were assessed for the study. The sampling procedure is presented in Table 1.

Table 1: Sampling Procedure and Sample Size

Zone	LGAs	Population	Sample Size (100%)
Western zone	Bauchi	22	22
	Bogoro	1	1
	Dass	3	3
	Toro	5	5
Total		**31**	**31**

Reconnaissance Survey, 2022

Method of Data Collection
Primary data were collected using a structured questionnaire. Information collected include paddy procurement cost, processing costs such as diesel, electricity, machine

repairs and maintenance, firewood, labour, sack, tax, etc., returns from main product and by-products and problems encountered by rice mills in the study area.

Method of Data Analysis

Data were analyzed using descriptive statistics and budgetary models. Descriptive statistics presented in frequencies, percentages and means was used to analyze specific objective three. Farm budget models were used to analyze specific objective one and two. The models are specified in the following equations 1 – 6:

$$VA = C_{PT} - C_{PU} \quad (1)$$

Where; VA = Value Added, C_{PT} = Cost of purchasing transformed paddy/milled rice (₦), C_{PU} = Cost of paddy/milled rice in its untransformed form (₦)

$$PE = \frac{VAP}{CPS} \times 100 \quad (2)$$

Where; PE = Processing Efficiency, VAP = Value Added by Processing, CPS = Cost of Processing Services

$$OR = \frac{TVC}{GI} \quad (3)$$

Where; OR = Operating Ratio, TVC = Total Variable Cost, GI = Gross income

$$FR = \frac{TFC}{GI} \quad (4)$$

Where; FR = Fixed Ratio, TFC = Total Fixed cost, GI = Gross income

$$GR = \frac{TC}{GI} \quad (5)$$

Where; GR = Gross Ratio, TC = Total cost, GI = Gross income

$$CTR = \frac{GI}{NW} \quad (6)$$

Where; CTR = Capital Turnover Ratio, GI = Gross income, NW = Net worth

RESULTS AND DISCUSSION

Processing Efficiency of Modern Rice Mill

The value addition and processing efficiency of modern rice mill are presented in Table 2. The result indicated that the average purchase price was ₦25,306.45, the average resell price was ₦31,854.84 and the cost of processing was ₦2,680.69 per 100kg bag. Modern rice milling added a total value of ₦6,548.39 per 100kg bag paddy and processing generates an income 244.82% higher than processing cost. This implies that modern rice mills contribute a share of 20.6% to the consumer price of rice and that rice milling is very efficient in the study area. The rule stated that, the higher the efficiency ratio, the higher the processing efficiency. This is similar to the finding of Obinna, *et al*. (2020) that rice mill added value of ₦5000 by processors, equivalent to 2% of the retail price of milled rice. The result is also in line with the finding of Inuwa *et al*. (2011) who reported a value addition of ₦5,736,658.82 per annum and processing efficiency of 243.31% by rice millers in Kano State and confirmed that the value added by millers was higher compared to that of marketers (wholesaler and retailers).

Table 2: Value addition and processing efficiency of rice modern rice mills per 100kg of paddy

Variables	Values
Purchase price (100kg of paddy)	₦25,306.45
Resell price (50kg of polished rice)	₦31,854.84
Cost of processing services	₦2,680.69
Value addition	₦6,548.39
Processing efficiency	244.28%

Source: Field survey, 2023

Financial Performance of Modern Rice Mills

Financial test ratios which include operating ratio, fixed ratio, gross ratio and capital turnover ratio for modern rice mills were computed and the result thereof are presented in Table 3. The results revealed that operating, fixed and gross ratios were 0.58, 0.07 and 0.65 respectively. All the three ratios were less than one indicating that rice milling was a viable enterprise and both fixed and variable assets are optimally utilized. The 0.58 operating ratio implies that 58% of gross income goes to operating expenses. The 0.07 fixed ratio implies that only 7% of gross income is taken by fixed expenses and the gross ratio of 0.65 implies that total cost (both fixed and operating) takes 65% of gross income and the mill is left with 35% of gross income as net income. The capital turnover ratio was 1.96, this implies that for every ₦1.00 of the investment an income of ₦1.96 was generated for the mill. This confirmed the fact that rice mills are able to turn their investments into income to a greater extent. This agrees with the findings of Khorne *et al.* (2019) who reported similar ratios in India. The finding is also similar to that of Akanbi *et al*. (2023) who reported a capital turn-over of 1.49 for rice processor in Kwara State, Nigeria.

Table 3: Financial test ratios of modern rice mills

Variables	Amount (₦)	Ratios
Fixed cost (FC)	1,067,370.96	-
Operating cost (OC/TVC)	9,194,480.64	-
Total cost (TC)	10,261,851.60	-
Gross income (GI)	15,849,961.28	-
Net worth (NW)	97,187,096.77	-
Fixed ratio	-	0.07
Operating ratio	-	0.58
Gross ratio	-	0.65
Capital turn-over ratio	-	1.96

Source: Field Survey, 2023

Constraints Affecting Modern Rice Mills

The constraints affecting mills were accessed using a four-point Likert type, the mean was determined and ranked based on the level severity. The result is presented in Table 4 showed that inadequate working capital and high costs of paddy procurement were the serious problems impeding mills performance, with a mean score of 3.32 and 3.03, ranked first and second respectively. Interruption in power supply and seasonality were next, with equal mean of 3.00 and ranked third. Similarly, Price fluctuations and supply shortage had equal mean score of 2.94 and were ranked fifth. The least problem affecting mills performance is the competition with imported rice ranked eleventh, this is not unconnected with the total ban on rice importation by the president Buhari regime, weeding out foreign rice from the market and enabling domestic mills determine their prices. In line with this, Pham (2016) asserted that most of rice mills in Nigeria are suffering with shortages of supplies of national electricity, paddy and spare parts, as well as with very high bank interest rate, up to 25% per annum. Also, Ajit e*t al.* (2019) ranked the problems faced by rice milling units in order of magnitude as; interruption in power supply, high cost of working capital repairs and maintenance, difficulties in labour availability, transportation problems and high costs of paddy procurement.

Table 4: Constraints Affecting Modern Rice Mills

Problems	Very Severe	Severe	Less Severe	Not Savere	Mean	Rank
Inadequate working capital	14 (45.2)	13 (41.9)	4 (12.9)	-	3.32	1st
High costs of paddy procurement	11 (35.5)	10 (32.5)	10 (32.5)	-	3.03	2nd
Interruption in power supply	7 (22.6)	15 (48.4)	9 (29.0)	-	3.00	3rd
Seasonality in supply	10 (32.3)	12 (38.7)	8 (25.8)	1 (3.2)	3.00	3rd
Supply shortage	9 (29.0)	14 (45.2)	5 (16.1)	3 (9.7)	2.94	5th
Price fluctuations	8 (25.8)	15 (48.4)	8 (25.8)	-	2.94	5th
Problems regarding repairs and maintenance	6 (19.4)	11 (35.5)	14 (45.2)	-	2.74	7th
Difficulties in labour availability	1 (3.2)	10 (32.3)	20 (64.5)	-	2.39	8th
Transportation problems	2 (6.5)	8 (25.8)	21 (67.7)	-	2.38	9th
Storage problems	1 (3.2)	3 (9.7)	27 (87.1)	-	2.16	10th
Imported rice competition	-	6 (19.4)	20 (64.4)	5 (16.1)	2.03	11th

Source: Field Survey, 2023

CONCLUSION AND RECOMMENDATIONS

Modern rice mill is a viable enterprise as indicated by the financial indices. There are prospects for modern rice mills in the study area, however higher profit awaits if all constraints are properly addressed. The study recommends that modern rice mills should form clusters in order to demand necessary facilities such as adequate electricity and water supply collectively from concerned service providers. Rice millers should source credit facilities from formal financial institutions in order to acquire the required working capital and promote the growth and development of the domestic rice milling sector. Rice mills should also adopt out-grower scheme as an alternative source of paddy.

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Effect of Vegetation Cover and Land Use on Soil Infiltration Rate in the Sudan Savana of Nigeria

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Abstract
*This study investigates the impact of vegetation and land use on soil infiltration characteristics in Nigeria's Sudan savanna. Twelve soil samples (0-20cm depth) were collected from four adjacent land uses at Bayero University Kano's Research and Teaching Orchard farm: mango plantation, citrus plantation, arable land, and fallow land. Laboratory analysis assessed pH, electric conductivity (EC), organic matter (OM), exchangeable bases, and particle size distribution, while infiltration rates were measured in situ. Results showed low organic matter content (<1.73%) across all land uses, with significant variations in particle size distribution and EC. Fallow land had high sand content (73.3%), while citrus plantations had high clay content (15.41%). Mango plantations exhibited high EC (0.7ds/m). Effective cation exchange capacity (ECEC) was low (<6 cmol/kg) across all land uses. Notably, a negative correlation between clay content and infiltration rate (r = -0.70**) suggests that breaking up clay soils and incorporating organic matter could improve soil structure and enhance infiltration, supporting sustainable agricultural practices. These findings inform effective soil management and conservation strategies for the region.*

INTRODUCTION

Soil water plays a vital role in plant growth, serving as a medium for nutrient supply and influencing crop productivity (Stekauerova *et al*., 2016). Soil infiltration, connecting surface water, groundwater, and the bio-earth cycle, affects soil water replenishment and moisture storage. Cover crop residues enhance infiltration, reduce runoff and erosion, and promote soil biological activity (Derpsch *et al*., 2014).

Land use and land cover significantly impact infiltration rates, with factors like plant canopy, residue cover, and soil surface roughness influencing water absorption (Carlesso *et al*., 2011). Infiltration rates are sensitive to management changes and are closely linked to soil characteristics, including physical, chemical, and biological aspects (Hillel *et al*., 1998; Hudson *et al.,* 1994; Emerson *et al*., 1995).

The Nigerian Sudan Savanna Zone, spanning 22.8 million hectares, experiences a tropical climate with high temperatures, brief wet seasons, and extended dry periods (Manyong *et al*., 1995). The region's rainfall patterns are erratic, with significant variability impacting water availability (Sowunmi and Akintola, 2010). The mean annual

rainfall is approximately 1,300 mm, but its distribution can exacerbate moisture stress during critical growth periods.
This study aims to investigate the impact of vegetation and land use on soil infiltration rates in the Sudan Savanna of Nigeria.

MATERIALS AND METHODS

Study Area

The experiment was conducted at the Teaching and Research Orchard Farm Department of Agronomy, Bayero University Kano, Nigeria located in the Sudan savanna agroecological zone of Nigeria (Latitude $11^0$58’N and Longitude 8^0 26’E at an Altitude of 460m).

Research description and soil sampling

The experiment involved four adjacent land use types as follows: mango plantation, citrus plantation, arable land and fallow land. soil samples in each of the four land use types were conducted using a stratified random sampling technique (Peterson *et al.*, 1986). Where each land use type was divided into three equal sub-divisions (pseudo-replicates). Three random samples were taken using auger from each sub-division (pseudo-replicates) at each depth and bulked to give one composite sample. An infiltration study and undisturbed soil samples were respectively conducted and taken at the center of each sub-division (pseudo-replicates).

Field and Laboratory Analysis

Infiltration measurement was conducted using a portable double-ring infiltration meter. The double ring infiltrometer consist of a large outer ring and a small inner ring. The infiltrometer has an outer ring of 11cm and an inner ring of 6cm in diameter. Other accessories used include calibrated ruler and stop watch.

The infiltration study was commenced by adding water to the outer ring and allowing the water to infiltrate into the soil for sometimes before water was added to the inner ring. This was done with the aim of providing buffer to discourage lateral flow and encourage one-dimensional flow (Clemmens, 1981). The depth of water infiltrating into the soil was measured using calibrated ruler attached to the inner ring at 2,3,5,5,10,10,20,20,20, ……minutes, respectively and a corresponding time interval which is equivalent to 2,5,10,15,25,35,55,75,95, …. minutes, respectively.

Bulk density was measured using core method (Blake and Hartge, 1986).

Soil pH was measured both in water and in 0.01M KCl using 1:2.5 soil/water solution (Nelson, 1979). The electric rod of the EC meter is inserted into solution and the values were readout in dS/m.

Soil organic matter (OM) was determined using the acid dichromate wet oxidation method of Walkey and Black as describe by Nelson *et al.* (1982) was use in determination of the soil organic carbon content in this study. Then the result obtain is multiplied by 1.72 to obtain the value of the soil organic matter of the soil.

Particle size distribution of the soil less than 2-mm fine earth fraction was analyzed using Bouyoucos (1951) hydrometer method as described by Gee *et al*. (1986).

Data Analysis
The collected data was subjected into a one-way analysis of variance (ANOVA) to test the effect of the land use types using Genstat statistical software. Mean values across the land use types with a significant difference were compared and contrast using Duncan's Multiple Range Test (DMRT). In addition, the relationship between measured soil properties were evaluated using correlation matrix analysis using the same Gentsat statistical software.

RESULTS AND DISCUSSION
The study revealed consistently low organic matter content (<1.73%) across all land uses, with citrus and mango plantations showing slightly higher values (Table 1). This aligns with previous findings (Yang *et al*., 2005; Souza *et al*., 2019; Yadav *et al*., 2020). Citrus plantation soils were slightly more acidic, likely due to the release of organic acids and compounds from citrus tree roots (Alam *et al*., 2017).

The relative proportion of sand, silt, and clay was not significantly affected by land use types, possibly due to the adjacent land areas' similar textures. However, citrus plantation soils had higher silt and clay content (Table 1), potentially enhancing nutrient supply. Research has shown that citrus root exudates significantly enhance the concentration of clay particles smaller than 2 μm by 20%, altering soil properties and promoting nutrient availability (Wang *et al*., 2015). Mango plantation soils exhibited the lowest bulk density (Table 2), consistent with findings that mango leaf litter reduces bulk density (Kumar *et al*., 2018).

Infiltration rates varied across land uses, with arable land (214 mm/h) and fallow land (200 mm/h) showing higher rates than citrus (90 mm/h) and mango plantations (88 mm/h) (Table 2). This may be attributed to the lower clay content in arable and fallow lands. Interestingly, negative correlations were observed between clay and infiltration rate, as well as organic matter and infiltration rate (Table 3). These findings align with previous reports that sand has higher infiltration rates than clay (Kuok *et al*., 2023). Excessive organic matter can clog soil pores, reducing infiltration rates, particularly if not fully decomposed or composed of large particles (Jaber *et al*., 2013).

Table 1: Effect of Land Use Type on Soil Organic Matter, pH, Particle Size Distribution and Electric Conductivity (EC)

Land use	Organic Matter (%)	pH	Sand (%)	Silt (%)	Clay (%)	EC (dS/m)
Citrus plantation	1.17a	5.71b	58.6b	26.0a	15.41a	0.29a
Mango plantation	1.02a	5.91ab	62.6ab	22.7ab	14.75a	0.70a
Arable land	0.70a	5.97ab	63.3ab	24.0ab	12.75a	0.37a
Fallow land	0.73a	6.10ab	73.3a	16.7b	10.08a	0.25a
Significance	NS	NS	NS	NS	NS	NS
SED	0.318	0.134	5.68	3.54	2.653	0.355

Means are separated within a treatment column at 5% level of significance using Duncan Multiple Range test.

Table 2: Effect of Land Use on Soil Bulk Density and Soil Infiltration Rate

Land use	BD (g/cm^3)	IR (mm/hr)
Citrus plantation	1.50a	90.0b
Mango plantation	1.42b	88.0b
Arable land	1.56a	214.0a
Fallow land	1.50a	200.0a
Significance level	NS	*
SED	0.085	43.4

Means are separated within a treatment column at 5% level of significance using Duncan Multiple Range test.
BD; Bulk density, IR; Infiltration Rate.

Table 3: Correlation Coefficient across the Studied Soil Characteristics

	pH	OM(%)	EC(ds/m)	Sand(%)	Silt(%)	Clay(%)	Ca(cmol/k	Mg(cmol/	K(cmol/kg	Na(cmol/l	BD(g/cm3	IR(mm/hr)
pH	1.0000											
OM(%)	-0.2992											
EC(ds/m)	0.0891	0.6692										
Sand(%)	0.3233	-0.5730	-0.3800									
Silt(%)	-0.3431	0.4040	0.2350	-0.9591								
Clay(%)	-0.2410	0.7394	0.5406	-0.9015	0.7423							
Ca(cmol/k	-0.3508	0.5795	0.5157	-0.8760	0.7897	0.8670						
Mg(cmol/	-0.0717	0.2727	0.3703	-0.4789	0.4457	0.4526	0.6845					
K(cmol/kg	0.1988	0.3434	0.5079	-0.3010	0.2041	0.4009	0.4789	0.2546				
Na(cmol/l	-0.1013	-0.2793	-0.2247	0.0925	-0.0270	-0.1779	0.0265	-0.1066	0.1112			
BD(g/cm3	-0.1458	-0.1452	0.0756	0.0101	0.0194	-0.0535	0.0875	0.1131	0.2236	-0.1539		
IR(mm/hr	0.5233	-0.5961	-0.3827	0.5691	-0.4240	-0.6995	-0.5425	0.0115	-0.3280	0.0463	0.1354	1.0000

OM; Organic matter, EC; Electric conductivity, BD; Bulk density, IR; Infiltration rate.

CONCLUSION AND RECOMMENDATIONS

The results highlight the importance of considering soil texture, organic matter, and land use in managing infiltration rates and nutrient availability. Strategies to improve soil structure, such as incorporating organic amendments or reducing tillage, may enhance infiltration and promote sustainable agricultural practices. Overall, understanding these relationships is crucial for developing effective soil management strategies and optimizing land use in the Nigerian Sudan Savanna.

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Gender Roles in Agricultural Production in Ikwuano Local Government Area, of Abia State, Nigeria

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Abstract
Agriculture plays a crucial role in the socio-economic fabric of Nigeria, particularly in rural areas such as Ikwuano Local Government Area, Abia State. This study examines gender roles within agricultural production, focusing on the challenges faced by women and the initiatives aimed at promoting gender equality in this sector. The analysis identifies multiple barriers hindering women's full participation and economic empowerment in agriculture, including limited access to land, financial resources, agricultural inputs, and decision-making authority. These challenges are compounded by cultural norms, legal constraints, and socio-economic disparities that perpetuate gender inequalities. To address these issues, the study proposes comprehensive recommendations: enhancing access to land rights through policy reforms; improving women's access to financial services and agricultural extension programs; promoting gender-sensitive policies and capacity-building initiatives; fostering collaborative partnerships; raising awareness to challenge harmful gender norms; and establishing monitoring mechanisms to track progress. By implementing these recommendations, stakeholders can create an enabling environment that empowers women farmers, promotes sustainable agricultural practices, and contributes to broader rural development goals in Ikwuano Local Government Area and beyond.
Keywords: Gender, Agricultural, Women farmers, Gender equality

INTRODUCTION

Agriculture plays a pivotal role in the socio-economic fabric of Nigeria, particularly in rural areas where it serves as a primary source of livelihood and sustenance for millions. Within Abia State, the agricultural sector not only contributes significantly to the state's economy but also shapes the daily lives and roles of its inhabitants, including those in Ikwuano Local Government Area. This paper explores the intricate dynamics of gender roles within agricultural production in Ikwuano, focusing on how these roles are defined, maintained, and evolving in the face of socio-cultural norms and economic realities. Abia State, located in the southeastern region of Nigeria, boasts a diverse agricultural landscape characterized by the cultivation of crops such as cassava, yam, maize, and vegetables, alongside livestock farming. Agriculture in Abia State contributes significantly to food security, rural employment, and income generation, playing a crucial role in poverty alleviation and economic development (FAO, 2020).

Numerous agricultural development programs are currently operational in Nigeria, aiming to bolster food production and elevate living standards. Despite women farmers' active involvement in production, processing, and marketing, they face formidable social and economic constraints that hinder their access to scientific and technological knowledge (Daman, 1997). This deficiency in technical expertise prevents them from optimizing farm inputs for maximum yields. Additionally, factors such as ignorance, low income (Adekanya, 1988; Inter-American Development Bank, 2000), limited access to credit facilities, and inadequate communication channels (Nonyelu, 1996; FAO, 2006) restrict many women from fully participating in agricultural programs. These challenges significantly curtail their efforts to enhance food production for the growing population.

Odoemelam et al. (2014) highlights that differences in yield between male and female farmers are not due to lower skill levels among women, but rather stem from constraints in accessing agricultural inputs and resources. Weisfeld (2008) emphasizes the critical role of rural women in ensuring food security, as they predominantly produce the majority of food and meet their families' basic needs. However, the World Bank (2008) argues that women's potential in agriculture remains largely unrealized, contributing to lower agricultural productivity and food security. Despite women constituting a significant portion of smallholder farmers, they only control approximately 1 percent of land, limiting their access to credit, technical assistance, and participation in decision-making processes (World Bank, 2008).

Nigerian women farmers, despite constituting 68.8 percent of the labor force and contributing 80 percent of the national food output, face significant challenges. They lack adequate recognition and access to necessary agricultural extension services, which are crucial for enhancing productivity (Adekanya, 1988; Nwansat, 2002). This marginalization is exacerbated by their subordinate status in male-dominated cultures, often conflicting with household responsibilities (Protz, 1977). Moreover, women's contributions to agriculture are frequently underestimated, and gender-disaggregated data is lacking, perpetuating the assumption that agriculture is a male domain (Ekong, 2003). In Ikwuano Local Government Area of Abia State, the agricultural sector plays a pivotal role in the local economy, supported by fertile lands and favorable climatic conditions. However, challenges such as land tenure issues, limited access to agricultural inputs, and gender disparities in resource allocation persist (Njoku, 2018). Understanding gender roles in agriculture is crucial for addressing these challenges, as cultural norms and historical practices often shape the division of labor and access to resources within rural communities (Olayemi & Ogunbameru, 2019).

Women in Ikwuano typically perform tasks such as weeding, crop processing, and managing household food security, yet they encounter barriers such as restricted access to land and financial resources (Adewumi & Olukosi, 2017). Efforts to promote gender equality in agriculture have seen progress through government policies and NGO interventions that advocate for women's land rights, access to credit, and technical training (FAO, 2022). These initiatives aim to empower women farmers, enhance their productivity, and foster sustainable agricultural practices.

Gender Roles in Agricultural Production

Gender roles in agricultural production within rural communities, such as those found in Ikwuano Local Government Area of Abia State, Nigeria, are deeply entrenched in cultural norms and traditional practices. These roles delineate distinct responsibilities for men and women, influencing their participation in different stages of agricultural activities. According to research by Nnadozie and Osondu (2018), men typically engage in tasks requiring physical strength and technical expertise, such as land preparation, plowing, and the cultivation of cash crops like cassava and yam. They also often oversee larger livestock management, contributing significantly to household income and food security.

In contrast, women's roles in agriculture are characterized by activities such as weeding, harvesting, and post-harvest processing, which includes tasks like milling and pounding. These tasks are essential for ensuring food preservation and household food security (FAO, 2020). Women also manage smaller livestock, such as poultry and goats, which provide additional sources of income and nutrition for their families (IFAD, 2021). Beyond the division of labor, gender roles influence decision-making processes and access to resources within agricultural households. Men typically hold primary decision-making authority concerning land use, investments in agricultural inputs, and participation in market activities. This authority is reinforced by cultural norms that prioritize male leadership in economic and agricultural matters (UN Women, 2021).

Conversely, women's decision-making authority tends to focus on household management, including food consumption patterns, budgeting, and the allocation of income derived from agricultural activities (IFAD, 2021). However, women often face challenges in accessing essential resources and services. For instance, access to land is a critical issue as women in many rural areas of Nigeria encounter legal and customary barriers that restrict their rights to own or control land independently (FAO, 2022). Additionally, women often have limited access to credit, agricultural extension services, and modern farming technologies, which are crucial for enhancing productivity and profitability in agriculture (IFAD, 2021). These challenges perpetuate gender inequalities and contribute to lower agricultural productivity and economic empowerment among women compared to men. Efforts to promote gender equality in agriculture are essential for achieving sustainable rural development and food security. Policies and programs aim to address these challenges by advocating for women's land rights, improving access to financial services, and providing gender-sensitive agricultural extension services and training (UN Women, 2021). Such initiatives not only aim to empower women economically but also contribute to overall agricultural productivity and community development.

Decision-making and Resource Allocation in Gender Roles within Agricultural Production

Decision-making and resource allocation within agricultural production are critical aspects that reflect and reinforce gender roles in rural communities such as Ikwuano Local Government Area in Abia State, Nigeria. These processes are shaped by cultural norms, legal frameworks, and socio-economic dynamics, often resulting in disparities between men and women.

- **Men's Decision-making Authority**: In traditional agricultural societies, men typically hold primary decision-making authority concerning land management, agricultural investments, and participation in market activities (FAO, 2020). This authority is rooted in patriarchal norms that prioritize male leadership in economic and agricultural matters. For example, men decide which crops to plant, when to plant and harvest, and how to allocate agricultural income (UN Women, 2021).
- **Women's Decision-making Roles**: While women contribute significantly to agricultural production and household food security, their decision-making roles are often confined to managing household expenses, food distribution, and small-scale financial matters (IFAD, 2021). Women's influence in broader agricultural decisions is limited due to factors such as restricted access to land, financial resources, and formal education (FAO, 2022).

- **Challenges in Resource Allocation**: One of the primary challenges faced by women in agricultural production is access to land. In many regions of Nigeria, including Ikwuano, cultural and legal barriers restrict women's rights to own or control land independently (FAO, 2022). This limits their ability to expand agricultural activities, secure loans, and participate fully in agricultural markets. Furthermore, women often lack access to credit, agricultural extension services, and modern farming technologies, which are essential for enhancing productivity and profitability in agriculture (IFAD, 2021).
- **Initiatives Promoting Gender Equality**: Efforts to promote gender equality in agriculture focus on addressing these challenges and enhancing women's decision-making power and access to resources. Policies and programs advocate for women's land rights, improve access to financial services, and provide gender-sensitive agricultural extension services and training (UN Women, 2021). These initiatives aim to empower women economically, increase their participation in agricultural value chains, and contribute to overall agricultural productivity and rural development.

Challenges Faced by Women in Agricultural Production

Women in agricultural production in regions like Ikwuano Local Government Area of Abia State, Nigeria, encounter a multitude of challenges that hinder their full participation, economic empowerment, and overall well-being. These challenges are rooted in cultural norms, legal constraints, and socio-economic disparities that perpetuate gender inequalities in rural communities.

- **Access to Land**: One of the most significant challenges faced by women in agriculture is limited access to land. In many traditional societies, including parts of Nigeria, land ownership and control are primarily vested in men due to cultural and legal barriers (FAO, 2022). Women often have restricted rights to own or inherit land independently, which limits their ability to expand agricultural activities, secure loans using land as collateral, and participate fully in agricultural markets.
- **Access to Financial Resources**: Women frequently lack access to credit and financial services essential for investing in agricultural inputs, improving farm productivity, and expanding their agricultural enterprises (IFAD, 2021). Financial institutions may hesitate to lend to women due to factors such as lack of collateral, limited financial literacy, and discriminatory practices.
- **Limited Access to Agricultural Inputs and Technologies**: Women farmers often face challenges in accessing modern farming technologies, high-quality seeds, fertilizers, and pest management tools that are critical for enhancing agricultural productivity (UN Women, 2021). This limits their ability to improve crop yields, increase income, and adopt sustainable farming practices.
- **Gender-based Division of Labor**: There is a persistent gender-based division of labor in agriculture, where women are primarily responsible for tasks such as weeding, harvesting, and processing crops, while men undertake more lucrative and decision-making-intensive activities like land preparation and marketing (Nnadozie & Osondu, 2018). This division reinforces women's role in unpaid and often undervalued work within the agricultural sector.
- **Limited Access to Extension Services and Training**: Agricultural extension services and training programs are crucial for providing farmers, particularly women, with technical skills, knowledge of market trends, and sustainable agricultural practices. However, women often have limited access to these services due to factors such as distance to extension offices, lack of tailored programs addressing their needs, and cultural norms that prioritize men's participation (FAO, 2020).

- **Cultural and Social Norms**: Deep-seated cultural beliefs and social norms often restrict women's mobility, decision-making authority, and participation in community and agricultural leadership roles (IFAD, 2021). These norms reinforce gender inequalities and limit women's ability to advocate for their rights and interests within agricultural settings.
- **Climate Change Vulnerability**: Women farmers are disproportionately affected by climate change due to their roles as primary caregivers and providers of food and water within households (UN Women, 2021). Climate variability and extreme weather events can exacerbate existing vulnerabilities, affecting crop yields, water availability, and food security for women and their families.
- **Initiatives Addressing Challenges**: Efforts to address these challenges include policy interventions aimed at promoting women's land rights, improving access to financial services, enhancing agricultural extension services, and providing gender-sensitive training and capacity-building programs (UN Women, 2021). These initiatives seek to empower women economically, enhance their resilience to climate change impacts, and promote sustainable agricultural practices.

Initiatives Promoting Gender Equality in Agricultural Production

Promoting gender equality in agricultural production is crucial for sustainable rural development and enhancing food security. In regions like Ikwuano Local Government Area of Abia State, Nigeria, several initiatives have been implemented to address gender disparities and empower women in agriculture.

- **Policy Reforms and Legal Interventions**: Governments and international organizations have enacted policy reforms to promote women's land rights and improve their access to agricultural resources. For instance, legal reforms in Nigeria aim to protect women's rights to land ownership and inheritance, thereby reducing barriers that hinder women's access to land (FAO, 2022).
- **Access to Financial Services**: Enhancing women's access to financial services is critical for empowering them economically in agriculture. Microfinance initiatives and village savings and loan associations (VSLAs) provide women with access to credit, savings, and financial literacy training, enabling them to invest in agricultural inputs and expand their farming activities (World Bank, 2020).
- **Gender-sensitive Agricultural Extension Services**: Gender-sensitive agricultural extension services play a vital role in equipping women farmers with technical knowledge, skills, and information on sustainable farming practices. These services help improve productivity, enhance crop yields, and empower women to adapt to climate change impacts (IFAD, 2021).
- **Capacity-building and Training Programs**: Capacity-building programs focus on enhancing women's entrepreneurial skills, leadership capabilities, and access to market information. Training in agribusiness management and value chain development empowers women to participate more effectively in agricultural markets and decision-making processes (UN Women, 2021).
- **Advocacy and Awareness-raising**: Civil society organizations and NGOs play a crucial role in advocating for gender equality in agriculture. They raise awareness about the importance of women's contributions to agriculture, challenge discriminatory practices, and advocate for policy reforms that promote gender-responsive agricultural development (Oxfam, 2021).
- **Gender Mainstreaming in Agricultural Policies**: Integrating gender considerations into agricultural policies ensures that women's specific needs and contributions are recognized and addressed. Gender mainstreaming efforts aim to

create inclusive agricultural development programs that benefit both men and women, thereby promoting sustainable rural livelihoods (World Bank, 2020).

- **Multi-stakeholder Partnerships**: Collaborative efforts between governments, international organizations, research institutions, and community-based organizations are essential for scaling up gender equality initiatives in agriculture. These partnerships leverage resources, expertise, and best practices to create sustainable impacts and empower women farmers (Oxfam, 2021).

CONCLUSION AND RECOMMENDATIONS

Gender equality in agricultural production is not just a matter of fairness; it is crucial for achieving sustainable rural development, enhancing food security, and promoting inclusive economic growth. In regions like Ikwuano Local Government Area of Abia State, Nigeria, addressing gender disparities in agriculture requires multifaceted approaches that tackle structural barriers, empower women economically, and promote their leadership in agricultural decision-making. Throughout this discussion, it has become evident that women in agriculture face significant challenges, including limited access to land, financial resources, agricultural inputs, and decision-making authority. These challenges are exacerbated by cultural norms, legal constraints, and socio-economic disparities that perpetuate gender inequalities. However, initiatives promoting gender equality in agriculture offer promising pathways forward. Policy reforms that protect women's land rights, improve access to financial services, and integrate gender considerations into agricultural policies are essential steps in creating an enabling environment for women farmers. Moreover, gender-sensitive agricultural extension services, capacity-building programs, and advocacy efforts play pivotal roles in equipping women with the skills, knowledge, and resources needed to enhance their agricultural productivity and resilience. Collaborative partnerships between governments, international organizations, NGOs, and local communities are critical for scaling up these initiatives and ensuring sustainable impacts. By leveraging diverse expertise, resources, and best practices, these partnerships can effectively address the complex challenges faced by women in agriculture and promote inclusive rural development. Hence, achieving gender equality in agricultural production is not only a moral imperative but also a strategic investment in sustainable development. Empowering women as key agents of change in agriculture not only enhances their livelihoods and well-being but also contributes to broader socio-economic development goals. As we look towards the future, continued commitment to gender-responsive policies, inclusive practices, and collaborative partnerships will be essential for realizing the full potential of women in agriculture and building resilient rural communities.

Based on the challenges and initiatives discussed regarding gender roles in agricultural production in Ikwuano Local Government Area of Abia State, Nigeria, the following recommendations are proposed to promote gender equality and enhance women's empowerment in agriculture:

- **Enhance Access to Land Rights**: Implement and enforce policies that guarantee women's equal rights to land ownership, inheritance, and control. This includes raising awareness among communities about the benefits of gender-equitable land tenure systems and addressing legal and cultural barriers that restrict women's access to land.
- **Improve Access to Financial Services**: Expand access to microfinance, savings groups, and credit facilities tailored to women farmers. Provide financial literacy training to enhance women's financial management skills and empower them to invest in agricultural inputs, technologies, and market opportunities.

- **Strengthen Agricultural Extension Services**: Develop and implement gender-sensitive agricultural extension programs that provide women farmers with training, technical assistance, and information on sustainable farming practices, climate resilience, and market trends. Ensure these services are accessible, relevant, and responsive to women's needs.
- **Promote Gender-sensitive Policies and Programs**: Integrate gender considerations into agricultural policies, programs, and projects at all levels. Ensure that policies address the specific challenges faced by women in agriculture and promote their equal participation in decision-making processes, agricultural cooperatives, and community organizations.
- **Support Capacity-building and Skills Development**: Invest in training and capacity-building programs that enhance women's agricultural and entrepreneurial skills. Provide leadership training, business development support, and opportunities for networking and mentorship to empower women as leaders and change agents in agriculture.
- **Foster Collaborative Partnerships**: Strengthen partnerships between governments, civil society organizations, international agencies, research institutions, and private sector entities to mobilize resources, share knowledge, and scale up successful gender equality initiatives in agriculture. Collaborate to promote inclusive policies and practices that benefit women farmers.
- **Raise Awareness and Challenge Gender Norms**: Conduct awareness-raising campaigns and advocacy efforts to challenge harmful gender stereotypes, norms, and practices that perpetuate inequalities in agriculture. Promote positive portrayals of women's roles and contributions in agriculture and advocate for cultural shifts towards gender equality.
- **Monitor and Evaluate Progress**: Establish monitoring and evaluation mechanisms to track progress towards gender equality in agricultural production. Collect sex-disaggregated data, conduct gender analyses, and use evidence-based findings to inform decision-making, improve program effectiveness, and address emerging challenges.

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Performance of NERICA Rice Varieties in Flash Flood Conditions: Upland and Lowland Agroecological Systems

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Abstract
This study assessed the performance and resilience of selected rice varieties, NERICA (N4, N7, N14), Haenuki (Oryza sativa) and CG14 (Oryza glaberrima), to flash floods under upland and lowland agroecological growing conditions towards determining the potentials of the interspecific hybridized NERICA rice varieties in withstanding the growing challenge of flash floods to rice cultivation. The results demonstrate that the varieties exhibited significant variation in their growth and yield responses to flash floods. N4 showed minimal elongation, while N7 and Haenuki displayed rapid recovery post-submergence. The findings provide valuable insights for appropriate variety selection and rice production strategies in flood-prone regions. The study suggests NERICA 7 to be most desirable in tolerance to flash flood.

INTRODUCTION
Rice (*Oryza* spp), an essential source of nourishment to half of the world's population is among the most widely grown crops globally (Fukagawa, N. K., & Ziska, L. H., 2019). Globally, cultivation of rice is conducted in lowland or upland agroecological systems. Despite the wide cultivation of rice globally, its cultivation is confronted with climate change challenges, especially the recurrent flash floods. Flash floods, the rapid increase in water levels resulting in the submergence of rice plants usually after heavy rainfall has become a persistent threat to rice cultivation and food security. It has become an almost annual occurrence in rice producing countries. Van and Ferrero (2016) established that there have been notable advancements in rice technology, such as the development of the interspecific hybridized New Rice for Africa (NERICA) varieties to address various rice yield challenges. NERICA varieties combines both desirable traits of *Oryza glaberrima* (African) and *Oryza sativa* (Asian rice), to offer potential resilience to rice production challenges, although very little research has been done to study the various NERICA varieties as potential solutions to flash floods. This study aims to evaluate the performance of NERICA rice varieties under simulated flash flood conditions in both upland and lowland agroecological systems, determine which of the varieties is most tolerant to flash flood conditions, and establish the extent of yield loss in each variety ascribable to flash flood.

MATERIALS AND METHODS

The study was conducted at Yamagata University, Japan, using a randomized complete block design with four replicates of Six (6) rice varieties planted in pots and subjected to flooding and unflooded treatments using lowland and upland agroecological conditioning. The rice varieties were NERICA 1(N1), NERICA 4 (N4), NERICA 7 (N7), NERICA 14 (N14), CG14 and Haenuki. The treatments subjected to flooding were submerged in flash flood simulation for six (6) days at the thirteen (13) days after transplanting. Growth parameters, including plant height, tiller number, leaf number, Chlorophyl SPAD values, heading date were measured, just as, yield parameters such as grain yield, filled to empty grain percentage as well as panicle height were determined calculated. Data were analysed using R program version 4.2.3 subjected to analysis of variance (ANOVA), Welch Two Sample t-tests and Simultaneous Tests for General Linear Hypotheses Multiple Comparisons of Means: Tukey contrasts analysis based on the statistical design to assess the varieties responses.

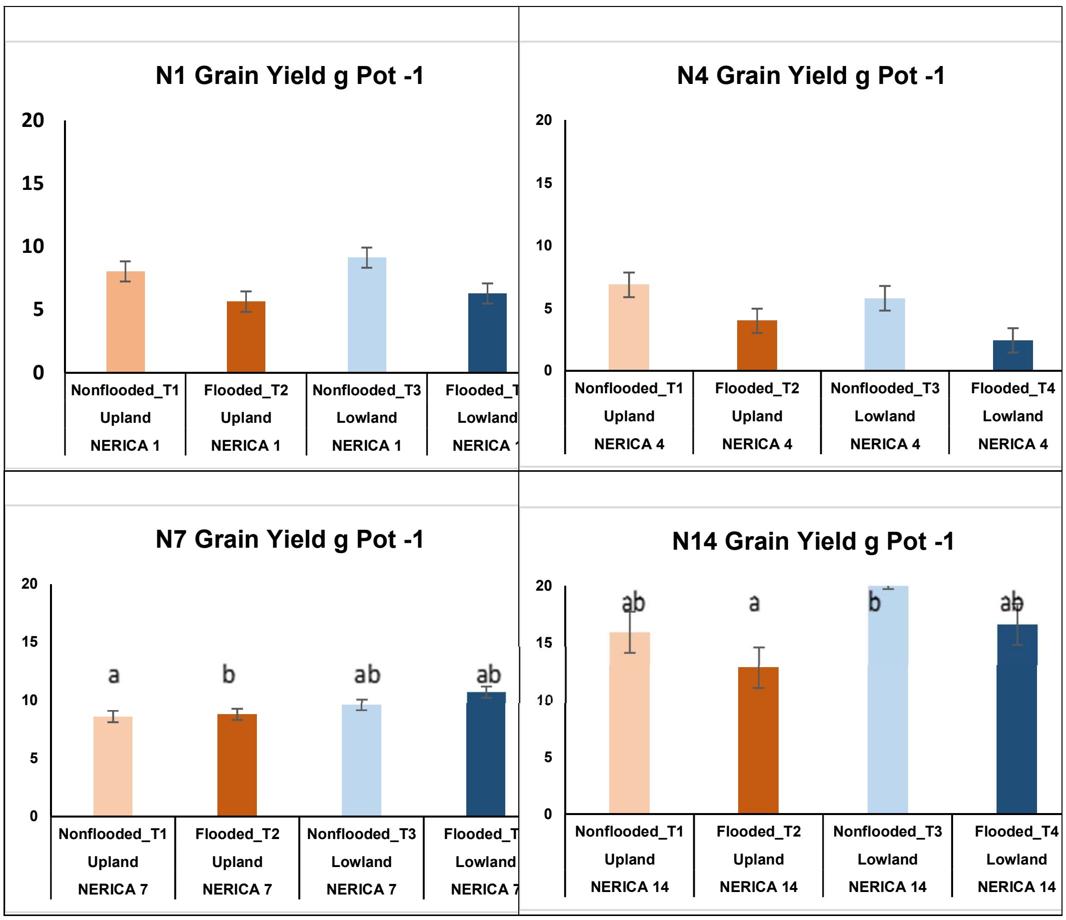
RESULTS AND DISCUSSION

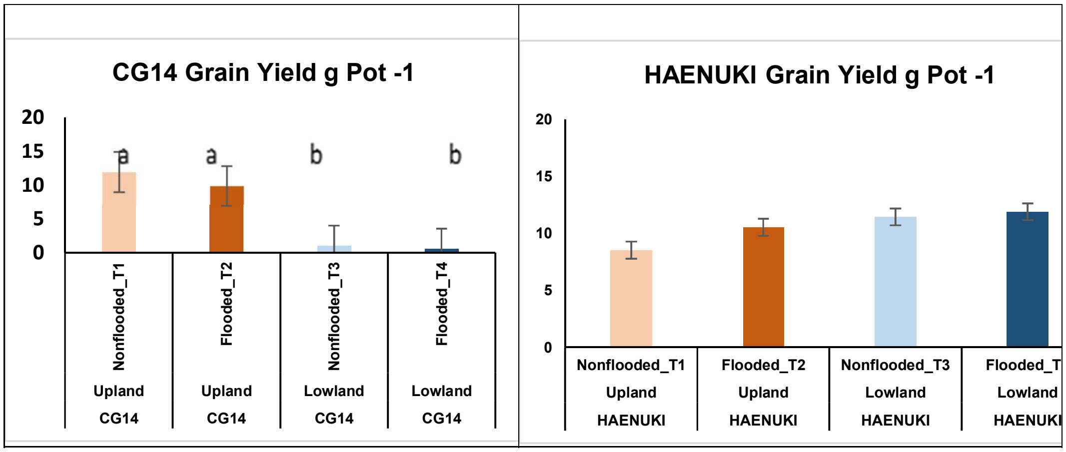
Flash floods significantly affected plant height, tiller number, and SPAD values, with notable differences among varieties. The performance of plant height showed successive increments with advancement in crop growth stage and elongation for all varieties subjected to flash flood submergence, as similarly reported by Mangaraj S. et al. (2022) and the findings of Kawano, N et al. (2008). For flash flood treatments, N4 exhibited the least elongation in both agroecological conditions but with lowest elongation under lowland conditions, suggesting it is less prone to height increases during submergence. Tillering reduced during submergence for all varieties with N4 recording least elongation in lowland condition and Haenuki recording lowest tillering rate during submergence period in upland condition. Flood treated N1 recorded delayed heading just after CG14. N7 did not demonstrate any significant change in heading when comparing flooded and non-flooded treatments as shown in Table 1 below.

Table 1: Average days to Heading (DTH) for each variety in both upland and lowland flooded and non-flooded treatments

Agroecological Condition	Variety	Average Days to Heading (DTH)		Average Tiller Number		Plant Height at Harvest (PHH) cm	
		Non-flooded	Flooded	Non-flooded	Flooded	Non-flooded	Flooded
Upland	NERICA1	86	92	10.8	10.3	79.8	76.0
	NERICA4	80	83	15.5	19.3	70.1	65.6
	NERICA7	80	84	13.3	13.0	85.5	86.1
	NERICA14	70	74	13.0	13.5	78.6	79.8
	CG14	95	98	25.3	20.3	93.6	95.1
	HAENUKI	85	85	21.0	17.8	68.9	68.6
Lowland	NERICA1	89	91	14.3	13.8	78.9	79.1
	NERICA4	81	83	22.0	28.0	70.5	59.1
	NERICA7	80	81	14.3	15.5	84.0	84.5
	NERICA14	72	74	16.3	16.0	87.8	85.4
	CG14	97	101	30.5	27.0	82.1	91.0
	HAENUKI	83	84	26.0	20.8	65.9	71.6

N7 and Haenuki showed the fastest recovery post-submergence in lowland conditions, highlighting their potential for cultivation in flood-prone areas. There was a general reduction in chlorophyll formation during submergence in both upland and lowland conditions for all rice varieties, but at varying rates with reduction in chlorophyll was most obvious in lowland conditions compared to upland. The decline in chlorophyll formation during submergence for all varieties, allude to the findings of Lin, C., et al (2024). The yield analysis indicated that flash floods reduced tiller number and yield, but lowland conditions allowed for better recovery compared to upland conditions. The filled grain percentage in flood treated NERICA 7 was seen to be comparable to the percentage recorded for non-flooded treatments in both upland and lowland. While only Upland CG14 and Haenuki had better filled grain of all varieties and conditions. Meanwhile, Lowland flooded and non-flooded CG14 recorded the lowest filled grain to empty grain ratio. For panicles, lowland conditions for all varieties were better compared with flooded treatments N14 having better panicle numbers in the same lowland than non-flooded. From Figure 1, Flooded NERICA 7 and Haenuki in both agroecosystems had better yields than non-flooded treatments. While NERICA 4 demonstrated good yield only in upland flood conditions.





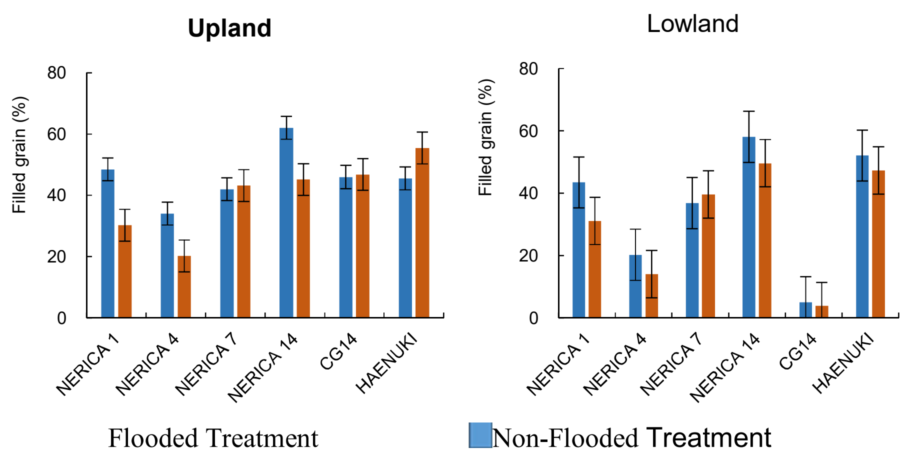


Figure 2. Percentage Filled Grain; Shows relationship between the percentage of filled grain in the grain yield flooded and flooded treatment of each variety

Grain yield of N7 in Figure 2 as well as N1 and Haenuki had no significant difference, but the percentage grain yield presented in Figure 2 demonstrates that Flood treated NERICA 7 had similar output to non-flooded in both upland and lowland alluding to limited yield loss even after subjecting it to flash flood. While CG14 and Haenuki subjected to flash flood had acceptable filled grain percentages only in upland conditions.

CONCLUSION AND RECOMMENDATIONS

This study provides critical insight into the performance of NERICA varieties while discovering that NERICA varieties exhibited varying degrees of resilience to flash floods across upland and lowland agroecological systems, with specific varieties showing promise for cultivation in flood-prone areas especially NERICA 7 and NERICA 4. It also demonstrates that NERICA 14 grown in upland conditions had the most significant grain loss due flash flood. It further showed NERICA 7 and Haenuki emerging as the most resilient under flash flood by demonstrating ability to maintain grain yield compared to others. Despite the constraints of the experiment being conducted in controlled environment, the study contributes to the ongoing efforts to improve rice production in the face of climate change and provides a foundation for future research and breeding initiatives focused on enhancing flood resilience in rice. These results pave the way for future field studies and breeding programs focused on enhancing flood tolerance in rice, thereby contributing to sustainable rice production and food security in vulnerable regions.

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Effect of Cashless Policy on Agricultural Activities of Arable Crop Farmers in Egbeda Local Government Area, Oyo State, Nigeria

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Abstract
This study analyzed the effects of cashless policy on agricultural activities of arable crop farmers in Egbeda Local Government, Oyo State. Multi-stage sampling procedure was used to select 120 respondents, while interview schedule was used to obtain primary data. Data were analyzed using frequency, percentage, mean, and Pearson's Product Moment Correlation (PPMC) at p=0.05. The results revealed that respondents had an average of 52 years of age, 6 persons per household, 21.9 years of farming experience, and 2.8 hectares of farm size. The cashless policy positively impacted in areas of transparency of financial transactions (mean=3.78), convenience of financial transactions (mean=3.77), and effective management of financial records (mean=3.74). However, on a negative note, it aided difficulties in accessing funds promptly due to technical issues (mean=3.68). There was significant relationship between effects and challenges of the cashless policy among arable crop farmers. The study concluded that the cashless policy had brought about positive and negative effects on the finances of arable farmers. The study recommends more awareness, increased mobile/internet network coverage and availability of more cash points to support arable crop farmers to adapt effectively to the cashless policy.
Keywords: Cashless policy, Arable crop farming, Mobile banking, Financial transaction.

INTRODUCTION

Nigeria currently imports various quantities and varieties of foods to feed her teeming population. The cashless policy introduced by the Central Bank of Nigeria (CBN) is strategy develop a cashless economy. One of the prerequisites for the development of national economy is to encourage a payment system that is secure, convenient and affordable (Kuma et al., 2023). A cashless economy's effects on productivity for arable farmers hinges on multiple elements. As noted by Umar et al. (2023), surging prices and insecure food access for rural agriculturists intertwine with policy-shaped farming challenges in places like Nigeria.

The general objective is to assess the effects of cashless policy on agricultural activities of arable crop farmers in Egbeda Local Government, Oyo state. The specific objectives of the study were to: (i) analyze the effects of cashless policy among the arable crop farmers, (ii) identify the challenges facing the arable crop farmers towards cashless policy. The Null Hypothesis tested in the study shows that: ($H0_1$) There is no significant relationship between the effects and challenges of utilization of cashless policy by arable crop farmers' activities.

METHODOLOGY

The study was carried out in Egbeda Local Government Area of Oyo State, Nigeria. The study population were selected Arable crop farmers Registered with Agricultural Development Programme (ADP) in Egbeda Local Government, Oyo state. Multistage sampling procedure was used to select the respondent. These stages are: Step 1 involved a simple random sampling was used to select farmers registered under ADP in Egbeda Local Government Area because they were easily accessible. Step 2 involved a simple random sampling of 10 arable crop farmers were selected in each community to make it a total of 120 respondents.

This study utilized Primary Data that was gathered through an Interview Guide from Arable crop farmers. Face and content validity was used for this study. For face validity, the research was given to my supervisor and experts in the field of agricultural extension and rural development for correction, while content validity was used to gather the instruments. Test -retest method was used to determine the consistency of the instrument and was given to the respondents outside the study to ascertain the level of reliability.

The effects of cashless policy among arable crop farmers was measured using 5-points Likert scale of SA (5), A (4), U (3), D (2), SD (1). The challenges was measured at interval level as; Major factor (3), Minor factor (2), Not a factor (1). Data was analyzed using descriptive statistics including frequency counts, percentage, mean, and standard deviation for the objectives. Pearson Product Moment Correlation (PPMC) was used to test the hypothesis.

RESULTS AND DISCUSSION

Effects of cashless policy on arable crop farmers

The result in Table 1 shows that Out of 120 respondents, the majority of the respondents with ($\bar{x}$=3.78) agreed that the cashless policy has positively impacted transparency of their transactions. This implies that most arable crop farmers believe adopting cashless systems like mobile money, bank transfers, and digital payments has made their financial transactions more transparent and open (Fagbuyi et al., 2023). The majority of respondents agreed there was convenience to conducting transaction, giving it a mean score of ($\bar{x}$=3.77). This implies that most arable crop farmers find digital payment methods convenient for conducting transactions as a result of the cashless policy. Only a small percentage (11.7%) disagreed with this statement. This indicates that the cashless policy has facilitated more convenient digital payment transactions for most farmers in this sample (Soom et al., 2024). The result in Table II also shows that "Cashless policy has helped majority of the respondents with ($\bar{x}$= 3.74) to manage their financial records more effectively. This implies that cashless policy has helped most arable crop farmers better manage their financial records. Only a small percentage (6.7%) disagreed with the statement.

Table 1: Effects of Cashless Policy on Arable crop farmers

Variables	Mean	Rank
Convenient to conduct transactions using digital payment methods due to the cashless policy.	3.77	2nd
Cashless policy has positively impacted the transparency of your financial transactions.	3.78	1st
I always have issues with delayed payments when receiving funds digitally due to the cashless policy.	2.94	8th
During cashless policy, I was able to track my financial transactions more effectively.	3.63	5th
I occasionally feel more secure about my financial transactions as a result of the cashless policy's implementation.	3.42	6th
Cashless policy has helped me in managing my financial records more effectively.	3.74	3rd
I occasionally face difficulties accessing funds promptly due to technical issues related to the cashless policy.	3.68	4th
Cashless policy has hindered my overall financial security as an arable crop farmer.	2.96	7th
Cashless policy has negatively impacted my overall income as an arable crop farmer.	2.70%	12th
I perceive the cashless policy as a hindrance to the traditional farming practices that involve cash transactions.	2.77	10th
Cashless policy has not helped me in managing my financial records more effectively.	2.78	9th
Inconvenient to conduct transaction using digital payment methods due to the cashless policy	2.73	11th

Source: Field Survey, 2023

Challenges facing arable crop farmers towards cashless policy

As shown in Table 4, Transaction charge cost and fees (mean=1.60) ranked first, Limited access to technology and infrastructure (1.48) ranked second, seasonal and irregular income from agricultural produce through environmental factor (mean=1.22) ranked while cultural and behavioral factor (mean=0.84) ranked ninth as the least severe constraint faced by arable crop farmers to utilize cashless policies.

Table 2: Challenges facing arable crop farmers towards cashless policy

Variables	Mean ($\bar{x}$)	Rank
Limited access to technology and infrastructure	1.48	2nd
Easy access to financial support from government	1.60	1st
Lack of digital literacy on the usage of mobile phone to access information	1.02	5th
Digital infrastructure in rural areas e.g. mast, agricultural equipment, water system	0.98	7th
Transaction charge cost and fees	1.60	1st
Risk of cyber security threat e. g theft through exposure of security pin	0.99	6th
Cultural and behavioral factor to using digital technology to make transaction	0.84	9th
Unreliable mobile network coverage	1.04	4th
Poor record-keeping and documentation	0.94	8th
Seasonal and irregular income from agricultural produce through environmental factor like erosion, land degradation	1.22	3rd

Source: Field Survey, 2023

Testing of hypothesis

The result of the hypothesis shows that there is no significant relationship between utilization of cashless policy and arable crop farmers with the use of cashless payments and productivity. This implies that cashless policy has an effect on outputs of the arable crop farmers. The result of the hypothesis shows that there is a significant relationship between the challenges/effects of cashless policy and the agricultural activities of arable crop farmers in the study area which was tested using Pearson's Product Moment Correlation. This implies that cashless policy does have an effect on the productivity of arable crop farmers.

Table 3: Relationship between effects and challenges of cashless policy among arable crop farmers' production

	r-value	p-value
Challenges and effect of cashless policy	0.355	0.001

Decision criteria: Reject null hypothesis if p≤0.05, accept null hypothesis if p>0.05

CONCLUSION AND RECOMMENDATIONS

In conclusion, this study provides important insights on the effects of cashless Policy on agricultural activities of arable crop farmers in Egbeda Local Government. The findings reveal that a cashless policy holds promise for improving financial inclusion and convenience, but requires overcoming barriers to technology access and trust. The impact is highly dependent on the specific conditions and demographics of the local agricultural systems. Comprehensive training and support services may be needed to enable farmers to effectively leverage digital payments and finance tools. Overall, the study provides a useful baseline understanding of how cashless policy had impacted amongst arable crop farmers in Egbeda Local Government, Oyo State. Thus, extension agent should conduct surveys with a representative sample of arable crop farmers in Egbeda to understand their current banking and digital literacy levels, access to technology, trust in digital systems, and opinions on potential benefits/challenges of a cashless system.

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Potential Nutritional Health Benefits and Microbial Quality of Washed Fresh Okra (*Abelmoschus esculentus*) Water

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Abstract
Okra is an important dietary component rich in nutrients. The considerable attention given to fresh okra-infused water as a beverage in recent times among people necessitates the importance of assessing its microbial quality in sustaining good dietary behaviour. Standard Laboratory protocols for microbial analysis were employed. This reveals the transmitting potential of fresh okra infused in normal saline. Microbes were isolated with colonies above 1cfu/g in the cultured plates. However, the results imply that the consumption of okra-infused water may have adverse effects when appropriate and adequate measures are not in place. Hence, consumers must always observe and wash properly, using safe drinking water for processing to avert potential health hazards.
Keywords: Okra, health benefits, potentials, microbial quality, processing

INTRODUCTION
Fruit-bearing vegetables such as Okra are widely known for their dietary health-promoting nutrients and a good source of antioxidants (Bonciu, 2020) that can support human health. Okra-infused water has attracted great interest as a beverage for nutritional health maintenance in the body system since it contains several nutrition-beneficial elements that can revitalize human health. However, scientific evidence to validate its potential use in supporting human health remains limited. Okra is a potent source of dietary fibre. Research has shown promising nutritional evidence as regards nutritional contents (United States Department of Agriculture, 2019) and additive enrichment potential in food (Adetuyi, Ajala & Ibrahim, 2021). Mucilage, the slimy component of Okra has been implicated to possess useful health potential substances such as polysaccharides (Anastasakis, Kalderis & Diamadopoulos, 2021). Moreover, Okra as a "functional food" in human nutrition benefits human well-being (Barcellos & Lionello, 2011). This is due to their antitumor, antioxidant, antimicrobial (Ameena, Dilip, Saraswathi, Krishnan, Sankar & Simi, 2010) anti-inflammatory, hypoglycemic, and immune-modulatory properties (Elkhalifa, Alshammari, Adnan, Alcantara, Awadelkareem, Eltoum, Mehmood, Panda & Ashraf, 2020). The natural polysaccharides (Anastasakis, Kalderis & Diamadopoulos, 2021) found in Okra mucilage cannot be underestimated as an excellent health promoter in an individual diet. Therefore, its ability to be subjected to tests and as an alternative means of getting its locked-up nutrients and other essential active compounds raw through its infusion in water by cutting into slices benefits a lot. Hence, the ability of the fruit vegetable being purchased

contaminated from the source and sellers in various locations in an unhygienic condition could expose the consumers' health to danger. The consumption and use of fruit vegetables in their raw and not properly washed state, have been proven to be a means by which human pathogens are transmitted (Bergal, Sodha & Shaw, 2013). The ability of contaminated fresh Okra fruits infused in water to affect the potential nutritional value cannot be underrated in human dietary behaviour and guidance. Understanding the transmission potential and microbial quality of the infused Okra beverage is essential in sustaining good human daily nutritional intake as food-borne illnesses can result when prepared unhygienically by the consumer.

Botanical grouping of okra fruit vegetable

Kingdom: Plantae
Clade: Angiosperm
Clade: Eudiocots
Clade: Rosids
Order: Malvales
Family: Malvaceae
Genus: *Abelmoschus*
Species: *A. esculentus*

Okra (*Abelmoschus esculentus*) as Fuctional food

Functional foods are supposed to improve the proper functioning of human health by stimulating nutrients and phytochemical compounds leading to enhanced biological activities that can benefit the health and improve the functionality of an individual. Nutrients and phytochemical compounds found in Okra qualify it as a potential functional food. Mucilaginous contents of okra are paramount to the functional health activities of the fruit. In support of this, Adetunji and Dada (2014) pointed out that the contents of Zn and Ca in the okra are higher than the mineral content of the whole okra fruit.

Daily Nutritional Health Profile of raw okra in human diet

Serving size: one cup

Table 1: Daily Nutrition of Okra Water

	Amount per serving	**% Dv**
Macronutrients		
Calories	33kj	-
Protein	1.93g	-
Fat	0.19g	-
Carbohydrates	7.45g	-
Fiber	3.2g	-
Vitamins		
Vitamin C	23mg	25%
Folate	60mcg	15%
Vitamin K	31.3mcg	26%
Minerals		
Sodium	7mg	-
Magnesium	57mg	13%

- Daily value not established. Source: U.S. Department of Agriculture: Fooddata central

Other dietary components of okra fruit

- **Antioxidants and Phytochemicals**: Flavonoids, Phenolic acids, Saponins, Terpenoids and Carotenoids
- **Beneficial compounds:** Okra gum(soluble fiber), Lectins, and Polyphenols

- **Other mineral and vitamin components:** Phosphorus(P), Manganese(Mn), Iron(Fe), Potassium(K), Vitamin A and Vitamin B6.

Acclaimed Health benefits of okra infused water

Okra infused drink as beverage is popularly consumed and prepared by people due to its acclaimed nutritional health benefits which cannot be separated from the researched elemental nutritional constituents of the vegetable fruit itself. While this beverage is assumed to be contributing to the well-being of most people, researched scientific nutritional health benefits of okra cannot be sidelined as it serves to support the acclaimed benefits. Chalsea Rae Bourgeois, (2024) underlined the health benefits of okra water in relation with the scientifically supported research benefits of whole okra fruit which is, as follows with little modification:

- **Improve digestion**: Indigestion brings about discomfort in the gastrointestinal system of an individual. The mucilaginous content of okra has been implicated in neutralizing stomach acid associated with intestinal discomfort and speeding up gastrointestinal indigestion and stomach disorder.
- **Improve skin appearance**: Although, eating a diet rich in all essential nutrients are paramount to looking healthy among young and older adults. Okra water might be active in improving skin appearance due to the combined effect of vitamin A and vitamin C components of the fruit vegetable which makes the implicated okra water being beneficial to the skin. Also, Okra immune-modulatory activities may be assumed to lessen the age-related deterioration of immune response in the human body system.
- **Support weight loss efforts**: Okra water is often claimed to support weight loss thus contributing to satiety, fat binding, and reduced overall calorie intake. Okra extracts are reported to have significant weight loss in mice with diabetes. However, the intake of okra water may serve as a diabetes management practice in humans as it can help to compensate for the volume of urine passed by the sufferers while balancing the amount of water lost. Hence, research on its clarity as a potential weight loss drink in human diets is important to public health.
- **Support Blood Sugar Control:** This claim needs more significant scientific data to uphold its nutritional health benefit significance in okra water. However, whole okra fruits are known for their anti-diabetic properties thus improving blood sugar levels. Hence, studies on whole fruit oral capsules among 60 participants every six hours led to a decrease in fasting blood sugar and haemoglobin AIC levels over eight weeks.
- o Above all, when taking okra water to obtain its acclaimed nutritional health benefit, consumers need to ensure that the safety aspect of it is considered before consumption and consideration in their diets to lead to a healthy lifestyle.

MATERIALS AND METHODS

Sample Collection

Fresh Okra fruits were purchased from Towobowo Market and hawker at different locations in Igboora into a sterile polythene bag. These samples were tagged, Sample A - C and were taken into the Laboratory for further analysis. The microbial quality of the sample was checked using pour plate method.

Sterilization of materials

Petri plates, other glass wares and media (agar) used were sterilized at 121 degrees centigrade for 15 minutes in an autoclave in the Laboratory.

Preparation of sample for microbial quality

A portion (200g) of the weighed samples was soaked in normal saline (0.9%) enough to cover the samples in a clean and separate container to detach the microbial contaminants of the Okra fruits. Several agitations of the samples in normal saline were performed then the samples were removed, and the solution with serial dilution 10^{-4} was used to inoculate plate count culture media in duplicate. The agar was prepared according to the manufacturer's instructions. A complete colony count was carried out to quantify the microbial load. The culture was aerobically incubated at appropriate temperatures and hours for accurate results.

Data analysis

Table 2 shows that the washed water from the sampled okra is contaminated with microbial load. This suggests that the fruit is prone to contamination and the microbes could endanger human health. The contaminant found in the okra fruit indicates improper handling and processing, cleaning of the fruit with contaminated water, cross-contamination from other fruits during transportation and processing, processing container and tools, as well as other external factors to which they are exposed (Gupta, Satpati, Nayek & Garai, 2010; Daryani, Ettehad, Sharif, Ghorbani & Ziaei,2008), could be responsible for their contamination. The presence of microbial contaminants in sampled okra fruits might be enough to produce contamination that can cause an infection to consumer's health.

Table 2: Microbial quality of sampled okra washed water

Sample code	Count (x 10^4cfu/g)
A	2.4
B	2.5
C	1.2

CONCLUSION

This study draws the attention of the populace to focus on the microbial negative impact of okro water on human health to facilitate good dietary habits. Okra fruits have been shown to harbour microbes and contain active ingredients in maintaining the nutritional health status showing curative effects in some illnesses. Hence, proper handling and preparation should be observed while preparing the okra water for its human health benefits to minimize the danger of waterborne diseases among consumers. Thus, appropriate preventive measures should be used to reduce potential health hazards.

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Usage of Artificial Intelligence Digital Technology for Information Management among Agro-Researchers and Extension Workers on in Oyo State, Nigeria

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Abstract
This study was conducted to examine agro-researchers and extension workers usage of artificial intelligence digital technology for information management in Oyo State. Simple random sampling technique was used to select 160 respondents. Data were collected with the use of well-structured and validated questionnaire. Descriptive statistics was used to analyze the objectives while t-test was used to test the hypothesis. Findings show that 93.8% of extension workers and 85.0% of agro-researchers were aware of chatgpt. Also, 76.3% of extension workers and 60.0% of agro-researchers always used Chat GPT. Majority of agro-researchers (83.8%) and extension agents (75.0%) stated that artificial intelligence (AI) tools were very suitable for information management. Majority of agro-researchers (83.8%) and extension workers (91.3%) understood that artificial intelligence (AI) is the science of creating intelligent machines and programs. There was no significant difference (t-value = 0.301, df = 159) in the awareness of artificial intelligence between extension workers and agro-researchers. The study concludes that extension workers and agro-researchers were favourably disposed to usage of artificial intelligence tools. There is need for policy formulation to enhance integration of artificial intelligence in research and extension for effective service delivery.
Keywords: Artificial intelligence, agro-research, extension

INTRODUCTION

One of the most significant advancement in the agricultural sector is the introduction of Artificial Intelligence (AI). AI is the science of making intelligent machines and programs. It is rooted in the principle that machines can accurately describe and replicate human intelligence, allowing them to efficiently carry out tasks ranging from basic to the most complex. According to Adilakshmi *et al.,* (2021), AI technologies are made by studying how the human brain thinks and how people learn, make decisions, and work while solving a problem. The idea of AI is to create technologies that mimic the functioning of the human brain. (Adilakshmi *et al*., 2021). Information and Communication Technologies (ICTs) in Agriculture are important for the development of a viable and sustainable food security strategy (Miiro *et al.,* 2020; Ridley *et al.,* 2019). According to Rakhra *et al.* (2022), artificial intelligence-based technologies have aided in increasing productivity across all industries, including the agricultural sector by addressing challenges in areas such as crop yield, irrigation, soil content sensing, crop monitoring, weeding, and crop establishment. For instance, Singh and Jain (2022) stated that artificial intelligence technologies help in the production of healthy crops, pest control and soil monitoring and improve a wide range of agriculture-related tasks in the entire food supply chain including harvesting, processing, and marketing. Farmers can increase their income by finding market opportunities where they can compete on their skills and quality of product rather than by just offering the lowest price (Macharia *et al.,* 2016). It is well known that agricultural extension professionals are very significant in agricultural transformation in Africa, including Nigeria because they have the expertise to communicate innovation and technologies to the majorly resource-poor farmers. Recently, leveraging on the high rate of utilization of mobile-phone among Nigerians, including farmers (both in the urban and rural communities), the conventional face-to-face extension professionals' contacts with farmers are gradually being supported with AI-based mobile phone-enabled digital technologies (Rotondia *et al*., 2020). Olagunju *et al*. (2021) observed that agricultural extension services primarily relied on "on-the-field" methods, including activities like demonstration plots, group training, and farm visits. These approaches involved direct face-to-face interactions (Maertens *et al*., 2020). Farinde *et al*. (2022) reported that physical distance-related COVID-19 measures prevented such the former approach, compelling the extension workers to adopt digital tools for delivery services to farmers. Application of AI could expand the scope of agricultural extension services. According to Jones (2019), there is limited research on the specific ways that AI can be used to improve extension services and agro-research with specific applications such as predictive analytics, data visualization and automated decision-making. This creates a need for more research on the specific applications of AI and potential impact of the applications on extension services and agro-research.

Objectives of the study

The main objective was to examine agro-researchers and extension workers usage of artificial intelligence digital technologies for information management in Oyo State.
The specific objectives were to:

i. describe the personal characteristics of agro-researchers and extension workers in Oyo State;
ii. examine agro-researchers and extension workers usage of artificial intelligence digital technologies;
iii. ascertain the appropriateness of artificial intelligence digital technologies to agro-research and extension;
iv. examine the perception of agro-researchers and extension workers about artificial intelligence digital technologies.

Hypothesis of the study

The hypotheses of the study were stated in null form as follow:
Ho1: There is no significant difference between extension workers and researchers on awareness of Artificial intelligence digital technologies

METHODOLOGY

The study was conducted in Oyo State, Southwest, Nigeria. Oyo State. The population of the study comprises all agro-researchers and extension workers in Oyo State, Nigeria. Simple random sampling technique was used to select four agro-research institutes out of the existing six. These include Institute of Agricultural Research and Training (IAR&T), Nigerian Institute of Horticultural Research (NIHORT), National Cereal Research Institute (NCRI) and National Centre for Genetic Resources and Biotechnology (NACGRAB). Twenty research scientists were selected using simple random sampling techniques from each of the selected research institutes to arrive at a total of eighty (80) respondents. On the other hand, two Agricultural Development Zones were randomly selected for the study. They were Ibadan/Ibarapa and Oyo ADP zones. Two blocks were selected using simple random sampling techniques from the existing eight blocks in each of the zones. Four cells were randomly selected from each of the selected blocks making a total of eight cells. Ten extension workers were selected using simple random sampling technique from the selected cells to arrive at a total of eighty (80) respondents. Data were collected with the use of well-structured and validated questionnaires which were administered to respondents in the study area. Descriptive statistics such as frequency count, percentages and mean were used to analyze the objectives while chi-square was used to test hypotheses one and two while t-test was used to test the hypotheses.

RESULTS AND DISCUSSION

Usage of artificial intelligence by agro-researchers and extension workers

Table 1 showed the usage of artificial intelligence among agro-researchers and extension workers in the study area. Results showed Chat Gpt (60.0%), Gpt Zero (40.0%), Quillbot (36.3%) and browse AI were always used by the respondents. Furthermore, majority (76.3%) always used Chat Gpt. Other AI tools used were Chat pdf (50.0%), Gpt Zero (47.5%), Browse AI (45.0%). Moreover, Otter (61.3%), Jasper chat (55.0%), Title generator pro (48.8%), Spinach (46.3%), Sematic scholar (45.0%) were never used by extension workers. The pooled results showed that ChatGpt (68.1%), Chat pdf (50.6%), Gpt zero (43.8%) and Browse AI (43.1%) were always used by both agro-researchers and extension workers. This implies that agro researchers, extension workers always used Chat gpt. Rospigliosi, (2023) reported that ChatGPT is replete with remarkable features through its underlying technologies such as machine learning and natural language processing. Its capabilities span across a broad spectrum, from completing texts, answering questions, to even spawning original content.

Appropriateness of artificial intelligence for agro-research and extension

Results in Table 2 show the appropriateness of usage of artificial intelligence for agro-research and extension in the study area. The result showed that majority (83.8%) of agro-researchers and (75.0%) of extension workers considered AI tools as very appropriate for information dissemination. Also, (58.8%) of agro-researchers and (57.5%) of extension workers considered AI as very appropriate for knowledge sharing. In addition, (60.0%) of agro-researchers and (48.8%) of extension workers viewed AI as very appropriate for literature reviews. This indicated a general favorability towards AI technologies in agro-research and extension, particularly for information dissemination, knowledge sharing, and literature reviews. Baidoo-Anu and Owusu Ansah (2023) found that the advantages of Chat-GPT include personalized learning, the encouragement of interactive learning, and the potential for formative assessment that supports teaching and learning and provides continuous feedback.

Perception of agro-researcher and extension workers about usage of artificial intelligence

Table 3 shows the perception of agro-researcher and extension workers about usage of artificial intelligence in the study area. Results shows that agro researchers strongly agree that AI can be vulnerable to hacking and security breach, AI can improve production / productivity and income of farmers ($\bar{x}$= 3.38), AI plays crucial roles in addressing priority problem ($\bar{x}$=3.24), AI help users in stream line tasks ($\bar{x}$= 3.20) and AI facilitate fostering the development of new agriculture solution ($\bar{x}$=3.18). Also, extension workers perceived that AI can be vulnerable to hacking and security breach ($\bar{x}$ = 3.45), AI plays crucial roles in addressing priority problem ($\bar{x}$=3.33), AI can improve production / productivity and income of farmers ($\bar{x}$= 3.25) and AI can emerge complex ethical question ($\bar{x}$=3.11). Pooled results showed that both agro researchers and extension workers strongly agreed that AI can be vulnerable to hacking and security breach ($\bar{x}$= 3.41), AI can improve production / productivity and income of farmers ($\bar{x}$= 3.31), AI plays crucial roles in addressing priority problem ($\bar{x}$=3.28) and AI can emerge complex ethical question ($\bar{x}$=3.12). This implies that extension workers and agro researchers strongly agreed that AI can improves production / productivity and income of farmers and plays crucial roles in addressing priority problem. This result gives credence to the submission of Farinde et al. (2022) that high-cost implication, low level of literacy and lack of technical know-how among extension professionals and farmers are the constraints to the use of AI-based digital tools for extension practices in Nigeria. Furthermore, there is low-level digital education and skills, as well as inadequate digital infrastructure, such as data, software, and hardware infrastructure, which are basic requirements for the functioning of AI digital tools (Nikola et al., 2019; Tsan *et al*., 2019).

Test of difference between extension workers and researchers on awareness of Artificial intelligence digital technologies

The t-test analysis in Table 4 shows that there was no significant difference (t-value = 0.301, df =159) in the awareness of artificial intelligence between extension workers and researchers. This implies that extension workers and researchers were aware of artificial intelligence.

CONCLUSION AND RECOMMENDATIONS

The study concluded that agro-researchers and extension workers were aware of chatGpt and it was commonly used among the artificial intelligence tools. AI was reported to be very appropriate for information dissemination, knowledge sharing and there was positive perception about the usage of AI even though some challenges may have constrained the users. It is therefore training should be organized for agro-researchers and extension workers to increase their proficiency in AI. Also, there is need for policy formulation that will enhance integration of artificial intelligence in research and extension for effective service delivery to end users.

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Table 1: Usage of artificial intelligence by agro-researchers and extension workers (n=160)

AI tools	Agro-researchers				Extension workers				Pooled			
	AU	RU	NU	M	AU	RU	NU	M	AU	RU	NU	M
Chat Gpt	48(60.0)	18(22.5)	14(17.5)	1.43	61(76.3)	10(12.5)	9(11.3)	1.65	109(68.1)	28(17.5)	23(14.4)	1.53
Gpt Zero	32(40.0)	24(30.0)	24(30.0)	1.10	38(47.5)	21(26.3)	21(26.3)	1.21	70(43.8)	45(28.1)	45(28.1)	1.15
Chat Pdf	41(51.3)	20(25.0)	19(23.8)	1.28	40(50.0)	21(26.3)	19(23.8)	1.26	81(50.6)	41(25.6)	38(23.8)	1.27
Abstract Maker	25(31.3)	28(35.0)	27(33.8)	0.98	21(26.3)	25(31.3)	34(42.5)	0.84	46(28.8)	53(33.1)	61(38.1)	0.91
Jasper Chat	17(21.3)	28(35.0)	35(43.8)	0.78	15(18.8)	21(26.3)	44(55.0)	0.64	32(20.0)	49(30.6)	79(49.4)	0.71
Otter	17(21.3)	24(30.0)	39(48.8)	0.73	14(17.5)	17(21.3)	49(61.3)	0.56	31(19.4)	41(25.6)	88(55.0)	0.64
Semantic scholar	30(37.5)	21(26.3)	31(38.8)	0.96	26(32.5)	18(22.5)	36(45.0)	0.88	56(35.0)	39(24.4)	65(40.6)	0.94
Scholarcy	28(35.0)	21(26.3)	31(38.8)	0.96	24(30.0)	30(37.5)	26(32.5)	0.98	52(32.5)	51(31.9)	57(35.6)	0.97
Quillbot	29(36.3)	23(28.8)	28(35.0)	1.01	28(35.0)	21(26.3)	31(38.8)	0.96	57(35.6)	44(27.5)	59(36.9)	0.99
Title generator pro	19(23.8)	25(31.3)	36(45.0)	0.79	17(21.3)	24(30.0)	39(48.8)	0.73	36(22.5)	49(30.6)	75(46.9)	0.76
Grammarly Go	31(38.8)	23(28.3)	26(32.5)	1.06	31(38.8)	23(28.8)	26(32.5)	1.06	62(38.8)	46(28.8)	52(32.5)	1.06
Spinach	24(30.0)	17(21.3)	39(48.8)	0.81	18(22.5)	25(31.3)	37(46.3)	0.76	42 (26.3)	42(26.3)	76(47.5)	0.79
Browse AI	33(41.3)	24(30.0)	23(28.8)	1.13	36(45.0)	21(26.3)	23(28.8)	1.16	69(43.1)	45(28.1)	46 (28.8)	1.14

Source: Field survey, 2024. Figures in parenthesis are percentages. AU = Always used; RU = Rarely used; NU = Never use; M = Mean

Table 2: Appropriateness of artificial intelligence digital technologies for agro-research and extension (n = 160)

Application of AI tools	Agro-researchers				Extension workers				Pooled			
	VA	A	NA	M	VA	A	NA	M	VA	A	NA	M
Information dissemination	67(83.8)	12(15.0)	1(1.3)	1.83	60(75.0)	19(23.8)	1(1.3)	1.74	127(79.4)	31(19.4)	2(1.3)	1.78
Knowledge sharing	47(8.8)	31(38.8)	2(2.5)	1.56	46(57.5)	29(36.3)	5(6.3)	1.51	93(58.1)	60(37.5)	7(4.4)	1.53
Literature review	48(60.0)	24(30.0)	8(10.0)	1.50	39(48.8)	36(45.0)	5(6.3)	1.43	87(54.4)	60(37.5)	13(8.1)	1.46
Publication	43(53.8)	26(32.5)	11(13.8)	1.40	31(38.8)	30(37.5)	19(23.8)	1.15	74(46.3)	56(35.0)	30(18.8)	1.27
Data collection	43(53.8)	27(33.8)	10(12.5)	1.41	33(41.3)	34(42.5)	13(16.3)	1.25	76(47.5)	61(38.1)	23(14.4)	1.33
Data analysis	44(55.0)	22(27.5)	14(17.5)	1.38	32(40.0)	26(32.5)	22(27.5)	1.13	76(47.5)	48(30.0)	36(22.5)	1.25
Advisory service	27(33.8)	31(38.8)	22(27.5)	1.06	24(30.0)	39(48.8)	17(21.3)	1.09	51(31.5)	70(43.8)	39(24.4)	1.07
Access to inputs	39(48.8)	29(36.3)	12(15.0)	1.34	23(28.8)	37(46.3)	20(25.0)	1.04	62(38.8)	66(41.3)	32(20.0)	1.18
Financial services	27(33.8)	28(35.0)	25(31.3)	1.03	18(22.5)	30(37.5)	32(40.0)	0.83	45(28.1)	58(36.3)	57(35.6)	0.92

Source: Field survey, 2024. Figures in parentheses are percentages. VA = Very appropriate; A = Appropriate; NA = Not appropriate; M = mean

Table 3: Perception of agro-researcher and extension workers about the usage of artificial intelligence (n = 160)

Application of AI tools	Agro-researchers					Extension workers					Pooled				
	SA	A	DA	SD	M	SA	A	DA	SD	M	SA	A	DA	SD	M
AI can be vulnerable to hacking and security breach	41(51.3)	28(35.0)	11(13.8)	0(0.0)	3.38	44(55.0)	30(37.5)	4(5.0)	2(2.5)	3.45	85(53.1)	58(36.3)	15(9.4)	2(1.3)	3.41
AI plays a crucial roles in addressing priority problem	30(37.5)	40(50.0)	9(11.3)	1(1.3)	3.24	31(38.8)	44(55.0)	5(6.3)	0(0.0)	3.33	61(38.1)	84(52.5)	14(8.8)	1(6)	3.28
AI can improves production / productivity and income of farmers	37(46.3)	36(45.0)	7(8.8)	0(0.0)	3.38	35(43.8)	32(40.0)	11(13.8)	2(2.5)	3.25	72(45.0)	68(42.5)	18(11.3)	2(1.3)	3.31
AI fits well in the existing condition and practices	29(36.3)	37(46.3	17(21.3)	5(6.3)	3.13	18(22.5)	37(46.3)	19(23.8)	6(7.5)	2.84	47(29.4)	74(46.3)	28(17.5)	11(6.9)	2.98
AI helps users in streamline tasks	33(41.3)	34(42.5(	9(11.3)	4(5.0)	3.2	24(30.0)	34(42.5(	13(16.3)	9(113)	2.91	57(35.6)	68(42.5)	22(13.8)	13(8.1)	3.06
AI can emerge complex ethical question	29(36.3)	34(42.5)	15(18.8)	2(2.5)	3.13	27(33.8)	36(45.0)	16(20.0)	1(1.3)	3.11	56(35.0)	70(43.8)	31(19.4)	3(1.9)	3.12
AI facilitate fostering the development of new agriculture solution	31(38.8)	34(42.5)	13(16.3)	2(2.5)	3.18	23(28.8)	41(51.3)	11(13.8)	5(6.3)	3.03	54(33.8)	75(46.9)	24(15.0)	7(4.4)	3.1

Source: Field survey, 2024. Figures in parentheses are percentages. SA = Strongly agree; A = Agree; DA = Disagree; SD = Strongly disagree. M = $\bar{X}$

Table 4: Test of difference between extension workers and researchers on awareness on artificial intelligence digital technology

Variables	t-value	df	P-value	Decision
Awareness of artificial intelligence between agro-researchers and extension workers	0.301	159	0.764	Not Significant

Source: Field survey, 2024

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Effect of Legume Cover Crop and Varying Rates of Nitrogen on Growth Yield and Soil Properties of Tomato in the Southern Guinea Savannah

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Abstract

To increase tomato fruit yield in an intensive cropping system we experimented in 2018 and 2019, at the research and teaching farm area of the College of Agriculture and Animal Science, division of Agricultural College, Ahmadu Bello University Mando Road Kaduna to test the effects of the application of different nitrogen rates (0, 40, 60 and 120 kg Nha^{-1}) on either plots incorporated with green manure or left fallow on the growth and yield of tomato. The experiment was laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The results showed that nitrogen rates combined with green manure increased the important morphologic al characters measured and gave the highest and significant fresh marketable tomato yield of 11.2-ton ha^{-1} achieved with 60 kg N ha^{-1} compared to 8.94 and 9.62-ton ha^{-1} attained with 60 kg N ha^{-1} compared to 8.94 and 9.62-ton ha^{-1} attained with 60kg N ha^{-1} and 120 kg N ha^{-1} application on fallow plots respectively. The control planted on fallow gave the least total yield (4.98-ton ha-1). The soil pH, Ca and Mg in the 0 – 15 cm top soil were improved averaged across two years.

Keywords: Green manure, nitrogen fertilizer, fallow tomato, and mungbean

INTRODUCTION

Tomato (*Solanum Lycopersicum* L.). is grown on about 5 million hectares of land worldwide with production of nearly 129 million tons. The production, productivity and national average yield of tomato in Nigeria is about 10-ton ha^{-1}. This is low compared to neighboring countries like Ghana and Code voire and other parts of the world having tomato average yield of 13-ton ha^{-1} (FAO, 2013). Increasing production of the crop has a great role to strengthen the growing vegetable industries in the country. However, the production and productivity of the crop in the country is influenced by different factors. Frequent tillage and serious soil erosion might have led to rapid decomposition of soil organic matter in the Nigerian Cropping Systems. Use of green manure is an option to improve soil organic matter.

After harvest in the wet season there is always a window period of about 40 – 60 days before the dry season, green manure can be grown as cover crops. Apart from the green potential benefits of recycling nutrient elements from deep soil, legumes generally have a higher nitrogen content than that of non-legumes because many of them fix nitrogen symbiotically with rhizobia.

MATERIALS AND METHODS

Experiment Site

An experiment was carried out at the College of Agriculture and Animal Science, Division of Agricultural Colleges, Ahmadu Bello University, Mando road, Kaduna during the dry season at the teaching and research farm of agronomy unit close to the college dam to examine the effect of four levels of nitrogen rates (0, 40, 80 and 120 kg Nha^{-1}) combined with either incorporation of cover crops of nitrogen (N) for tomato compared with when N alone is applied under intensive management cropping system. The College of Agriculture and Animal Science lies on latitude 10^0 58' N and longitude 7^0 42' E (GSP 20) at 459 m above sea level in the southern guinea savannah. The region has an average temperature of 25^0C, and an average rainfall of 600 mm perannum.

Cultural Practices

The soil is a ferruginous soil with a sandy loam texture, having a pH of 5.76, organic matter content, 10.8 g/kg total Nitrogen N, 0.66 g/kg, available P, 6.5 mg/kg, CEC 6.7 cmol/kg Ca 1.40 cmol/kg, K 0.58 cmol/kg Mg 3.54 cmol/kg and Na 4.00 cmol/kg Black (1965).

Treatment and Experimental Design

The treatment consists of four urea levels 0, 40, 80 and 120 kg N/ha factorially combined with either green manure or fallow plots. The experiment was laid out in Randomized Complete Block Design (RCBD) and replicated 4 times. The site was marked out into 32 units plots of size 4m x 4m (16 m^2) with raised embankment.

Land preparation sowing and weeding

The plots of the experimental field were planted with seeds at about 160,000 plants/ha using 25cm x 25cm spacing recommended for mungbean grain production. After 8 weeks of planting the green manure was uprooted and incorporated insitu. This was manually done using a hand hoe. One week after the incorporation of green manure the seeds of Graftor an improve tomato cultivar 8-week seedlings uprooted from the nursery located outside the main field was transplanted on the manure incorporated plots as well as on the fallow plot. Transplanting was done in May of each year, at 5 cm depth and the spacing of 20cm intra-row and 60 cm inter-row.

Fertilizer application: Fertilizer was applied according to the treatments using urea for N, single super sulphate (P_20_5 30%) for P and muriate of potash (K_20 60%) for K. Irrigation before and after transplanting through furrows were directed between channels dug between the strips of the 4m length basins at harvest tomato was handpicked at 9 and 12WAT. Weeding was done at 2 and 6 weeks after transplant.

Data Collection

Data was taken from 4 randomly tagged plants of each gross plot at three weeks' interval for periodic observation. The mean of the four plants was calculated and recorded for each plot.

Statistical Analysis

Data collected was subjected to statistical analysis of variance (ANOVA) as described by snedecor and Cochran using statistical analysis system 9SAS institute 1997), and

Duncan Multiple Range Test (DMRT) 9duncan, 1955) was used to separate the treatment means. Mean effect of the factors were obtained in accordance with the procedure of Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The data on table 2 shows that there was a significant effect at 6, 9 and 12WAT.
A higher significant difference was recorded in tomato planted on plots incorporated with mung bean combined with nitrogen compared to the fallow plots applied with urea. Relatively higher plant height more number of leaves; longer leaf length and under width of tomato were recorded using green manure combined with urea compared to the fallow plots applied with urea. This might be attributed to increased pH and CEC that resulted. In general improvement in plant growth recorded might have translated into increased yield of tomato through better nutrient availability in the GM treated plots.

The increase in the performance of tomato as a result of incorporation of green manure combined with urea compared to fallow applied with urea could be due to increased availability of soil OM, P, K, Ca and Mg concentrations from the manures as these were initially low at the 0-15 cm soil layer. The growth and development of plants were largely affected by nutrient availability in their surroundings. Plant utilizes macronutrients such as nitrogen, P and K as the materials synthesize many important biological macromolecules such as DNA, RNA proteins, enzymes lipids etc. These molecules are used as building to build plant, cells and tissues, hence the more nutrients available to the plant, the better the growth performance of plants would be. Several authors have also reported an increased yield of tomato with incorporation of green manure.

CONCLUSION AND RECOMMENDATIONS

In conclusion all the treatments statistically out yielded the control. However, incorporation of legume mungbean combined with fertilizer out yield the plots left fallow before the next planting.

Table 1: Some chemical properties of mungbean cover crop used as GM in the experiment in southern savannah

Parameters	Property (kg/ha)[a]
Total N g/kg	2.80×10^3
Total P g/kg	15.41×10^3
Total K mol/kg	1.00^2
Ca mol/kg	0.24×10^2
Mg mol/kg	0.21×10^2
K	1.38×10^2

Note a = Property values refer to the average 3 t/ha fresh mungbean biomass incorporated treatment

Table 2: Effect of fertilizer nitrogen (N) with green manure and fallow on number of leaves of tomato, average over 2018 and 2019

	No. of leaves of Tomato plant Fallow				No. of leaves of Tomato plant Green Manure			
N (kg ha-1)	3WAT	6WAT	9WAT	12WAT	3WAT	6WAT	9WAT	12WAT
0	21.33	46.67[c]	102.67[b]	106.57[c]	22.96	48.30[c]	104.30[b]	108.30[c]
40	22.67	51.62[b]	108.33[b]	114.60[a]	23.89	52.89[b]	109.55[b]	115.89[b]
80	23.00	66.67[a]	114.67[a]	115.00[b]	24.19	67.86[a]	115.86[a]	116.19[b]
120	24.00	70.64[a]	125.67[a]	127.00[a]	25.08	71.75[a]	126.75[a]	128.08[a]
SE±	0.547	1.07	0.76	1.37	0.547	1.07	0.76	1.37

Means followed by the same letter within the same column of any set of treatments are not significantly different at 5% level of probability using DMRT.
* = significant at 5% probability level ** = significant at 1% probability level, NS = Not significant, SE = Standard error. WAT = Weeks after transplanting.

Table 3: Effect of nitrogen fertilizer with green manure and fallow on plant height of tomato

	Plant height of tomato Fallow				Plant height of tomato Green Manure			
N (kg ha-1)	3WAT	6WAT	9WAT	12WAT	3WAT	6WAT	9WAT	12WAT
0	24.33[b]	63.47[c]	64.5[b]	61.58[c]	25.96[b]	65.1[c]	66.13[b]	63.21
40	27.00[b]	63.18[b]	70.83[a]	68.00[bc]	28.22[b]	64.4[b]	72.05[a]	69.22
80	28.18[a]	63.50[a]	72.59	73.00[a]	29.37[a]	64.69[a]	73.69[a]	74.19[a]
120	31.00[a]	68.5[a]	76.50[a]	76.50[a]	32.10[a]	69.58[a]	77.58[a]	77.51[a]
SE±	0.47	0.605	0.944	0.950	047	0.605	0.944	0.950

Means followed by the same letter within the same column of any set of treatments are not significantly different at 5% level of probability using DMRT.
* = significant at 5% probability level ** = significant at 1% probability level, NS = Not significant, SE = Standard error. WAT = Weeks after transplanting.

Table 4: Effect of green manure (GM) and fertilizer nitrogen (N) on fruit yield of tomato and residual effect on subsequent tomato yield, average over 2018 and 2019

	Tomato fruit yield (t ha^{-1})		Residual effect on tomato fruit yield (t ha^{-1})	
N (kg ha-1)	Fallow	Green manure	Fallow	Green manure
0	**4.58**	**7.44**	**3.23[e]**	**4.46[c]**
40	7.80	9.48[b]	3.30[d]	5.37[b]
80	8.94[c]	11.20[a]	3.63[d]	6.1[a]
120	9.62[bc]	11.41[a]	4.38[cd]	6.47[a]
SE±	0.75	0.95	0.15	0.15

Means followed by the same letter within the same column of any set of treatments are not significantly different at 5% level of probability using DMRT.
* = significant at 5% probability level ** = significant at 1% probability level, NS = Not significant, SE = Standard error WAT = Weeks after transplanting

Table 5: Effect of green manure (GM) plus nitrogen (N) at 80kgN h^{-1} and fallow plots plus nitrogen at 80kgN h^{-1} on some chemical properties of ferruginous soil (0-15 cm), averaged over 2018 and 2019

Characters	Fallow	Green manure
Chemical properties		
pH in H_20	5.76	7.7
Organic carbon g/kg	1.08	1.19
Total nitrogen g/kg	0.66	0.92
Available P mg/kg	6.5	7.8
Exchangeable bases cmol/kg		
Ca	1.40	1.93
Mg	3.54	3.77
K	0.58	0.48
Na	4.00	3.81
CEC	6.7	7.32

Means followed by the same letter within the same column of any set of treatments are not significantly different at 5% level of probability using DMRT.
* = significant at 5% probability level ** = significant at 1% probability level, NS = Not significant, SE = Standard error.

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Virus Types and Distribution in Cowpea Seeds in Selected Markets of Katsina State, Sudano-Sahelian Savannah of Nigeria

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Abstract
Field surveys were conducted during the 2024 wet season to identify and determine the distribution of cowpea viruses in Katsina State, Nigeria. Three locations were visited during the surveys. Seed samples were collected from various markets from the three locations. The antigen coated plate - enzyme linked immunosorbent assay (ACP–ELISA) method was employed for virus detection in the collected samples. Results showed that Blackeye cowpea mosaic virus (BICMV), Cowpea mild mottle virus (CPMMV) Cucumber mosaic virus (CMV) and Cowpea mottle virus (CPMoV) were the viruses detected. Thus BICM and CMV were more prevalent in all cowpea varieties. The detection of these viruses in seeds of cowpea in the surveyed areas indicates their importance in the ecology, survival and the significant role they play in the epiphytology of the various virus diseases. The occurrence of BICMV, CPMoV and CPMMV in few cowpea varieties is believed to be the first report in the study area

***Keywords: ACP-ELISA, Cowpea, Occurrence, Susceptible, Virus*.**

INTRODUCTION

Cowpea (*Vigna unguiculata L. Walp.*) is an important grain legume, a major staple food crop for household nutrition in sub-Saharan Africa, especially in the dry savanna regions of Nigeria. It plays an important role in human nutrition, food security, and income generation for both farmers and food vendors in the region. The grain is rich in protein (25%), carbohydrates, vitamins, and minerals and complements the mainly cereal diet in countries that grow cowpea as a major food crop (Singh *et al*., 1995). In Nigeria, farmers who cut and store fodder for sale at the peak of the dry season have been found to increase their annual income by 25% (Dugje *et al.* 2009). Cowpea also plays an important role in providing soil nitrogen to cereal when grown in rotation, especially in areas where poor soil fertility is a problem.

Cowpeas are susceptible to a wide range of insect pests and pathogens which can cause damage at all stages of growth (Aliyu *et al*., 2012). Smallholders and medium scale farmers are faced with two factors that constitute the major constraints to the cropping of cowpea i.e abiotic and the biotic (Dugjie *et al.*2010). Diseases of cowpea which constitute biotic constraints are usually induced by fungi, bacteria, nematodes, viruses (Alegbejo, 2015) and the parasitic flowering plants such as *Striga gesnerioides* and *Alectra vogelii* (Dugjie *et al.*2010). Virus diseases are considered to be a major limiting factor for the production and productivity of legumes in the tropical and sub-tropical countries (Bashir *et al*., 2008).

Virus, an economic important disease agent in cowpea seeds causes serious problems such as reduction in yield and germination, changes in shape and colour of seeds (Mandhare and Gawade, 2010). Seed-borne viruses are important for source of diseases at the beginning of production even at low rates of seed transmission (Alabi *et al*., 2010). In addition, seed-borne viruses can aggravate other transmission methods and cause disease to spread rapidly. Seed-borne and seed transmitted viruses are also damaging to cowpea productivity owing to inherent primary inoculum and potential for their widespread. Also, information on the possibility of seed transmission in virus infected cowpeas will be valuable to numerous cowpea farmers. The study therefore was to determine virus types and distribution in cowpea seeds in some selected markets in Katsina State, Sudano-Sahelian Savannah of Nigeria.

MATERIALS AND METHODS

Description of study area

The study was conducted in 2024 wet seasons at five major grain markets in Katsina (12°26'N and 07°29'E, 212 m above sea level), Nigeria. The average annual rainfall is about 700 mm. The pattern of rainfall in the area is highly variable. The vegetation of the area is the Sudan Savanna type which combines the characteristics and species of both the Guinea and Sahel Savanna (Abaje *et al*., 2014).

Sample collection

A multi-stage sampling procedure was employed to select five major grain markets in Katsina, these includes Ajiwa, Funtua and Dutsin-Ma respectively. From each market, 20g of cowpea seed samples was collected irrespective of the variety, preserved in air-tight vial tubes and transferred to the laboratory at the Department of Crop Protection, Faculty of Agriculture, Federal University Dutsin-Ma for serological test.

Serological detection of legume viruses in cowpea seed samples

The sampled seeds were subjected to Antigen – Coated PlateEnzyme-Linked Immunosorbent Assay (ACP - ELISA) as described by Kumar (2009). Samples were ground in coating buffer at a rate of 100 mg/mL (1:10 w/v). Wells of microtitre plates were coated with 100 µL of each sample. Plates were incubated at 37 ^{o}C for 1 hour, washed thrice at three minutes intervals with Phosphate Buffered Saline-Tween (PBS-T) and tap-dried. One g of healthy cowpea leaf was ground with 20 mL of conjugate buffer. The crude extract was filtered and rabbit antibody for various legume viruses was added at 1:10,000. One hundred µL of this was loaded into each well. The plate was incubated at 37 ^{o}C for 1 hour, washed thrice with PBS-T and tap-dried. This was followed by addition of 100 µL of anti-rabbit, goat anti-mouse diluted with conjugate buffer at the rate of 1:15,000 dilutions. Also, another round of incubation at 37 ^{o}C for 1 hour was performed and plates tap-dried after washing with PBS-T. Substrate was prepared using *p*-nitrophenyl phosphate and diluted in substrate buffer at the rate of 1 mg/ml and 100 µLof the substrate solution was added to each well. The plate was then incubated in the dark at room temperature of 37 ^{o}C. Absorbance values were quantified at 405 nm using a microplate reader (MRX, Dynex Technologies, Inc., USA) after overnight. Values were accepted to be positive when the optical density reading was at least twice that of the mean for the negative controls.

RESULTS AND DISCUSSION

Identification of Legume Viruses

Results obtained from the identification of the viruses infecting cowpea seeds in Katsina State, Sudano-sahelian Savanna of Nigeria using ACP - ELISA are shown in Table 1. The results showed the presence of viruses in locations studied. *Blackeye cowpea mosaic virus* (BlCMV), *Cowpea mild mottle virus* (CPMMV), *Cucumber mosaic virus* (CMV) and *Cowpea mottle virus* (CPMoV) were the only viruses detected in the seed samples tested. These viruses occurred in single and mixtures of two or more on at the different markets surveyed. Specifically, BICMV was detected in Kwankwasiya, Mai Fitila and Kanaando varieties in higher concentrations in samples obtained at Ajiwa. Also, CMV was detected in Dan Arba'in and Dan Sayi varieties at Ajiwa, although not as high as BICMV. Same trend was observed with samples collected from the other location with BICMV and CMV as dominant viruses infecting same cowpea varieties with higher concentrations. CPMMV was detected in few samples at Ajiwa and Dutsin-Ma although in a milder/very low concentration while CPMoV was detected in Dan Arba'in and Kananado varieties at Ajiwa, Kwankwasiya had higher concentration of CPMoV at Funtua while at Dutsin-Ma, Mai Fitila and and Kwankwasiya were the major viruses recorded with high concentration.

Table 1: Reaction of cowpea seed samples from selected markets in Katsina State, Nigeria during the 2024 wet season in Enzyme-Linked Immunosorbent Assay (ELISA)

	Polyclonal antibody						
Location & Variety	BICMV	CABMV	CMV	CPMMV	CPMoV	CYMV	SBMV
AJIWA							
Dan Arba'in	0.273	0.132	0.942*	0.314	0.554*	0.269	0.149
Dan Sanyi	0.192	0.119	0.812*	0.21	0.132	0.201	0.231
Kwankwasiya	0.991*	0.173	0.238	0.235	0.157	0.217	0.217
Mai Fitila	0.854*	0.129	0.184	0.359*	0.149	0.142	0.146
Kananado	0.882*	0.171	0.825*	0.176	0.473*	0.187	0.199
FUNTUA							
Dan Arba'in	0.231	0.11	0.502*	0.21	0.11	0.241	0.301
Dan Sanyi	0.421*	0.09	0.411*	0.214	0.211	0.219	0.21
Kwankwasiya	0.426*	0.137	0.536*	0.134	0.788*	0.162	0.146
Mai Fitila	0.208	0.119	0.203	0.201	0.196	0.114	0.106
Kananado	0.132	0.201	0.312	0.119	0.21	0.201	0.201
DUTSIN-MA							
Dan Arba'in	0.093	0.11	0.208	0.239	0.19	0.116	0.119
Dan Sanyi	0.491*	0.217	0.039	0.219	0.22	0.191	0.201
Kwankwasiya	0.835*	0.137	0.544*	0.523*	0.323*	0.169	0.151
Mai Fitila	0.671*	0.167	0.597*	0.276	0.543*	0.186	0.211
Kananado	0.133	0.156	0.201	0.2	0.172	0.11	0.192
Diseased control	2.562	2.138	2.915	2.424	2.876	2.454	2.899
Healthy control	**0.294**	**0.138**	**0.245**	**0.161**	**0.141**	**0.242**	**0.246**
Buffer	0.186	0.128	0.175	0.128	0.178	0.182	0.205

BICMV: *Blackeye cowpea mosaic mosaic virus*; CABMV: *Cowpea-aphid borne mosaic virus;* CMV: *Cucumber mosaic virus*: CPMMV: *Cowpea mild mottle virus*; CPMoV: *Cowpea mottle virus*; CYMV: *Cowpea yellow mosaic virus;* SBMV: *Southern bean mosaic virus*.

The detection of BlCMV, CMV, CPMMV and CPMoV at all surveyed markets within the state collaborate the findings of Aliyu *et al.* (2012) who discovered two different types of viruses from the same genus co-existing in the nearby field in Kwara State, Nigeria. However, the implication of this is that subsequent mutation and replication of the viruses could simply result in several serotypes with varying degree of pathogenicity on the one hand and multiple infections of legume crops on the other hand. The occurrence of CPMoV and CPMMV in naturally infected cowpea is believed to be the first report from Katsina State. BlCMV was detected at Ajiwa, Futua and Dutsin-Ma in mixture with CMV. Multiple virus infection in field-grown plants modifies symptoms and essentially precludes field diagnosis (Alegbejo, 2015). Shoyinka *et al*. (1997) earlier reported CPMoV and CPMMV in Samaru, Kaduna State which is a neighboring State to Katsina State. In addition, the seed borne nature of CPMoV (Alabi *et al*., 2010), and recent detections suggest that the virus could be spreading through seeds to other parts of the Agro-ecological zone of Nigeria. Odedara (2011) reported CPMoV as seed-borne virus that is considered as major constraint to yield in legume fields, because emerging plants are quickly exposed to viral inocula producing greater damage at early stages of crop plant development and this shows how important the virus could be in the ecological zone.

CONCLUSION AND RECOMMENDATIONS

The survey results provided baseline information on the occurrence and distribution of cowpea viruses in Katsina State. Virus diagnosis showed that four important legume viruses (BlCMV, CMV, CPMoV and CPMMV) were prevalent in some specific locations surveyed. There is the need, therefore, for constant monitoring of legume fields through regular disease surveys to identify new and emerging viruses because these facts present a good starting point for legume virus diseases diagnosis in the study area. The ultimate goal of this information has the possibility of designing sustainable management strategies for legume viral diseases. This could be of agricultural importance for food security.

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Genotype by Environment Interaction of some Elite Lowland Rice (*Oryza sativa)* Grown across Diverse Environments in Nigeria

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Abstract

Multi environmental trial is an important aspect of plant breeding programme and cultivar introduction which is aimed at developing stable and adaptable genotypes. Genotype by environment interaction were conducted for twelve elite rice genotypes across five environment which included Akure in ondo state Badeggi in Niger state, Bacita in Kwara state Birnin kebbi in Kebbi state and Warri in Delta state all in Nigeria. The experimental design was randomized complete block design across all location, the experiment treatment were the twelve rice genotype and the five locations. Grain yield analysis was conducted using Additive Main effect and Multiplicative Interaction (AMMI) and Genotype and Genotype by Environment interaction (GGE) Biplot methods. The result revealed significant difference @ P ≤ 0.05 for genotype location and genotype by location interactions. AMMI analysis of variance revealed that the first two interaction principal component axis IPCA1 and IPCA2 accounted for 68.6% and 18.2% respectively. FARO 44 performed best in location Akure and Warri, FARO 67 performed best in location Bacita and Kebbi. The GGE Biplot revealed FARO 67 as the most Ideal Genotype, hence, the genotype would be considered more adapted to wide range of environments than the rest of the genotypes.

Keywords: Genotype, Environment, Lowland, Stable, Nigeria

INTRODUCTION

One of the most important foods consumed worldwide is rice (*Oryza sativa* L.), which is a staple diet for more than four billion people, that provides 35-80% of total calorie uptake globally (Wassmann *et al.,* 2009). Rice is liable to an annual increase in demand that makes it more difficult to provide (Khush, 1997). The rice crisis scenario is a serious issue, and increasing sown areas would not likely increase global rice output (Khush, 1997). The sustainability of rice production depends on the development of new rice cultivars with high yield and stable performance across diverse environments (Akter *et al*. 2014). Yield is a complex character which is dependent on a number of other characters and is highly influenced by many genetic factors as well as environmental fluctuations. On the other hand, the G x E interaction is an important aspect of both plant breeding program and the introduction of new crop cultivars (Akter *et al.* 2014). The level of performance of any character is a result of the genotype (G) of the cultivar, the environment in which it is grown (E), and the interaction between G and E (GEI) (Leon *et al*. 2016). Interaction between these two explanatory variables gives insight for identifying genotype suitable for specific environments. The environmental effect is typically a large contributor to total variation (Lee *et al.,* 2023). Moreover, G x E interactions greatly affect the phenotype of a variety, so the stability analysis is required to characterize the performance of varieties in different environments, to help plant breeders in selecting desirable varieties. Multi-environment trials (METs) play an important role in selecting the best cultivars to be used in future years at different locations and in assessing a cultivar's stability across environments before its commercial release. The study of the GxE interaction may assist understanding of stability concept. Information on the structure and nature of GE interaction is particularly useful to breeders because it can help determine if they need to develop cultivars for all environments of interest or if they should develop specific cultivars for specific target environments. GxE can occur for quantitative traits of economic importance and is often studied in plant and animal breeding, genetic epidemiology, pharmacogenomics and biology research. In order to identify superior genotypes across multiple environments, plant breeders conduct trials across locations and years, especially during the final stages of cultivar development. GxE is said to exist when genotype performance differs over environments. Performance of genotype can vary greatly across environment because of the effect of environment on trait expression. The aim of the study was to identify high yielding rice varieties that are stable in performance across the five locations and also evaluate the genotype by environment interaction and stability studies of some elite lowland rice genotypes grown across diverse locations.

MATERIALS AND METHODS

The experiment was conducted during 2022 rainy season at National cereals research institute Badeggi Niger state Nigeria and three of its outstations in Bacita kwara state, Birnin kebbi kebbi state and Warri Delta state. The Fifth location was a Farmers Field in Akure. Badeggi and Bacita are in the southern guinea savannah, Birnin kebbi is in Sudan savannah region, Akure belongs to the derived savannah while Warri belongs to rain forest agro ecological zone. The treatment were 10 elite lines of lowland rice with two checks fitted into a randomized complete block design with Four replication across the three environments. All agronomic practices were carried out following standard methods and procedures. Rice seeds were seeded in the nursery in a well prepared seed bed. Transplanting was carried out after 21 days using crop spacing of 0.2m by 0.2m at a depth of 3cm. N.P.K 15:15:15 was used to supply 40kg N 40Kg P_2O_5 and 40Kg k_2O at Basal while 46% urea fertilizer was applied in split dose to supply the remaining 40kg N at both tillering stage and panicle initiation stage. Weeding was done when appropriate, glyphosate and butachlor were used as pre-emergence herbicides while Rice pro which contain (2, 4 dichlorophenoxyacetic acid and propanil) was used as post emergence herbicides. Harvesting was done when at physiological maturity when more than 90% of the entire field has changed coloured to golden brown. Harvesting was carried out with the aid of a sickle on a plot basis. Harvested rice were kept in a paper bags and properly labelled after which the rice was properly dried threshed and winnowed. Grain yield data was collected and was subjected to combined analysis of variance using Statistical tools for Agricultural Research (STAR) version 2.0.1 software. Means were separated using Duncan multiple range test @ $P \leq 0.05$ probability level. Stability analysis were carried out using plant breeding tools (2014) version 1.3.

RESULTS AND DISCUSSION

Table 1.0 shows that significant difference @ P ≤ 0.05 for genotypes location and genotype by location interaction. This implies that the genotype are different from each other and also the location are different from each other. AMMI analysis of variance revealed that the first two interaction principal component axis IPCA1 and IPCA2 accounted for 68.6% and 18.2% of the total variation explained by genotype by location sum of squares these findings is in harmony with the findings of Ghazy *et al*., (2023) who worked on yield stability of some improved rice varieties tested over diverse locations in Ethopia. Abebe *et al.,* (2023) reported similar result pattern where the first two interaction principal component axis accounted for more than 70% of the total variation explained by the sum of square of genotype by environment interaction.

Table 2.0 shows mean grain yield of rice genotypes grown across different location. The result revealed significant difference among genotypes @ p ≤ 0.05 for all location. This indicates a significant level of environmental influence on the grain yield which ranged between 1729.17 – 9024.50 kg/ha. Fig 1.0 shows the AMMI biplot for the genotypes grown across diverse environment. The biplot revealed that genotypes SC2024, SC2026 and SC2028 are stable genotypes. Genotypes with IPCA1 scores of close to zero had small interaction effect and consider stable similar result pattern were obtained by Akter *et al.,* (2014) who worked on stability analysis of some hybrid rice using AMMI model. Fig 2.0 shows the mean verse stability biplot. It revealed that blue line with double arrow head measured the degree of stability while the dotted blue line measured average yield. The genotype at the centre of the concentric circle is the ideal genotype. Genotype SC2026, SC2024 SC2027, SC2002, and SC2028 are the stable genotypes while Genotype SC2010, SC2009 and FARO 44 are unstable. Genotype G12 is the ideal genotype, result is in harmony with the findings of Mostafavi *et al*., (2011) who worked on stability analysis of rice genotypes base on GGE biplot method in Iran. Fig 3.0 revealed the genotypes that performed best in a given environment. Genotypes at the vertex of the polygon performed best in their respective environments. The winning genotypes are those in the polygon vertex. FARO 44 performed best in Akure and Warri while FARO 67 performed best in Bacita and Kebbi locations. Similar result pattern were obtained by Sharifi *et al.,* (2017) who worked on genotype by environment interaction in rice using AMMI model in Iran.

CONCLUSION AND RECOMMENDATIONS

Rice grain yield is a complex trait that is affected by numbers of component characters along with the environment directly or indirectly. The presence of genotype by environment interaction was established among the twelve elite rice lines grown across five environments. FARO 67 is the most stable genotype across all environments under test

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Table 1: Additive and Multiplicative interaction analysis of variance

Source of Variation	Df	Sum of Square	Mean Square	% explained
Environment (E)	4	4.06E+08	101530433.67**	
Genotype (G)	11	85966998	7815181.65**	
Genotype*Environment interaction	44	2.57E+08	5834598.93**	
IPCA1	14	1.76E+08	12581700.00**	68.6
IPCA2	12	46742207	3895183.90**	18.2
IPCA3	10	32915042	3291504.20**	12.8
IPCA4	8	921302.9	115162.90*	0.4
IPCA5	6	0	0	0

Table 2: Mean grain yield performance of rice genotypes across different location

Genotype	Akure	Bacita	Badeggi	Kebbi	Warri
SC2024	5907.25[h]	7791.58[f]	4791.67[c]	5666.67[d]	8041.75[c]
SC2022	5471.50[i]	5750.00[j]	4875.00[c]	4687.50[e]	5505.00[h]
SC2010	3296.75[k]	7875.00[ef]	5208.33[a]	5916.67[c]	5482.50[h]
SC2026	7412.75[d]	9437.17[b]	4437.50[e]	6337.50[b]	7356.00[d]
SC2019	6493.25[g]	8437.50[d]	5300.00[a]	6250.00[b]	6520.00[f]
SC2003	5991.00[h]	8604.17[c]	3916.67[f]	5635.42[d]	6063.25[g]
SC2009	8016.00[c]	6458.33[i]	1729.17[i]	4197.92[f]	8093.75[c]
SC2002	4306.25[j]	7937.42[e]	4612.50[d]	5656.25[d]	8486.25[b]
SC2027	6701.75[f]	8479.17[d]	4645.83[d]	5937.50[c]	6745.75[e]
SC2028	7146.00[e]	7333.08[g]	5025.83[b]	5552.08[d]	7257.25[d]
FARO 44	8991.75[a]	6625.00[h]	2666.67[h]	4020.83[g]	9024.50[a]
FARO 67	8344.25[b]	10666.58[a]	3750.00[g]	6583.33[a]	8396.75[b]
MEAN	6506.54	7949.58	4246.6	5536.81	7247.73
SE±	60.42	50.39	33.67	61.78	68.68
CV	1.31	0.9	1.12	1.58	1.34

Means followed with same alphabet (s) are not significantly different @ $P \leq 0.05$

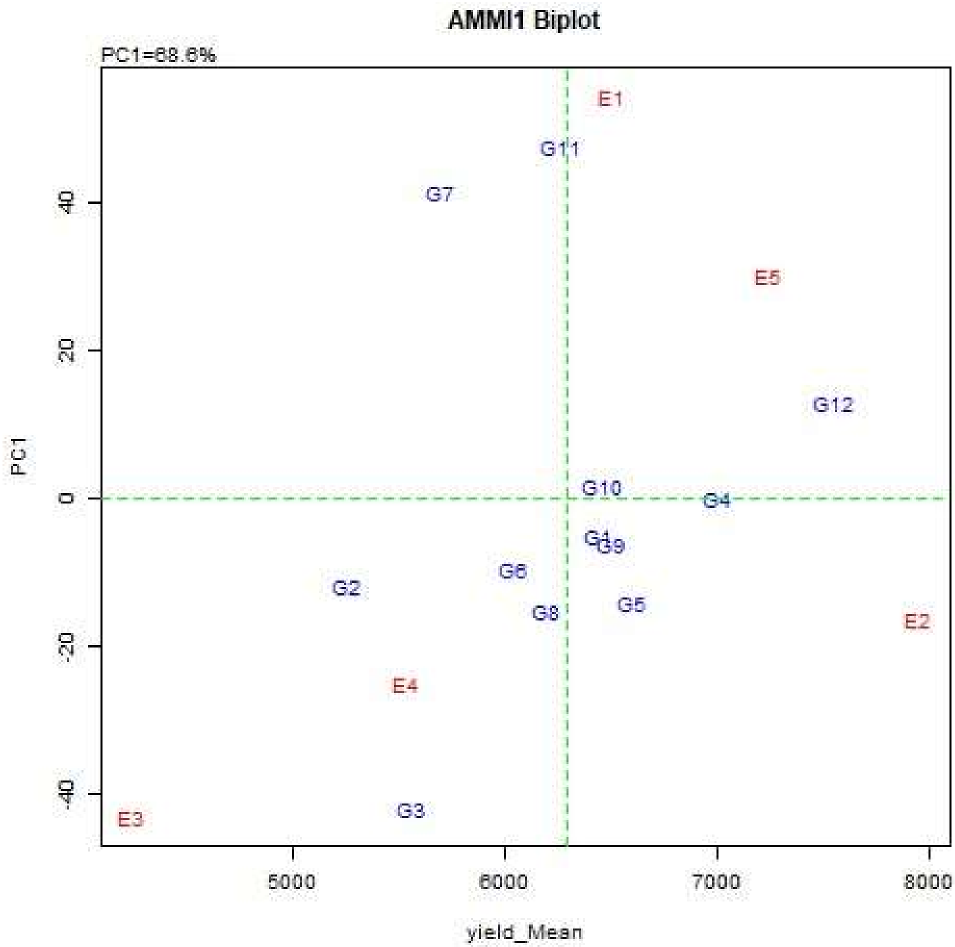

Figure 1: AMMI 1 Biplot for grain yield (tha-1) of 12 rice genotypes (G) and five environments (E) using genotypic and environmental scores.

Key: G1=SC2024; G10=SC2028; G2=SC2022; G11=FARO44; G3=SC2010 G12=FARO 67; G4=SC2026; E1= Akure; G5=SC2019; E2= Bacita; G6=SC2003

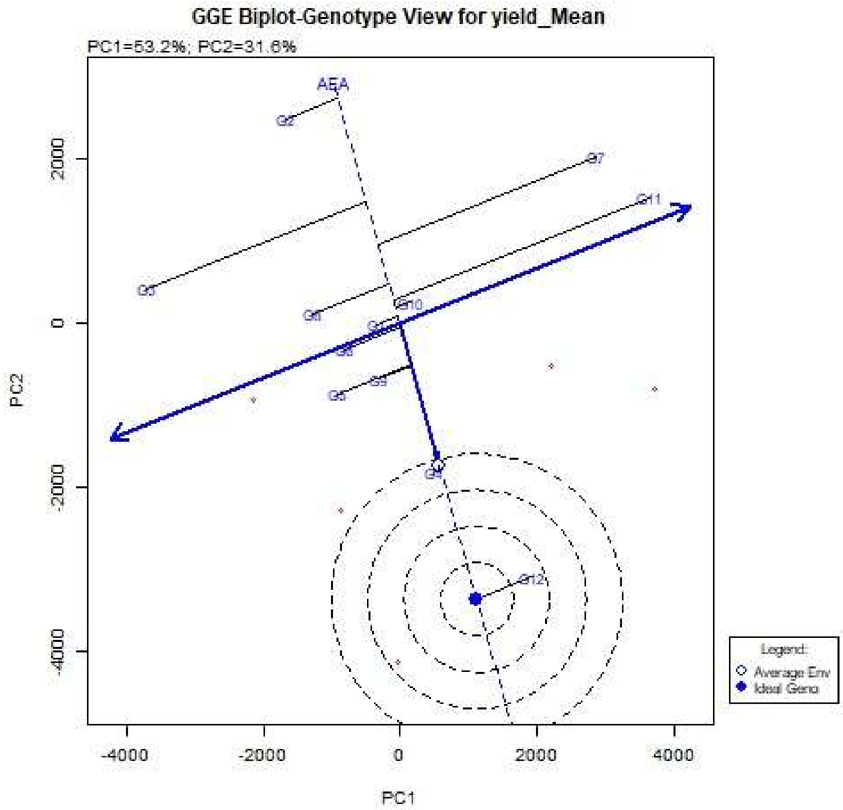

Figure 2: Mean verse Stability

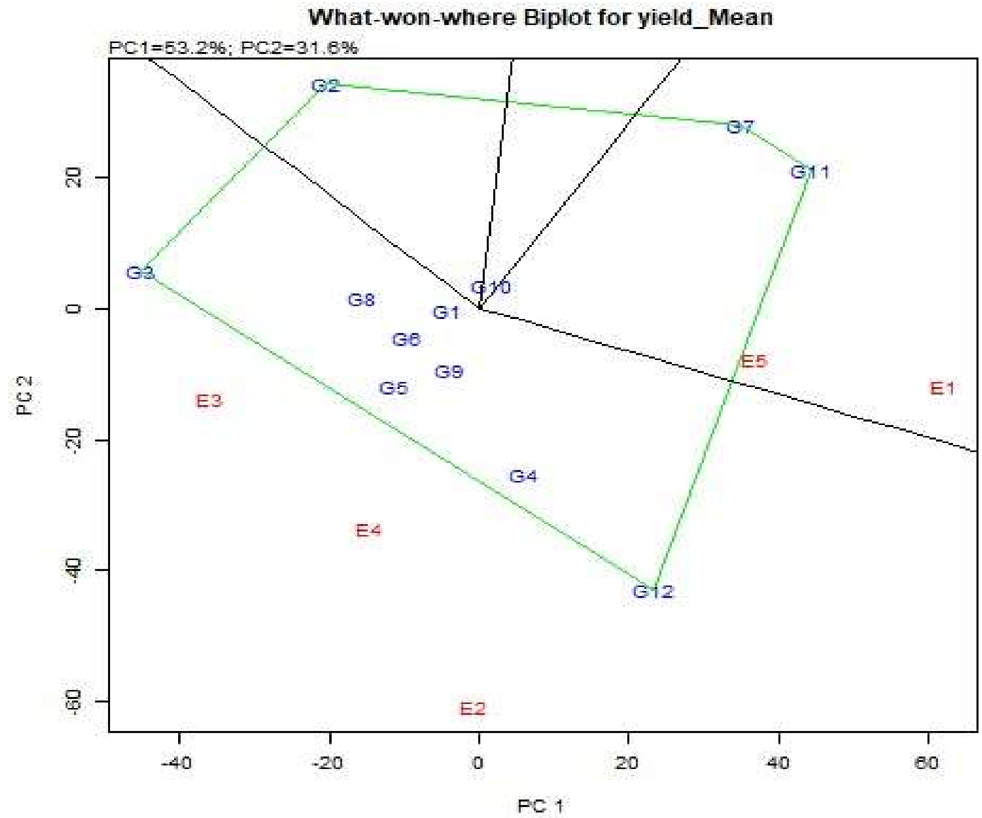

Figure 3: GGE biplot for which won where

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Effect of Planting Materials and Fertilizer Rate on the Yield of Sweetpotato in Iresi, South-Western Nigeria

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Abstract
Field experiment was conducted at Iresi, Southwestern Nigeria during the 2023 cropping season to determine the effect of planting materials and fertilizer rate on the yield of sweetpotato. In this year, the experiment was laied out as a 4x3 factorial in a randomized complete block design (RCBD) with three replicates. The treatments comprised three levels of sweetpotato genotypes (Ex-igbariam, King-J and Mothers delight) and the fertilize rates (0kg/ha, 200kg/ha, 400kg/ha and 600kg/ha). Mothers Delight gave the highest marketable root yield (20.0 kg/ha) at 200kg/ha or 0kg/ha fertilizer rate followed by Ex-Igbariam at 0kg/ha fertilizer application. Fertilizer rate at 200kg/ha and 0kg/ha gave the highest weight (Mothers delight) and the variety that gave the highest root yield was Mothers delight and is recommended for yield of sweetpotato planting materials in Iresi Southwestern Nigeria.
Keywords: Planting materials, Fertilizer rate, Yield, Sweetpotato

INTRODUCTION

Sweetpotato (*Ipomoea batatas* L.) is a versatile and nutritious root crop cultivated in more than 100 countries. It is rich in simple and complex carbohydrates and dietary fibers and also provides nutritionally significant quantities of ascorbic acid, riboflavin, pyridoxine, iron, calcium, and protein. Orange-fleshed varieties are rich in beta-carotene, a nutrient that may be effective in preventing certain types of cancer according to Prakash, (1994) and has also been sustainably used in public health campaigns for the alleviation of vitamin A deficiency (Van Jaarsveld *et al.*, 2005). Among the food crops, sweetpotato has the highest recorded net protein utilization based on the percentage of food nitrogen retained in the body. The nutritional superiority of this crop also includes presence of nutraceuticals and a glycemic index much lower than that of the Irish potato (Kays 1992, 2005a). Its consumption is reported to help stabilize blood sugar levels and to decrease insulin resistance. It has also been successfully used in a number of African countries to combat widespread vitamin A deficiency that results in blindness and even death of 250,000–500,000 children per year. This crop is very productive and has the potential to play a key role in national economies.

Soil for planting sweetpotato are sandy loams, leveled or slightly sloped, moderately fertile and well drained. Poorly drained, heavy soils with clay will result in irregularly sized and shaped fleshy roots. Soils high in organic matter may result in rough, cracked, jumbo-sized roots. Avoid soils contaminated with diseases, nematodes or sweetpotato weevils. Optimum soil pH range is 5.5-6.8, it is sensitive to alkaline and saline soils. Cultivar selection may vary depending on soil type where the crop will be grown. Fertilizer applications should be made to complement the nutrient content already available in the soil. In order to know the soil fertility status for sweetpotato production, it depends on the soil test prior to and after planting. Applications which are made above levels required by plants may result in excessive foliage growth at the expense of root growth, nutrient leaching into aquifers, and in undesirable accumulation of salts in the soil root zone. Sweet potato is a crop that requires not only nitrogen and phosphorus but especially adequate potassium for optimum root growth. High nitrogen will cause excessive vine growth at the expense of root yields and may result in root cracking. Planting on recently manured soils should be avoided because it renders the tubers to become more susceptible to scurf infection. The objective of the study was to determine the effect of planting materials and fertilizer rate on the yield of sweetpotato.

MATERIALS AND METHODS

The study was conducted in 2023 cropping season at the National Root Crops Research Institute (NRCRI), Iresi Southwestern Nigeria. Iresi is located within latitude 7^0 56′ N and longitude 4^0 50′ E. Soil test was done to determine the physicochemical properties of the soil in the planting season. The experiment was planted on a fresh site that had been fallowed for one year. The field was prepared by slashing, ploughed and harrowed. The field was marked out into three replications and each replicate was divided into 12 plots measuring 2mx3m (6m^2). The spacing between each replicate was 1m and the spacing between each plot was 0.5m. The experiment was a Factorial in Randomized Complete Block Design (RCBD) with three replications. The genotypes of the sweetpotato were EX IGBARIAM, KING J and MOTHERS DELIGHT and the fertilize rates were 0kg/ha., 200kg/ha., 400kg/ha and 600kg/ha Five plants were tagged and data were collected on them. The sweetpotato vines were 25cm long and had at least 4 nodes. The seed vines were inserted in which two nodes were inside the soil and the remaining two nodes. It was planted 1m between the ridges and 0.3m apart along the row on the ridges. Fertilizer application (NPK 15:15:15) was done at 4WAP at different rates. The seed vines were treated with Decis EC 12 by dipping and spread under shade for one hour before planting. It was treated so that pest will not attack it most especially termites and weevils. Weeding was done manually three times using Indian hoe. Cross bars were constructed to control erosion.

Yield parameters recorded were number of marketable root yield per plot, weight of marketable root yield per plot (kg), number of unmarketable root yield per plot, weight of unmarketable root yield per plot (kg) and biomass (kg). Data were analyzed using Genstat Statistical package version 9. Comparison of treatment means for significance was done by the use of least significant difference (LSD) at the probability level of 0.05.

RESULTS AND DISCUSSION

Mothers Delight gave the highest marketable root yield (20.0 kg/ha) at 200kg/ha or 0kg/ha fertilizer rate followed by Ex-Igbariam at 0kg/ha fertilizer application (Table 1.0). Fertilizer rate at 200kg/ha and 0kg/ha gave the highest weight (Mothers delight) (Table 2.0) and the variety that gave the highest root yield was Mothers delight (Table 3.0).

CONCLUSION

Mothers Delight gave the highest marketable root yield and weight which is recommended for yield of sweetpotato planting materials in Iresi Southwestern Nigeria.

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Table 1: Effect of fertilizer rate on marketable root yield (t/ha) of Sweetpotato planting material in 2023

Fertilizer rate (kg/ha)	Treatments			Mean
	Ex- Igbariam	**King-J**	**Mothers Delight**	
0	16.3	10.0	20.6	**15.6**
200	11.4	12.2	20.6	**14.7**
400	13.3	14.5	16.7	**14.9**
600	7.8	13.9	15.0	
Mean	**12.2**	**12.7**	**18.2**	**12.2**

LSD ($_{0.05}$) for fertilizer (F) means = 14.18

Table 2: Effect of fertilizer rate on weight (kg) of marketable root of Sweetpotato per plot (cm^2) in 2023

Fertilizer rate (kg/ha)	Treatments			Mean
	Ex- Igbariam	**King-J**	**Mothers Delight**	
0	10.00	6.00	12.33	**9.44**
200	6.00	7.33	12.33	**8.55**
400	8.00	8.67	10.00	**8.89**
600	4.67	8.33	9.00	**7.33**
Mean	**7.17**	**7.58**	**10.92**	

LSD ($_{0.05}$) for fertilizer (F) means = 6.80

Table 3: Effect of fertilizer rate on the total root yield (kg/ha) of Sweetpotato planting material in 2023

Fertilizer rate (kg/ha)	Treatments			Mean
	Ex- Igbariam	**King-J**	**Mothers Delight**	
0	8.36	3.96	4.40	**8.22**
200	6.84	7.34	7.00	**8.58**
400	4.40	3.56	5.42	**5.39**
600	2.76	2.22	6.24	**3.74**
Mean	**5.59**	**4.27**	**5.77**	

LSD ($_{0.05}$) for fertilizer (F) means= 4.09

Analysis of Route of Exposure to Pesticide Toxicity among Rice Farming Households in Katsina State, Nigeria

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Abstract
The study investigates the route of exposure to pesticide's toxicity among rice farming households in katsina state, Nigeria. Primary data were collected through a well-structured questionnaire administered to 288 rice farmers selected using a multistage random sampling technique. Data were analyzed using descriptive statistics and multivariate probit model. The socioeconomic analysis reveals that majority (43%) of the respondents were between 39-48 years old, with an average age of 46.5 years. Most (98.7%) were male, 88.2% were married, and the average household size was 8. The regression analysis shows that the model had a good fit, with a log pseudo-likelihood value of -541.76. The analysis of the identified exposure routes to pesticide toxicity for inhalation shows that Age of rice farmers and adherence to instructions were negatively significant (P<0.05). Pesticide preparation methods were positively significant (P<0.05). Wind frequency was positively significant (P<0.1). For Oral exposure age of the farmer and adherence to instructions were negative significance (P<0.01) while pesticide preparation methods were also negatively significant (P<0.05). For ocular exposure, only farming experience was positively significant (P<0.01). Dermal exposure reveals that age was negatively significant (P<0.05) and extension visit and packaging were positively significant (P<0.01). The study concludes that socioeconomic factors significantly influence pesticide exposure among rice farmers, emphasizing the need for targeted safety interventions. The study recommends implementing enhanced farmer education through improved extension service delivery, establishing environmental safeguards, and adopting alternative pest control methods for rice farmers. Tailored interventions for different age groups and regular health monitoring are also essential.
Keywords: Pesticide-toxicity, Rice-farmers, Multivariate-Probit-Model, Katsina-state

INTRODUCTION

The significance of pesticide use in agriculture, particularly in rice farming, cannot be overstated. Pesticides are employed for effective pest control and increased crop yield. However, improper handling, insufficient safety awareness, and inadequate protective measures can lead to significant exposure to toxic chemicals, resulting in both short-term and long-term health consequences for farmers and their families.

In Katsina State, as in many regions, rice farming heavily relies on pesticides to combat pests and diseases. While these chemicals are essential for crop protection, they can become hazardous when mishandled. Farmers are often exposed to pesticides through various routes, including dermal contact, inhalation, ingestion, and contaminated water or food sources.

Despite the benefits of pesticides in enhancing crop yields, improper handling, lack of awareness, and inadequate protective measures pose significant exposure risks to toxic chemicals among farming households. Addressing these issues is crucial for safeguarding the health of farmers and ensuring sustainable agricultural practices.

Farmers and their families often remain unaware of the dangers associated with pesticide exposure, which can occur through skin contact, inhalation, ingestion, and environmental contamination. This issue is exacerbated by limited access to training, insufficient PPE, and poor enforcement of regulations, leading to both acute and chronic health problems. Immediate symptoms can include headaches and nausea, while long-term effects may involve respiratory issues, neurological disorders, and an increased risk of cancer. The extent of exposure remains poorly understood, leaving farming communities vulnerable to ongoing health risks.

Given the critical role of rice farming in the study area, it is essential to analyze the specific routes of pesticide exposure and their associated health impacts. This study aims to identify key exposure pathways and assess the potential health effects on rice farming households. By highlighting the risks posed by pesticide toxicity, the research seeks to improve safety practices, raise awareness, and inform policy on safer agricultural methods. Understanding these exposure pathways is vital for developing effective interventions and educating farmers on safer practices, ultimately contributing to public health and agricultural sustainability in the study area.

MATERIALS AND METHODS

The study focuses on Katsina State, established on September 23, 1987, by splitting from Kaduna State. Located between latitudes 11°03' and 13°05'N and longitudes 7°21' and 9°02'E, Katsina shares borders with Niger to the north and Kaduna, Jigawa, Kano, and Zamfara States. Covering approximately 24,192 square kilometers, it has a projected population of 9,921,456 as of 2021. The predominantly Hausa/Fulani population relies heavily on agriculture, making Katsina Nigeria's top cotton producer. The state also prioritizes livestock rearing, with agricultural products supporting various industries. Key industrial enterprises include Dana Steel Rolling Company and Katsina Flour Mills. The region experiences abundant rainfall, allowing both cash and food crop cultivation, alongside irrigation farming in river basin areas.

The study employed multi-stage sampling techniques, starting with purposively selecting two KATARDA Zones (Dutsinma and Funtua) due to their concentration of rice farmers. Next, Musawa and Matazu were randomly chosen from Dutsinma, while Kafur and Malumfashi were selected from Funtua. Three villages were then randomly chosen from each Local Government, resulting in 12 villages. Finally, 228 respondents were randomly selected proportionate to the size from the total population of 532 registered rice farmers in the area.

$$n = \frac{N}{1 * (N)e2} \tag{1}$$

where;

n	=	Sample size determination
N	=	Total number of Rice farming in all 12 villages,
e^2	=	confidence level $(0.05)^2$

While for the proportionate sampling the expressions were as follows

$$n = \frac{X}{D} * N \quad (2)$$

Where:
n = Sample Size of the Rice Farmers selected per Community
X = Number of the Rice Farmers in Farming Community
D = Total number of the Rice Farmers in all 12 Farming Community
N = Recommended Sample Size by Yamani's formula

RESULTS AND DISCUSSION

Socio-economics characteristics of the respondent

The socio-economic characteristics of rice farmers in the study provide essential insights into their demographics and farming practices. Most farmers (43.4%) are aged 39-48, indicating they are in their economically active years, capable of effectively managing their farms. The majority (98.7%) are male, attributed to socio-cultural factors, with 88.1% married, suggesting the potential for family labor support. Most farmers (40.8%) have primary education, enhancing their ability to use pesticides wisely. A significant portion (82.0%) has 1-10 years of farming experience, indicating skillfulness in agricultural practices. Additionally, 67.5% of farmers operate small farms (0.25-1 ha), emphasizing small-scale agriculture in the region. Farming serves as the primary income source for 84.0% of the respondents, while limited access to credit facilities (95.6% lack access) negatively impacts their ability to adopt safer pesticide practices.

Table 1: Socio economic characteristics of the rice farmers

	Variables	Frequency	Percentage
Age	20 – 30	6	2.5
	31 – 40	40	17.5
	41 – 50	99	43.4
	51 – 60	54	23.7
	70 & above	29	12.7
Gender	Male	225	98.7
	Female	3	1.3
Marital status	Single	12	5.3
	Married	201	88.2
	Divorce	15	6.6
Household's Size	1-10	19	8.3
	11-20	195	85.5
	21-30	14	6.1
Educational Status	Non formal	76	33.3
	Formal education	152	66.7
Farming experience	1-10	187	82.0
	11-20	36	15.8
	21-30	5	2.2
Farm size (ha)	0.1-0.5	154	67.5
	0.6-1.0	66	28.9
	1.1 & above	8	3.5
Credit access	Yes	10	4.4
	No	218	95.6
	Total	228	100

Source: Author's Computation (2023)

Multivariate Probit (MVP) regression analysis of exposure routes to pesticide toxicity

The estimates of the factors predisposing farmers to pesticide toxicity are thereafter, presented in table 6

The result of the estimated Multivariate Probit (MVP) regression analysis revealed that the Log pseudo-likelihood value of −541.76 with an associated Chi-square value of 93.53 is significant (P< 0.01). This suggests that the model has a good fit. Results of the four routes of exposure are presented in the following order; inhalation, mouth, eye and dermal.

Inhalation: Age of the farmers (X_1), pesticide preparation methods (X_4), pesticide label adherence (X_7) and wind frequency Training(X_9) were found to increase the rice farmers' probability of exposure to pesticide toxicity through inhalation in the study area. Age of the farmers was negatively significant (p<0.05). This implies that as the farmer age increases the probability of exposure to pesticide decreases. This is in line with the findings of Smith et al., (2022), whose found that as farmers age increases, their probability of pesticide exposure through inhalation decreases. Several studies have highlighted that older farmers may be less exposed to pesticides due to various factors. For instance, older farmers might adopt different farming practices or use less hazardous pesticides compared to younger counterparts. Additionally, they might spend less time directly applying pesticides or have reduced physical activity in the field, which can lower exposure risk. Supporting evidence study by Zhang et al. (2023) found that older farmers showed a statistically significant reduction in the likelihood of acute inhalation exposure to pesticides compared to younger farmers. Pesticide preparation methods was positively significant (p<0.05). This signifies that the probability of farmer inhaling the toxic decreases when the pesticide is not mixed with other chemicals. This is also in agreement of the finding's of Liu et al. (2023) whose found that pure pesticide formulations were associated with a lower probability of inhalation compared to mixtures with other chemicals. Farmers adherence to instruction was negatively significant (p<0.05). It means there is less likelihood of farmers having incidence of toxic inhalation when they adhere to pesticides instruction from manual and label. This is in line with the finding of Liu et al. (2023), his findings revealed that farmers who followed label instructions experienced significantly fewer toxic inhalation incidents. The study reported a negative significance at p < 0.05, confirming that proper adherence is associated with a reduced likelihood of inhalation exposure.

Frequency of wind was positively significant (p<0.1). This implies that the more the occurrence the windy condition during spraying of pesticides in rice farming the more likely the occurrence of toxic inhalation incidence. .farmers should regularly monitor weather focus to implement protocols that guide farmer on how to adjust pesticide application schedules based on weather condition.

Mouth**:** Three variables; Age of rice farmers, pesticide preparation methods and adhere to pesticides instruction from manual and label significantly influenced factors predisposing farmers to pesticide toxicity through mouth. Rice farmers' age was negatively significant (p<0.01). This connotes that as rice farmer advances in age, there is less likelihood to fall victim of mouth toxic incidence. The result implies a strong statistical relationship between age and reduced likelihood of mouth toxicity. This result might suggest that older farmers, potentially due to their greater experience or knowledge, are less prone to experiencing pesticide-related toxicity. It may also reflect improved practices or adaptations over time that mitigate exposure risks (Smith et al., 2022). Pesticide preparation methods was negatively significant ($p<0.05$). Farmers who mixed pesticides with other chemical were less likelihood to be affected by the toxicity of the pesticide (Jones and Brown, 2022). The study found that the likelihood of significant toxicity ($p < 0.05$) was lower when farmers mixed pesticides with other chemicals according to specified instructions. This suggests that adhering to recommended preparation methods can mitigate the adverse effects of pesticide use. Adhere to pesticides instruction from manual and label was negatively significant ($p<0.01$). It implies that farmer who adheres to instruction are less likelihood to be affected by the toxicity of the pesticide. This is in line with findings of (Liu *et al*. 2023).

Eye: The experience of rice farmers was only variable that significantly influenced the farmers exposed to pesticide toxicity. Experience was positively significant ($p<0.01$). It signifies that there households is more likelihood of eye infection among the older farmers than the younger farmers. . Findings indicate that the likelihood of eye infections is significantly higher among farmers with less experience it also suggests that more experienced farmers may be better equipped to handle pesticides safely, potentially reducing the risk of eye-related issues (Johnson and Brown, 2024).

Dermal: table 4 presents three factors that significantly influence the exposure route through the skin or dermal. They are rice farmers' age, pesticide packaging, and frequency of extension visit. Age was negatively significant ($p<0.05$). It implies increase in farmers age decrease the probability of being dermally infected. This is in line with the findings of Lee and Wang (2024) who found that as farmers age increases, their probability of pesticide exposure through dermal decreases. Packaging was positively significant ($p<0.01$).It means that *probability of farmers' exposure to pesticide toxicity through skin increased with leaking pesticide packaging materials. Damalas and Eleftherohorinos (2011) opined that, the size of cans, bottles, or other liquid pesticide containers may affect the potential for spillage and splashing on the user of the pesticide.* Extension visit frequency was positively significant ($p<0.01$). It can therefore be inferred that increase in extension visit to the rice farmers decreases the likelihood of rice farmer pesticide infection through their skin.

CONCLUSION AND RECOMMENDATIONS

The study concludes that socioeconomic factors, such as age, farming experience, and adherence to safety instructions, significantly affect pesticide exposure among rice farmers in Katsina State, Nigeria. It highlights the need for targeted safety interventions to reduce health risks. Key recommendations include enhancing farmer education through improved extension services, promoting alternative pest control methods, and strengthening environmental safeguards. Tailored support for different age groups and regular health monitoring are essential. Additionally, improving pesticide packaging and encouraging adherence to safety practices can further mitigate exposure risks, leading to safer and more sustainable rice farming in the region

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Table 2: Estimates of determinant of Exposure routes to pesticide toxicity by rice farming households
Robust

Variable	NASAL		ORAL		OCULAR		DERMAL	
	Coeff. (Z-values)	Std. Error. (P>Z)	Coeff. (Z-values)	Std. Error. (P>Z)	Coeff. (Z-values)	Std. Error. (P>Z)	Coeff. (Z-values)	Std. Error. (P>Z)
Age (X_1)	-0.033** (-2.420)	0.014 (0.016)	-0.048*** (3.720)	0.013 (0.0020)	0.019 (1.560)	0.012 (0.118)	-0.032** (-2.260)	0.014 (0.024)
Educational Level (X_2)	-0.035 (-0.610)	0.058 (0.544)	0.049 (0.880)	0.056 (0.378)	0.012 (0.220)	0.055 (0.827)	-0.077 (-1.440)	0.053 (0.150)
Experience (X_3)	0.049 (1.140)	0.043 (0.255)	-0.002 (-0.060)	0.037 (0.951)	0.150*** (4.180)	-0.036 (0.002)	0.037 (0.840)	0.044 (0.398)
Training frequency (X_4)	0.016 (0.180)	0.091 (0.857)	-0.018 (-0.210)	0.085 (0.832)	0.047 (0.560)	0.083 (0.573)	0.035 (0.400)	0.089 (0.692)
Number of protective Method (X_5)	-0.024 (-0.410)	0.058 (0.683)	-0.002 (-0.040)	0.050 (0.972)	-0.001 (-0.020)	0.048 (0.982)	0.060 (1.060)	0.056 (0.287)
Pesticide Preparation Method (X_6)	0.660** (2.130)	0.310 (0.033)	-0.519** (-1.990)	0.261 (0.047)	-0.208 (-0.790)	0.263 (0.429)	0.112 (0.410)	0.273 (0.681)
Pesticide Label Adherence (X_7)	-1.105** (-2.170)	0.509 (0.030)	-1.662*** (-3.350)	0.496 (0.001)	-0.122 (-0.300)	0.401 (0.760)	0.467 (1.110)	0.420 (0.266)
Farm Size (X_8)	-0.191 (-1.390)	0.137 (0.164)	0.081 (0.680)	0.119 (0.495)	-0.090 (-0.700)	0.127 (0.482)	-0.066 (-0.490)	0.133 (0.622)
Frequency of wind incidence (X_9)	0.077* (1.670)	0.046 (0.094)	-0.040 (-0.950)	0.043 (0.344)	-0.012 (-0.270)	0.043 (0.789)	-0.008 (-0.170)	0.045 (0.864)
Packaging (X_{10})	-0.880 (-1.550)	0.569 (0.122)	0.232 (0.480)	0.487 (0.634)	0.252 (0.510)	0.496 (0.612)	1.739*** (2.880)	0.603 (0.004)
Frequency of Extension Visit (X_{11})	0.021 (0.450)	0.048 (0.656)	0.042 (0.900)	0.047 (0.369)	-0.033 (-0.700)	0.047 (0.485)	0.089* (1.900)	0.047 (0.057)
_constant	1.962*x (1.990)	0.986 (0.0701)	0.8684** (2.160)	0.865 (0.0169)	3.2412*** (3.650)	0.888 (0.003)	4.0650*** (4.230)	0.961 (0.028)
	Wald chi2(44) = 93.35 Prob > chi^2 =0.0000 Log pseudolikelihood = -541.76035 N=228							

Source: field survey 2024 ***,**,* sig.@1%, 5% &10% respectively.Figures in parenthesis are Z-values and Standard errors.

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Assessment of Smallholder Rice Farmers' Productivity under Climate-Smart Agricultural Practices in Nasarawa State, Nigeria

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Abstract
The study focused on the assessment of rice farmers' productivity under climate-smart agricultural practices in Nasarawa State. Cross-sectional data was used to collect information from 164 rice farmers using a multistage sampling technique. which involves the purposive selection of three local governments in the state, the purposive selection of rice farmers and a random selection of respondents among the farmers. The socioeconomic characteristics informed that 72.12% of the farmers were married, mostly male (58.18%) with an average of 43 years, 35.15% had no formal education with a household size of 8 and a farm size of 1.62 ha. 61.82% had a productivity that was less than 1. The results further indicated that the higher the number of climate-smart agricultural practices (CSAP) adopted the higher the productivity level. It was recommended that farmers should be better sensitized about the benefits of adopting multiple CSAPs to increase their productivity.

INTRODUCTION

Rice is a household meal that is cultivated and consumed in all geopolitical zones in Nigeria with a consumption per capita of 33.4kg in 2021. In 2024 rice has consistently been used as a palliative material against economic shocks in the country. The quantity of milled rice produced in Nigeria was 5.2 million metric tonnes and could only meet 57% of rice demand locally as of 2023. The demand and supply gap in rice production is widening, resulting in huge import bills for rice. Rice imports have affected the domestic production of Nigeria's local rice (Ademiluyi, Okeke-Agulu, and Folorunso, 2021).

Nigeria produces more than 46% of the rice harvested in West Africa, making it the top producer on the continent but her rice productivity is among the lowest within neighbouring countries, with average yields of 1.51 tonne/ha. In this area, farming is marked by an over-reliance on rainfall and is usually done by households with few inputs (Mekonnen, Tessema, Ganewo & Haile, 2021) making it vulnerable to even minor climatic changes or extreme weather events which could have significant impact on agricultural productivity (Kotir, 2011; Mulwa, Marenya &Kassie (2017); Nelson, 2014).

It is challenging to maintain rice productivity due to the country's rapid population growth, frequent droughts, frequent floods, land degradation, rising rural-urban migration, low agricultural production, declining land area per capita, and antiquated agricultural technology (Ugwoke, Gershonb, Becchioa, Corgnatia & Leone, 2020). About 57% of Nigeria's rice consumption comes from domestic production (KPMG Global, 2022); the remaining 43% is from illicit imports or smuggled rice. According to figures released by the Nigeria Bureau of Statistics, in 2019 rice accounted for 4.92% of total household expenditure and 8.69% of household food expenses. Therefore, the government's utmost priority is to satisfy domestic demand; if possible, it subsequently aspires to become internationally competitive (Albert, Ibris & Ugwu, 2021).

Climate-smart agriculture (CSA) has been prescribed as the solution to feed the expanding population without harming the ecosystem (FAO, 2021; Williams et al., 2015). CSA is a group of agricultural practices and technology that lower GHG emissions, increase resilience, and increase productivity all at once. It is unique in a few aspects, even though it is based on current agricultural knowledge, technologies, and sustainability ideals because it specifically addresses food production as affected by climate degradation, takes into account the trade-offs and synergies between mitigation, adaptation, and productivity in a systematic manner and includes a variety of technologies and practices that are adapted to particular socio-economic and agro-ecological circumstances, such as precision farming, agroforestry, conservation agriculture, climate-resilient crop varieties, water management plans, and better livestock management.

This research work considers the socio-economic characteristics of rice farmers in the study area and assesses the productivity of rice among the climate-smart agricultural practices adopters.

METHODOLOGY

Study Area

Nasarawa state is situated in the North Central region of Nigeria, flanked to the east by Taraba and Plateau states, to the north by Kaduna State, to the south by Benue and Kogi states, and to the west by Federal Capital Territory. It is located between longitudes 8^{o} 20' to 8^{o} 40'E and latitudes 8^{o} 20' to 8^{o} 38'N. It has a total area on land is 2,797.5 square kilometers. It is made up of thirteen local government areas. The Major crops grown in this area are rice, cassava, millet, yam, sorghum, sesame, and maize. Goats, cattle, and sheep are often raised as livestock. The region is primarily a plain with gentle slopes that are drained by the Benue and Mada Rivers. Like other characteristics of the tropical continental climate, it has distinct dry and rainy seasons.

Sampling Technique and Method of Data Collection

The multistage sampling procedure was employed for the collection of data from the rice farmers in the study area. The first stage was the purposive selection of Nasarawa state and three local government areas in the state (Wamba, Doma and Lafia) based on her rice production prevalence and her vulnerability to climate change (Sallawu, Tanko Nmadu & Coker, 2020). Again, there second stage involves a purposive selection of communities in each local government area due to the intensification of rice farming in the domain. This was followed by a random selection of 164 rice farming households in Nasarawa state. A structured questionnaire was used to collect cross-sectional data from primary sources were used.

Analytical Technique

Descriptive statistics was used for the socioeconomic characteristics of the rice farmers in the area while the TFP index was used to calculate the rice farmers' productivity in the study area. The data of rice output and the variabke cost of production were used to compute the total factor productivity of the respondents. This followed, Mcbride and Key

(2003), Fakayode, Babatunde and Ajao (2008), and Ojoko (2021). Where TFP was measured as a ratio of output to variable cost. That is:

$$TFP = \frac{Y}{TVC}$$

Where,

Y = output quantity (in Kg of maize grain equivalent)
TVC = total variable cost (N) TFP = $\sum P_i X_i$
P_i = unit price of the i*th* variable input
X_i = quantity of the i*th* variable input.
P_1X_1 = labour cost
P_2X_2 = fertilizer cost
P_3X_3 = seed cost
P_4X_4 = water cost
P_5X_5 = insect/pesticide cost
P_6X_6 = land preparation cost
P_7X_7 = harvesting cost

The total fixed cost (TFC) function was ignored by the method because TFC does not influence either profit maximization or resource use effectiveness. TFC is consequently set as a constant.

Based on the opinions of Latruffe (2010) and Umar et al. (2011), the TVC (₦/ha) used included fertilizer cost (both organic and inorganic) (Kg/ha), the quantity of seeds sown (Kg/ha), labour used (man-days/ha), pesticides (litre/ha), and herbicide (litre/ha).
The indices for input and output quantities, as well as the final TFP index, were calculated using the Fisher index formula with the use of the TFP Index Programme (TFPIP) version 1.0. The quantities of the inputs and outputs as well as their costs were normalised to per hectare. The benchmark TFP, according to Ball et al. (2001), was 1.00. TFP less than one (TFP 1) denoted decline, whereas TFP greater than or equal to one (TFP 1) denoted advancement.

RESULTS AND DISCUSSION

Socio-economic characteristics

The table below summarised the socio-economic characteristics of the rice farmers in the study area. This age distribution suggests that rice farming is predominantly practiced by middle-aged individuals who are likely to have a good balance of physical strength and experience, which is crucial for the adoption and implementation of climate-smart agriculture (CSA) practices. This finding conforms to the report of Ayinde *et al.* (2013). With about 58.18% male rice farmers it can be said that the male predominance could influence the adoption rate of CSA practices, as men often have greater access to resources, education, and extension services compared to women. This is in line with the argument of Zaknayiba and Tanko (2013) who noted the dominance of the male gender among the crop farmers.

Table 1: Socioeconomic characteristics of the respondents

Socioeconomic Characteristics	
Variable	**Percentage**
Rice Farmer's Age	
21-30	(8.48)
31-40	(32.12)
41-50	(40.00)
51-60	(16.97)
Above 60	(2.42)
Mean	43
Sex	
Male	(58.18)
Female	(41.82)
Marital Status	
Married	(72.12)
Single	(16.36)
Widowed	(7.27)
Educational Status	
No Formal Education	(35.15)
Primary Education	(11.52)
Quranic Education	(2.42)
Secondary Education	(26.67)
Tertiary Education	(24.24)
Household Size	
1-5	(33.33)
6-10	(50.91)
Above 10	(15.76)
Mean	8
Rice Farm Size	
0.01-5.00	(96.36)
5.01-10.00	(3.64)
Mean	1.62

Source: Field Survey Data, 2024

The high proportion of married farmers (72.12%) indicates stable household structures which can facilitate the collective decision-making necessary for adopting CSA practices. The study area has a higher proportion of farmers (35.15%) with no formal education. This agrees with Pelemo et al. (2019) in Kogi State that farmers have low literacy level. The household size is averaged 8. Larger household sizes can provide more labour for farming activities, which is beneficial for adopting labour-intensive CSA practices . The average rice farm size was 1.62 which suggests that most rice farmers may struggle to achieve high levels of productivity, particularly in the absence of intensive CSA practices.   The findings is in agreement with that of Modi (2017) and Umar *et al.* (2015) who Farm size is directly correlated with the potential productivity and income of farming households.

Productivity Analysis of the Rice Farming Households

Total Factor Productivity (TFP) measures the efficiency with which inputs are converted into outputs. The productivity analysis focused on the TFP of rice farming households in Nasarawa States. TFP indices were calculated using the Fisher index formula, with a benchmark TFP of 1.00. A TFP less than 1 indicates a decline in productivity, while a

TFP of 1 or more signifies an advancement. The results obtained indicated varying levels of productivity between the two states and the pooled data. These results are presented in Table 2 for better understanding.

Although, the results obtained below stated that 61.82% had a TFP less than 1.00, it however demonstrates a mixed but slightly more stable productivity situation with a mean TFP of 0.9890. While more than half of the farmers are below the productivity benchmark, the mean value suggests that many farmers are close to maintaining stable productivity levels. The near-stable productivity suggests that while some farmers may experience income stagnation, others could potentially improve their earnings with slight productivity improvements.

Assessing the Rice Productivity Based on Level of Utilisation of Climate-Smart Agricultural Practices

To identify the climate-smart agricultural practices (CSAP) in the study area, Henry Garrette rank method was used (the result is not included). Each practice was ranked according to its level of utilization by the respondents. To assess the level of utilization of CSAP among respondents, an index was calculated. This index was derived by dividing the total rank score obtained by each respondent by the maximum possible rank score for all CSAPs used in the study area. The resulting index score, which ranges from 0 to 1, reflects the level of CSAP utilization by each respondent. Based on the index score, respondents were classified into four categories:

- **0 =** no-utilsation (Non adoption) of CSAPs
- **0.01 – 0.33 =** low (less frequently) utilisation of CSAPs
- **0.34 – 0.66 =** medium (moderate) utilisation of CSAPs
- **0.67 – 1.00 =** high (more frequent;y) utilisation CSAPs

Table 2: Analysis of rice farmers total factor productivity in Nasarrawa (n=164)

TFP index range	Level of CSAPs Utilisation				Mean Value
	Non	Low	Medium	High	
<1.00	16(88.98)	36(70.59)	25(60.98)	25(46.30)	102(62.20)
≤1.00	2(11.11)	15(29.41)	16(39.02)	29(53.70)	62(37.80)
Mean Value	0.7517	0.9017	1.0266	1.1217	0.9889
Min. Value	0.2722	0.2143	0.3952	0.518	0.2143
Max. value	1.273	1.9624	2.0831	2.2995	2.2995

Source: Field Survey Data, 2024

As seen above, it can be stated that 88.89% of those rice farming households who did not use CSA were unproductive while 11.11% were otherwise with a mean value of 0.7517. On the other hand, 70.59% of those with low utilisation were unproductive while 29.41% were productive with a mean value of 1.9624. Those in the medium utilisation level category had 60.98% of them to be unproductive and 39.02% to be otherwise with a mean level of 2.0831. In the same vein, those in high utilisation category had 46.3% rice farming households to be unproductive while 53.7% with a mean value of 2.2995. Cummulatively, 62.20% of rice farming households in Nasarawa state was unproductive and 37.8% were productive. It can thus be implied that the productivity level in Nasarawa was low and CSAP adoption should be encouraged and other factors affecting productivity of rice should be attended to

CONCLUSION AND RECOMMENDATIONS

It can be concluded that CSAP boosts the productivity of rice farmers in the study area and the more practices used the better the productivity.

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Effect of Tillage and Rhizobia Inoculation on Root and Shoot Biomass of Cowpea and Selected Soil Physical Properties during Growing Period in Ilorin, Kwara State Nigeria

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Abstract
The fixation of nitrogen by legumes such as cowpea is a cheap way of fixing atmospheric nitrogen to plant available form. However, the inoculation of this grain legumes with rhizobium bacteria are poorly researched in Ilorin area of Nigeria. This study was conducted to examine the influence of tillage and rhizobium strains on root biomass, shoot biomass, soil bulk density and total porosity. Tillage systems adopted were conventional tillage (CT) and no-till (ZT) while the rhizobia inoculation used were Nodumax from IITA (I), USDA cultured inoculant (C) and the control (Z). The results indicates that CT had significantly higher root, shoot biomass and 100 grain yield (g) of cowpea compared with ZT. Nodumax rhizobia had significantly higher root and shoot biomass than control. However, C gave a significant higher grain yield than I and the control.The soil bulk density was higher under NT than CT from week 1 to 4, whereas CT had higher BD than NT at week 6. However, higher TP was observed from week 1 to 6 under CT compared with NT. There was no significant influence of rhizobia on BD as well as TP.
Keywords: Tillage; Rhizobium; Biomass

INTRODUCTION

Cowpea (Vigna Unguiculata L Walp.) has a high Socio-economic importance and is one of the most important sources of protein (Fisola *et al*., 2022) and of great importance in the basic diet of the Nigeria population. Cowpea promotes buildup of organic matter, carbon and nitrogen fixation, this in turn promotes soil fertility and improve the soil physical characteristics (Sanchez- Navarra *et al*. 2015). Tillage is a mechanical manipulation of soil to provide a favorable condition for crop production. Soil tillage consists of breaking the compact surface of earth to a certain depth and to loosen the soil mass, to enable the roots of the crops to penetrate and spread into the soil. The ability of cowpea to fix nitrogen through biological nitrogen fixation is a cheap and sustainable alternative to Inorganic Fertilizer (Abdel Fattah *et al* 2010). In the past, studies have been conducted to determine the effect of rhizobia inoculation on nodulation, shoot biomass and yield of selected grain legumes (Woomer *et al*., 1997). Reduced tillage positively influences several aspects of the soil whereas excessive and unnecessary tillage operations give rise to opposite phenomena that are harmful to soil. Relatively, information on rhizobia inoculation on different tillage systems is scanty. Therefore, combined effect of tillage and rhizobium inoculation looks promising in improving soil quality. This study aimed to examine the effect of tillage and rhizobia on cowpea biomass and selected soil physical properties.

MATERIALS AND METHODS

Research area

The trial was conducted at the university of Ilorin teaching and research farm. The study site is located on a latitude 8°46' N and longitude 4°66' E located in the university of Ilorin, Kwara state, Nigeria. The city of Ilorin sits on a large expanse occupying about 468 km² and falls in the transitional zone of the forest and guinea savannah region of Nigeria. There are two characteristic climatic seasons in Ilorin, the dry season, and the rainy season. It is categorized under the bimodal rainfall pattern with high rainfall in June and September and a rainfall break between mid – July and August. The mean annual rainfall varies between 1000 mm — 1500mm. The average annual rainfall is however 1200mm and the average minimum and maximum temperatures are about 24.6ºC and 29.4ºC respectively.

Experimental design

The experiment was laid out in a randomized complete block design (RCBD) with a split block arrangement and replicated three times. It includes two tillage systems, conventional tillage (CT) and no-till (NT) in the main plots and three rhizobia treatments nodumax (I), USDA cultured inoculant (C) and the control in the sub-plot.

Soil routine analysis

The intact soil sample of the experimental site was collected at 0-15cm depth using core sampler. Soil bulk density was determined, and total porosity was calculated.

Data Analysis

The data obtained were subjected to Analysis of Variance (ANOVA) to determine significant difference in root and shoot biomass and selected soil physical properties among different treatments. All statistical analysis were conducted using SAS software (version 9.2, 2010).

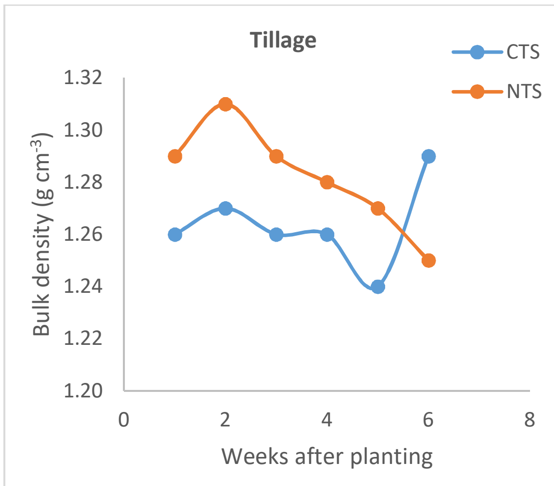
RESULTS AND DISCUSSION

Table 1 shows that CT had significantly higher root, shoot biomass and 100g grain yield compared with ZT. Nodumax rhizobia had significantly higher root and shoot biomass than control. The USDA cultured rhizobia gave a significant higher grain yield than I and the control. The significantly higher root and shoot biomass obtained under CT compared with ZT plots suggested that soil compaction of deeper soil layers under ZT impeded the optimal development of roots and the growth of the main root and shoot biomass (Martinez *et al*., 2008) while conventional tillage increased root penetration and crop growth (Shirani *et al.*, 2002).

The soil bulk density was higher under NT than CT from week 1 to 4, whereas CT had higher BD than NT at week 6 (Figure 1). However, higher TP was observed from week 1 to 6 under CT compared with NT. There was no significant influence of rhizobia on BD as well as TP (Fig. 1 and 2). This study agrees with the work of several researchers. Rahman *et al.* (2008), Sime *et al.* (2015), Alasinrin *et al*., (2024) observed significantly lower BD under conventional tillage (CT) compared with under ZT, whereas others (e.g. Ishaq *et al*. 2002; Puget and Lal 2005; Busari 2017) reported lower soil bulk density (BD) for ZT. These conflicting findings may result from differences in climate conditions, soil properties and interactive effects of variables (Rasmussen 1999)

Table 1: Effect of tillage and Rhizobia inoculation on shoot, root biomass, nodule fresh weight and grain yield

Tillage	Shoot biomass (g pl$^{-1)}$	Dry root biomass (g Pl^{-1})	Nodule fresh weight (g Pl^{-1})	100 grain
CTB	38.89a	9.18a	76.94	15.78a
NTB	33.67b	7.10b	80.85	13.67b
LSD	2.66	0.80	14.24	1.02
Rhizobia				
C	36.17ab	7.94b	75.83	16.33a
I	38.17a	8.97a	84.79	14.83b
Z	34.50b	7.52b	76.06	13.00c
LSD	3.25	0.98	17.44	1.25



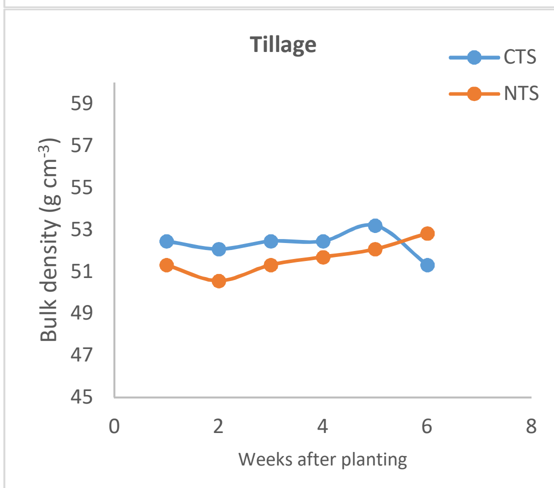


Figure 1 and 2: Effect of tillage ond soil bulk density and total porosity

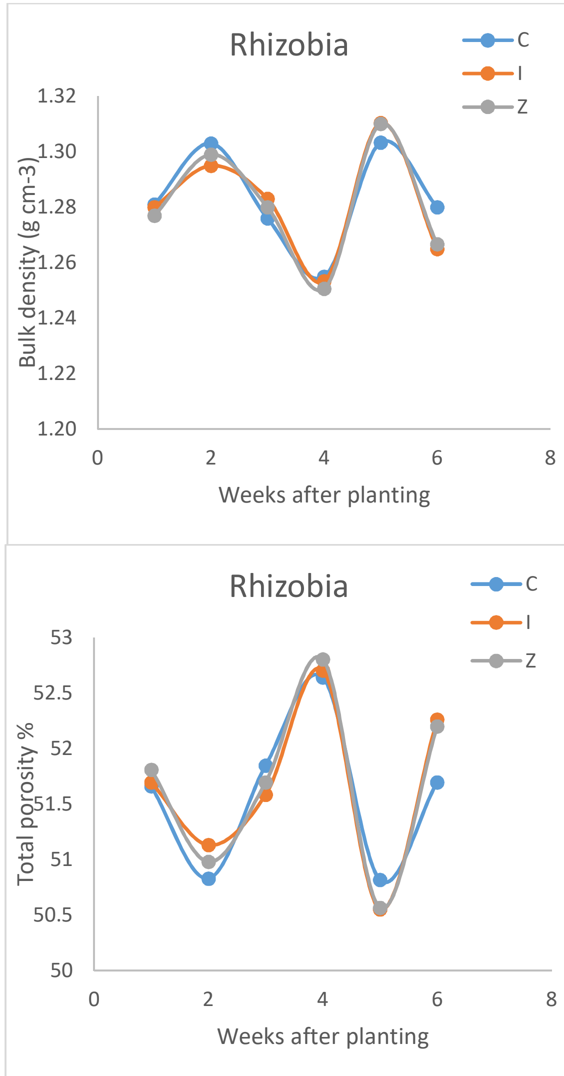


Figure 3 and 4: Effect of rhizobium inoculation on soil bulk density and total porosity

CONCLUSION AND RECOMMENDATIONS

The result showed that conventional tillage had significantly higher root, shoot biomass and 100 grain yield of cowpea compared with no-till. However, higher soil bulk density and lower porosity were recorded under no-till compared with conventional tillage.

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Evaluation of *Kigelia africana* Leaf and Fruit Meals on Reproductive Responses of Rabbits

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Abstract
This research was conducted at University of Ilorin Teaching and Research Farm. Total of 108 rabbits bucks and does in ratio 2:1 were randomly allotted to nine (9) treatment groups in a factorial 2×4 plus control. The nine (9) treatment groups consisted levels of fruit and leaf meals of Kigelia africana (KA) plant independently fed at 0%, 5%, 10%, 15% and 20% inclusion. The effect of KA fruit and leaf meals were investigated on the reproductive performance of rabbits. The results revealed that the FSH, LH and testosterone concentrations were significantly (p>0.05) increased at 20% inclusion. However, the KA parts as a factor was not significantly influenced. Similarly, the LH was significantly influenced in doe with increasing level of the treatments. Subsequently, the libido of the rabbits were also significantly (p>0.05) improved. It can be concluded from the results obtained from this study that KA fruit and leaf meals can be used in rabbit feeding to improve libido which led to a better reproductive performance of both buck and the does. It can be concluded from this study that KA fruit and leaf meals can be added to rabbit diets to improve their reproductive performance.

INTRODUCTION

Rabbits are obtainable in almost every part of the world with no taboo attached to its consumption. They are excellent converter of less quality feed to meat, hence can be produced with less quality feed material. Its fast growing potential and short gestation period make it suitable for addressing the problem of animal protein shortage as human population increases. Nutrition is one of the important elements responsible for reproductive performance, growth and development of rabbits as it enhances the genetic makeup and expression, resulting in maximum growth. In animal production however, non-conventional feed stuff with little or no competition with human can be used in order to reduce cost of production. Like ruminants, rabbits have ability to utilize fibrous feed materials that are cheaper in price and still able to convert it to meat; with the help of some bacterial present in their hind gut. Ethnobotanical trees such as *Kigelia africana* can supply the feed materials which can be utilized by animals while reducing the cost of production since it is almost free in areas where the trees are predominant. Its fruit weighs between 4 - 10 kg and hangs from a long and fibrous stalk, it can also be found in open woodland (Ogbeche *et al*., 2002; Abioye *et al*., 2003; Owolabi *et al*., 2007; Owolabi and Omogbai, 2007). The seed and the leaf of this plant have been reported to contain reasonable amount of crude protein, crude fibre, vitamin and mineral, (Eliton *et* *al*., 2011) which may be beneficial to animals if appropriately included in their diet. This knowledge is important for assessment of levels of safe use, and specifically the nature of its effect (beneficial, neutral or harmful) as measured at the level of reproductive performance of rabbit.

MATERIALS AND METHODS

Diet preparation

Kigelia africana fruit and leaf used for this experiment were collected within Ilorin, Kwara State, Nigeria. They were properly washed and allowed to drain. The fruits were finely chopped and air dried. The dried fruit and leaf were milled with a bore milling machine in to a powder form. Experimental diets of varied levels (5%, 10%, 15% and 20%) of *Kigelia africana* fruit and leaf meal were compounded independently (Table 1 and 2) with a common control. The diets were formulated to meet the nutrient requirements of rabbits recommended by NRC (2000).

Experimental plan and feeding trial

A total of one hundred and eight ten weeks old rabbits were used for this experiment. Seventy-two (72) rabbit does and thirty-six (36) bucks in ratio 2:1 were randomly allotted to nine (9) treatment groups containing eight does and four bucks per treatment, in a factorial 2×4 plus control. The nine (9) treatment groups A, B, C, D, E, F, G, H, and I consisted levels of fruit and leaf meals of *Kigelia africana* plant independently fed at 0%, 5%, 10%, 15% and 20% inclusion. Rabbits were housed individually and had access to feed and water *ad libitum*. The experiment lasted for twelve weeks.

Hormone analysis

At weeks eight and sixteen following the commencement of the experiment, blood samples were collected from eight rabbits per treatment. The blood collected after feeding for the period of sixteen weeks was evaluated to determine whether the *Kigelia africana* parts (fruit and leaf) can be used for a longer period in rabbit diets without posing detrimental effects. The blood was collected before meal during the early hour. The rabbits were restrained in a rabbit restrainer and blood was collected through their ear vein using a sterilized disposable syringe and needle into sterilized plastic plane bottles for determination of reproductive hormones such as Testosterone, Leutilizing hormone (LH) and Follicle stimulating hormone (FSH) and progesterone using methods described by Azu *et al*., (2010).

Pubertal characteristic observations

At six weeks after the commencement of the experiment (16-weeks of age), libido of bucks and does were observed. The rabbit bucks were closely observed for pubertal signs and reproductive alertness by introducing does to bucks. Does from each treatment were introduced to the bucks of corresponding treatments to observe any mounting/receptivity attempts. Receptivity of rabbit does and reaction/activity of the bucks were observed from the time of introduction and noted in seconds as described by Gado *et al*., (2015). The responses were recorded in second for each treatment groups. This process was repeated twice, first at 18 weeks and at 22 weeks of age when larger percentage of receptive does and active bucks were obtained. Age at which each rabbit attained puberty/sexual maturity was recorded based on their responses.

Statistical Analysis

All data obtained was subjected to statistical analysis using the analysis of variance (ANOVA) procedure following a Factorial Design (SAS, 2012) and the levels of significance was determined using the Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

The results of reproductive hormones of rabbits fed *Kigelia africana* (KA) fruit and leaf meal are presented in tables 2 and 3. The KA parts was not a significant factor (p>0.05) for all the hormones measured. However, the inclusion level significantly influenced their concentrations. This indicates that the amount of phyto-compounds present in both fruit and leaf are greatly dose dependent. For the does, the FSH and LH concentrations increased with increasing level of the treatments. Reproductive hormones such as testosterone follicle stimulating hormone (FSH) and luteinizing hormone (LH) are essential in ensuring development of sex organs and exhibition of sexual behaviors and maturity in rabbits. From this experiment, the KA fruit significantly reduced the reaction time and also increased libido. Testosterone, with the help of FSH and LH greatly influence the pubertal attainment in animals. Testosterone synthesis which occurred within the Leydig cells of the testes is known to be triggered by binding luteinizing hormone (LH) to the plasma membrane receptors on Leydig cells of the testes (Beattie *et al*., 2013) therefore, it synthesis is proportionate to the plasma concentration of LH. In this study, the levels of selected hormones investigated at pubertal stage revealed that as the level of dietary inclusion of KA fruit and leaf increased, the concentration of these reproductive hormones also increased. This could be as a result of presence of several nutrients and phytochemicals which has been reported to possess anti-oxidant properties (Aliyu and Adeyina, 2022) that can greatly influence weight gained and other physiological performance by the rabbit. This in return could have led to corresponding testicular growth since improved nutrition has been reported to have a great influence on growth and testicular function, leading to a better reproductive performance of animals. More so, the presence of phytochemicals in KA meals might have stimulating effects on the hormonal responses of the rabbits. Testosterone concentration obtained in this study is higher than that reported by Gado *et al*. (2003) who fed multi-enzyme based diet in matured rabbits, the variation in the results could be due to many other factors apart from nutrition, one of which is the use of antioxidants to prevent or reduce the effects of oxidative stress which happened to be a factor affecting reproductive performance in both animals and man. Oxidative stress occurred when there is imbalance in the body antioxidant level which can lead to reproductive impairment such as reduction in testosterone synthesis. The use of antioxidant has been proven to enhance testicular function like testosterone production, (Attia and Kamel, 2012) as well as improved semen quality (Aliyu and Adeyina, 2018). The antioxidant potentials of the KA fruit and leaf can be attributed to the combined effects of vitamin E, zinc, flavonoids and other phytochemicals present since they are all known antioxidant agents (Aliyu and Adeyina, 2022).

At 23 weeks of age, rabbit bucks on the leaf exhibited a significantly (p<0.05) longer reaction time than those fed fruit. Whereas, no significant difference (p>0.05) was observed in the reaction time of bucks at 25 weeks. However at graded levels, the reaction time was significantly lowered at 20% inclusion. The reduced reaction time can be attributed to increased synthesis of testosterone which is a major hormone that helps sexual characteristic development.

In conclusion, using *Kigelia africana* as part of rabbit diet can increase the libido and sexual performance of the buck while improving the receptivity in the doe.

Table 1: Composition of Experimental Diet Supplemented with *Kigelia africana* Fruit Meals

Ingredients	A	B	C	D	E
Maize	30	30	30	30	30
Soybean Meal	20	20	20	20	20
Wheat Offal	8	6	6	3	1
Maize offal	16	15	14	18	22
Rice husk	22	20	16	10	3
Fish Meal	1	1	1	1	1
KAFM	0	5	10	15	20
Salt	0.5	0.5	0.5	0.5	0.5
Dicalcium phosphate	2	2	2	2	2
Lysine	0.05	0.05	0.05	0.05	0.05
Premix	0.45	0.45	0.45	0.45	0.45
Total	**100**	**100**	**100**	**100**	**100**
%crude protein	16.06	16.08	16.36	16.61	16.98
% crude Fibre	11.11	11.71	11.88	11.80	11.50
ME (Kcal/kg)	2,456.40	2,366.83	2,286.66	2,247.39	2,212.82

*KAFM= *Kigelia africana* fruit meal, ME- metabolizable energy

Table 2: Effect of Kigelia africana Fruit and Leaf Meals on Reproductive Hormones of Rabbits Bucks

KA Parts	FSH (pg/ml)	LH (ng/dl)	TESTOSTERONE (ng/dl)
Fruit	121.86	1.72	73.33
Leave	122.83	1.81	69.51
P value	0.92	0.48	0.11
Inclusion Levels (%)			
0	100.29^{b}	1.58^{bc}	54.82^{c}
5	114.53^{ab}	2.03^{a}	75.12^{b}
10	119.80^{ab}	1.49^{c}	73.55^{b}
15	133.03^{ab}	1.98^{ab}	67.91^{b}
20	144.09^{a}	1.77^{abc}	85.70^{a}
P value	0.07	0.04	<.0001
Parts*Levels	*	*	*
P value	0.74	0.13	0.55
SEM	6.84	0.09	1.62

KA= *Kigelia africana*, a, b, c – means with different superscripts are significant along the column, S- significant, NS – not-significant, SEM= Standard Error of Mean

Table 3: Interactions between KA Parts and Inclusion Levels of Kigelia africana Fruit and Leaf Meals on Rabbit Buck Reaction Time at 18 weeks

Inclusion Level (%)						
KA Parts	**0%**	**5%**	**10%**	**15%**	**20%**	**SEM**
Fruit	37.25^{a}	23.25^{b}	18.50^{b}	17.50^{bc}	11.75^{c}	1.86
Leaf	37.25^{a}	22.75^{b}	21.25^{b}	23.75^{b}	23.25^{b}	1.86

KA= *Kigelia africana*, a, b, c – means with different superscript are significant along the row, SEM=Standard Error of Mean

Table 4: Effect of *Kigelia africana* Fruit and Leaf Meals on Reproductive Hormones of Rabbits Does

KA Parts	FSH (pg/ml)	LH (ng/dl)	PROGESTERONE (ng/dl)
Fruit	105.39^{a}	1.70	14.52
Leave	89.23^{b}	1.57	14.40
P value	0.03	0.31	0.76
Parts*Levels	NS	*	NS
P value	0.07	0.007	0.56
SEM	4.92	0.08	0.28

KA= *Kigelia africana*, a, b, c – means with different superscripts are significant along the column, *- significant, NS – Not-significant, SEM= Standard Error of Meal

Table 5: Interactions between ka parts and inclusion levels for luteinizing hormone of rabbits fed kigelia africana fruit and leaf meals

Inclusion Levels (%) KA Parts	0%	5%	10%	15%	20%	SEM
Fruit	0.91^{b}	1.99^{a}	1.95^{a}	1.67^{ab}	1.99^{a}	0.20
Leaf	0.91^{b}	0.86^{b}	2.19^{a}	1.92^{a}	1.99^{a}	0.20

KA= *Kigelia africana*, a, b, c – means with different superscript are significant along the row, SEM=Standard Error of Mean

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Influence of Water Stress and Mulching on Growth and Yield of *Stevia rebaudiana*

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Abstract
This study was conducted to evaluate irrigation schedules and to establish the extent of tolerance in the Stevia Plant in National Cereal Research Institute Badeggi, Bida. Eighteen plastic posts and two seedlings per pot were used and soil samples were collected randomly beside the screen house. the treatments are 0 ton/ha rice husk + once irrigation per week, 6 ton /ha + once Irrigation per week, 0 ton /ha + once irrigation per week, 3 ton/ha + 2 twice irrigation per week and 6 ton/ha rice husk + 2twice irrigation per week were investigated. The experiment was laid in a random and complete block design (RCBI) with three replications all data collected were subjected to Analysis of Variance (ANOVA) using statistical tool for agricultural research STAR (Version, 2013) package. Means were separated using Duncan multiple range test *(DMRT). The results revealed that at 6 ton/ha rice husk + 2twice irrigation per week recorded high water management that all other treatments studied. Also, the results revealed that at 6 ton/ha rice husk + 2twice irrigation per week for weed dry weight and density recorded higher percentage of weed dry weight and density respectively. The results further revealed that at 6 ton/ha rice husk + 2 twice, irrigation per week recorded higher yield than all other treatments in the studied.*

Keywords: Water stress, Stevia, Mulching, Rice husk

INTRODUCTION

Stevia (Stevia Rebaudiana Berton) is an herbaceous zero-calorie natural sweetener plant. It’s belonging to family Asteraceae. It is known by different names which include sweet herb, sweet leaf, honey leaf, candy leaf and honey herb (Yandev et al 2012).
Stevia is a perennial nature plant and endemic shrub that grows up to one meter. Flowers are white in colour with pale purple throat and arranged in the form of small corymbs. The root lead an extensive system.

The stem is woody and the upper surface of leaves slightly glandular pubescent. Stevia (S. Rebaudiana Berton) is native to North-Eastern Paraguay and grow in sandy soil. It was first established in Japan in 1968. It is Steviobioside, dulcoside and rebaudiosides ABC and E.

An extraction of Stevia is known as a stevioside. It is 100 to 400 times sweeter than sucrose, the common sugar (Pande and Gupta, 2013). The stevia sweeteners have no adverse effects on human health and safe for diabetic (Misra, 2011). Stevia can be used as a substitute to sucrose and they are natural sources of non-caloric sweetener, also an alternative to the synthetic sweeteners agents that are now available to the diet conscious consumers. Water stress is one of the main abiotic stress factors, which leads to changes in morphological, physiological and biochemical responses of plants. Consequences, plant growth and crop production are negatively affected (Youfi *et al*, 2016). It is also characterized by the reduction of leaf water status, which affects photosynthesis through the limitation of the efficiency of the photosystem II (PSII) activity (Fini *et al*, 2013). This effect depend largely on plant species and water stress severity (Aref *et a*l., 2013). Stevia is a drought susceptible species (Shock, 1982). It can survive in areas of continuous moisture but not withstand the prolonged water logging conditions (Bonalisio *et al* 1982). Water stress also impact physiological responses such as photosynthetic rate (A) transpiration rate (E) and stomatal conductance (Gs) of many plants (Methobo *et al*, 2017). Due to the short time of stevia introduction on optimal agronomic management practices and especially the influence of water availability on its establishment and production. Therefore, this work was carryout to evaluate the growth and yield responses during the gravity period of the various treatments imposed.

MATERIALS AND METHODS

The trial was conducted at the screen house of National Cereal Research Institute Badeggi, Nigeria in 2024. The soil samples were collected randomly beside the screen house. The plastic pots were purchased at new Market Bida. The treatments consist of T_1 0 ton /ha + once irrigation per week, T_2 3 ton /ha + once irrigation per week, T_3 6 ton /ha + once irrigation per week, T_4 0 ton /ha + 2twice irrigation per week, T_5 3 ton I ha + 2twice irrigation per week, T_6 6 ton I ha + 2twice irrigation per week. Each of the pot consist of two seedlings per pot. The experiment design was randomize complete block design (RCBD) replicated three times. The data collected from each experimental pots were analyzed using Analysis of Variance to determine the effect of water stress. Duncan multiple range test was used to separate the means at 0.05 level of significance.

RESULTS AND DISCUSSION

Branches

The effect of water loss management of branches of stevia at 3 & 6 weeks in Badeggi is shown on table 1. Number of branches of stevia differed significantly among the water loss management throughout the sampling periods in this trial. At 3 weeks, the application of 3 ton/ha + 2twice irrigation per week was statistically higher among other treatments. Application 0 ton/ha + 2twice irrigation per week has lower number of branches but similar with 3 + /ha + once week and 6 + /ha 1 once per week treatments at 6 weeks, the application of 3 + /ha + 2twice irrigation per week and 6 + /ha + 2twice irrigation per week produced similar highest number of branches than all other water loss management treatments.

Plant Height

The effect of water loss management on plant height of stevia at 3, 6, & 12 weeks in Badeggi is shown in table 1. Water loss management had a significant effect on plant height across the sampling time in this study. At 3 & 6 weeks, the application of 6 ton /ha + 2 twice irrigation/week and 3 ton /ha + 2twice irrigation per week produced taller plants which were statistically similar with the application of 3 ton /ha + once irrigation per week, 6 ton /ha+ once irrigation per week and 0 ton/ha + 2twice irrigation per week than the other treatments.

Yield

The effect of water loss management on yield of stevia in Badeggi shown on Table 1. Leave yield was significantly different among the water loss management treatments. The application 6ton/ha + 2twice irrigation per week recorded higher yield than all the other water loss management. But 0 ton /ha + 2 twice irrigation per week was lower but similar with 0 ton /ha + once per week, 3 ton + /ha once irrigation per week and 6 ton /ha + once irrigation per week on the study.

Water Loss
The effect of water loss management on the plant of stevia at 3, 4, 5 & 6 at Badeggi is shown on table 2, water loss management had a significant effect on plant of stevia throughout the sampling period in this trial. At 3 WAS, the application of 6 ton /ha + 2 twice irrigation per week recorded higher water management than all the other treatments. But treatments 0 ton/ha + once irrigation/week 3 ton /ha + once irrigation/week and 6 ton /ha + once irrigation/week was lower but statistically similar with 0 ton/ha + 2 twice irrigation/week in this study. At 4 weeks, the application of 6 ton/ha + 2 twice irrigation/week had significant higher water management than all the other treatments but treatment 0 ton/ha + once irrigation/week was lower but statistically similar with 3 ton/ha once irrigation in this study. At 5 WAS, the application of 6 ton/ha + 2 twice irrigation per week and 3 ton/ha + 2twice produce higher water management than all other treatment, but 0 ton/ha + once irrigation and 3 ton/ha + once was lower but statistically similar with 6 ton/ha + once irrigation in this study.

Weed Dry Weight
Other effect of water management on the weed dry weight stevia at 3 & 6 WAS in Badeggi, is shown in table 4. Water management had a significant effect on weed dry weight of stevia plant in this study. At 3 WAS, the application of 6 ton/ha + 2 twice irrigation recorded significantly higher weed dry weight than all other treatments but 0 ton/ha once and 3 ton/ha + once was lower but statistically similar with 0 ton/ha + 2 twice irrigation treatments. At 6 WAS, the application of 3 ton/ha + 2 twice and 6 ton/ha + 2 twice irrigation recorded significantly similar highest weed dry weight than all other treatments but 0 ton/ha + once, and 3 ton/ha + once/week was lower but statistically similar with 0 ton/ha + 2 twice irrigation in this study.

Weed Density
The effect of water management on weed density of stevia plant in Badeggi is shown in table 4. Water management had a significant effect on weed density through the sampling period in this study. At 3 WAS, the application of 6 ton/ha + 2 twice irrigation/week recorded significantly higher weeds than all other treatments, but 0 ton/ha + once irrigation per week, 3 ton/ha + once and 6 ton/ha + once irrigation was lower but statistically similar with 0 ton/ha + 2 twice irrigation/week. At 6 WAS, the application of 6 ton/ha + 2 twice irrigation recorded higher weed dry weight than all the other treatments but 0 ton/ha + once irrigation was lower but statistically similar with 3 ton/ha + once and 0 ton/ha + 2 twice irrigation/week in this study.

In addition, some studies reported that water stress limit stevia plant height and dry leave yield in relation to total biomass produced (Aladakatti *et al*. 2012, Shi & Ren 2012, Kanta *et al* 2017).

Severe decrease in leave yield of stevia due to imposed water stress observed in this study confirms the report of Muhammad et al. 2022 that reveal Water stress considerably minimized the yield of wheat and Farooq et al. 2015 stated that the

reduction in grain yield of wheat under water stress may be due to leaf senescence acceleration, degeneration of photosynthesis and sink restrictions.
The lower fresh biomass and dry leaf yields associated with un-mulch plots could be as a result of the reduction in water availability can be explained by inhibition of leaf growth and plant height, reduction nutrient uptake, transport and distribution (Rouphael *et al.,* 2012) and considerable decrease photosynthesis and canopy structure (Bhatt and Rao, 2005).

In line with our results weed population and dry matter accumulation by weeds were significantly influenced by mulch treatments as documented by Kumar et al. 2014. However they further revealed that the dry weight of weeds in plots treated with mulches was less, which could be attributed to higher crop growth, as reflected in crop plant height, causing early canopy of crop and ultimately smothering of the weeds.

CONCLUSION

From the results of this study, 6 ton/ha rice husk + 2 twice per week shows higher values than all other treatments in the experiment, therefore, the experiment will continue for onward recommendations.

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Table 1

TRT	Branches at 3 MAP	Branches at 6 MAP	PLH at 3 MAP	PLH at 6 MAP	PLH at 12 MAP	YIELD
1	26.67bc	29.00d	40.33c	45.00b	42.67c	3.53c
2	35.67abc	45.00bc	55.33b	52.67 ab	51.00bc	4.67c
3	38.33abc	58.33ab	59.67b	67.33ab	69.00ab	5.80bc
4	24.33c	43.33cd	62.33ab	51.67ab	46.00c	3.67c
5	53.33a	62.00a	66.33ab	69.00a	70.33a	12.07ab
6	51.67ab	68.00a	73.33a	69.67 a	73.33a	15.80a
SE ±	7.89	4.32	3.42	7.12	5.67	1.92
CV %	25.2	10.38	7.02	14.73	11.82	30.97

Table 2

TRT	Water loss at 3 weeks	Water loss at 4 weeks	Water loss at 5 weeks	Water loss at 6 weeks
1	22.33c	20.00d	15.33 c	14.00b
2	25.07c	23.73cd	17.07 c	15.00 b
3	26.00bc	24.67c	19.33bc	16.33b
4	27.33bc	27.33bc	21.67b	17.33 b
5	30.67ab	30.33ab	27.00a	18.67 b
6	33.33a	32.67a	31.00a	25.00a
SE ±	1.49	1.17	1.21	1.6
CV%	6.64	5.42	6.78	11.05

Table 3

TRT	Weed Dry Weight at 3 weeks	Weed Dry Weight at 6 weeks	Weed Density at 3 weeks	Weed Density at 6 weeks
1	0.05c	0.37c	4.67c	7.67d
2	0.17c	0.83bc	6.00bc	12.67bcd
3	0.87b	0.90b	6.33bc	16.00abc
4	0.57bc	0.67bc	5.67bc	11.00cd
5	1.13 b	2.23a	9.00ab	18.33ab
6	2.40a	2.33a	11.33a	20.67a
SE±	0.19	0.15	1.26	1.9
CV%	27.94	14.81	21.57	16.13

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Fundamentals in Taro (Cocoyam) Production, Processing and Utilization for Food Security in Nigeria

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Abstract
Taro (cocoyam) is a vital root crop in Nigeria, contributing significantly to food security and economic stability. This paper reviews the value chain of taro production, processing, and utilisation, emphasising its role in enhancing food security. Taro, belonging to the Araceae family, is cultivated primarily in Nigeria the largest producer globally. The crop's high nutritional value, economic potential, and adaptability to various agroecological zones make it indispensable. This review covers agronomic practices, pest and disease management, and post-harvest processing techniques crucial for optimising taro production. Additionally, it highlights the crop's utilisation in various forms, including flour, chips, and flakes, which add value and extend shelf life. The paper concludes with recommendations for improving taro production and processing to ensure sustainable food security in Nigeria.

***Keywords**: Taro, Cocoyam, Food Security, Nigeria, Processing*

INTRODUCTION

Taro (cocoyam), a member of the monocotyledonous family Araceae, is a herbaceous plant with a condensed underground stem known as a corm, where starch is stored (Amadi, Onyeka, and Uko, 2018). The corm is surrounded by outgrowths called cornels, attached either directly or via a short neck region. Fibrous roots emerge from the corm's apex. The major genera cultivated and consumed are *Colocasia esculenta* and *Xanthosoma maffafa*. *Colocasia* leaves are rounded with the petiole attached near the middle of the lamina, while *Xanthosoma* leaves are long-stalked with a deep indentation at the base (Mbanaso *et al*., 2008). *Colocasia* is often referred to as "taro cocoyam" or "old cocoyam," whereas *Xanthosoma* is known as "new cocoyam." The centre of origin for *Colocasia* spp., also called Old Yam in West Africa, is the region occupied by Myanmar and Bangladesh in Southeast Asia (FAO, 2012). *Xanthosoma* originated from South America and the Caribbean. In Africa, cocoyam is commonly grown in Nigeria, Togo, Cameroon, Gabon, and Ghana, where it is a staple food and income source. Nigeria is the largest producer, with about 5.49 million metric tonnes annually, accounting for 45.9% of global output and 72.2% of West African output (Chukwu, 2002-2011). In 2015, Nigeria's total production was estimated at 4.007 million metric tonnes (Chukwu, 2020). Cocoyam ranks third among root and tuber crops after cassava and yam, serving as a crucial carbohydrate staple, especially in Nigeria's southeast, South-

South, and some middle belt areas. This review explores the fundamentals of cocoyam production, processing, and utilisation for food security in Nigeria.

MATERIALS AND METHODS

Study Area

The study was conducted in various agro-ecological zones of Nigeria, focusing on regions with significant cocoyam production.

Planting Materials

Recommended landraces of cocoyam, such as NRCRI ACC. No. NXs 001 (Ede-ocha), NXs 002 (Ede uhie), and others were used. Cocoyam was propagated vegetatively using shoots, small cormels, or setts cut from large corms.

Land Preparation

Land preparation involved site selection, clearing, and soil amendment with fertilizers or organic manure. Mounds and ridges were prepared using native hoes or tractor-mounted implements.

Taro (cocoyam) production

Cocoyam could be produced or cultivated either for subsistence or for commercial purposes. However, materials needed for optimum production include arable land, planting materials, capital, labour, agro-chemicals, farm tools and technical know-how. **Land Preparation**: Cocoyam is planted upland or under lowland culture (flooded) (Nwadili *et al*., 2016). Land preparation starts with site selection and land clearing. Rich loamy soil is advised to be selected. This will inform the need for soil amendment with fertilizers or organic manure.

(i) **Mounds:** The top soil is scrapped together with the native hoe, Indian hoe or shovel into heaps of loose soil. These mounds are spaced 50cm apart.
(ii) (ii) **Ridges:** The loose soil is firmed up into ridges using tractor-mounted implements after ploughing and harrowing and are made at a spacing of 1.0m apart and across the slope of the field. The operation can be carried out using the native hoe, India hoe or shovel where the tractor-mounted implements are unavailable.

Planting Materials: The recommended landraces of cocoyam could be used as planting material: NRCRI ACC. No. Local name: NXs 001 - Ede-ocha, NXs 002 - ede uhie, NXs 003 – okorokoro, NCe 001 – cocoindia, NCe 002 - ede ofe green, NCe 003 - ede ofe purple, NCe 004 – ede ofe giant, NCe 005 – Ukpong, NCe 006 – Ghana. Cocoyam is propagated vegetatively using the shoot, which is the top of the main plant containing about 5cm of the corm and leaves cut off from about 20cm above the base, small cormels or setts cut from large cormels or setts cut from large corms.

Method of Planting: Cocoyam is planted 50cm apart on 1-meter ridges or 50 x 50 cm on mounds. Planting depth should be 10-15 cm with the growing bud facing upward. These plant populations would be obtained by planting the cocoyam at a spacing of 50cm apart on the 1-meter ridge and the plantain 6.25m on one side of each ridge. **Time of Planting:** Cocoyam should be planted at the onset of the rains. The period from the first week of April to the first week of May is recommended for best yields. Where irrigation is available, it can be planted at any time of the year. In addition, the incidence of field diseases like the Cocoyam Root Rot Blight Complex (CRRBC) is higher with late planting. **Weed Control;** Weed control is critical during the early part of growth when the canopy is not fully formed. The first weeding should be at 3-4 weeks and the second at 8 weeks after planting. Hand tools like the native hoe can be used. Care should be taken to avoid damaging the shallow roots. Weeding should be done from the bottom to the top of the ridges or mounds up, to cover exposed corms and cormels. Cocoyam responds well to mulching.

Fertilizer Application: Cocoyam has a high requirement for potassium and calcium, and responds well to nitrogen. Fertilizer should be applied at the rate of 60kg N, 10kg P, and 50kg K on soils low in N and K but medium in P, especially for production of *Colocasia spp*. This is equivalent to three bags (3 bags) of the compound fertilizer 20:10:10 applied per hectare. The application should be in split doses to minimize leaching.

Pest Control: The important pests of cocoyam in south-eastern Nigeria are nematodes, termites, scale insects, mealybugs, tuber borers and vertebrates like wild fowls. These pests predispose the corms and cormels to fungi, which cause rots in cocoyam. Nematodes, such as the root-knot nematode, attack the underground portions causing abnormal growths and irregular swellings of cocoyam. These lead to stunting of the plant.

Disease Control: The main diseases of cocoyam include corm rot (collar rot), soft rot, cocoyam root rot blight complex (CRRBC) and leaf blight of *Colocasia*. The fungus *Sclerotium rolfsii* causes corm rot soft rot is caused by the fungus, *Pythium*, bacteria or a combination of both and attacks *Xanthosoma* and *Colocasia*. The pathogens live in the soil and attack the roots, corms and cormels, causing them to rot. The leaves also turn yellow and wilt. The leaf blight disease is a fungal disease of *Colocasia* caused by *Phytophthora colocasiae*. It attacks the leaves of cocoyam, causing the death of portions of such leaves. Control measures include: (i). Use of clean, disease-free planting materials., (ii). Use of slow decomposing grass mulch, (iii). Deep planting to the depth of 20cm, (iv). Crop rotation and (v) Avoidance of infected soil. Control of the Cocoyam Rot Blight Complex using fertilizer rich in potassium (K). Moreover, planting cocoyam on a piece of land from which maize has been harvested will help in checking some of these diseases.

Harvesting: Cocoyam is mature and ready for harvest when most leaves have turned yellow (senescence). This occurs 7 to 9 months after planting depending on the variety. However, if the growing conditions are favourable, the yellowing of the leaves will not be appreciably high at this time. Harvesting is done with simple hand tools, pulling up the plants by the hand. The whole plant may be dug up and the cormels separated from the corms. When assembling and grading cocoyam after harvesting, it is necessary to separate healthy ones from the diseased ones and also separate them according to species and varieties [that is Colocasia (ede-ofe) and Xanthosoma (ede uhie) should be separated from each other]. This also helps in selecting the healthy cocoyam during harvesting. With this, the diseased free ones are separated from the rot and mould (NRCRI, 2023).

Pest and Disease Management

Pest control included managing nematodes, termites, scale insects, and mealy bugs. Disease control focused on corm rot, soft rot, and leaf blight, using clean planting materials, slow-decomposing grass mulch, deep planting, crop rotation, and potassium-rich fertilizers.

RESULTS AND DISCUSSION

The study found that cocoyam production depends on proper agronomic practices, pest and disease management, and timely planting. The use of recommended landraces and appropriate planting techniques significantly improved yield. Pest and disease management practices reduced crop losses, ensuring higher productivity.

Cocoyam Processing/Utilization

Cocoyam cannot be eaten raw. Therefore, it undergoes some forms of processing before utilization or consumption. Again, during the peak season, most farmers sell their farm produce (corms/cormels) at very low prices. To prevent this, farmers can process cocoyam into various products for storage and utilize at home or as value-added products for income generation. Cocoyam can be processed into two major forms: flour and flake (Okonkwo *et al*, (2014). Major equipment for cocoyam processing is a cooking pot, a big plastic bucket, a sharp knife, a stove (charcoal, kerosene, gas or electric), a big mat, and mortar for local processing. However, for commercial purposes, the following equipment is required: solar dryer, pressure pot, sealing machine, weighing scale, corn milling machine, slicing machine and peeling machine or lye solution. According to Clifford, *et al*., (2013), it is processed as shown in Table 1 below:

Table 1: Processing of Cocoyam

Processing Methods	Description
Processing of Cocoyam into Chips	- Use Xanthosoma spp. for fufu and Colocasia spp. for soup thickening. - **Washing**: Clean corms and cormels to remove dirt. - **Precooking**: Boil 20 mins to 2 hrs to reduce oxalate. - **Peeling**: Remove the skin. - **Slicing**: Cut into 2–5 cm thick pieces for faster drying. - **Fermentation**: Soak chips for 24 hours if not pre-cooked. - **Drying**: Sun-dry and cover to avoid contamination. - **Storage**: Keep in airtight containers in a dry place.
Processing of Cocoyam into Flour	- Use Xanthosoma for fufu flour and Colocasia for soup-thickening flour. - **Washing**: Clean in water. - **Precooking & Peeling**: Boil for 20 mins to 2 hrs and peel manually. - **Slicing**: Cut into 2–5 cm pieces. - **Fermentation**: Soak for 24 hrs if not pre-cooked. - **Drying**: Sun-dry and cover. - **Milling**: Grind into flour. - **Sieving**: Sieve and store in airtight containers.
Processing of Cocoyam Paste	- Wash, peel or boil cocoyam. - Pound cooked corms in a mortar or use a grinding machine.
Processing of Cocoyam into Flakes	- **Selection**: Choose firm, healthy corms. - **Washing & Boiling**: Boil Xanthosoma for 1–3 hours and Colocasia overnight. - **Peeling & Slicing**: Peel and slice the corms. - **Drying**: Sun-dry and cover to prevent contamination. Store with dried pepper.
Processing of Cocoyam into Porridge	- Break flakes into smaller pieces and soak for 30 mins to 1 hour. - Cook for 15–20 minutes. - Mix with vegetables, pigeon peas, and palm oil on a porridge dish.

CONCLUSION AND RECOMMENDATIONS

Cocoyam's high nutritional value and economic potential make it a vital crop for food security in Nigeria. However, challenges such as pest and disease infestations and inadequate processing facilities hinder its full potential. Recommendations include adopting integrated pest management practices, improving access to clean planting materials, and investing in processing infrastructure to add value and extend shelf life.

Cocoyam is a crucial crop for food security in Nigeria, with significant potential for economic growth. By addressing challenges in production and processing, Nigeria can enhance cocoyam's contribution to food security and economic stability. Further research and investment in sustainable practices are essential for optimizing cocoyam production and utilization.

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Effect of Date of Planting on Taro (*colocasia esculenta* (l.) Schott) Flowering and Tuber Yield in Umudike Southeastern Nigeria

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Abstract
Taro Leaf Blight (TLB) disease is devastating and debilitating disease of field Taro. To determine the time for crossing block establishment in the rain-fed agriculture is imperative. Hence, a trial was conducted in Umudike Southeastern Nigeria to determine the Effect of Date of Planting on Taro (Colocasia Esculenta) Flowering and Tuber Yield with objectives: to determine the time for Taro crossing blocks establishment, to generate botanical seeds, to select high flowering, corm+cormels yielding cultivars as parents for future breeding plan and to select cultivars resistant to TLB. Two sets of crossing blocks were established in first week of April and first week of July 2023. Corm sett size of 100 to 150g of the 16 cultivars of Taro were laid down in plot size of 20m^2 and spaced 100cm within plants and 100cm between ridges. To avoid erratic flowering, gibberellic acid (GA$_3$) prepared at 500ppm was applied at 3-leaf stage. Crosses were made. Data were on: number of plants flowered, number of fruit-heads, number of seeds, weight of corm+cormels and response of cultivars to TLB. Data were analyzed with ANOVA. Results indicated that TLB was prevalent in April which led to no flower and seed production while in July, reduction in rainfall distribution resulted to low bulking of the Taro tubers. The cultivar SM126/29 gave the highest number of fruit-heads in April and flowered in July but failed to produce botanical seeds. Cultivars with mean weight of corms +cormels higher than the general mean were selected as parents for future crossing block.
Keywords: Taro, Hybridization block, crosses, Time of planting and Parents

INTRODUCTION

Taro (*Colocasia esculenta*) and Tannia (*Xanthosoma saggittifolium*) mainly found in West Africa and popularly called cocoyam are important members of the *Araceae* family. However, Taro has been on the high pedestal for feeding over 800 million people in over 90 countries across the globe (FAOSTAT, 2022). The physiological and agronomical variability that has been observed in Taro revealed interesting traits that can be exploited in breeding programmes. The Taro landraces have been recognized as a special germplasm base with distinctive organoleptic and adaptability traits that can increase the income of farmers through their value-added products.

The objectives of Taro improvement programme as recognized by Godden (1999) differ according to location, end-use of the corm and cormels, and the available resources. However, the common goal for each programme are high yield, yield stability, high nutritional quality and resistance to abiotic and biotic stresses. Parental selection for hybridization is necessary to develop heterosis for yield, early maturity and other good agronomic characteristics. Due to the distinctive qualities and adaptation to local soil and climatic conditions, local Taro varieties are often used as parents as reported by Ivancic (2003). Landraces are cultivated in many states of the country and this present a wide diversity of morphological, phenological and agronomical traits that can be exploited in breeding programmes.

Several morphological and agronomical characters present polymorphism among them, Jackson and Pelomo (1980) observed that growth habit and vigour, flesh colour and organoleptic quality are related traits. According to Onyeka et al (2011) TLB has been a devastating field diseases of Taro. However, crosses has to be made between landraces to produce F_1 hybrids which would be compared with commercial landraces in open field cultivation in term of yield, vigour, pests and diseases reactions. Morphological and molecular distances between the parents will have to be used to predict the progenies performances (Laurie and Niederwieser, 2004).

In order to develop new varieties and increase the genetic base of Taro, crossing block had to be established and hybridization has to take place for the generation of botanical seeds. Therefore the objectives of this trial were: to determine the time for Taro crossing blocks establishment for botanical seed generation, to generate botanical seeds for the development of new Taro progenies, to select high flowering and corm+cormels yielding cultivars as parents for future breeding plan and to select cultivars resistant to major biotic stresses of Taro.

MATERIALS AND METHODS

Two sets of crossing blocks were established in June 26th 2023 at the Western experimental field of National Root Crops Research Institute, Umudike on sandy loam soil of Field H5. The first crossing block of the Taro (*Colocasia Species*) was established in the first week of April and the Second crossing block was established precisely first week of July 2023. The land area for the experiment was slashed, ploughed and ridged. The field was then demarcated into plots and Blocks. In the first crossing block, Ten (11) exotic lines and five (5) landraces of Taro varieties totaled 16 cultivars were established in 16 plots. Each plot contained 20 plants stand per plot. Each plot measured 20m2 (4 x5m ^{2}) and replicated three times. The first trial was established in the first week of April, 2023, while in the second crossing block was established in first week of July 2023. The each corm sett weight for each cultivar was 100 to 150g. The corm sett was planted 100cm within plants on the crest of the ridge and 100cm between ridges. To overcome the problem of erratic flowering, freshly prepared gibberellic acid (GA_3) was applied to the plants at the 3-leaf stage at the rate of 500ppm per plant of Taro. Flowering and production of fruit-heads commenced two and half months after induction with gibberellic acid and continued until the Taro plants started to senescence.

Bi parental crossing in Inter-varietal crosses were made in the controlled crosses carried out. (Control crosses between landraces and exotic lines, and within exotic lines). Data were collected as follows: number of plants that flowered, number of fruit-heads (berries) per cultivar and total number of seeds collected per cultivar. Also collected were: weight of corm+cormels per cultivar and response of the cultivars to major biotics stresses of Taro. Data collected were statistically analyzed using ANOVA and means were separated using Standard Error of difference mean.

RESULTS AND DISCUSION

Number of plants that flowered and Seed production in April field establishment:
The result of the: Number of Taro plants that flowered, Total number of fruit heads, Total number of seeds, produced by the Taro plants established in the crossing block in the months of April and July 2023 are presented in Table 1. The result indicated the mean total number of Taro plant that flowered in the month of April 2023 was 115 which was equivalent to 82% of the mean number of Taro plants established in the crossing block. The mean total number of fruit-heads harvested was 201 with mean of 12.6 per plant. Mean total fruit heads ranged from one (NCe/005 (Ukpong)) to 20 (SM126/29) with mean of 12.6 per Taro plant. However, these number of fruit heads produced no fruit-heads (berry) and no seeds were collected. This was as result of the attack of Taro leaf blight that attacked the fruit-heads, the peduncles and the Taro leaves. This led to the death of the fruit-heads which resulted into no seed production. This was observed from the disease score rating in the plots established in April. The disease score rating ranged from 3.2 (moderate) for SM138/32 to as high as 4.4 (very severe) for Ede-Ofe – Green NCe/002 with mean of 3.9 severity score. This severity rating affected the Taro plants established in April severely. Hollaway et al (2007) reported that Taro Leaf Blight Caused *by Phytophthora colocasiae* is favoured by very wet conditions which facilitates entry of the fungi into the plant. The disease tends to occur when plant biomass is high and leaf microclimates are humid. The spores are airborne and germinate during periods of leaf wetness or high humidity. Rain splash is generally required to release and spread the spores formed during the initial infection and humid conditions or leaf wetness are required for their germination. Also that increased CO_2 levels are expected to increase canopy growth and density, which will increase canopy humidity and length of leaf wetness. The cultivar that gave the highest number of fruit-heads (21) was SM126/29 in April and flowered in July (4 mean of flowers) but failed to produce botanical seeds.

Number of plants that flowered and Seed production in July field establishment:
There were mean total of 13 Taro plants that produced flowers after hormonal induction in the crossing block established in July with mean of 0.8 per plant. This very low average indicated that many Taro plants did not produce any flower. However, the flowers did not developed into fruit heads and seeds were not collected (nil). This resulted into total nil for number of fruit heads, which showed that there were no flower production by all the parents in the hybridization block. However the TLB disease severity score indicated that TLB disease severity in July planting ranged from 1.1 (no disease present) for most of the cultivars to severity score of 3.3 for some cultivars (Table 1). This observation concur with Challinory et al (2006) findings that hotter, drier conditions are likely to reduce the impact of TLB disease

Weight of Corms+cormels
The result of the weight of Corms+cormels of the Taro plants established in April and July 2023 are presented in Table 2. The yield of the cultivars established early in April differed significantly (p<0.01) and ranged from **7.7 (**SM132//25) to as high as 14.5t/ha (Ukpong NCe/005) with mean of 10.3t/ha per plant. Cultivars that yielded more than the grand mean could be selected as good candidate for further evaluation. The July cultivar evaluation also differed significantly (p<0.01) and ranged from 0.4 t/ha for SM138/28 to 7.2t/ha for Cocoindia NCe/001 with mean of 6.7t/ha per plant however, the yield of April (73%) was higher than the yield of Taro in July (27%) by 46%. According to Onwueme and Sinha (1999), tuber bulking in Taro takes place three months after planting and invariably which coincide with the time of flower production and high moisture requirement. If hybridization block for Taro was established at the time when moisture

content of the soil is low/reducing, it will drastically affect the yield of corm+cormel and flowering may not be effective no matter whether the clones were inducted or not except if complemented with irrigation.

CONCLUSION AND RECOMMENDATIONS

High humidity adversely affected flower production during period of high field humidity in April, when the Taro Leaf Blight disease is prevalent, it destroyed the flowers, fruit-heads and berries leading to no botanical (true) seed production. This affected breeding plans and objectives. The cultivar that gave the highest number of fruit-heads (21) was SM126/29 in April and flowered in July (4 mean of flowers) but failed to produce botanical seeds. Cultivars with mean number of corms +cormels higher than the general mean could be selected as parents for the crossing block. Again establishment of hybridization block at the period leading to sharp and sudden reduction in rainfall distribution led to low bulking rate of the Taro tubers. Planting for flower induction and seed set during drier periods of the year could be supplemented with controlled irrigation as the crop requires high soil moisture for flowering and seed set plus corm+cormel bulking for high tuber yield..

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Table 1: Mean total number of plants that flowered, Mean total of number of fruit heads (berries), Mean total number of seeds of Taro plants and reactions of the Taro plants to biotic stresses in April and July 2023.

Clone Name	April, 2023			July, 2024			Apr-23	Jul-23
	Mean no. of plants flowered per cultivar	Mean total no. of fruit heads collected per cultivar	Mean total no. of seeds collected per cultivar	Mean no. of plants flowered	Mean total no. of fruit heads collected per cultivar	Mean total no. of seeds collected by cultivar	Mean score Taro leaf blight (1 -5)	Mean score Taro leaf blight (1 -5)
Cocoindia NCe/001	7	6	nil	nil	nil	nil	4.2	3.2
Ede-Ofe – Green NCe/002	5	7	nil	nil	nil	nil	4.4	1.3
Ede-Ofe Purple NCe/003	6	10	nil	nil	nil	nil	4.3	2.3
Akiri NCe/004	8	5	nil	nil	nil	nil	4.1	2.4
Ukpong NCe/005	2	1	nil	nil	nil	nil	4.3	3.2
SM158/24	9	8	nil	nil	nil	nil	4.1	1.1
SM132//25	9	9	nil	1	nil	nil	4.1	2.1
SM132/26	7	18	nil	1	nil	nil	3.3	3.3
SM132/27	5	17	nil	nil	nil	nil	3.3	2.3
SM13828	7	15	nil	3	nil	nil	4.2	2.2
SM136/36	9	12	nil	nil	nil	nil	3.5	1.1
SM126/29	9	20	nil	4	nil	nil	4.1	2.1
SM138/002	8	16	nil	nil	nil	nil	3.3	2.1
SM138/31	7	12	nil	nil	nil	nil	4..1	1.2
SM138/32	9	13	nil	1	nil	nil	3.2	2.1
SM136/33	8	11	nil	3	nil	nil	3.4	1.4
Total	115	201	nil	**13**	**nil**	**nil**	**1.4**	**1.4**
Range	9-Jul	20-Jan	nil	**4-Jan**	**nil**	**nil**	**3.2-4.4**	**1.1-3.3**
Mean	7.2	12.6	nil	**0.8**	**nil**	**nil**	**3.9**	**2.1**

***Note**: Taro leaf blight disease severity scoring; where 1= no disease symptom, 2= symptom present, 3 = symptom moderate, 4 = symptom severe, 5 = symptom very severe, crop almost dead.*

Table 2: Number of Corm+cormels, weight of Corms+cormels

S/No.	Clone Name	Mean fresh weight of Corms+cormels (t/ha) established in April, 2023	Mean fresh weight of Corms+cormels (t/ha) established in July 2023
1	Cocoindia NCe/001	9.2	7.2
2	Ede-Ofe –Green NCe/002	8.4	6.4
3	Ede-Ofe Purple NCe/003	10.4	4.3
4	Akiri NCe/004	11.7	2.7
5	Ukpong NCe/005	14.5	5.5
6	SM158/24	7.9	4.7
7	SM132//25	7.7	5.4
8	SM132/26	9.1	3.1
9	SM132/27	12.4	4.2
10	SM138/28	9.9	0.4
11	SM136/36	8.7	2.6
12	SM126/29	10.3	3.1
13	SM138/002	8.7	4.2
14	SM138/31	13.7	3.7
15	SM138/32	9.2	1.2
16	SM136/33	13.3	4.3
	Mean	**10.3**	**3.9**
	Range	**7.7-14.5**	**0.4 -7.2**
	SED	**12.4****	**7.6**73=27=46**

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Effect of Different Levels of Fertilizer Application on the Yield of UMUSPO3 and TIS 87/0087 (*Ipomea batatas*) in Umudike Abia State, Nigeria

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Abstract
Sweetpotato is an important staple food for human consumption. This study evaluated sweetpotato yield in response to fertilizers. It was conducted at the National Root Crops Research Institute Umudike Western field in 2023 cropping season. A randomized complete block experimental design was used in a 2 × 5 factorial arrangement laid out in three replications. The treatment comprise of five levels of fertilizer rates; NPK 12: 12: 17 (0, 200, 400, 600 kg/ha) and poultry manure at the rate of 5t/ha. Marketable and un-marketable root yields were evaluated. NPK at the rate of 600kg/ha efficiently increased the yield of marketable and un-marketable roots, respectively. The marketable and un-marketable root weight of TIS 87/0087 (26.76 t/ ha) was higher than the basal recommendation at 400kg/ha (18.44 t/ha). The applications of poultry manure alone at 5t/ha produced a significantly greater yield on both varieties. Organic and inorganic fertilizer application did not significantly (P>0.05) influence storage root yields on VI (Mother's delight) likely due to the fairly fertile soils used, SPVD challenge and the inconsistent rainfall at pre-harvest stage. This research finding concludes that both varieties used in this study responded to the treatments applied to them especially at the highest and basal concentration of applications. The results illustrate the importance of the choice of variety and fertilization in improving sweetpotato productivity.
Keywords: sweetpotato, fertilizer, root yield

INTRODUCTION

In the world, sweetpotatoes rank sixth in importance among food crops, behind rice, wheat, potatoes, maize, and cassava, particularly when it comes to the quantity of carbohydrates they contain. However, in developing nations, they rank fifth (Hoppenstedt et al., 2017, FAO 2021). Over 105 million metric tons are produced annually worldwide, with 95% of that amount grown in developing nations. China has the largest sweetpotato cultivation area in the world, with 2.4 million hectares cultivated annually and 51.8 million tons produced there (FAO, 2021). Nigeria grows sweetpotatoes on 114,741 hectares annually, producing 4.5 million metric tons (FAOSTAT, 2021). Sweetpotatoes are the fifth most widely grown crop in Nigeria, according to the International Potato Center (CIP) (2020) and FAO (2021). They are grown throughout the nation, particularly in areas with favorable soil and climate conditions like the North Central (Plateau, Nasarawa, Benue, Kogi, and Niger), North

East (Adamawa, Taraba, and Gombe), South East (Imo, Abia, Anambra, Enugu, and Ebonyi), and South-South (Rivers, Delta, Bayelsa, and AkwaIbom) (FAO,2021).

These days, because of the new tendencies in human nutrition in emerging nations, it is regarded as an innovative crop, primarily in the dietary domain. As a short-term crop that can be grown year-round, sweetpotatoes are hardy, productive, and tolerant of harsh environmental conditions. As such, they can help ensure that food is available throughout the year compared to other crops; sweetpotatoes generate carbohydrates substantially more quickly and with less labor and resource usage (Adepoju et al., 2022). In Nigeria, sweetpotatoes are eaten in a variety of ways, including roasted, fried, made into chips, powdered flour, and juiced—the orange-fleshed variety being one of the most promising sources of beta-carotene due to its high vitamin A concentration (Neela & Fanta, 2019). Many industrial applications exist for sweetpotatoes (Lin et al., 2007). It is a typical source of industrial raw materials, including vinegar, lactic acid, starch, acetone, edible and fermentable syrups, industrial alcohol, dye, and yeast (Adepoju et al., 2022). In Nigeria, the output of sweetpotatoes remains low when compared to the crop's potential for productivity, which can exceed 29 tons per hectare. Despite all of these advantages, Nigeria's prospective production of 20 to 25 tons/ha for sweetpotatoes, particularly orange flesh, is still far lower than the current yield of 6.20 tons/ha (CIP, 2020).

Higher crop yields can be attained, nevertheless, if the right management strategies are used (Fernandes et al., 2021). Therefore, increasing the yield of sweetpotatoes in Nigeria without compromising the quality of their storage roots or perhaps improving them through the use of green manure and NPK fertilization remains a pressing need and a significant research problem in the field of sweetpotato science. Sweet potato storage roots are a fantastic source of nutrients (Corr^ea, et al., 2017), with low levels of fat and sodium and high levels of protein, dietary fiber, carbs, and minerals (Fernandes et al. 2021). However, agronomic management techniques have a significant impact on the nutritional makeup of sweetpotatoes. In order to boost agricultural productivity in West Africa (Bourke, 1985; Alves et al., 2009; Ukom, et al., 2009; Leonardo et al., 2014) , proper fertilization either organic or inorganic influences the development of sweetpotato storage roots and may also raise their protein, calcium, and magnesium contents (Phillips, et al., 2005; Ukom et al., 2009; Santos Neto, et al., 2017).

Soil amendments, like fertilizer, can boost crop output and improve sweetpotato yields. Nitrogen and potassium significantly influence root tuber productivity and nutritional makeup (Darko et al., 2021). In impoverished tropical soils, sweetpotatoes benefit from fertilizers high in potassium and nitrogen. Sweetpotatoes, particularly OFSPs, are perishable due to high moisture content. Pre-harvest techniques like chemical management are popular, but incorporating new techniques and considering pre-harvest elements like fertilization could help minimize deterioration and extend storage life. The purpose of this research is to evaluate how fertilizer rates affect two enhanced sweet potato types.

MATERIALS AND METHODS

The study was conducted at the research farm of National Root Crops Research Institute (NRCRI) Umudike, Nigeria. The soil samples of 1kg were collected at the 5cm radius to a soil profile (depth) of 0-30cm in the location with the aid of soil core in plastics bags to the NRCRI laboratory and air dried for studies. The soil samples were collected following the guidelines of Schoeneberger *et al.* (2012). The experimental design of the field was 2x5 factorial arrangements on a plot size of 12M^2 laid out in a randomized complete block design (RCBD) with 3 replications. One thousand two hundred sweet potato vines of Mother's delight and TIS 87/0087collected from NRCRI were planted. The treatment comprises of 5levels of fertilizer rates; NPK 12:12:17 (0, 200, 400, 600kg/ha) and poultry manure at the rate of 5t/ha. The weights of marketable and un-marketable tubers were collected at harvest. Data collected were subjected to analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Table 1 shows the result of pre-planting analysis of selected soil properties. The texture of the soil of the studied area is moderately drained acidic loamy sand and this may be attributed to the parent material (coastal plain bands). The pH of the soil reaction was strongly acidic. Organic carbon, total N and exchangeable K values were generally low. Similarly the effective cation exchange capacity was equally low.

Table 1: Physico-chemical properties of the experimental farm before planting

Soil Physical Properties	Value
Sand %	72.4
Silt %	12.3
Clay	15.3
Textural class	Sandy loam
Chemical Properties	
Ph(1:2.5 H2O)	5.4
Available P (Mg/Kg)	18.5
Organic Carbon %	1.4
Organic matter %	2.41
Total N %	0.1
Exchangeable cation	cmol/kg
Ca	4.2
Mg	2.2
K	0.2
Na	0.15
Exch. Acidity	1.84
Effective cation exchange capacity (ECEC)	8.59
Base Saturation (BS) (%)	79

Table 2 reveals the number and weight of tuber at harvest. The result shows that treatment V1M had the highest mean number of marketable and un-marketable tubers but these didn't translate to a high weight. While treatment V2F6 had the highest mean weight of 26.76t/ha as against 5.60 of V1F6.

Table 2: Mean number and weight of sweetpotato roots at harvest

Treatment	MRTN	UMRTN	TTRTW (t/ha)
V1F0	9^{b}	15.67^{bc}	4.51^{b}
V2F0	7.67^{b}	4.33^{c}	7.05^{b}
V1F2	21^{ab}	18^{abc}	5.00^{b}
V2F2	15.33^{ab}	7.67^{bc}	15.14^{ab}
V1F4	35.67^{ab}	28^{ab}	8.38^{b}
V2F4	24.33^{ab}	4.67^{c}	18.44^{ab}
V1F6	26.67^{ab}	24.67^{abc}	5.60^{b}
V2F6	12^{b}	6.67^{bc}	26.76^{a}
V1M	48^{a}	39^{a}	7.47^{b}
V2M	9.67^{b}	8.33^{bc}	11.17^{b}
MEAN	**20.93**	**15.70**	**10.95**
HSD	**19.96**	**12.17**	**8.86**

MRTN= Marketable Root Number, UMRTN= Unmarketable Root Number, TTRTW= Total Root Weight, V1= Mother's delight (UMUSPO3), V2= TIS 0087/87

Table (1) revealed that the texture of the studied area was loamy, sandy and this may be attributed to parent materials (coastal plain sand). This agrees with the finding of Anikwe (2000) who observed that coastal plain usually gives rise to coarse sandy soil. The PH of the soil was acidic and the organic carbon and organic matter were generally low. Similarly, carbon exchange capacity was low. This suggests that the soil is low in fertility. This could be attributed to increased pressure on land use for cropping.The performance of V2 (TIS 0087/87) in table2 was superior to VI (Mothers delight) across all treatments for sweet potato yield. This is due to the high performance of V2 as a variety being vigorous and high yielding and not being susceptible to SPVD. Treatments with poultry manure (VIM & V2 M) had between 7-11t/ha and similar results were observed by Ezechi et al. (2022). This nutrient is recommended for increasing the production of marketable roots per plant. This nutrient source can favor the formation and redistribution of carbohydrates because of its composition. Late planting, leaching of fertilizers and cylas incidence can hamper good production and impact the environment. However, when vines are planted and fertilizers are applied at the time of the greatest crop demand, leaching losses are avoided and pest and diseases attack are highly reduced.

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Bioefficacy of African curry leaves (*Ocimum gratissimum L.*) and Sodom Apple (*Callostropis procera Desr*) in the Management of Maize Weevils (*Sitophilus zeamais (Mostch)*

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Abstract
Laboratory study was conducted at the Federal College of Agricultural Produce Technology Kano (11^{0}58'00'N/8^{0}.34'00E) to evaluate the Bio-efficacy of African curry leaves (Ocimum grattisimum L) and Sodom Apple (Callostropis procera Desr) in the management of maize weevils (Sitophilus zeamais motsch). The treatments of 5g, 10g and 15g each of African curry leaves and Sodom apple leaves and a combination of both was introduced into kilner jar containing 50g each of maize with 5 pairs of S.zeamais motsch and arranged in Completely Randomized Block design and repeated 3 times. The result obtained from the study revealed that a combination of C. procera and O. gratissimum retard insect emergence and insect mortality at the demunitive period of storage during the trail period.Therefore, C. procera and O. gratissimum can be used alternatively to synthetic insecticides to control Sitophilus zeamais motsch during a diminutive phase of storage hence will helped to improve farmers livelihood, food security and economic well being at the rural areas with little pesticide residue.

INTRODUCTION

Maize (*Zea mays* L.) is the major cereal crops produced worldwide (Ranum, *et al*., 2014) which is the second most important crop after rice in Nigeria (MoAD, 2016). The total annual production is about 23-thousands metric tons with a yield of 2458 mt/ha (MoAD, 2014). It covers about 78% of the total cultivated areas in hilly areas and 26.9% of the total cereal crop cultivated (AICC, 2017). These crops are susceptible by a wide range of insect pests both in field and storage condition (Neupane *et al.,* 1991). Out of them, maize weevil (*Sitophilus zeamais* Motsc.) is the most important pest in a storehouse in Nigeria (Sherpa *et al*., 1997). This pest damages the harvested maize by making holes and feeds the inner starch which causes weight loss and reduced the quality (Trematerra, *et al*., 2013). The average loss by *S. zeamais* is estimated about 20-80% in tropical countries (Pingali and Pandey, 2001).

A considerable amount of grain weight losses including a loss in quality which will be observe in the storehouse. The appropriate and safe weevil management practices are lacking in storehouse in Nigeria. However, use of (*Calostropis procera and Ocimum gratissinum*) is the common practices all over Nigeria, Atawodi, *et al*.,(2009). The current pesticide management practices deteriorate the health and environment and caused many complex health problems (Talukder and Howse, 1994). Further, pesticide management is an expensive and non-easy method to smallholding farmers (Iloba and Ekrakene, 2006). These plant materials have the potentiality to repel the storage pest from the storehouse (Neupane, 2009). Some plants and their parts such sweet flag stolen, *Azadirachta indica* oil, *Azadirachta indica* seed powder, *Zanthoxylum alatum* seed powder, *Artemisia vulgaris* leaf etc have been used to manage the diverse categories of storage (Sharma *et al.,* 2016; Paneru *et al*., 1997). The use of plant products that possess bio pesticidal activity has been particularly active, especially in the last 30 years (Lale, 2012, Ajayi *et al*., 2017), thus stated that farmers in many parts of Nigeria use locally available materials of plants origin to treat their grains or seeds before storage and claimed that these materials successfully controlled infestation against storage insect pests. Plants are like natural laboratory where great number of chemicals are biosynthesized and may be considered as the most important sources of chemical compounds. Different parts of plants are used in protecting crops from the menace of pests and diseases. Prakash *et al*., (2008) stated that, direct spray application of various extracts of biologically active plant products can be used such as leaves, stems, roots and whole plants especially for the control of soft bodied insect pests which feed on the leaves and tender plant parts. Lale (2012) found that, of the several plant species screened, *Azadirachta indica, A Juss*, *P. guineenses* and *Dennettia tripetla* Bak are among the most effective, with broad spectrum of activity in pest control. This study aim to evaluate the potentials of botanical materials on bio–efficacy of African curry leave (*Ocimum gratissimum* L) and Sodom apple (*Calostropis procera Ders*) in the management of maize weevil (*Sitophilus zeamais motsch*).

MATERIALS AND METHODS

The research was conducted at Federal College of Agricultural Produce Technology, in the Department of Pest Management Technology Laboratory located in the Northern Guinea Savannah of Nigeria.Tarauni Local Government Area has an average temperature of 32 degrees Celsius and a total area of 28 square kilometers. The rainy and dry seasons are the two different seasons experienced by the Local Government Area, which has a typical tropical climate. Tarauni Local Government Area has an average relative humidity of 29% and it has a population of 221,367 with a latitude and longitude of 11.9586 ^{0}N and longitude of 8.5443^{0}E as at the 2006 census. The materials used were leaves of African curry leaves and sodom Apple, Mortar and pestle, maize grains, rubber bands, kilner jar and adults of *S.zeamais* Moscht. The *sitophilus zemais* M.was collected from the inoculated maize seeds at the Federal College of Agricultural Produce Technology Kano, Pest Management Technology Laboratory. Adult of *sitophilus zeamais* M. was inoculated under ambient condition. They were cultured in a kilner jar containers which was covered with a muslin cloth and the surface of the glasses was held with rubber bands to avoid suffocating the insect. The culture was kept under normal room temperature. 10 males and females adult of *S.zeamais* was introduce into each treatment. The leaves of these botanical plants (*Ocimum grattisimum L*. and *Calostropis procera Desr*) was collected from the college botanical garden, the leaves were washed properly with ethanol and dried under room temperature between 18- 21 days. Then each was grounded into powder form with mortar and pestles to get a smooth and fine form of the leaves powder. The treatment was arranged in completely randomized block design repeated 5 times. 5g, 10g and 15g each of African curry leaves and Sodom apple leaves and a combination of both was introduced into kilner jar containing 50g each of maize with *S.zeamais* Motsch. Data were collected on Mortality rate, Oviposition, % Weight loss and Number of holes.

Determination of insect mortality
Mortality rate was determined after few days of introducing the grounded powders of Africans curry leaves and Sodom apples into the kliner jar, the adult *S.zeamais* were dead and touched with forceps and found immobile; and was recorded.

Determination of numbers of holes
The rate of number of holes was determined by taking out a known 25% of infested treatment made by maize weevils, observed, extrapolated and recorded.

Determination of % weight loss
Weight loss was determined before and after the experiment, this was conducted, which is the initial and final weight and it was taken using sensitive weighing scale on each treatment and computed as:

$$\frac{W_1 - W_2}{W_n} \quad X\ 100$$

Determination of oviposition
The number of eggs laid was counted using hand lens and extrapolated to 100%

Determination of adult emergence
The number of emerged adults were counted using hand lens and then recorded.
Data collected was subjected to the analysis of variance (ANOVA) where the F value found significant among the treatment means was tested as described by the Snedecor and Cochran (1967) using WASP version 10.0 software and the means was separated using LSD. Also correlation matrix among the parameters were determine as described by Steel and Torrie (1984).

RESULTS AND DISCUSSION
Result from table 1 shows that at 10DAT (10 Days after Treatment) application of the treatment shows significant differences among the different treatment and the control. Where application of *C. procera* shows little mean weight loss compared to other treatment. However, other application were statistically at par with the control. However, at 20DAT, lesser mean weight loss was observed at the application of *O. gratissimum* better than all other treatments though statistically the same with the other application of the treatments. At 30DAT, lowest mean weight loss among the treatment was obtained using *C. procera* and is statistically the same with the mixture. However, significant weight loss was observed in the control. During the trail at 40DAT, lowest mean weight was observed and recorded among the treatment observed was obtained using *C. procera* than all other treatments and is statistically the same with the mixture, however; highest significant weight loss was observed in the control.

Mean effect treatment of *C. procera, O. gratissimum* and the mixture was observed on insect mortality in table 2. Results shows that, at 10DAT (10 Days after treatment), there was no significant differences between the treatments and control. However, at 20DAT, highest number of insect mortality of *S. zeamais* was observed using mixture of *C. procera* and *O. gratissimum.* At 40DAT, mixture of *C. procera* and *O. gratisimum* gives significant number of insect mortality compared to all other treatments. Result from table 3 at 20DAT (20 Days after treatment) shows mean lowest number of holes by *S.zeamais* was observed as noticeable at the mixture of *C. procera* and *O. gratisimum*. At 40DAT, least number of holes by *S. zeamais* was recorded in the mixture of the plant materials with highest number of holes by *S.zeamais* in the control.With the advent of new discoveries of the toxic effects of most chemical pesticides on our crops, which could serve as carcinogens sources, not cost effective and raising environmental concerns; with adverse effect on human populace who consume food crops, hence the need to venture into this research to come up with a natural plants such as *C. procera* and *O. gratissimum* which are known to possess pesticide properties without adverse effect on human and effectively curbing the destructive effects of insect pest on our crops. From the research conducted, it was observed that at 40DAT (40 Days after treatment) the highest effect of the combined leaves gave the highest mortality on *S. zeamais* with the least number of destruction on *S.zeamais*. As such these research if funded using the ethanolic extract of *C. procera Ders* and *O. gratissimum* L. into by the Federal Ministry of Agriculture and Food Security could bring to an end the age long grains wastage as experienced by farmers harvest that are frequently destroyed by *S zeamais* when combine with sensitization on (GAP) good agricultural practices.

Table 1: Mean effect treatment on weight loss of *Calostropis procera* Ders and *Occimum gratissimum* L. on adults *S. zeamais* Mots

Treatments	10DAT	20DAT	30DAT	40DAT
T1	4.500b	4.250b	6.000c	8.000c
T2	9.750a	5.250b	12.500a	13.750a
T3	7.750ab	11.500a	7.500bc	9.000bc
T4	6.500b	7.500ab	9.750ab	11.250ab
CD(0.05)	3.123	4.256	2.901	2.863

Means followed by the same letter(s) in the vertical column are not statistically different at 5% level of probability.

Table 2: Mean effect treatment on mortality rate of *Calostropis procera* and *Occimum gratissimum* on adults *S. zeamais* Mots

Treatments	10DAT	20DAT	30DAT	40DAT
T1	6.233bc	4.123b	9.333bc	10.333bc
T2	6.567b	8.433a	10.200b	10.767b
T3	7.000a	8.133a	11.900a	11.800a
T4	6.333bc	8.667a	9.467bc	11.233a
CD(0.05)	0.747	1.191	1.930	0.888

Means followed by the same letter(s) in the vertical column are not statistically different at 5% level of probability.

Table 3: Mean effect treatment of *Calostropis procera* and *Occimum gratissimum* on adults S. zea meas Mots on number of holes

Treatments	10DAT	20DAT	30DAT	40DAT
T1	3.075	4.325c	5.575	7.425c
T2	3.325	4.725bc	6.450	8.075b
T3	2.800	4.750bc	6.075	8.300ab
T4	3.450	5.225a	6.175	8.725a
CD(0.05)	NS	6.556	NS	0.63

Means followed by the same letter(s) in the vertical column are not statistically different at 5% level of probability.

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Weed Phytosociological Attributes of Sugar Beet at Badeggi, Nigeria

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Abstract
A weed population trial was undertaken to determine the prevalence and distribution of weeds, and asses weed flora shift in major sugar beet growing soils at Badeggi Nigeria. The selected soils are namely Loamy, Alluvial and Clay soil. The sugar beet fields were assessed using a 1.0 m x 1.0 m quadrat placed randomly at the vegetative stage. Weed seedlings in each quadrat were clipped at the soil level and identified according to standards. Results revealed that a total of 38 weed species were recorded. Graminaea and Compositae were the most abundant and diversified families based on the number of species recorded. Individual weed species show variation in their abundance, dominance and frequency. The most frequent weed species in the Sugar beet fields irrespective of the soils were Hyptis suaveolens, Paspalum scrobiculata, Kyllinga squamulata, Dactylactenum aegypium and Cynadon dactylon and were considered as the most important species in the surveyed areas. Thus, when devising weed control strategies options should be considered for the location of similar weed flora and vice versa.
Keywords: Weed flora, Sugarcane, Survey, Weed Prevalence, Distribution

INTRODUCTION
The weed flora of sugar beet plants varies by location due to environmental conditions, irrigation, fertilizer use, soil type, weed control practices, and cropping sequences. Weed growth, population density, and distribution are influenced by soil and climatic factors, and farmers' management practices (FAOSTAT, 2019). The density of weed species can change based on seed purity, crop rotation, harvest time, fertilization, and weed control methods (Bassey *et al*., 2021). Effective weed control requires identifying, characterizing, and quantifying weed species in specific areas. Information on weed density, distribution, and species composition helps predict yield losses and determine the economic feasibility of controlling specific weeds. Therefore, continuous trials on weed flora are necessary. This experiment aimed to categorize weed prevalence and distribution in sugar beet growing areas in the southern Guinea savanna of Nigeria.

MATERIALS AND METHODS
Trial on weed flora was conducted in three major soils for sugar beet growing areas of the Southern Guinea savanna namely, Loamy soil, Alluvial and Clay soil, at the NCRI Sugarcane field, Badeggi (Lat. 90 45‟ N, long. 60 07‟ E and 89 m above sea level), in

2023/24 during the wet and dry season. Weed density was determined at 2, 4 and 6 WAP. Weed samples were collected from a 1 m^2 quadrat on each plot. The weed plants in each quadrat were pulled out and counted. The weeds were identified using the Handbook of West African Weeds (Akobundu *et al*., 2016). The data on weed species composition were analyzed by abundance (A), dominance (D), frequency (F), and similarity index (SI) determinations using the principles presented by Das (2011). The composition of the weed flora was analyzed by calculating the following:

Relative Abundance: This is the number of individuals of different species in a community per unit area in the quadrats where they occurred. It is used in determining the dominance of a species and can be expressed as follows:

$$\mathrm{R.A} = \frac{Total\ number\ of\ individual\ of\ a\ species\ in\ all\ the\ quadrats}{Total\ number\ of\ quadrats\ in\ which\ the\ species\ occurred}$$

$$= \sum \frac{WI}{n}$$

Where ∑ Wi is the sum of individuals of a species occurring in all the quadrats, and "n" is the number of quadrats in which the species occurred (Das, 2011).

Relative Dominance*:* Relative dominance is the proportion of the basal area of a species to the sum of the basal coverage of all the species in an area. It is expressed as the percentage value obtained by dividing the abundance of a species by the total sum of the abundance of all species:

$$\text{Relative dominance (R.Do.)} = \frac{Abundance \text{ of a species}}{\text{Sum}-\text{total of } abundance \text{ of all species}} \text{x } 100$$

$$= \frac{A}{\sum Ai} \text{ x } 100$$

Where 'A' is the abundance of a species and '(∑Ai)' is the sum of the abundance of all species (Das, 2011).

Relative Frequency: Relative frequency can be determined from absolute frequency or by the following formula using several species-wise occurrences of species out of a total number of quadrats studied. It is useful in computing the ecological importance i.e., the importance value index (IVI) of individual weed species in the plant community (Das, 2011).

$$\text{Relative frequency (RF)} = \frac{Number\ of\ occurrence\ of\ a\ species}{Sum\ of\ occurrence\ of\ all\ species} \text{ x } 100$$

RESULTS AND DISCUSSION

The trial recorded 22 weed species in alluvial soil, including 11 broadleaved weeds, 8 grassy weeds, and 3 sedges. Frequency, abundance, and dominance levels ranged from 0.49% to 14.71%, 2.00% to 38.33%, and 0.98% to 18.69%, respectively. The most frequent species were *Hyptis suaveolens*, *Cynodon dactylon*, *Dactylactenum aegyptium*, *Commelina benghalensis*, *Cyperus esculentus*, *Sebastiania chamaelea*, and *Corchorus olitorius*. The least frequent were *Gomphrena celosiodes*, *Tridax procumbens*, *Sesamum alatum*, *Calopogonium mucunoides*, and *Leucas martinicensis*. The most abundant species included *Boerhavia diffusa*, *Cynodon dactylon*, *Hyptis* *suaveolens*, *Digitaria nuda*, and *Brachiaria deflexa*. The least abundant were *Tridax procumbens*, *Physalis angulata*, *Leucas martinicensis*, *Rottboellia cochinchinensis*, *Sebastiania chamaelea*, *Sesamum alatum*, and *Calopogonium mucunoides*. Dominant species with levels greater than 51% were *Boerhavia diffusa*, *Cynodon dactylon*, *Hyptis suaveolens*, *Digitaria nuda*, and *Brachiaria deflexa*. In loamy soil, 34 weed species were recorded: 14 broadleaved, 17 grassy, and 3 sedges. Frequency, abundance, and dominance levels ranged from 0.38% to 17.56%, 2.50% to 38.0%, and 0.46% to 7.19%, respectively. Frequent species included *Paspalum scrobiculatum*, *Kyllinga squamulata*, *Eleusine indica*, *Imperata cylindrica*, *Brachiaria jubata*, and *Digitaria horizontalis*. Least frequent were *Desmodium tortuosum*, *Ipomoea asarifolia*, *Chloris pilosa*, *Ludwigia hyssopifolia*, *Cyperus rotundus*, *Corchorus olitorius*, *Trianthema portulacastrum*, *Eragrostis tremula*, and *Andropogon gayanus*. Dominant species with levels greater than 45% were *Setaria pumila*, *Kyllinga squamulata*, *Andropogon gayanus*, *Setaria barbata*, *Brachiaria deflexa*, *Setaria longiseta*, and *Desmodium tortuosum*. In clay soil, 31 weed species were recorded: 20 broadleaved, 8 grassy, and 3 sedges. Frequency, abundance, and dominance levels ranged from 0.46% to 16.20%, 2.0% to 26.75%, and 0.85% to 11.37%, respectively. Frequent species included *Hyptis suaveolens*, *Dactylactenum aegyptium*, *Commelina benghalensis*, *Cleome hirta*, *Ipomoea asarifolia*, and *Digitaria nuda*. Least frequent were *Axonopus compressus*, *Passiflora foetida*, *Sesamum alatum*, *Corchorus olitorius*, and *Eleusine indica*. Dominant species with levels greater than 45% were *Setaria barbata*, *Hyptis suaveolens*, *Setaria longiseta*, and *Phyllanthus niruri*. The high frequency of these species indicates their importance as troublesome weeds due to rapid growth, abundant shading, and high phenotypic plasticity, contributing to their ecological success and dominance in sugarcane fields (Ramirez et al., 2017; Welday et al., 2018). Variations in weed species' abundance, dominance, and frequency are attributed to differences in farmers' practices, soil types, and climatic conditions.

CONCLUSION AND RECOMMENDATIONS

Generally, from this weed population trial, it can be concluded that the assessed Sugar beet growing on different soils in the Southern Guinea savannah was highly diversified in weed species and contained different individual species with varied levels of abundance, dominance and frequency. The most dominant families according to the frequency and number of weed species were Graminaea and Compositae, considered the most important species in the experimental areas. Weed composition varied between the different soils in the experimental areas. Further identification of weed species composition, characteristics and flora change in these Sugar beet-producing areas is necessary, to adopt effective weed management options that would encourage farmers to produce Sugar beet in these areas.

Table 1: Weed composition, frequency, abundance and dominance on alluvial soil

Weed species	LC	MG	Freq	Abun	Dom
Corchorus olitorius (L.)	A	B	6.86	6.14	2.99
Hyptis suaveolens (Poit)	A	B	14.71	16.63	8.11
Digitaria nuda (Schumach)	A	G	5.88	16.50	8.04
Imperata cylindrical (Linn.)	P	G	1.47	10.67	5.20
Gomphrena celosiodes (Mart.)	A	B	0.49	6.00	2.93
Tridax procumbens (Linn.)	A	B	0.49	2.00	0.98
Cyperus esculentus (Linn.)	P	S	8.33	10.59	5.16
Brachiaria deflexa(Schumach)C.E	A	G	3.43	14.29	6.97
Commelina benghalensis(L.)	P	S	8.33	7.76	3.79
Dactylactenum aegyptium (Linn.)	P	G	10.29	9.81	4.78
Paspalum scrobiculatum Linn.	A	G	3.43	6.86	3.34
Rottboellia cochinchinensis(Lour.)	P	G	1.47	2.67	1.30
Phyllanthus niruri(Schum.&Thonn)	A	G	5.39	11.09	5.41
Cynadon dactylon(Linn.)	A	S	11.27	19.57	9.54
Sebastiania chamaelea	A	G	7.35	4.00	1.95
Boerhavia diffusa	P	B	2.94	38.33	18.69
Physalis angulate	A	B	1.47	2.00	0.98
Schwenckia Americana	A	B	2.45	5.20	2.54
Tephrosia linearis	P	B	1.96	5.00	2.44
Leucas martinicensis	A	B	0.98	2.00	0.98
Sesamum alatum	A	B	0.49	4.00	1.95
Calopogonium mucunoides	A	B	0.49	4.00	1.95

Table 2: Weed composition, frequency, abundance and dominance on Loamy soil

Weed species	LC	MG	Freq	Abun	Dom
Andropogon gayanus	P	G	0.76	29.00	5.37
Kyllinga squamulata(Thorn.ex Vahl	A	S	13.36	36.00	6.67
Cynadon dactylon(Linn.)	P	G	1.15	9.33	1.73
Setaria verticillata	A	G	1.15	8.67	1.61
Cleome viscose (L.	A	B	1.53	7.00	1.30
Setaria pumila (Poir)	A	G	1.91	38.80	7.19
Eragrostis tremula (Hochst.ex.Steud	A	G	0.76	22.00	4.08
Sacciolepis Africana (Hubb & Snowd	P	G	2.29	18.33	3.40
Panicum laxum Sw.	A	G	1.15	25.67	4.76
Seteria barbata (Lasr.)Kunth	A	G	3.05	28.00	5.19
Euphorbia hirta (Linn.)	A	B	1.15	4.67	0.86
Digitaria horizontalis(Willd.)	A	G	5.73	22.53	4.18
Tridax procumbens (Linn.)	A	B	1.15	4.67	0.86
Eleusine indica(L) Gaertn.	A	G	9.16	25.13	4.66
Brachiaria jubata (Fig&De Not.)	A	G	5.34	22.86	4.24
Cyperus esculentus (Linn.)	P	S	3.82	16.40	3.04
Brachiaria deflexa(Schumach) C.E	A	G	6.49	30.35	5.62
Imperata cylindrical (Linn.)	P	G	1.91	15.60	2.89
Trianthema portulacastrum(Linn.)	A	B	0.76	11.00	2.04
Tephrosia bracteolate (Guill &Perr.)	A	B	1.53	2.50	0.46
Dactylactenum aegyptium (Linn.)	A	G	4.58	25.75	4.77
Setaria longiseta (P.Beauv.)	A	G	1.15	27.33	5.07
Chloris pilosa	A	G	0.38	13.00	2.41
Corchorus olitorius(L.)	A	B	0.76	3.00	0.56
Ipomoea asarifolia(Desr.)Roem	P	B	0.38	4.00	0.74
Digitaria milangina	A	G	3.05	16.50	3.06
Cleome hirta	A	B	1.15	5.00	0.93
Commelina diffusa(Burm.)	P	B	1.91	8.80	1.63
Cyperus rotundus(Linn.)	P	S	0.76	5.00	0.93
Hyptis suaveolens(Poit)	A	B	1.15	3.33	0.62
Paspalum scrobiculatum Linn.	P	G	17.56	29.02	5.38
Desmodium tortuosum(Sw.)DC.	A	B	0.38	6.00	1.11
Ludwigia hyssopifolia	A	B	0.76	4.00	0.74
Commelina benghalensis	P	B	1.91	10.40	1.93

LC- Life cycle, MG- Morphology

Table 3: Weed composition, frequency, abundance and dominance on Clay soil

Weed species	LC	MG	Freq	Abun	Dom
Digitaria nuda (Schumach)	A	G	5.56	6.17	2.62
Dactylactenum aegyptium (Linn.)	A	G	10.19	8.18	3.48
Merremia aegyptia (Linn.)	A	B	1.85	2.00	0.85
Seteria barbata (Lasr.) Kunth	A	G	7.87	11.41	9.10
Kyllinga squamulata (Thorn.	A	S	1.39	4.00	1.70
Sida corymbose (R.E. Fries)	A	B	3.70	2.50	1.06
Hyptis suaveolens (Poit)	A	B	16.20	11.89	9.30
Tridax procumbens (Linn.)	A	B	1.39	2.00	0.85
Eleusine indica(L) Gaertn.	A	G	4.17	5.56	2.36
Setaria longiseta	A	G	0.46	14.00	10.20
Phyllanthus niruri (Schum.&Thon	A	B	2.78	10.00	8.50
Commelina benghalensis (L.)	P	B	1.85	3.00	1.27
Cynadon dactylon (Linn.)	P	S	7.87	8.12	3.45
Euphorbia heterophylla (Linn.)	A	B	0.93	2.00	0.85
Corchorus olitorius (L.)	A	B	0.93	2.00	0.85
Rottboellia cochinchinensis (Lour.)	A	G	0.46	2.00	0.85
Ipomoea asarifolia(Desr.)Roem	P	B	1.39	3.33	1.42
Paspalum scrobiculatum Linn.	P	G	5.56	6.83	2.90
Cleome hirta	A	B	1.39	3.33	1.42
Hibiscus asper (Hoek.f.)	P	B	6.02	2.46	1.05
Cyperus esculentus (Linn.)	P	B	3.70	1.75	11.37
Cyperus rotundus (Linn.)	P	S	3.70	8.75	3.72
Oldenlandia herbacea (Linn.) Roxb.	P	B	1.39	2.67	1.13
Sesamum alatum (Thonning)	A	B	0.46	1.00	6.80
Boerhavia diffusa	A	B	3.70	1.75	4.99
Physalis angulate	A	B	1.39	8.67	3.68
Senna obtusifolia	A	B	0.93	2.00	0.85
Axonopus compresus	A	G	0.46	2.00	0.85
Passiflora foetida	P	B	0.46	2.00	0.85
Schwenckia Americana	P	B	0.93	2.00	0.85
Clome viscose	A	B	0.93	2.00	0.85

LC- Life cycle, MG- Morphology

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Profitability Analysis of Groundnut (*Arachis hypogeal*) Production in Michika Local Government Area of Adamawa State, Nigeria

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Abstract

The study on profitability analysis of groundnut production was carried out in Michika Local Government Area of Adamawa State, Nigeria. The specific objectives were to determine the cost and returns of groundnut production in the study area. Primary data were collected from 120 groundnut farmers using structured questionnaires during the 2023 cropping seasons. A multistage sampling technique was employed to select the 120 groundnut farmers from the Local Government from which input-output data were collected for the study. The tool of analysis used was net farm income. The net farm income was used to estimate the profitability of groundnut production in the study area. The result of the study revealed that the average total revenue generated from groundnut production and the average total cost of production were ₦542,003.10/ha and ₦299,030.80/ha respectively. The return per naira invested was ₦1.81k which implies that for every ₦1.00 invested in groundnut production in the study area, a profit of 81k was made. This indicates that groundnut farming in the study area is profitable.

Keywords: Profitability, Groundnut, Production, Adamawa state

INTRODUCTION

Groundnut (*Arachis hypogaea*) is a key oil seed, food crop, and in fact a cash crop in Nigeria. According to Godfrey *et al.* (2020), over the years, groundnut plants is an excellent cash crop for domestic markets as well as source of foreign exchange earnings for both developing and developed countries.

METHODOLOGY

Study Area

Michika Local Government Area (L.G.A.) of Adamawa State was the study area for this research. It has an area of 822.3km^2, with a population of 155,238 [National Population Commission (NPC), (2006)] and a projected population of 244,837 as at 2023 at 2.7% annual growth rate. It is situated at the far north east of the state which lies between latitude 10^{0} 32^{1} N and 10^{0} 14^{1} N and Longitude 13^{0} 19^{1} E and 13^{0} 25^{1} E.

Sampling Procedure and Sample Size

Multistage sampling technique was used to select groundnut farmers for the study. In the first stage, Michika Local Government Area of Adamawa State was purposively selected based on the prominence of groundnut production out of 21 Local Government Areas (L.G. As). In the second stage, two major and accessible groundnut producing villages are purposively chosen from each district. Thirdly, 35% of the given sample frame of groundnut farmers in each chosen village was randomly selected using random numbers from the list of the farmers. Thus, a total of 120 groundnut farmers were proportionally selected which served as the sample size for the study (Table 1).

Table 1: Sample frame and sample size of groundnut farmers in the study area

Districts	Villages	Sample frame	Sample size (35%)
Michika	Bokka	35	13
	Jang	40	14
Nkafa	Diaka	25	9
	Dzali	19	7
Madzi	Gra	17	6
	Kubi	9	3
Futu	Futuless	8	3
	Yagaghe	12	4
Garta	Pee	26	9
	Hule	27	10
Bazza	Bazza Margi	18	6
	Jigalambu	14	5
Zah	Sufuku	10	4
	Zah Megha	33	12
Vi/Bakka	Minkisi	10	4
	Jigalambu	12	4
Sina	Demsa	15	5
	Anguwar Layi	13	5
Total		**343**	**120**

Source: Field Survey, 2023

Data Collection

Primary data were obtained from the sampled groundnut farmers. The data were collected using a structured questionnaire and the data collected include information on inputs and output.

Analytical Techniques

Net farm income was used to determine the costs and returns associated with groundnut production in the study area. The Net farm Income (NFI) is stated as follows:

$$NFI=TR-TC \quad (1)$$

Where;

NFI = Net Farm Income (₦)
TR = Total revenue (₦)
TC = Total cost of production (₦)
TC = TVC+TFC
TVC = Total Variable Cost (₦)

TFC = Total Fixed Cost (₦)

The fixed inputs are not normally used up in a production cycle. They were depreciated using the straight-line method given by:

$$D = \frac{P-S}{N} \quad (2)$$

Where;

D = Depreciation (₦)
P = Purchase Value (₦)
S = Salvage Value (₦)
N = Life span of asset (years)

Return per naira invested (RPNI) is obtained by dividing the gross income (GI) over the total cost (TC).

Therefore,

$$RNI = \frac{GI}{TC} \quad (3)$$

Where;

RNI = Return per naira Invested
GI = Gross Income
TC = Total Cost

Decision Rule:

RNI >1, it indicates there is profit in production
RNI= 1, implies break-even in groundnut production
RNI< 1, indicates that the farmer operates at loss.

RESULTS AND DISCUSSION

Costs and returns of groundnut production

The result in Table 3 showed costs and returns of groundnut production in the study area. The total cost of variable input was estimated to be ₦285,730.10. The total fixed cost was estimated to be ₦13,300.7. The value of output/ha was estimated to be ₦542,003.10 while the net farm income per hectare was ₦242,972.3. This implies that groundnut production in the study area is profitable. The result of this study agrees with findings of Lawal and Muhammad (2018) and Madaki *et al*. (2016). The result also revealed that the cost of fertilizer accounted for 55.79% of the total cost of production. This means that cost of fertilizer can drastically decrease the profit of the production of groundnut in the study area. This is contrary to the work of Hajara *et al*. (2023) who reported that transportation accounted for highest percentage (44%) of the total production cost. The return per naira invested (RPNI) was estimated to be ₦1.81k, this indicates that for every ₦1.00 invested in producing groundnut from one hectare, 81k was made. Therefore, the costs and returns analysis revealed that groundnut production in Michika L.G.A. of Adamawa State is profitable.

Table 2: Average Costs and Returns per hectare of groundnut production

Variables	Values/ha (₦)	% Contribution
Variable cost		
Seed (kg)	49,047.2	16.40
Fertilizer (kg)	166,820.3	55.79
Agrochemical (litres)	32,000.6	10.70
Labour (man days)	18,780.7	6.28
Land preparation	8,280.7	2.77
Planting	1,600.4	0.54
Fertilizer application	2000.5	0.67
Weeding	2600.10	0.87
Harvesting	4600.2	1.54
Total variable cost	**285,730.1**	**95.56**
Fixed costs		
Cost of renting land	10,000.5	3.34
Depreciation of tools (hoe, cutlass and knapsack sprayer)	3,300.2	1.10
Total fixed cost	**13,300.7**	
Total cost	**299,030.80**	
Total revenue	**542,003.10**	
Net Farm Income (NFI)=TR-TC	**242,972.3**	
Returns per naira invested (RPNI) = TR/TC	**1.81**	

Source: Field survey, 2023

CONCLUSION AND RECOMMENDATIONS

Based on the result of this study, it can be concluded that production of groundnut in Michika L.G.A. is profitable by returning 1.81 to every ₦ 1.00 invested. Groundnut being an important staple food in the study area and Nigeria in general, any attempt to increase its productivity would be a right step in the right direction towards the resolution of food crisis and would also increase Nigeria Gross Domestic Product (GDP).

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PROCEEDINGS

Evaluation of Growth and Yield Parameters of Ten Improved Cowpea [*Vigna unguiculata* L. (Walp)] Varieties in a Rainforest Location

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Abstract
As a result of the gap in the level of production of cowpeas [Vigna unguiculata L. (Walp)] between the savannah and forest regions of Nigeria, this study evaluated relationships among cowpea traits from seedling to maturity, determined the traits that contribute most to optimum yield performance, and determined the effect of genotype on the adult plant traits of cowpea. Ten cowpea varieties planted in 2-replicates randomized complete block design were monitored for seedling emergence and vigour using emergence percent (E %), emergence index (EI) and emergence rate index (ERI) as indices. Data on flowering, number of leaves per plant, pods per peduncle, pods per plant, peduncles per plant; and days to 95% maturity, plant height, pod length and leaf size per plant were measured. Results show that E% and EI had significant correlations with first flowering (-0.54 and 0.66** for E%_5DAP and EI, respectively), leaf size (0.56* and -0.52*, respectively), and days to 95% maturity (-0.53* and 0.60*, respectively). Most mature plant traits had significant negative correlations with the number of days to 1^{st}/50 % flowering and 95 % maturity; and positive correlations with leaf number and size per plant ($P \leq 0.01$). ANOVA showed that genotype significantly influenced the number of days to the initiation of the first flower and pod length ($P \leq 0.01$) but had no effect on other mature cowpea traits. Conclusively, significant relationships exist among cowpea traits beyond the seedling stage. High seedling vigour resulted in early flowering and maturity, which in turn, resulted in optimum growth and yield performance. Therefore, it is necessary to carefully nurture cowpea from the seedling stage to ensure optimum yield in the rainforest.*

Keywords: Crop morphology, crop physiology, growth analysis, seedling emergence and vigour, Vigna unguiculata L. (Walp)

INTRODUCTION

Cowpea [*Vigna unguiculata* L. (Walp)] is an annual herbaceous legume from genus *Vigna.* Its origin and domestication occurred in Africa near Ethiopia and subsequently was developed mainly in the farms of the African savannah (Dorvlo *et al.,* 2022). Cowpea plays a critical role in the lives of millions of people in Africa and other parts of the developing world, where it is a major source of dietary protein that nutritionally complements staple low-protein cereal and tuber crops, and is a valuable and dependable commodity that generates income for farmers and traders. Cowpea is a valuable component of farming systems in many areas because of its ability to restore soil fertility (Fatokun *et al*., 2018).

In Nigeria the crop is mostly cultivated in the savannah regions of the North. It has been reported that cowpea, has competitive advantage in sandy soils, does not tolerate excessively wet conditions, and should not be grown on poorly drained soils (Omoigui *et al.,* 2018). One of the most remarkable cowpea attributes is its ability to thrives in dry environments. Also, the number of days to maturity depends on the cowpea variety, ranging from 100 days in determinate types to 110 days or longer in semi-determinate types. The climate will also have an effect on the length of growing seasons, the hotter the weather the shorter the maturity period (Akande *et al.*, 2012). It has also been reported that some cowpea varieties are photoperiod sensitive, flowering in response to the length of darkness rather than daylight. These, perhaps, are few reasons for the gulf in production and the yield gap between the forest and savannah regions of Nigeria (Guzzetti *et al.*, 2020), with the contrasts in the rainfall and incident solar radiation patterns between the regions.

Some challenges to agricultural production especially crop production include climate change, population increase, urbanization, shrinking agricultural land, declining soil fertility, and consequently food insecurity (Fayose, 2022). Therefore, there is urgent need to boost crop production by expanding capacity of production and increasing productivity per unit land area to ameliorate the prevailing food security challenges in the country. In order to ensure that the aforementioned gap in cowpea yield between the savannah and the forest regions of Nigeria is bridged, there is a need to evaluate different aspects of cowpea growth and development in order to properly adapt cowpea production to the variability in environmental and climatic conditions and the myriad of contemporary challenges to significantly bridge the yield gap in the face of rising food security crisis and climate change in Nigeria. Consequently, this study was conducted to achieve the following objectives: to (i) evaluate relationships among cowpea traits from seedling to maturity, (ii) determined the traits that contribute most to optimum yield trait expression, and (iii) determined the effect of genotype on the adult plant traits of ten cowpea varieties.

MATERIALS AND METHODS

The experimental land within the Ekiti State Polytechnic Teaching and Research Farm (EKSPOLY TRF), located at 7° N 54´34" 5° E 18´54" and 556 masl was tractor-ploughed and manually pulverized for planting using hoes and cutlasses. Field layout was 2-replicate RCBD, spacing was 0.75m by 0.2m and total field dimension was 15m by 5.5 m. Seeds, three per hole were sown and later thinned to two plants/stand giving a total plant population of 133,333 plants/ha. Ten improved cowpea varieties which were erect and drought tolerant, were sourced from the International Institute of Tropical Agriculture IITA, Ibadan, Nigeria, eight of the varieties were white-grained, two, brown. The varieties were monitored for seedling emergence and vigour, flowering, and yield parameters including number of pods per peduncle, pods per plant, peduncles per plant, days to 95% maturity and pod length. Other data collected include number of leaves per plant, plant height and leaf size per plant. Data were subjected to ANOVA and Pearson correlation analysis.

RESULTS AND DISCUSSION

As expected, seedling vigour traits, E%, EI and ERI were highly significantly correlated to each other ($R \leq 0.01$; Table 1). This result has also been reported in the literature as studies on cowpea genotypes have shown that seedling vigour traits, such as E%, EI, and ERI, are highly correlated with each other (Ajala, 2004).

There were significant correlations of E% at 5DAP (0.56*) and EI (-0.52*) with leaf size/plant, number of days to 95 % maturity (-0.53* and 0.60** for E% at 5DAP and EI, respectively), and number of days to 1^{st}/50% flowering ($P \leq 0.01$). This indicates that vigorous growth at the seedling stage significantly reduced the number of days to flowering, and maturity and resulted in vigorous and healthy growth at the adult stages. Beyond the seedling stage, early flowering increased overall plant size as leaf size/number of leaves and peduncles per plant; plant height and pod length all had significant negative correlations with 1^{st} and 50% flowering ($P \leq 0.01$). Furthermore, delayed time to flowering resulted in delayed maturity with the positive correlations of 1^{st} and 50% flowering with 95% maturity (0.89** and 0.91** for 1^{st} and 50% flowering, respectively). Results hitherto have shown that high seedling vigour improved overall plant performance by causing early flowering and shortened growth cycle. This is reasonable as vigourous and healthy plants often exhibit better photosynthetic efficiency and high pest cum diseases resistance capacity, thereby enabling plants to complete their life cycle and proceed to seed production which is the business of all green plants, in a timely manner (Dai *et al*., 2017).

All adult and yield parameters such as number of pods per plant, peduncles per plant, pods per peduncle and pod length had strong positive correlations with one another ($P \leq 0.01$). This suggests that strong and positive growth in one resulted in similar growth in the other (Table 1). The leaf is the site of photosynthesis which is the major process of nutrition for green plants (Patil *et al*., 2018). Therefore, it is expected that healthy and vigorous leaves will result in healthy plants with optimum growth and development of vital parts as long as other necessary condition such as edaphic and climatic are favourable, as all the aforementioned parameters also had strong positive correlations with leaf no/size per plant. Also, the adult and yield parameters had negative correlations with 95% maturity which is in tandem with earlier results that vigorous growth at the seedling and flowering stages resulted in optimum growth at the adult stages, thereby reducing days to maturity or causing maturity to happen in a timely manner. However, taller plants delayed maturity and vice-versa as plant height had positive correlation with days to 95% maturity (0.61**). Why taller plants resulted in delayed cowpea maturity is unclear. Bobos *et al*. (2022) reported that the relationship between plant height and days to maturity in cowpea varieties is complex and influenced by various factors. Umar *et al*. (1970) reported positive correlation between plant height and days to maturity. However, the specific reasons for this correlation in cowpea are unclear. Singh *et al*. (1995) also observed the same result which is similar to the result obtained in the present study. These findings suggest that the relationship between plant height and days to maturity in cowpea is likely influenced by a combination of genetic, environmental, and physiological factors. Also, cowpea varieties have different growth forms.

Table 1a: Pearson correlation of traits of ten cowpea varieties, monitored from seedling to maturity in the late season at the EKSPOLY TRF

	E%_5DAP	**E%_7DAP**	**E%_9DAP**	**EI**	**ERI**	**1st Flower**	**50% flower**
E%_5DAP							
E%_7DAP	0.93**						
E%_9DAP	0.92**	0.98**					
EI	-0.84**	-0.74**	-0.65**				
ERI	-0.85**	-0.92**	-0.92**	0.73**			
1st Flower	-0.54*	-0.45*	-0.39	0.66**	0.52*		
50% flower	-0.44	-0.34	-0.29	0.58**	0.45*	0.95**	
leaves/plant	0.26	0.13	0.15	-0.25	-0.17	-0.43	-0.55*
Leaf size/plant	0.56*	0.42	0.37	-0.52*	-0.32	-0.63**	-0.59**
pods/plant	0.29	0.13	0.14	-0.33	-0.17	-0.52*	-0.64**
peduncles/plant	0.32	0.15	0.16	-0.37	-0.18	-0.64**	-0.71**
Pods/peduncle	0.39	0.24	0.22	-0.49	-0.31	-0.55*	-0.68**
Plant height	0.36	0.19	0.18	-0.39	-0.20	-0.54*	-0.64**
Pod length	0.35	0.32	0.30	-0.33	-0.28	-0.57**	-0.59**
95 % maturity	-0.53*	-0.38	-0.35	0.60**	0.45*	0.89**	0.91**

*, ** - F – Statistic significant at 5% and 1% level of probability, respectively. E%_5,7&9 DAP are emergence percent at 5, 7 and 9 days after planting, EI and ERI are emergence index and emergence rate index, respectively.

Table 1b: Pearson correlation of traits of ten cowpea varieties, monitored from seedling to maturity in the late season at the EKSPOLY TRF

	leaves/plant	**Leaf size/plant**	**peduncles/plant**	**Pods/peduncle**	**Plant height**	**Pod length**	**95 % maturity**
Leaf size/plant	0.71**						
pods/plant	0.95**	0.73**					
peduncles/plant	0.89**	0.74**	0.95**				
Pods/peduncle	0.88**	0.68**	0.87**	0.81**			
Plant height	0.93**	0.78**	0.91**	0.84**	0.88**		
Pod length	0.54*	0.58**	0.58**	0.58**	0.55*	0.67**	
95 % maturity	-0.56**	-0.64**	-0.63**	-0.73**	-0.66**	0.61**	-0.46*

*, ** - F – Statistic significant at 5% and 1% level of probability, respectively.

Some are trailers, while others are erect and semi-erect, each requiring slightly different climatic conditions for growth and development. Omoigui *et al*. (2018) observed that some cowpea varieties are photoperiod sensitive irrespective of their growth form and must be planted to coincide with the period of the year when the day-length is shorter, as failure to do so will promote vegetative, rather than reproductive growth, delay maturity significantly and affect yield negatively. Perhaps, this might explain the strange positive correlation of plant height with maturity. The present experiment was planted in the late season of 2022 where factors are expected to be favourable and the varieties evaluated are the erect types. Therefore, the reason why increased plant height would delay maturity and vice-versa remains unclear.

ANOVA revealed significant varietal effect for E% at 9DAP, EI and ERI at the seedling stage, and 1st flowering, pod length and 95% maturity at the flowering and maturity stages (Table 2). Other traits were not significantly affected by genotype.

CONCLUSION AND RECOMMENDATIONS

High level of relationship was observed among the cowpea traits evaluated in this study throughout the growth cycle. Vigorous growth at the seedling stage favoured early flowering and optimum adult growth. It also promoted

Table 2: Mean squares from the ANOVA of seedling and adult plant traits of ten cowpea varieties monitored at the EKSPOLY TRF

Source	Df	ꞌE%_9DAP	EI (Days)	ERI (Days)	Days to 1st flowering	50% flowering	Pod length (cm)	95% maturity
Replication	1	1544.53*	1.13**	113.21*	145.8**	174.05**	4.16**	204.8**
Variety	9	442.25	0.18**	38.30*	24.67**	32.23	9.16**	18.64
Error	9	166.11	0.025	10.72	3.91	12.94	0.01	9.13
Total	19	369.46	0.157	29.18	21.21	28.45	4.56	23.94
CV (%)		20.8	2.7	29.81	3.84	6.03	1.04	4.62

*, ** - F – Statistic significant at 5% and 1% level of probability, respectively. CV – Coefficient of variation in percentage. Df – Degree of freedom, ꞌ See Table 1

Important yield parameters and caused crops to mature on time. Early flowering favoured increased plant size and early maturity. However, increased plant height caused delayed maturity. Genotype affected seedling growth, but did not affect most adult and yield parameters of the cowpea varieties evaluated in this study. Therefore, cowpea varieties must be carefully nurtured from seedling the seedling stage to ensure optimum growth and yield performance in the rainforest of Southwestern Nigeria.

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Women and Youths Cooperatives Awareness, Attitude and Participation towards Turmeric Processing In South East Nigeria

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Abstract
The study determined the women and youth cooperatives' awareness, attitude and participation towards turmeric processing in South East Nigeria. A multi-stage sampling procedure was used to select hundred and thirty-five (135) turmeric processors for the study. A well-structured questionnaire was used to collect data from the respondents. The data collected were analyzed using descriptive statistics, mean, four-point mean rating scale and multiple regression techniques. The result shows that the majority of the marketers were female and are married; they are still in their active age. The result of the awareness of turmeric technologies shows that most processors are aware of them. The processing technology was observed to be effortless (3.88), and the respondents disagreed that it is expensive (2.47). The educational level attended by the turmeric processors increased the performance level of the processors. It is recommended that, machines should be made available for peeling and slicing to make turmeric processing technologies easier, faster and more efficient.
Keywords: Cooperative, Turmeric, Processors and South East

INTRODUCTION
Turmeric (botanically known as Curcuma longa Linn), the 'golden spice of life', is a root crop in the same family as ginger. Yet, it receives less attention from Nigerian farmers despite having enormous potential for local industries and exports. It is used in the food, cosmetic and pharmaceutical industries. It is used as a spice and a significant curry powder component. Turmeric is also used in the cosmetics industry because of its brilliant yellow colour and characteristic perfume. It is also used as a dye for colouring fabrics. NRCRI has developed a lot of technologies for turmeric rhizome production and processing. Creating awareness and utilizing the technologies developed by the National Root Crops Research Institute and IITA and the subsequent transfer to farmers and processors are essential. The study's objectives were to describe the socioeconomic characteristics of the processors, to determine the awareness of the technologies, to ascertain the attitude towards turmeric processing, to determine the level of Utilization of turmeric rhizome and to analyze the factors affecting the use of the technologies.

MATERIALS AND METHODS
The study was conducted in the Southeast Nigeria. The zone comprises five states: Abia, Anambra, Ebonyi, Enugu, and Imo States. It also has a rural population density of 173 persons per square kilometre (NPC, 2014). About 60-70% of the inhabitants are

engaged in agriculture, mainly crop farming, animal rearing, food processing, and farm produce marketing. A multi-stage sampling procedure was used to select the respondents for this study. The target population was turmeric processors. The turmeric processors were randomly sampled. The first stage involved a purposive selection of three states, Abia, Imo, and Ebonyi, out of the five states in the Southeast geo-political zone. These states were chosen based on their high-level activities in turmeric production. In the second stage, two agricultural zones were purposively chosen from each of the states, and three blocks were randomly selected from each zone and three circles from the block, which gave a total of 27 circles. A multi-stage random sampling technique was used to select five turmeric processors. It was compiled with the aid of community residents, extension agents, and turmeric processors. These gave 135 turmeric processors in the areas. Primary data were collected using well-structured questionnaires administered to turmeric processors. The data collected from the turmeric respondents were analyzed using descriptive statistics such as percentage, frequency distributions, mean, four-point mean rating scale and multiple regression techniques.

Objective one was achieved using descriptive statistics. Objectives two and three were achieved using a four-point mean rating scale, and Objective four was achieved using the ordinary least squares regression equation expressed implicitly in equation 1;

$$Y = f(X_1, X_{2,}, \ldots\ldots X_{10,}) \quad (1)$$

From the equation, the model is specified in equation 2 explicitly as,

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8 + b_9x_9 + b_{10}x_{10} + b_{11}x_{11} + b_{12}x_{12} + U \quad (2)$$

Where,

Y = Utilization level
X_1 = age (yrs)
X_2 = Gender (1=female; 0 = male)
X_3 = Educational level (yrs);
X_4 = Extension Visits (number)
X_5 = experience in processing (yrs)
X_6 = Household Size (Number);
X_7 = Membership of Cooperatives dummy (Member =1; Not member = 0);
X_8 = Distance to Source of Credit (km)
X_9 = Income (₦)
X_{10} = Transportation cost (₦)
X_{11} = Storage cost (₦)
X_{12} = Processing Price (₦)
U_i = error term

RESULTS AND DISCUSSION

The result of the distribution of respondents according to awareness of turmeric technologies is shown in Table 1.

Table 1: Distribution of respondents according to awareness of the turmeric technologies

Variable	Frequency	Percentage (%)
Awareness of turmeric techno.		
Yes	85	62.96
No	50	37.04
Total	**135**	**100**

Table 1 shows that 62.96% of the processors know the turmeric processing technologies. The processors know how to clean and Peel turmeric, slice it, parboil it, dry it, mill it, etc. The processors are aware of processing technologies, while 37.04% of the processors are unaware of the technologies. The result of the respondents' distribution according to the turmeric processing attitude is shown in Table 2.

Table 2: Distribution of respondents according to their attitude of turmeric processing

Variable	SD	D	UND	A	SA	Total	Mean
Cleaning and Peeling turmeric is difficult.	15(15)	20(40)	20(60)	41(164)	42(210)	489	3.62
Slicing is hard	16(16)	25(50)	19(57)	38(152)	37(185)	460	3.41
Parboiling takes time	34(34)	43(86)	26	34(102)	24(96)	318	2.36
drying is stressful	33(33)	47(94)	13(39)	26(104)	16(80)	350	2.59
Milling is hard to do	60(60)	45(90)	12(36)	11(44)	7(35)	265	1.96
The technology is hard to understand	41(41)	43(86)	15(45)	17(68)	19(95)	335	2.48
The technology is straightforward	11(11)	15(30)	9(27)	44(176)	56(280)	524	3.88
The technology is expensive	41(41)	44(88)	10(30)	25(100)	15(75)	342	2.47
Grand mean							**2.85**

Source: Field Survey Data, 2023. Benchmark: 2.5. Five-point Likert scale: 1,2,3, 4 and 5

Table 2 shows that the respondents strongly agreed that cleaning and peeling turmeric is difficult (3.62) and slicing is hard (3.41). This is because they used manual methods to carry out these activities. The result showed that Parboiling does not take time, drying is not stressful, and milling is not hard. This is due to the machines used to carry out these activities. The processing technology is straightforward (3.88), but the respondents disagreed that it is expensive (2.47). It also enhances households' multidimensional well-being and improves the living standards of rural dwellers (Adjei *et al.,* 2009; Imai *et al.,* 2010). Finally, the result showed that the technology was not hard to understand. This means people's impression of processing turmeric is inaccurate, and efforts should be made to reduce the processing time.

The result of the distribution of respondents according to the level of Utilization of turmeric rhizome is shown in Table 3.

Table 3: Distribution of respondents according to the level of Utilization of turmeric rhizome

Turmeric	Not in used	Undecided	Fairly in use	Highly in use	Total	Mean
Dry Turmeric	17(17)	23(46)	43(129)	52(208)	400	2.96
Fresh Turmeric	22(22)	21(42)	41(123)	51(204)	391	2.90
Turmeric Powder	5(5)	16(32)	43(129)	71(284)	450	3.33
Turmeric Drink	24(24)	20(40)	42(126)	49(196)	386	2.85
Grand Mean						**3.01**

Source: Field Survey Data, 2023. Benchmark: 2.5. Four-point Likert scale: 1,2,3 and 4

There is a high utilization of turmeric powder, dry turmeric, fresh turmeric, and turmeric drinks, with the mean being more significant than the Grand mean (3.01) score. This shows that processed turmeric is beneficial and vital. It is used as a spice and beneficial health-wise as tea and drugs.

Table 4 shows the factors affecting the use of Turmeric processor technologies using OLS regression. The results of the regression analysis are shown in Table 4.

Table 4: Results of the factors affecting the use of the technologies by Turmeric processors

Variables	Linear	Exponential	+Semi-log	Double log
Constant	0.012 (6.21)***	0.007 (10.33)***	-0.000 (-14.21)***	0.000 (23.32)***
Age	0.4315 (1.15)	0.00331 (0.82)	4.7763 (0.94)	0.2142 (0.74)
Gender	-0.023 (-2.05)**	0.01755 (0.26)	-7.3457 (-4.24)	0.0133 (0.19)
Educational level	0.4803 (1.82)	0.01305 (1.71)*	0.004 2.92)***	0.0448 (0.75)
Extension service	0.0186 (0.03)	-0.00084 (0.00)	0.000 (4.12)***	3.006 (0.07)
Experience	0.000 (3.78)***	-0.00355 (- 0.66)	-1.6226 (0.82)	4.04575 (0.070)
Household size	-0.442 (-1.03)	-0.018 (-1.33)	-2.2624 (-1.08)	-0.0931 (-1.34)
Membership of cooperatives	2.877 (1.36)	0.083 (1.12)	0.044 (2.33)**	0.07015 (6.44)***
Distance to source Credit	-0.00 (-4.15)***	-0.000 (-4.13)***	-0.000 (-4.01)***	-0.5573 (-3.78)***
Income	0.00 (4.14)***	0.000 (4.66)	0.000 (5.03)***	3.4530 (4.31)***
Transportation cost	-0.063 (-0.42)	-0.0042 (-8.23)	-0.000 (-3.56)***	-0.092 (-1.67)*
Storage cost	-0.822 (-3.2)	-0.1469 (-2.55)	-0.008 (-2.23)**	-0.1423 (-3.6)
Process price	-1.8649 (-4.5)	-0.0403 (-4.3)	-0.015 (-2.12)**	0.8335 (1.66)
R^2	**0.5444**	**0.4213**	**0.6943**	**0.3014**
Adjusted R^2	**0.4798**	**0.3673**	**0.6132**	**0.3357**
F-stat	**6.57*** **	**5.83*** **	**9.05*** **	**5.11*** **

Source: Field Survey Data, 2023. ***, **, * = statistically significant at 1%, 5% and 10% respectively.

The semi-log functional form of the regression was chosen as the lead equation. The reason is that R^2 values were higher than the other three functional forms. The value of F-ratio (69%) was significant at the 1.0% probability level. This indicates that the model is a good fit. The coefficient of the level of education, number of extension visits, membership of cooperative societies, and income were all significant at a 1.0% probability level. The coefficients are positively related to the profit level of the turmeric processors.

The coefficient of education was significant at 1% and positively related to the use of turmeric processor technologies. This shows that an increased educational level attended by the turmeric processor would increase the performance level of the processors. This is in line with a priori expectations. The acquired education enables the processors to manage the processing techniques, leading to efficient performance. The finding agrees with (Apata *et al.,* 2009). Who reported that better education enables households to access and conceptualize information on improved farming methods and other related issues to enhance their welfare. The coefficient of extension visits was significant and positively related to the performance of processors. This implies the more the extension visits to the processors, the better the processor's performance. This is in line with the a *priori* expectation. The more the extension visits, the better the processor, as the processors are being directed, helped to identify their needs, problems, and opportunities that will help for higher performance in processing.

The coefficient of membership of the cooperative was significant at 1% and positively related to the performance of the processors. This could be that as a cooperative member, the union is secure and can make a decision that will stand for better members' performance. It may also be that the members know the processing techniques and, therefore, perform better than their counterparts who are not members. The coefficient of processors' income was significant and positively related to the performance of turmeric processors. This implies that an increase in the income of the processors will lead to a rise in their investment. It will encourage their investment in processing and create more money for saving. The finding agrees with (Anyanwu *et al.* 2016), who reported that the increase in the income of the respondents would increase their expenditure on value addition. This finding aligns with a*priori* expectation; an increase in income would enable the respondents to purchase the requisite inputs for enhanced output and income.

The coefficient of transportation was significant at 1% and negatively related to the performance of processors. This implies that as the cost of transportation increases, the processing performance decreases. The coefficient of storage cost was significant and negatively related to the performance; it is in line with the a*priori* expectation that significant expenses for marketing will lead to a reduction in performance. The coefficients of distance to the source of credit, transportation cost, storage cost, and purchase price were all significant at a 1.0% probability level and are negatively related to the performance level of the turmeric processing.

CONCLUSION AND RECOMMENDATIONS

The study revealed that most turmeric processors were females and were married. Most processors (62.96%) are aware of the turmeric processing technologies. The respondent has a positive attitude toward turmeric processing. The grand mean is 2.85. They strongly agree that technology is straightforward and understandable. There is a high level of Utilization of turmeric products with a Grand mean (3.01) score. It is recommended that, machines should be made available for peeling and slicing to make turmeric processing technologies easier, faster and more efficient.

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Mechanization of Turmeric Production as a Solution to Economic Nigeria's Growth

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Abstract
Apart from primary tillage operation, all other production processes (from planting to harvesting) of turmeric in Nigeria are done manually. Production of turmeric has been a challenge to farmers in Nigeria due to the absence of planting harvesting and processing machines. Farmers are left to the traditional method of planting with hoes and cutlasses. This method is time consuming costly, labour intensive, associated with human drudgery and a high demand for human energy Increased cultivation of turmeric in Nigeria will help not only to meet its own turmeric requirements but also help the country to boost its export. The need for mechanization of turmeric production in Nigeria and West Africa has become more acute in recent years due to the urgent need to accelerate food and fibre production for the teeming urban and rural population. This study explored empirically the role of Agricultural mechanization of turmeric production as a solution to the economic and industrial development of Nigeria. The problems of agricultural mechanization on turmeric production were identified and probable solution was discussed. The benefits of agricultural mechanization of turmeric were highlighted. The level of mechanization of turmeric production in Nigeria was also discussed and its impact analysed.
Keywords: Turmeric, production, mechanization, Nigeria

INTRODUCTION

In simple terms agricultural mechanization is the process whereby equipments, machineries and implements are utilized to boost agricultural and food production. Also it is the replacement of human and animal labour by mechanical devices in farming activities. Agricultural mechanization helps in reducing drudgery, increase food production, reduces human effort, and increase agricultural output. Mechanised agriculture is the process of using agricultural machinery to mechanise the work of agriculture, greatly increasing farm work productivity. Agricultural mechanization in Nigeria strongly rest on the development of machines and equipment locally. Mechanization reduces some of the gruelling tasks on the farm. Agriculture mechanization will play a significant role in economic development and industrial of the nation. In Nigeria, agriculture remains the most basic part of the economy, since is the largest sector in terms of share in employment. Agriculture has the potential to stimulate economic growth through provision of raw materials, food, jobs and increase financial stability.

Turmeric (Curcuma Longa Linn) is a stem tuber crop. It belongs to the same family as ginger (*Zingiberaceae*) and it grows in the same hot and humid tropical climates.

Turmeric major activeingredients oleoresin and turmeric oil are used for a wide range of culinary, confectionary, and pharmaceutical purposes (Amadi *et al*., 2017). In Nigeria, turmeric is cultivated mostly on subsistent bases in about 19 states and given different local names depending on the area. It is called atale pupa in Yoruba language; gangamauin Hausa; nwandumo in Ebonyi; ohubobochiin Enugu (Nkanu East); gigirinTiv; maginain Kaduna; turiin Niger State; onjonighoin Cross River (Meo tribe). (Nwaekpe, *et al*., 2015).

India is the largest producer, consumer and exporter of turmeric in the world. India accounts for about 80 per cent of total world production of turmeric, though major part of its produce is being utilized within the country (Singh 2004). Indian turmeric has been known to the world since ancient times. It has been used as a dye, medicine and flavouring since 600 BC (Srinivasan and Dhandapani 2013).

Turmeric occupies about 6 per cent of the total area under spices and condiments in India (Moghe *et al*., 2012). To most people in India, curcumin is a free radical scavenger and hydrogen donor, and exhibits both pro-and antioxidant activity (Hatcher et al., 2008). Modern medicine has begun to recognize its importance, as indicated by the over 3000 publications dealing with turmeric that came out within the last 25years (Sahdeo and Bharat, 2011). Turmeric is used widely in the preparation of soft drinks and beverages. The planting distance is normally 20 to 30 cm at a depth of 7.5 cm. (Madan2008) reported that the conventional methods need more labors with less field capacity, which increase cost of production. Conventional method of manual digging results into bruising and damaging of rhizomes which affect its quality and market price.

Nigeria is the fourth largest producer of turmeric with about 3% of the global annual production (Yusuf, 2016).Nigeria can play a leading role in turmeric production considering the prevailing favorable soil and climatic conditions in the country. Turmeric like ginger is now one of the main cash crops supporting the livelihood and improving the food, health and economic level of many turmeric growers and users in the main producing areas. Turmeric is cultivated commercially as an annual crop, by planting small rhizomes or pieces of rhizome either on flat soil or in furrows between ridges. Turmeric is ready for harvesting 7 to 10 months after planting, when the lower leaves turn yellow. Harvesting is done by digging the rhizomes up.

Turmeric is being harvested manually in Nigeria and as such only a few rhizomes are harvested. The farmers in Nigeria harvest turmeric rhizomes manually with hands and local knives or digging fork using family members or hired labour. Mechanization of turmeric production has received little attention in Nigeria. Most aspects of turmeric production are not mechanized. Machines for mechanization of turmeric production are available in many agricultural industrialized countries like India, China, and Malaysia etc. but not readily available here in Nigeria.

Level of Mechanization of Turmeric Production in Nigeria

Turmeric (*Curcuma longa Linn*) was one of the earliest oriental spices known to Europe. The crop was introduced by the Portuguese to West Africa and then to other parts of the tropics in the 16th century – these included the West African sub-region and Nigeria. It has been grown in Nigeria since about 1927 and since then it has steadily increased in importance as a valuable commodity. Being one of the cash crops grown in the country, turmeric has a great foreign exchange potential. Its price in the world market has remained attractive. Turmeric at the moment has both high domestic and international consumption rating compared with other export commodities. On the domestic scene, turmeric is gaining acceptance as a flavouring agent favourably competing with curry and magi cubes. Therefore, with the emphasis on local sourcing of raw materials, it is envisaged that turmeric will be industrially utilized on a large scale, considering its high demand in confectionary, beverages and pharmaceutical industries in Nigeria. Not with standing, turmeric production has not been an exception to the declining performance of agricultural production in Nigeria, hence it has not been able to realize its full potential as an export crop and a major foreign exchange earner. Nigeria attempted to implement an economic reform program called the National Economic Empowerment Development Strategy (NNEDS). In 2014, Nigeria changed its economic analysis to account for rapidly growing contributors to GDP, such as telecommunications, banking, and its film industry**.**

In 2005, Nigeria Inflation rate was an estimated 15.6%. Nigeria’s goal under National Economic Empowerment Development Strategy (NNEDS) is to reduced inflation to the single digits. By 2005, Nigeria Inflation stood at 9%. Nigeria ranked sixth worldwide and first in Africa in Farm output. Agriculture accounted for about 18% of the GDP, and almost one third of employment. Major agricultural products included cassava, corn cocoa, millet, palm oil, peanuts, Rice, rubber yams sorghum. In 2016, Nigerian economy slipped into recession for the first time in more than two decades, reflecting adverse economic shocks, the agricultural sector now has suffers from extremely low productivity, reflecting reliance on antiquated methods. Agriculture has failed to keep pace with the rapidly increasing population of the country, so that the country which once exported food, now imports a significantly amount of food to sustain itself**.**

Turmeric production process in Nigeria from bush clearing, cultivation, chemical application, harvesting, processing and transporting to markets is still labour intensive.Production is still largely done using traditional crude implements as the hoe. The farmers need modern farm implements. Lack of tractors and other machines for laborious land preparations and harvesting operations limits the hecterage of land put under cultivation. Farmers lack modern processing machines –washing, peeling, splitting, drying kilns etc. For instance, farmers split harvested turmeric rhizomes manually with knives. The absence of scientific research to backup the efforts of the farmers was among the factors that limited increased production. Nigeria are then ranked first in term of percentage of total hectares of ginger under cultivation but her contribution to total World output is too low compared to other countries. This can be attributed to the fact that most of production is undertaken by smallholders and traditional farmers with rudimentary production techniques and low yields. In addition, the smallholders farmers are constrained by many problems like the farmers do not see it as abusiness enterprise, therefore are not adequately focused on profit maximizing motive (FMA, 1993). Therefore, Nigeria has the potential to expand production in a medium to long term investment strategy that can develop into self-sufficient industry. Efforts should be made towards making the country food sufficient again through mechanization of turmeric production

Nigeria’s Contribution to Global Turmeric Production

Though Nigeria contributes about 3% to the global production of turmeric (Table1) cultivation practices have not been adequately researched. Due to the drudgery associated with the manual production of turmeric, most farmers are showing little or no interest in engaging into large scale production. As a result of the absence of implements for mechanization of turmeric in Nigeria, productivity has been low. Awareness creation of the economic importance of turmeric in medical and food industries should be encouraged in Nigeria. As this wonder spice now gets global recognition for its tremendous medicinal value, better cultivation methods need to be adopted.

Table 1: Percentage Contribution to the World Production of Turmeric

Country	Percentage contribution
India	78%
China	8%
Myanmar	4%
Nigeria	3%
Bangladesh	3%
Others	4%

Source: http://www.indianspices.com/pdf/state_prd.pdf

Benefits of Turmeric Production

Ginger is an important commercial crop with versatile applications - being a pungent spicy herb and one of the more popular food spices. Dried ginger is used in many different cooking methods - as condiment, ginger is used for flavoring many food products like tomato sauce or ketchup, salad dressings, meat sausages, gravies, pickles, curry dishes and so on. The recipes range from baked products like turmeric bread, turmeric biscuits, turmeric cookies to drinks like turmeric tea etc. Ginger contains about two per cent essential oil – oleoresins; extracted and distilled from rhizomes for various uses in confectionery, soap making, perfumery, beverages, food processing and pharmaceuticals industries etc., aside its medicinal qualities - consequent upon this, turmeric can be said to considerably hold great export and industrial potentials for the development of Nigeria.

Challenges of Mechanization of Turmeric Production in Nigeria

In Nigeria, the production of turmeric is still low because of little or no attention from turmeric mechanization. There is need therefore, to create awareness and increase the production of turmeric through mechanization. Turmeric is mostly cultivated by peasant farmers in small portion of land less than one hectare. This is as a result of drudgery associated with turmeric production. As an emerging crop in Nigeria, the need to develop efficient implements aimed at increasing turmeric production is paramount. There is an increase in the demand for processed products of turmeric in Nigeria which makes its large scale production attractive. In Nigeria, turmeric has not received the desired attention that will boost its large scale production.

The mechanization of turmeric production in Nigeria like any other crop is constrained by many factors. Some of which are:

- Land tenure system - the land tenure system in Nigeria to an extent discourage farmers from acquiring enough land for large scale farming.
- Poor infrastructure – the poor state of infrastructure facilities in Nigeria is also a factor hindering agricultural mechanization.
- Poverty and inaccessibility of credit. Majority of Nigeria farmers are poor, so, they lack the fund needed to purchase sophisticated farming machine.
- Literacy of the farmers: if estimate is anything to go by we have it that about 60percent of Nigeria farmers are illiterates.
- Lack of maintenance technicians: even when this sophisticated equipment is available, there are no technicians to take care of them or repair them when the need arises.

- Scarcity of machinery- even the few farmers that can afford these farming machines suffer setback. Because this equipment are not locally manufactured. And importing them from abroad attracts additional expenses and even takes time.
- Inconsistence government- for decades the government has continuously neglected the agricultural sector. Funds were not provided for purchase of agricultural equipment. And even when such considerations are made, the political class embezzles the money for personal use.

Impact of Mechanization of Tumeric Production on Nigerian Economy

Significant challenges will have to be overcome to achieve the level of agricultural productivity necessary to meet the predicted world demand for food, fiber, and fuel in 2050. Although agriculture has met significant challenges in the past, targeted increases in productivity by 2050 will have to be made in the face of stringent constraints including limited resources, less skilled labour, and a limited amount of arable land, among others. The metric used to measure such progress is total factor productivity (TFP) the output per unit of total resources used in production. According to some predictions, agricultural output will have to double by 2050 (GHI, 2011), with simultaneous management of sustainability. This will require increasing TFP from the current level of 1.4 for agricultural production systems to a consistent level of 1.75 or higher. To reach that goal, we will need significant achievements in all of the factors that impact TFP. Total production of ginger can be increased by increasing the yield, increasing the total hectares, improving the economics of production and stimulating demand for the commodity. Turmeric production in Nigeria today is laborious. Practically all operations are done manually.

CONCLUSION AND RECOMMENDATIONS

Turmeric farming is a booming business. It is quite popular due to its hot and sharp flavour and an oily substance. Turmeric is also known for its medicinal purposes. Many countries that came out of recession quickly use what their people produce with their hands. It has been shown that turmeric production is a very profitable venture and mechanization of turmeric production having being identified as a solution to our Economic development should be embraced by the government and corporate organization if we must develop economically and industrially. Develop effective clusters in form of cooperatives and commodity associations that can add value to unprocessed raw materials.

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Root and Tuber Crops Farmers' Challenges in Adapting to Climate Change in Ibarapa Local Government Area of Oyo State

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Abstract

The study assessed challenges in adapting root and tuber crops to climate change in Ibarapa, Oyo State, using a multi-stage sampling of 120 respondents. Data were collected through surveys and analyzed using descriptive and inferential statistics. Results showed that 48.5% of respondents were aged 45-54, 40.4% had over 11 years of schooling, and 53.5% had 4-6 household members. Most respondents (55.6%) inherited their land, 64.6% had frequent access to extension services, and 35.4% planted cassava. Key climate change indicators were high rainfall (86.9%) and drought (88.9%). Irregular rainfall (81.8%) was the main challenge, with adaptation strategies including early planting (91.9%), mixed farming (89.9%), and fertilizer use (85.9%). Major obstacles were inadequate government support (79.8%) and inadequate climate change information (94.9%). Significant factors included secondary occupation, land ownership, crop types, farming experience, and farm size ($p < 0.05$). The study recommended training and awareness programs on climate change impacts through workshops, seminars, and online courses.

Keywords: Root and tuber crops, Adaptation to Climate Change

INTRODUCTION

Root and tuber crops, such as cassava, sweet potato, yam, and potatoes, are crucial for global food security, especially in developing countries that rank among the top 10 food crops (Nweke, 2004). By 1997, their production in developing countries was valued at over $41 billion annually (Scott *et al*., 2000). These crops provide essential energy and nutrition to over 2 billion people and serve as food security crops, cash crops, livestock feed, and industrial raw materials (Nweke, 2004). Adaptation to climate change is vital for mitigating its negative impacts. Antle (2008) defines adaptation as practices that are less vulnerable under changed climates, while Wannasai *et al*. (2013) describe it as measures to reduce climate change's negative effects. Adaptation is crucial for enhancing resilience, particularly for the poor in developing countries (Deressa *et al*., 2009). Farmers' responses to climate change depend on their needs, challenges, and available resources (Meinzen-Dick *et al*., 2010). This study identifies the challenges of root and tuber crop farmers in adapting to climate change in Ibarapa, Oyo State. The specific objectives of the study are to:

i. Identify the socio-economic characteristics of the respondents in the study

ii. identify the perceived climate changes affecting root and tuber crop farmers in the study area
iii. identify the perceived effect of climate change on root and tuber crop farmers in the study area
iv. examine the adaption strategies to climate change by root and tuber crop farmers in the study area
v. evaluate the challenges to use of adaptation strategies to climate change among root and tuber crop farmers in the study area

Hypothesis of the Study
Ho: There is no significant relationship between the socio-economic characteristics of the respondents and challenges to the use of adaptation strategies to climate change among root and tuber crop farmers in the study area

METHODOLOGY

This study was conducted in Ibarapa Local Government Area of Oyo State, Nigeria. A multi-stage sampling procedure was used for this study. In the first stage, 3 out of 7 wards were randomly selected from the LGA which were Ayete1 and 2 (Ayete), Tapa 1 and Igangan1 and 2 (Igangan). In the second stage, four (4) villages were randomly selected from each ward to give twelve (12) villages. in the third stage, ten (10) root and tuber crop farmers were randomly selected from the twelve (12) villages to give a total number of one hundred (120) respondents used for the study. The objectives were analysed using descriptive hypotheses with inferential statistics (Chi-square and PPMC).

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents
The result showed that majority (83.8%) of the respondents were male, above one-third (48.5%) were between the ages of 45-54 years, spent 11 and above years in school (40.4%), above average (53.5%) of the respondents had between 4- 6 members in their household, the majority (75.8%) of the respondents engaged in other related livelihood activities, had (82.8%) had a farm size of between 1- 3ha, and above average (50.5%) of the respondents had between 21 and above years of farming experience, while majority (64.6%) of the respondents had access to extension services and (75.8%) of the respondents earned between N500,001 and N1,000000 annually while about one-third (35.4) mostly planted cassava. This aligns with the World Bank (2012) that studies in Africa have shown that when a crop is perceived as commercial, men are more likely to be more involved than women. Also, this is in line with the findings of Adesope, (2007) who found that age significantly contributed to the qualities associated with young and middle-aged people; such as their active involvement in farming activities and proneness to innovation. In the same vein, this finding agrees with Nnadi and Akwiwu (2008) who stressed the importance of education amongst youths, increased understanding of the need for farming and that education is an asset to understanding the effect of climate change

Table 1: Socio-economic characteristics of the respondents

Variables	Frequency	Percentage	Mean
Gender			
Male	83	83.8	
Female	16	16.2	
Age			
35-45	30	30.3	
45-54	48	48.5	48
55 and above	21	21.2	
Years spent in formal education			
1-5	34	34.3	
6-10	25	25.3	
11 and above	40	40.4	11
Household size			
1-3	46	46.5	4
4-6	53	53.5	
Secondary occupation			
Trading	75	75.8	
Artisan	24	24.2	
Farm size			
1-5	82	82.8	3
6-10	17	17.2	
Farming experience			
Less than 10 years	23	23.2	
11-20	26	26.3	
21 and above	50	50.5	23
Frequently extension contact in a year			
Frequently	64	64.6	
Occasionally	32	32.3	
Not at all	3	3.0	
Annual income			
100,000-500,000	21	21.2	
500,001-1000,000	75	75.8	
1000,001 and above	3	3.0	
Types of roots and tubers crop planted			
Yam	25	25.3	
Cassava	35	35.4	
Potato	15	15.2	
Cocoyam	5	5.1	
Carrot	8	8.1	
Ginger	6	6.1	
Sweet potato	5	5.1	

Perceived climate change affecting root and tuber crop farmers

The result in Table 2 shows that drought (88.9%) was their highest perceived effect of climate change of climate followed by high rainfall (86.9%) and high temperature (65.7%). This indicates that survey respondents identified drought and excessive rainfall as signs of climate change.

Table 2: Perceived climate changes affecting root and Tuber Crop farmers

Perceived climate changes	F	%
High Rainfall	86	86.9
Ocean current	43	43.4
Wind and air masses	40	40.4
Global warming	41	41.4
High Temperature	65	65.7
Drought	88	88.9

Perceived effect of climate change on root and tuber crop farmers

Table 3 revealed the effect of climate change on root and tuber crop farming production. The result shows that irregular rainfall of root and tuber crops (81.8%) was the major effect on root and tuber crop production followed by stunted growth of root and tuber crops (75.8%) and late maturity (73.7. This implies that irregular rainfall has a major effect on root and tuber crop production.

Table 3: Perceived effect of climate change on root and tuber crop farmers

Perceived climate changes	Yes	No
irregular rainfall	81.8	18.2
Soil erosion	49.5	50.5
Reduced yield of root and tuber crops	72.7	27.3
Stunted growth of root and tuber crops	75.8	24.2
Thin stem and tall root and tuber crops plant	67.7	32.3
Late maturity	73.7	26.3
Loss of land due to flood	71.7	28.3
The increased cost of root and tuber	63.6	36.4
Increased pest and disease infestation	50.5	49.5
Recurrent drought	81.8	18.2

Adaptation Strategy to climate change by root and tuber crops farmers

Table 4 showed that early planting (91.9%) was the most adaptive strategy used by the respondents, followed by mixed farming (89.9%) and use of fertilizer (85.9%). The implication is that the use of early planting, mixed farming and use of fertilizer were the major adaptation strategies to climate change used by root and tuber crop farmers in the study area.

Table 4: Adaptation strategies to climate change by root and tuber crop farmers

Adaptation strategies	F	%
Early planting	91	91.9
Mixed farming	89	89.9
Crop diversification	68	68.7
Mulching	75	75.8
Irrigation	64	64.6
Uses of organic fertilizer	85	85.9
Fertilizer application	65	65.7
Zero tillage	38	38.4
Switching to other source of income	39	39.4
Late planting	53	53.5
Shifting cultivation	43	43.4
Use of tolerant variety	74	74.7
Increased ridge size/height	62	62.6

Challenges to use of adaptation strategies to climate change among root and tuber crop farmers

Table 5 revealed the challenges to use of adaptation strategies to climate change among root and tuber crop farmers. The result shows that inadequate information on climate change had (94.9%) was the most constraint, followed by high cost of adaptation and inadequate government support which had (79.8%), poverty and poor link to inputs and output markets (78.8%) This implies that inadequate information on climate change was the major challenges to use of adaptation strategies to climate change by the respondents.

Table 5: Challenges to use of adaptation strategies to climate change among root and tuber crop farmers

Challenges	F	%
Inadequate information on climate change	94	94.9
High cost of adaptation	79	79.8
Shortage of labour	59	59.6
poverty and poor link to input and output markets	78	78.8
Lack of extension contact	50	50.5
Lack of money hinders farmers from getting the necessary resources and technologies.	78	78.8
Lack of Cooperative Society	74	74.7
Lack of government support in militating the climate change in the study area	63	63.6
Inadequate extension contacts	73	73.7
Inadequate government support	79	79.8

Chi-square analysis showing the relationship between the socio-economic characteristics of the respondents and challenges to using climate change adaptation strategies

Chi-square analysis showed that secondary occupation (p=0.008), mode of land ownership (p=0.000), types of crops grown (p=0.000), secondary occupation (p=0.000), farming experience (p=0.001), and farm size (p=0.001) all had a significance relationship. This implies these variables all had significant effects on challenges to the use of adaptation strategies to climate change among root and tuber crop farmers in the study area.

Table 6: Chi-square analysis showing the relationship between the socio-economic characteristics of the respondents and farmers' level of awareness of the effect of climate change

Variables	p-value	df	P-value	Decision
Mode of land ownership	30.717	5	0.000	Significant
Secondary occupation	15.510	5	0.008	Significant
Farming experience	20.287	5	0.001	Significant
Types of crops grown	68.946	30	0.000	Significant
Farm size	27.30	9	0.001	Significant

CONCLUSION AND RECOMMENDATIONS

The study concluded that most respondents were around 48 years old, had an average household size of 4, and 23 years of farming experience, primarily planting cassava. Drought and high rainfall were identified as climate change indicators, with irregular rainfall significantly affecting root and tuber crop production. Adaptation strategies included early planting, mixed farming, and fertilizer use, but faced constraints like inadequate climate change information, high adaptation costs, and insufficient government support. Significant factors affecting adaptation included secondary occupation, land ownership, crop types, farming experience, and farm size. The study recommends training programs and financial support for climate-resilient agriculture.

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Effect of Carbon and Ecological Footprints on Cassava Production in Nigeria

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Abstract

This study examined the effect of carbon and ecological footprints on cassava production in Nigeria from 1980 to 2022. The time trend series, Augmented Dickey-Fuller unit root test, trend and growth rate and autoregressive distributed lag model were employed in the data analysis. Data were collected from the World Bank Climate Change Knowledge Portal, Food and Agriculture Organization (FAO) publications and Global Footprint Network. Findings indicated that the annual growth rates of cassava production, carbon and ecological footprints in Nigeria during the study period increased and were relatively high. It was observed that the coefficient of ec footprint (-0.868) was negatively signed and statistically significant at a 1% alpha level thus negatively influencing cassava production within the study period while the coefficient of carbon footprint though not significant ($p < 0.05$), had a positive relationship with cassava production. Therefore, this research aimed to improve the variety of cassava for production in a way that achieves the necessary self-sufficiency even in cases of an increase in the carbon footprint and a reduction in the ecological footprint.

Keywords: Carbon footprint, Ecological footprint, Cassava production

INTRODUCTION

Root crops are edible energy-rich underground plant structures developed from modified roots but tuber crops are crops in which the edible energy-rich storage organs develop wholly or partly from underground stems (Nteranya/IITA, 2015). Cassava is one of the major root crops in Nigeria (Federal Ministry of Agriculture and Rural Development-FMARD, 2013). In 2019, Nigeria maintained its position as the top producer of cassava globally, with an output of 59.2 million tonnes and 7.2 million hectares cultivated. This information comes from the Food and Agriculture Organization (FAO) in 2020 and FAOSTAT in 2022. The production of root and tuber crops depends largely on favourable soil and environmental conditions in which carbon and ecological footprints are inclusive. Carbon dioxide (CO_2 emissions have long-term residual effects on the environment, affecting humans and ecosystems. In recent years, changing climatic parameters and CO_2 emissions have resulted in alarming outbreaks of several environmental risks affecting the ecological footprint of the nation (Amaefule *et al.,* 2023). Environmental footprint measures the amount of biologically productive land and water area required to produce all the resources an individual, population, or activity consumes and absorb the waste they generate, given prevailing technology and resource management practices (Global Footprint Network, 2021). Thus, it is the only metric that measures how much nature we have and how much nature we use. It can then be compared with biological capacity (bio-capacity), the magnitude of productive area available to generate these resources and absorb the waste (Ewing *et al.,* 2010). Carbon dioxide (CO_2 emissions have long-term residual effects on crop production, and the environment, affecting humans and ecosystems. On average, carbon footprint represents more than 50% of the total ecological footprint in the world (Global Footprint Network, 2018). Plants grown at higher concentrations of carbon dioxide have lower stomatal conductance and transpiration. This means that plants absorb less water and nutrients and biomass becomes less nutritious (FAO, 2022). Nigeria is expected to emit more GHGs very shortly. Such emissions will significantly affect the ecological footprint resulting in an environmental deficit region. This calls for more ambitious future mitigation efforts in keeping with the country's international climate commitments and massively increasing adaptation finance to contribute to the global efforts to achieve a net zero emission. However, the effect of carbon and ecological footprint on the agricultural sector is still limited in the literature. Taking the basis that little and limited research work has been reported and added to the literature, this research represents a fresh and obligatory attempt to examine the dynamics of carbon/ecological footprints and climate parameters, and how they influenced root and tuber crop production in Nigeria from 1980 to 2021.

METHODOLOGY

The study was carried out in Nigeria. The study made use of secondary data. The data were obtained from the World Bank Climate Change Knowledge Portal, Food and Agriculture Organization (FAO) publications and Global Footprint Network. The secondary data for the research covered a period of 1980-2022 comprising cassava production, carbon and ecological footprints.

Analytical procedures and model specifications

Unit root testing was done using the Augmented Dickey-Fuller (ADF). The study adopted econometric approaches such as trend analysis and ARDL to analyze the data collected. The trend and growth rate of cassava production, carbon and ecological footprints in Nigeria were realized using the quadratic trend equation and growth model, respectively. The model is stated as:

$$\text{In}C_{it} = \alpha o + \alpha_1 T + \alpha_2 T^2 + u_t \quad (1)$$

Where;

In	=	natural logarithm,
i	=	Cassava (metric tonnes); Carbon footprints (metric tonnes), Ecological footprints (g/ha)
T	=	time trend variable measured in years,
β_0, β_1	=	Parameters to be estimated,
u_t	=	error term.

The generalized ARDL (p,q) model is specified as:

$$C_t = \gamma_{0i} + \sum_{i=1}^{p} \delta_1 Y_{t-1} + \sum_{i=0}^{q} \beta_i^{`} X_{t-1} + \varepsilon_{it} \quad (2)$$

Where;

C_t	=	Cassava production;
B, δ	=	coefficients;
γ	=	constant; i = 1,...k: p, q = optional lags orders;

ε_{it} = vector of the error term.

The Bounds' test

The bounds test hypothesises that the coefficients of the long-run equations are all equal to 0, that is, there is no co-integration.

H_{01}: $b_1 = b_2 = b_3 = b_4 \ldots b_n = 0$

H_{A1}: $b_1 \neq b_2 \neq b_3 \neq b_4 \ldots b_n \neq 0$.

To perform the bounds test for co-integration, the conditional ARDL (p_1, $q_{i=1}$) model with n variables is specified as:

$$\Delta \text{InC}_t = a_{01} + b_1\text{InC}_{t-1} + b_2\text{InCfp}_{t-1} + b_3\text{InEfp}_{t-1} + \sum_{i=1}^{p} a_4\Delta\text{InC}_{t-1} + \sum_{i=1}^{p} a_5\Delta\text{InCfp}_{t-1} + \sum_{i=1}^{p} a_6\Delta\text{InEfp}_{t-1} + \varepsilon_t \quad (3)$$

Following the Bounds test, if there is no co-integration, the short-run ARDL (p_1, $q_{i=1}$) model is specified as:

$$\Delta\text{InC}_t = a_{01} + \sum_{i=1}^{p} a_1\Delta\text{InC}_{t-1} + \sum_{i=1}^{p} a_2\Delta\text{InCfp}_{t-1} + \sum_{i=1}^{p} a_3\Delta\text{InEfp}_{t-1} + \varepsilon_t \quad (4)$$

RESULTS AND DISCUSSION

Trend of Cassava production in Nigeria (1980-2022)

This trend reveals a continuous increase in cassava production during the period under study. The result further shows that cassava production was highest in Nigeria in 2018. Cassava production showed significant growth and a compound growth rate of 4.43% during the period under review (1980 – 2022). This is in line with the findings of Kenyon *et al.* (2016) who reported that the area of root and tuber crops annually planted in SSA (Nigeria inclusive) has progressively increased inch by inch over the years.

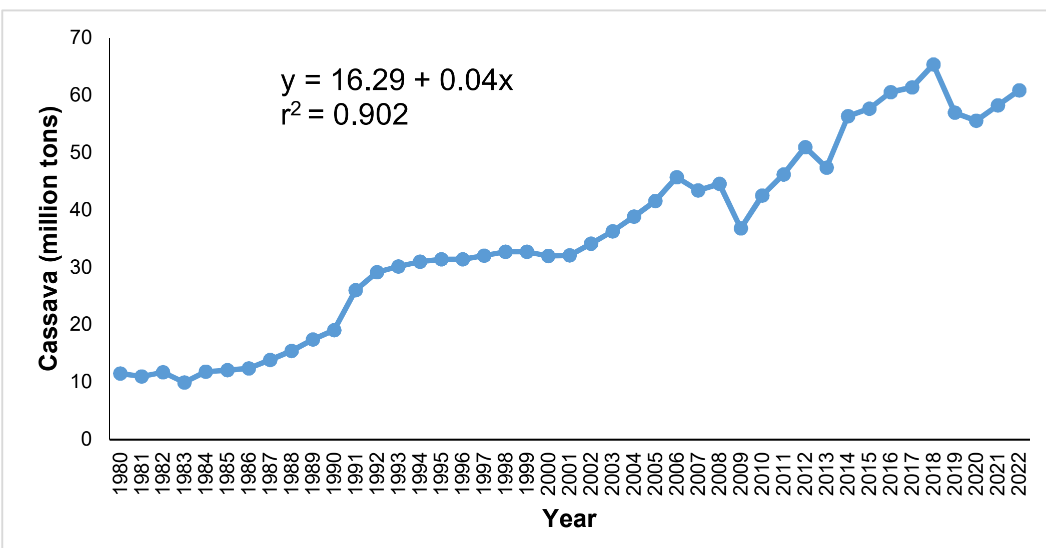

Figure 1: mean cassava output in Nigeria (1980 - 2022)

Results in Figure 2 showed that the carbon footprint in Nigeria from 1980 to 2022 maintained a steady rise from 1980 to 1989 before it decreased to 8.959kt in 1990, approximately constant values between 1990 and 1995 and a continuous upward trend from 2001 to 2022. The carbon footprints or CO_2 emissions maintaining an upward trend portends serious health implications and environmental hazards. This most dangerous and prevalent greenhouse gas is the major cause of climate change, which results in food supply disruptions, especially concerning root and tuber crop production,

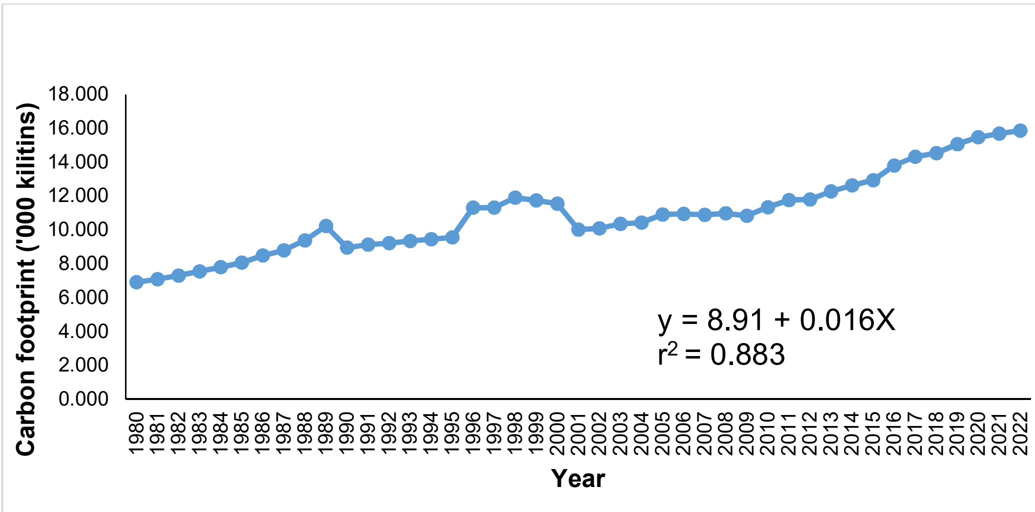

Figure 2: Annual mean carbon footprint in Nigeria (1980 - 2022)

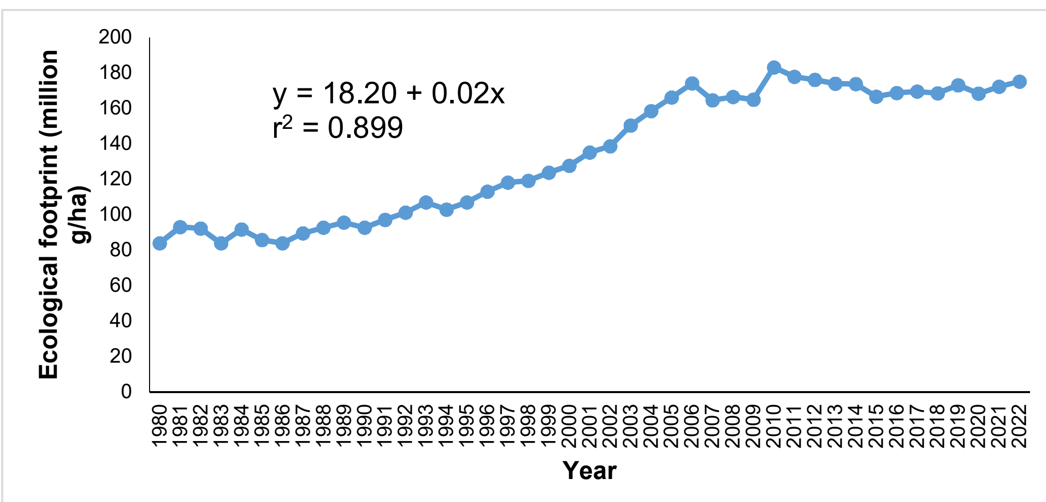

Figure 3: Annual mean ecological footprint in Nigeria (1980 - 2022)

Results in Figure 3 show that on average ecological footprint in Nigeria from 1980 to 2022 maintained an upward trend from 1980 to 2022. This implies an increase in the production and consumption activities of the country which may have deteriorating effects on the environment.

Unit Root Tests

The unit root test results were estimated by considering the order of integration of each variable using the Augmented Dickey-Fuller (ADF).

Table 1: Augmented Dickey-Fuller (ADF)/unit root tests

Variables	Test statistic	1%	5%	Order of Integration
ΔLnCassava	-0.554	-3.641	-2.955	1(1)
ΔLnCarbon footprint	-0.090	-3.641	-2.955	1(1)
ΔLnEcological footprint	-0.556	-3.641	-2.955	1(1)

Source: Computed by the author (2024)

Table 1 shows that all variables were stationary at order one, **I** (1). Therefore, the null hypothesis of the presence of a unit root is rejected. Thus, the use of autoregressive distributed lag (ARDL) estimation technique method is employed in this study

Relational Response of Cassava Production to Changes In Carbon And Ecological Footprints In Nigeria (1980-2022)

The estimated ARDL result of the response of cassava to changes in carbon and ecological footprints in Nigeria is presented in Table 2.

Table 2: ARDL estimates of the response of cassava production to changes in carbon and ecological footprints in Nigeria.

Variable	Coef.	Std. error	Z	P>|z|
Constant	-0.73766	1.4445	-0.51	0.613
Carbon footprint	0.0930985	0.1392989	0.67	0.508
Ecological footprint	-0.868362	0.2957122	-2.94***	0.006
R^2	0.9804			
R^{-2}	0.9782			
F statistic	450.16***			

Source: Computed by the author (2024)

The coefficient of ecological footprint (-0.868362) was negatively signed and statistically significant at a 1% alpha level. This result is in line with *a priori* expectation. Environmental footprint a method of measuring the overall impact of human activities on the earth (Kutlu and Kutlu, 2022) applied a negative influence on cassava production. This indicates that increased ecological footprints decreased cassava production in Nigeria. Carbon footprint and cassava production in Nigeria were positively but insignificantly related.

CONCLUSION AND RECOMMENDATIONS

Based on the findings of this study the following conclusions were drawn from the study. The annual growth rate of cassava production, carbon and ecological footprints in Nigeria during the study period increased and were relatively high. Ecological footprint hurt cassava production, while carbon footprint had a positive significance ($p < 0.05$). Research must be intensified to improve cassava variety for an increase in production in a way that their rate of growth will achieve the needed self-sufficiency even in the scenario of carbon footprint increase and decrease in ecological footprint. An increase in carbon emissions threatens domestic food production in Nigeria. This fact highlights the importance of ensuring adequate policy measures to drastically reduce the extent of carbon emissions, especially those emanating from bush burning, deforestation and fossil fuel consumption. Thus, increasing the environmental footprint in Nigeria due to food crop production.

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Influence of Different Rates of Poultry Manure on the Growth and Yield of Radish (*Raphanus sativus,* L.) at Naraguta Village, Jos, Platuea State Nigeria

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Abstract
An experiment at the University of Jos, Nigeria (May-August 2024) studied the effects of different poultry manure rates on radish growth and yield. Six treatments (0, 25, 50, 75, 100, and 125 kg/ha) were tested using a Randomized Complete Block Design. The highest growth parameters (number of leaves, plant height, leaf area, root length, root diameter, and root weight) were observed at 75 kg/ha. Soil analysis showed pH 6.4, with nutrient content in poultry manure including nitrogen (2.16%), phosphorus (0.58%), potassium (0.61%), sodium (0.24%), calcium (2.41%), and magnesium (1.3%). The study concluded that 75 kg/ha poultry manure optimizes radish growth.
Keywords: Control, Highest, Lowest, Manure, Poultry, Radish, Raphanus, Rate and Sativus

INTRODUCTION

Radish (*Raphanus sativus* L.) is an edible root vegetable from the Brassicaceae family, known for its rapid growth and adaptability. Originating in Asia, China, and Europe, it is cultivated in tropical and temperate climates (Etisami and Tajpour 2016). Radishes are typically grown for their tender young roots, which can be eaten raw in salads or as pickles, containing mustard oils that give a characteristic pungency. They provide moderate vitamin C (18%) and other nutrients in small amounts, including water (95%), carbohydrates (3%), protein (1%), and negligible fat. Radishes also contain sulforaphane, which has anti-cancer properties and acts as an expectorant (Genebank, 2022). The crop's easy cultivation and climate adaptability contribute to its popularity. Radish leaves are good sources of vitamin A and are used as leafy vegetables. Global radish production is about 7 million tonnes yearly, accounting for 2% of world vegetable production. Despite their benefits, radishes are not commonly cultivated or consumed in Nigeria. However, due to their nutritional and medicinal values, they could help address malnutrition in Nigeria (Ossai *et al*., 2020). Conventional agriculture's reliance on chemical fertilizers, which harm human health and the environment, has led scientists to advocate for organic fertilizers like poultry manure, which improves soil conditions and plant growth (Khatri *et al*., 2019). Organically produced radishes are of better quality and safer from nitrate accumulation. Poultry manure, in particular, enhances soil conditions and nutrient availability, boosting radish growth (Binju Maharjan, 2021). This research studied the effects of different rates of poultry manure on radish growth and yield.

MATERIALS AND METHODS

An experiment at the University of Jos, Nigeria (May-August 2024) studied the effects of different poultry manure rates on radish growth and yield. Six treatments (0, 25, 50, 75, 100, and 125 kg/ha) were tested using a Randomized Complete Block Design. The highest growth parameters (number of leaves, plant height, leaf area, root length, root diameter, and root weight) were observed at 75 kg/ha. Soil analysis showed pH 6.4, with nutrient content in poultry manure including nitrogen (2.16%), phosphorus (0.58%), potassium (0.61%), sodium (0.24%), calcium (2.41%), and magnesium (1.3%). The study concluded that 75 kg/ha poultry manure optimizes radish growth.

RESULTS AND DISCUSSION

The results indicated that the soil was slightly acidic and sandy loam soil. In the analysis, most of the elements in the soil were observed to be low. Soil amelioration using poultry manure is appropriate to increase crop yield (Table 1).

Table 1: Results of the physiochemical properties of the soil of the Experimental site

Element	Values
Soil pH (H_2O)	6.4
Sand (%)	61.56
Silt (%)	20.2
Clay (%)	18.44
Ca (cmol/kg)	1.85
Organic matter (%)	0.08
Mg (cmol/kg)	0.50
Na (cmol/kg)	0.19
K (cmol/kg)	0.09
EC (H+ + AL+)	1.60
CEC (cmol/kg)	4.34
N (%)	0.06
Organic carbon (%)	1.85
P (ppm)	8.0
EC	0.14

Source: Federal College of Land Resources, Kuru

Also, the results of the analysis of the nutrient content of the poultry showed that nitrogen, calcium and magnesium were higher than the remaining elements which were low.

Table 2: Results of the analysis of the nutrient content of Poultry manure

Element	Percentage nutrient content
Nitrogen	2.36
Phosphorus	0.68
Potassium	0.61
Sodium	0.25
Calcium	2.41
Magnesium	1.60

Source: Federal College of Land Resources

Effect of poultry manure on the number of leaves per plant

The experiment showed that poultry manure significantly influenced the number of radish leaves at 16, 32, and 48 days after sowing (DAS). The highest number of leaves per plant (2.8 at 16 DAS, 5.3 at 32 DAS, and 7.7 at 48 DAS) was recorded with 75 kg/ha of poultry manure. This rate was optimal, as higher rates did not increase leaf numbers. The lowest leaf numbers were observed in the control group with no manure. The study attributed these results to the low C/N ratio of poultry manure, which enhances nutrient release. Similar findings were reported by Umar *et al*. (2019) and Ijoyah and Sophie (2009).

Table 3: Effect of Poultry Manure rates on mean number of leaves per plant at 16, 32 and 48 days after sowing

Treatments (kgha^{-1})/DAS	16	32	48
0 (control)	2.2	4.1	5.3
25	2.2	4.1	5.3
50	2.5	5.1	7.5
75	2.8	5.3	7.7
100	2.3	4.8	7.7
125	2.3	4.4	6.5
LSD	1.3	1.8	4.0
CV (%)	9.72	10.77	13.63

Effect of poultry manure on plant height (cm)

The experiment showed that poultry manure significantly influenced radish plant height at 16, 32, and 48 days after sowing (DAS). The tallest plants (7.98 cm, 12.62 cm, and 15.75 cm) were observed with 75 kg/ha of poultry manure, followed by 50 kg/ha. The increase in height is attributed to the high concentration of readily available and slow-release nitrogen in the manure. Above 75 kg/ha, decline plant height (cm), indicating 75 kg/ha as the optimum rate. The shortest plants were in the control group with no manure. These findings align with previous studies by Khatri *et al*. (2019), Uddain *et al*. (2010), and Subedi *et al*. (2018).

Table 4: Effect of Poultry Manure on mean plant height (cm) at week 16, 32 and 48 days after sowing

DAS/Treatments(kgha-1)	**16**	**32**	**48**
Control	6.18	9.98	11.62
25	6.8	10.73	12.72
50	7.5	12.19	14.39
75	7.98	12.62	15.75
100	7.35	11.12	14.20
125	7.18	10.93	14. 45
LSD	3.19	1.85	3.55
CV (%)	8.64	8.67	10.53

Effect of poultry manure on leaf Area (cm²)

The experiment showed that poultry manure significantly affected radish leaf area at 16, 32, and 48 days after sowing (DAS). The highest leaf area (17.1 cm², 57.2 cm², and 133.01 cm²) was recorded with 75 kg/ha of poultry manure, followed by 50 kg/ha (15.7 cm², 54.4 cm², and 122.1 cm²). The increase in leaf area is attributed to the adequate release of nutrients, particularly nitrogen, which enhanced leaf widening and lengthening. The lowest leaf area was observed in the control group with no manure. These findings align with Kiran et al. (2019).

Table 5: Effect of Poultry Manure rates on Leaf Area (cm^2) per plant at 16, 32 and 48 days after sowing

DAS/Treatments (Kgha-1)	16	32	48
Control	10.3	34.9	68.2
25	11.6	39.2	87.9
50	15.7	54.4	122.1
75	17.1	57.2	133.0
100	13.2	44.3	106.9
125	13.7	39.5	105.1
LSD	13.9	24.9	107.9
CV (%)	18.53	20.01	22.45

DAS: Days after sowing

Effect of poultry manure rates on Root length, root diameter and root weight (yield, Kgha-1) at harvest.

The study showed that poultry manure positively affected radish yield attributes, including root length, diameter, weight, and overall yield. The longest roots (9.8 cm) and highest root diameter (12.6 cm) were recorded with 75 kg/ha of poultry manure, followed by 50 kg/ha. The highest root weight (183.3 g) was also observed at 75 kg/ha. These results suggest that 75 kg/ha is the optimum rate to maximise radish growth and yield. The findings align with previous studies by Baloch *et al*. (2014) and Kabita *et al*. (2024), which reported similar benefits of organic manures. The shortest roots and smallest diameters were in the control group with no manure.

Table 6: Effect of Poultry manure rates mean Root length, Root diameter and Root weight at 16, 32 and 48 days after sowing

Parameters	Root length (cm)	Root Diameter (cm)	Root weight (yield (kg)
Treatments/DAS	**16**	**32**	**48**
	7.9	8.1	67.2
25 $kgha^{-1}$	8.5	9.6	114.2
50 $kgha^{-1}$	9.5	12.3	158.5
75 $kgha^{-1}$	9.8	12.6	183.3
100 $kgha^{-1}$	9.1	11.3	136.2
125 $kgha^{-1}$	9.1	10.4	131.2
LSD	3.2	6.3	128.5
Cv (%)	7.0	15.4	28.4

CONCLUSION

The results indicated that using poultry manure in radishes increases yield and enriches the soil. Based on the outcome of this research work, it can be concluded that the application of poultry manure at the rate of 75$kgha^{-1}$ significantly increased the growth and yield parameters of radish beyond which the values of the parameter declined.

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Studies on Physico-Chemical Parameter, Fish Species Composition and their Condition Factor in Guma River in Obi Local Government Area of Nasarawa State, Nigeria

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Abstract
Study on the ichthyofauna and physico-chemical parameters of Guma River, Obi Local Government Area of Nasarawa State, was carried out for a period of four months (April-July, 2021). Fish specimen were obtained from the fishers fishing in the river while water sample were analysed twice a month using Lamotte aquaculture testing kit. The result showed that a total of 21 fish species belonging to 10 families were present in the river which was considered rich enough for that type of water body. The families Cichlidae, Characidae, Mormyridae, Bagridae and Clariidae constituted the dominant fish species in the river with 31.11%, 15.98%, 15.00%, 11.95% and 8.20% respectively. The result further shows that most of the fish species has condition factor above 1, with Sarotherodon galileaus having the highest condition factor of 3 while Clarias anguillaris has the lowest condition factor of 0.88. The result of water quality showed slight variations in the monthly means and station values. Despite these variations, the values obtained were within the recommended range for fish culture, for most of the tropical freshwater fish's production.
Keywords: Physico-chemical parameters, Guma River, Fish species and Condition factor

INTRODUCTION

Icthyodiversity of a river essentially represent the fish fauna diversity and their abundance (Shivashankar and Venkataramana, 2012). Monitoring of water quality is the first step that can lead to management and conservation of aquatic ecosystem. The seasonal variations in physio-chemical factors have a profound effect on the distribution and population density of both fauna flora in any aquatic ecosystem (Rafique *et al*., 2002). Poor water quality may be caused by low water flow, municipal effluents and industrial discharges (Chimanat and Traichaiyaporn, 2010). All living organisms have tolerable limits of water quality parameters in which they perform optimally. A sharp drop or an increase within these limits has adverse effects on their body functions (Kiran, 2010). Poor water quality can result in low profit, low product quality and potential human health risks. Production is reduced when the water contains contaminants that can impair development, growth, production or even cause mortality to the cultured species. Some contaminants can accumulate to the point where it threaten human health even in low quantities and cause no obvious adverse effects (Philminaq, 2014).

However, according to Jamu and Ayinla (2003), the yields of most of these inland waters are generally on the decline due to environment degradation such as water pollution and improper or poor management of fisheries resources. Environmental Protection Agency (EPA) recommended species richness and relative abundance as ecological risk assessment in aquatic ecosystem (EPA, 2007). Odo *et al*. (2009), reported an estimated fifty two (52) fish species belonging to seventeen (17) families from Anambra River, Nigeria. The fisheries and fish resources of Nigeria are not only of considerable economic important but they are also making a significant contribution to national food security and as well as providing a major source of employment in rural areas. The fish stock diversities are directly dependent on the quality and quantity of water resources in the country (Bolorunduro, 2003). Condition factor compares the wellbeing of a fish and is based on the hypothesis that heavier fish of a given length are in better condition (Bagenal and Tesch, 1978). Condition factor has been used as the index of growth and feeding intensity (Fagade, 1979). Condition factor decrease with increase in length (Fagade 1979); and also influence the reproductive cycle in fish (Welcome, 1979). This study is aim at determining the relationship between physio-chemical parameters and fish species of River Guma in Obi Local Government of Nasarawa State.

MATERIALS AND METHODS

Description of Study Area

The study was carried out in River Guma which is one of the perennial rivers in Obi L.G.A of Nasarawa State. The river is situated between latitude 8º. 201N and 8º. 231N and longitude 8º. 401E and 8º. 441E. The River is susceptible to flooding in raining season with high water volume, but less water during dry season.

Collection of Fish Specimen

Fish specimen were collected twice in a month from fishermen fishing in the river and was identified according to species and family as described by Olaosebikan and Raji (2013).

Physico-chemical Parameters Analysis

Water sample was collected twice in a month beginning from April, 2021 to July, 2021. Physico-chemical parameters of the water body was analyzed using LaMotte Aquaculture testing kit (model AQ-2 code 3633-03). Water temperature was determined in the field using an analog clinical thermometer of LaMotte aquaculture test kit. The water temperature was taken by lowering the electrode of the thermometer into the water at immersion level for 3-5 minutes and removed, the reading was taken immediately. The readings was taken in degree Celsius. Turbidity was determined in the field using Secchi disc.

Determination of Condition Factor and Fish Species Abundance.

Simple percentage was used to check for fish species abundance and the condition factor (k) of the fishes was estimated from the relationship of k= w (100).
Where: K= condition factor, W= weight of fish (g), L= fish length (Length of fish cm), 100= constant.

Statistical Analysis

Data obtained for physico-chemical parameters was subjected to one way analysis of variance (ANOVA) to verify significance difference using SPSS version 20.0. Means was separated using least significance difference (LSD) while descriptive statistic was used for fish species composition.

RESULTS AND DISCUSSION

Table 1: Mean Physico- Chemical Parameters Measured at Different Study Sites of Guma River

Parameters	Sites A	Sites B	Sites C
Temperature (°C)	25.50±0.50^a	26.45±0.25^a	26.50±0.50^a
Turbidity (cm)	20.50±0.50^a	22.25±0.25^a	23.50±0.50^a
Total Suspended Solids (ppm)	4.15±0.35^b	4.40±0.60^b	7.65±0.15^a
Ph	6.10±0.10^a	6.25±0.25^a	6.20±0.20^a
Dissolved oxygen (mg/l)	6.10±0.10^a	5.05±0.05^a	4.50±0.30^b
BOD (ppm)	1.11±0.10^c	2.23±1.40^b	2.95±0.15^a
Total hardness (ppm)	100.50±0.50^b	101.50±0.50^b	148.00±3.00^a
NH_3-N (ppm)	1.76±0.05^c	2.21±0.20^b	2.68±0.23^a
Alkalinity (ppm)	36.50±1.50^b	40.50±0.50^a	42.00±3.00^a
Electrical conductivity (µs/mm)	170.00±10.00^a	132.50±2.50^b	132.50±7.50^b

^{abc} Mean values with different superscript along the row are significantly different ($p<0.05$)

Table 2: Mean monthly physico-chemical parameters measured at different study months

	Temperature (^{0}C)	Turbidity (cm)	TSS (ppm)	pH	DO (mg/l)	BOD (ppm)	Hardness (ppm)	NH_3-N (ppm)	Alkalinity (ppm)	EC (µs/mm)
April	26.75^a	35.50^a	3.80^c	6.25^b	4.65^b	1.16^c	101.00^c	1.65^c	36.00^d	162.50^a
May	26.25^a	33.00^a	3.90^c	6.35^b	4.70^b	1.90^b	107.00^b	1.95^c	38.50^c	142.50^b
June	25.25^a	20.50^b	6.05^b	6.95^b	5.25^a	2.60^a	138.00^a	2.35^b	40.50^b	136.50^c
July	25.50^a	17.50^c	7.35^a	7.50^a	5.90^a	2.71^a	140.00^a	2.70^a	43.50^a	127.00^d
G.Mean	25.94	26.63	5.28	6.76	5.13	2.09	121.50	2.16	39.63	142.13
SEM	0.34	4.47	0.86	0.29	0.29	0.26	10.19	0.23	1.59	7.50

^{abc} Mean values with different superscript along the row are significantly different ($p<0.05$)

Table 3: Mean value of physico-chemical parameters measured in Guma river compared with recommended range of WHO (2010)

Parameters	Site average	Recommended range (WHO, 2010)
Temperature (°C)	26.15	15-35
Turbidity (cm)	22.08	30-40
Total Suspended Solids (ppm)	5.40	___
pH	6.18	5.5-9.0
Dissolved oxygen (mg/l)	5.22	5.0-8.0
BOD (ppm)	4.12	3.0-6.0
Total hardness (ppm)	116.67	75-150
NH_3-N (ppm)	2.21	0.05-0.15
Alkalinity (ppm)	39.67	25-100
Electrical conductivity (µs/mm)	145	10-100

Table 4: Fish Species Identified in Guma River and their Percentage Composition

Family	Species identified	Number identified	Percentage (%)
Cichlidae	*Tilapia zilli*	87	12.08
	Oreochromis niloticus	65	9.03
	Tilapia dageti	22	3.06
	Sarotherodon galilaeus	16	2.22
	Hemichromis bimaculatus	34	4.72
	Sub Total	**224**	**31.11**
Characidae	*Hydrocynus lineatus*	28	3.89
	Hydrocynus forskalli	49	6.81
	Alestes baremose	38	5.28
	Sub Total	**115**	**15.98**
Claridae	*Clarias gariepinus*	30	4.17
	Clarias anguillaris	18	2.50
	Heterobranchus bidorsalis	11	1.53
	Sub Total	**59**	**8.20**
Mormyridae	*Mormyrus rume*	65	9.03
	Mormyrops deliciosus	24	3.33
	Hyperopisusbebe occidentalis	19	2.64
	Sub Total	**108**	**15.00**
Bagridae	*Bagrus bayad*	57	7.92
	Clarotes laticipe	29	4.03
	Sub Total	**86**	**11.95**
Chanidae	*Channa obscura*	25	3.47
Malapteruridae	*Malapterurus electricus*	12	1.67
Gymnarchidae	*Gymnarchus niloticus*	37	5.14
Osteoglossidae	*Heterotis niloticus*	46	6.39
Mochokidae	*Synodotis clarias*	8	1.11
Total 10	**21**	**720**	**100**

Physico-Chemical Parameters of Guma River

Most of the physic-chemical parameters analysed were within range for most tropical fish species production and survival. The mean water temperature observed between the months of study could be attributed to the effect of rainfall within the months which makes the weather warm and thereby affect the temperature of the water. Boyd and Onwughara *et al*. (2013) observed that in tropical climate, water temperature are high all the year round, Obo *et al*. (2012) observed that warm water fish grow best at temperature of between 25.0°C and 32.0°C. As the fish are cold blooded animal, its body temperature changes according to that of environment affecting its metabolism, physiology and ultimately affect the production and survival (Murhekar, 2011).

Ombaka *et al*. (2013) suggested that the clay turbidity in water to 30 cm which is in line with the values obtained in this study. Bhatnagar *et al*. (2004) reported turbidity range from 30-80 cm good for fish health.

The result obtained for TSS ranges from shows that is within the acceptable range for fish production. Oluyemi *et al.* (2014) reported maximum limit of 600mg/L for TSS is acceptable for good fish production.

The average pH recorded during the study fall within the recommended range 6.5 to 9.0 by Buridi and Gedala (2014). Ombaka *et al*. (2013) gave a pH range of 5.0 to 9.5 as suitable for aquatic life.

Dissolved oxygen attribute the survival, growth, distribution, behavioural and physiological activities of aquatic organisms, the principal sources of oxygen in water is atmospheric air and photosynthetic planktons. The highest dissolved oxygen observed is between ranges and may be attributed to the greater and frequent agitation rate by wind current. Lower levels of oxygen in water indicate microbial contamination or corrosion of chemical substances in the aquifer (Olumuyiwa *et al*., 2012).

The BOD obtained in this study shows that the river is not polluted. KEBS (2010) reported that BOD range of 2 to 4 mg L-1does not show pollution while levels beyond 5 mg L-1are indicative of serious pollution.

The value obtained during the study for total hardness is at range according to Stone and Thomforde (2004) the desirable range is 50-150 mg L-1as CaCO3 and acceptable Range is above 10 mgL1as CaCO3. Santhosh and Singh (2007) reported that hardness range of 30-180mgL-1 is suitable for fish production.

According to OATA (2008) ammonia nitrogen levels below 0.02 ppm were considered safe which means the values obtained in this study are higher and unsafe for fish. This could be as a result of bacteria decomposition of organic matter such as wasted food, faeces, sewage (Bhatnagar and Singh, 2010).

The highest value 59.00mg/l recorded for alkalinity in site 3 might be as result of denitrification, photosynthesis, sulphate reduction is mainly responsible for increasing alkalinity, while the lowest value 25.50mg/l might be as a result of respiration, nitrification and sulphide oxidation decrease or consumed alkalinity (Nirmala *et al*., 2012).

The electric conductivity obtained in this study is in range with 30-5,000m Siemens/cm reported by Stone and Thomforde (2004) for fish production.

Fish Species Identified in Guma River and their Percentage Composition

The result of fish species composition of Guma River indicated that the river is very rich in fish Fauna diversity, as 21 species belonging to 10 families were recorded during the study period. The result of this study agrees with that of many researchers which include Abdullahi (2005) reported 26 species identified in River Benue around Boronji Area, Akanbi (2011), identified 26 species in Ogun estuary, Ogun State, while Nazeef and Abubakar (2013) reported 15 fish species in Dadin Kowa Dam Gombe State.

The dominance of Cichlid fishes (31.11%) is in line with what obtains in many other reservoirs and river in Africa (Balogun, 2005). The preponderance of the family in terms of species diversity, number and weight could be explained by the presence of high food resource (plankton), their prolific breeding capabilities and their strong adaptation to lacustrine conditions of these water bodies and good water quality. The high number of *Tilapia zilli*; (12.08%) could also be attributed to the absence of large numbers of predators (carnivorous species) to check their prolific breeding contributed to their high species index and abundance. Although, *Tilapia zilli* has been documented to be the dominant species in some African reservoirs (Komolafe and Arawomo, 2008), there is a likelihood of unbalanced population between forage to carnivorous species in the reservoirs. The low abundance of *Heterobranchus bidorsalis* and Synodontis clarias, in the families might be linked to their low rate of breeding, alteration in the river environmental conditions which could be less suitable for the species, migration and over exploitation of the families. The species are threaten ones and might become endangered in the river more so when it has only one species constituting the families. Wade (1985) stated that condition factor greater or equal to one is good. Most of the fish species has their condition factors greater than one. These could be attributed to the shallow nature of the river, good water quality, and suitable habitat for spawning as well as high rate of survival of larvae and fingerlings of different species coupled with high food resources accounted for the fish community composition in the river. The result of water quality parameter revealed that all the parameters are within the recommended range for fish production and survival of other fish food fauna. This is likely another reason for high record of fish species diversity in the river.

CONCLUSION AND RECOMMENDATIONS

The result of this study showed variation in fish species in the study area with Cichlidae being the most dominant fish species in the river. The high number of fish species recorded in this study shows that the river is productive. The presence of dominant species to be either primary or secondary consumers is indicating a high potential for sustainable fish production under adequate management. The good condition factor of the some species shows that there is input of allochthtonous material, and high primary productivities in the river, hence high availability of food resources and increase habitat biodiversity.

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Analysis of Climate Change Adaptation Measures in Rice Producing Areas in Niger State

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Abstract
The study examined the adaptation measures used by the rice producers in Niger State, Nigeria. A multistage random sampling method was employed to choose 150 rice producers (25 male 25 female each from zones A) of Niger State. The study make used of primary data, like group interview, personal phone calls, and questionnaire, which were administer to rice producers. The result shows that the adaptation measures used by rice producers include planting early maturing rice varieties, drought pest disease resistant varieties, early planting, pre – rain planting and late rain irrigation planting. Though few of the respondents have access to extension services, hence the study suggested providing for the rice producers enough extension knowledge, carrying out research on those adaptation measures adopted by rice producers to get the farmers acquainted with the scientific methods of practicing climate smart agricultural methods, putting in place financial and technical support to assist the producers in using those methods in modern ways to suit these climate changes in the study area.
Keywords Climate change, rice production, adaptation, measures and extension services

INTRODUCTION

Climate change has become serious issue as flooding, intermittent breakage of rainfall or drought is seen across the country in current years. Climate change especially in cultivated crops particularly in rice including root and tuber crops differ from decrease in taste and value and even low yield including land degradation. Climate is not longer more reliable like before when season is delineated with clear dry and raining seasons separately (Okonze., 2012). Even though majority of the farmers still depend on this scanty climate signs for crop production leading to waste of crop materials. NIMET(2012), argued that weather related disasters may ramify everywhere in few years to come if the trend of climate changes is allow to go on without mitigation. Investigation has revealed that climate change trend is fast increasing. This calls for urgent means of finding solutions to the ugly situation. If cannot be completely avoided but should be minimized. Researchers from different parts of the country have difference measures of mitigating climate change. Adaptation may reduce unwanted impacts of climate change although these adaptations were not given serious attention. The adaptation measures used by rice producers in the study area include planting early maturing rice varieties, use drought pest disease resistant varieties, early planting, pre – rain planting and late rain irrigation planting

According to Nandi *et al* (2012) rice seem to be the most vital world's food crop, being the most consumed food for over 50% of the world population, particularly Philippine, china, India and many other countries in Africa and Asia. Rice is the most popular eaten food across the all zones in Nigeria irrespective of economic classes. Consumption of rice continue to increase in Nigeria due to higher preference of consumers for rice, rapid population increase, urbanization and increase in income level (Kamai *et al.,*2020). These measures are all related to irrigate rice production in the study area. In Nigeria irrigated rice farming has long time history, since colonial era but was not recognized not until during the starvation and drought of seventies that much effort were made to irrigation system in Nigeria (Balogun*,et al.* 2021). Irrigated rice production in Nigeria become more operational with the introduction of Anchor Borrowers program which increase rice production in Nigeria and reduce the poverty level of small farm holders in the country drastically (Abdulmumini, 2021).

MATERIALS AND METHODS

The research was carried out in Katcha, Badeggi, Chanchaga and Rabba communities in zones A of Niger State which is located in southern Guinea savannah within latitudes 6^0 30'.and 11^0 20' N and Longitudes 2^0 30' and 10^0 30' E. These local communities are areas where crop production is main occupation especially rice production as the major source of income. The study area has many rice producers as their major occupation.. The study area has November – April as dry and May – October as raining seasons. The temperature range between 36^0 and $37^{c..}$ The impact of climate change has greatly affected the production of rice in the study area. The sampling size for the research was obtained using a multistage random sampling method that includes stage one and two. The first stage 3 local governments were randomly selected and one community chosen from each local government. These are Badeggi in Katcha local government, Chanchaga village in Lavun local government and Rabba in Mokwa local government. The second stage was selection of 50 rice farmer (25 male and 25 female) from each local government given a total of 150 rice producers. Descriptive statistics like frequency distribution, percentages mean and standard deviation were used to summarize the data.

RESULTS AND DISCUSSION

Socio-economic characteristics of rice farmers.

Table 1 shows the component of various factors for both male and female rice farmers. The variable considered were age farm size, marriage status, educational status, family size, farming experience, membership of the co-operative, annual income and access to extension services. The result depicts the age range of male to be 41 - 50 years while females were within the ranges of 51 to 60 years having 40% each in these categories, Average ages of male was 47 as against female which was 49. Majority of male have secondary education while female have primary with 44% and 40% respectively In the similar way both male and female have family sizes of between 6-10 and 1-5 persons equivalent to 46.6% and 40% for male and female respectively.

Farm size depicted that majority of male have between 3-4 hectares 46.6% while 46.6 of the female have between 1-2 hectares been the majority. The result also show that 80% of both male and female producers were married but reverse is the case with been the member of cooperative society with male having majority as member and female having majority as non-member of cooperative with 68% and53.3% respectively. In farming experience category majority of male have farming experience of 21-30 years (40%) and female have experience of 1-10 years (66.6%). This indicated that some of the male were even born in farming. The result also revealed that majority have no access to extension services as the data show that 97.3% and 93.3 of both male and female have no access to extension and have average annual income of 201,000-300,000 naira. The data have similarities in the result but with notable dissimilarities in socioeconomic factors particularly in farm size and farming experience.

Table 1: Socio- economic characteristics of respondents (n- 150)

Variable	**Male**		**Female**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Age (years)				
30 – 40	25	33.3	17	22.6
41 – 50	30	40	25	33.3
51 – 60	15	20	30	40
61 – 70	5	6.6	3	4
Mean	38	25	38	25
Education				
Primary	20	26.6	30	40
Secondary	33	14	25	33.3
Tertiary	7	9.3	15	20
Non- formal	10	13.3	5	6.6
Farm size (ha)				
< 2	15	20	35	446.6
2 – 4	35	46.6	20	26.6
5 -6	20	26.6	5	6.6
Above6	5	6.6	15	20
Family size				
1-5	25	33.3	30	40
6-10	35	46.6	28	37.3
>10	10	22.6	17	22.6
Marital status				
Single	5	6.6	2	4
Married	60	80	60	80
Divorced	5	6.6	3	4
Widowed	5	6.6	10	13.3
Member of cooperative				
Yes	51	68	35	46.6
No	24	32	40	53.3
Farming experience				
1 – 10	10	13.3	50	66.6
11 – 20	10	13.3	15	20
21 – 30	30	40	8	10.6
31 – 40	25	33.3	2	2.6
Access to extension				
No	73	97.3	70	93.3
Yes	2	2.6	5	6.6
Annual income				
100,000 – 200,000	5	6.6	3	4
201,000 – 300,000	10	13.3	6	8
Above 301,000	60	80	66	88

Source: Field survey, 2024

Farmers view on effect of climate change on the yield of rice

Climate change has been observed by the rice producer to have great negative impacts on the cultivation and yield of rice in so many ways like through variations in temperature, erratic rainfall and climate intensity on soil that may lead to soil erosion, floods and drought. Chukwuemeka, (2022) stated that climate change is a serious problem to agriculture and food security because of heavy reduction and waste of crops. The result in Table 2 show that majority of the rice producers both male and female pointed out that climate change decreases rice yield (75%) and also lead to late planting and late harvesting as indicated in the Table 2.

Table 2: Farmers view of climate change on rice yield

Variable	Male		Female	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Increase rice yield				
Yes	0	0	0	0
No	75	100	75	100
Decrease rice yield				
Yes	75	100	75	100
No	0	0	0	0
late planting of rice				
Yes	45	60	55	73.3
No	30	40	20	27.6
late harvesting				
Yes	48	64	45	60
No	27	36	30	40

Source: Field survey, 2024

Farmers source of information on weather

Table 3 depicts that majority of the rice farmers both male and female received information about weather from radio 50.6% and 69.3% followed by the research institutes 20% and 13% respectively. These were closely followed by cooperative societies as they share ideas. Extension, printed media and television were less significant in information sharing as shown in the Table 3.

Table 3: Farmers source of information on climate

Variable	Male		Female	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Farmer cooperative society	10	13.3	6	8
Extension agent	5	6.6	3	4
Research institute	15	20	10	13.3
Television	2	2.6	2	2.6
Radio	38	50.6	52	69.3
Printed Median	5	6.6	2	2.6

Source: Fiel survey, 2024

Mitigation and adaptation measures of climate to increase rice yield

Table 4 depicts the mitigation and adaptation measures used by rice farmers. The result revealed that majority of respondent both male and female 25.3% and 13% adopted planting early maturing rice varieties. This is closely followed by use of irrigation farming which is 21.3% and 80% for male and female respectively. This result indicates that majority of female farmers prefers dry season farming which is irrigation. Other measures adopted includes planting drought pest diseases resistance rice variety

25.3%, early planting, pre- rain planting and late- rain planting which were all 9.3% respectively.

Table 4: Adaptation measures adopted by farmers (n- 150)

Variable	Male		Female	
	Frequency	Percentage	Frequency	Percentage
PEMRV	19	25.3	10	13.3
DPDRRV	19	25.3	5	6.7
EP	7	9.3	-	-
PRP	7	9.3	-	-
LRP	7	9.3	-	-
IP	16	21.3	60	80

Source: Field survey, 2024

PEMRV – Planting early maturing rice variety
DPDRRV – Drought pest disease resistance rice variety
EP- Early planting
PRP – Pre- rain planting
LRP – Late rain planting
IP – Irrigation planting

CONCLUSION AND RECOMMENDATIONS

The study investigated the mitigation measures the rice producers adopted to reduce if not completely avoid the threat of climate change in their rice fields. The result shows that most of the farmers were aware of the climate change and took different measures. Most of the rice farmers were not enlighten and properly educated and guided on these strategies. The study therefore recommends giving farmers enough knowledge on climate smart agriculture by extension agents especially on these measures adopted by them.

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Physiological Evaluation of Different Organic Materials for Storage of Ginger Rhizomes

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Abstract
Ginger rhizome production in Nigeria is faced with the challenge of high postharvest losses. The study aimed was to assess the effect of organic materials on storage methods on the physiological and nutritional quantity of Ginger rhizomes. Two varieties of ginger rhizomes from two different locations were separated and stored using three different organic storage materials with control. Umugin 1 from Umudike stored with Grass coverings (UG1GS), Umugin1 from Umudike stored with wood shavings (UG1WS), Umugin 1 from Umudike stored with Palm bunch (UG1PB), Umugin 2 from Umudike stored with Grass (UG2GS), Umugin 2 from Umudike stored with Wood shavings (UG2WS), Umugin 2 from Umudike stored with Palm bunch (UG2PB), Umugin 1 from Kaduna stored with Grass (UG1GS), Umugin 1 from Kaduna stored with Wood shavings (UG1WS), Umugin 1 from Kaduna stored with Palm bunch (UG1PB). The UG1C, UG2C and UG1C were used as the control treatments for the three varieties. The temperature and humidity of the environment were monitored and the rhizomes were weighed monthly to access the weight loss, sprouting and proximate and oleoresin composition was determined using standard methods. The lowest percentage of weight loss was observed in sample-covered with grass.

Keywords: Storage, Ginger rhizomes, nutrient quality, organic materials, proximate and oleoresin composition.

INTRODUCTION

Ginger (*Zingiber Officinale*) is a very crucial cash crop in our country today, due to its vital oil and Oleoresin contents. Ginger processed into powder is used in the preservation of meat, soup making (Okafor and Okafor, 2007) and also in making beverages such as ginger drinks (Jakes and Susan, 2007). In Nigeria, among other spices, for instance, garlic, onion and pepper that are consumed, ginger is one of the majorly grown on a commercial scale for export and it is highly recommended in the international market due to its aroma and pungency that arises from its oleoresin (non-volatile) and essential oil (volatile) contents (Famurewa *et al*,.2011). However, ginger is grown by vegetative means. Ginger is planted during April-May and harvested about 7-8months from December- January after planting when the leaves turn yellow and gradually wither. Ginger is broadly utilized worldwide as a spice, flavouring agent and herbal remedy. It also helps in treating diseases in the traditional system for instance vomiting, palpitation, loss of appetite, digestion, inflammation and constipation (Singletary, 2010). Ginger contains 1-2% of essential oil, which provides a unique flavour to the spice (Lawrence B.M, 2000). In root and tuber crops, storage is one of the major challenges often beyond the usual farmer's control. In addition, it was reported that reducing post-harvest losses would be a valuable tool for preventing global food shortages (Ezeocha and Adamma, 2017). The main aim of storage is to prevent deterioration of the (physiological and nutritional) quality of the crops.

MATERIALS AND METHODS

The experiment was conducted between January 2022 to April 20023. A 10kg of freshly harvested ginger rhizome were obtained from the field of the Ginger Crops Programme of National Root Crops Research Institute Umudike and Maro station. The temperature and Humidity were done using the HTC-I Hygrometer. The organic materials, wood shavings were purchased at the timber market Umuahia and Palm bunch and Grass were obtained from within and used as storage materials. The samples were stored for a period of 3 months. Proximate analysis was done at the beginning of the experiment and monthly throughout storage using the AOAC 1990 method. Oleoresin content was determined using Onwuka (2005) method.

Nutritional composition and oleoresin content of ginger rhizomes at three-month storage

Sample	% MC	% CP	% FAT	% CF	% ASH	% CHO	EVkcal	%OLEO
Day 0	11.94a	8.16a	0.63c	7.56b	2.68a	69.05d	314.49e	7.74d
Umugin1C	9.45g	6.76e	0.46d	7.55b	2.69def	73.10c	323.44b	7.74abcd
Umugin2C	10.53c	6.86d	0.41e	7.05c	2.63gh	72.54f	321.27e	7.68de
Umugin1KC	9.50g	6.75e	0.47d	7.64ab	2.70cde	72.96d	323.03c	7.73abcd
Umugin1PB	9.73e	6.92c	0.57a	7.36c	2.76a	72.39g	322.26d	7.78ab
Umugin2PB	10.85a	7.02a	0.51c	7.64ab	2.71bcd	71.76i	319.67g	7.69cde
Umugin1KPB	9.71ef	6.91c	0.56ab	7.16c	2.75ab	72.42g	322.29d	7.79a
UmuginIWS	9.34h	6.58f	0.42e	7.72a	2.67efg	73.49a	323.99a	7.72cde
Umugin2WS	10.03d	6.72e	0.37f	7.52b	2.60h	73.37b	323.65b	7.66e
Umugin1KWS	9.31h	6.55f	0.43de	6.93d	2.66fg	73.53a	304.10h	7.72bcd
Umugin1GS	9.61f	6.82d	0.52bc	7.58b	2.75abc	72.74e	322.92c	7.76abc
Umugin2GS	10.70b	6.97b	0.45de	7.12c	2.68ef	72.10h	320.26e	7.68de
Umugin1KGS	9.62f	6.82d	0.51c	7.58b	2.74abc	72.73e	322.79c	7.73abcd

Umugin1C = Variety1Control; Umugin2C = Variety 2 Control; Umugin1KC = Variety 1Kaduna Control ; Umugin1PB = Variety1 Palm bunch; Umugin2PB = Variety2 Palm bunch; Umugin1KPB = Variety1Kaduna Palm bunch; Umugin1WS = Variety1 Wood shavings; Umugin2WS = Variety2 Wood shavings; Umugin1KWS = Variety1Kaduna Wood shavings ; Umugin1GS = Variety1Grass; Umugin2GS = Variety2Grass; Umugin1KGS = Variety1Kaduna Grass.

The nutritional composition and oleoresin content of ginger rhizomes at the onset and one-month storage are presented in Tables 1, 2, 3 and 4. The moisture content, crude protein, fat and oleoresin content of rhizomes showed a significant reduction over time of storage except for crude fibre, ash, and carbohydrate and Energy value. It has been reported that moisture and protein levels decrease with time (Maalekuu *et al*., 2014). This reduction could be due to respiration, transpiration and sprouting during storage. The crude protein recorded in this study was higher than the report in Odebunmi *et al*., 2010 which indicated that spices have lower crude protein. This lower content of protein in the rhizomes promotes its use as an additive in monogastric feeding. However, this physiological activity is promoted by high temperature and high humidity of the storage environment (Treche and Agbor-Egbe, 1996). There was an increase in crude fibre and ash content of the rhizomes in the first two months but a decrease occurred in the last month of storage. This increase could be obvious due to the high percentage of moisture loss during storage. The crude fibre was almost the same value when compared with work done by (Remadevi *et al.,* 2014). The ash content ranges from (2.76-2.17%) which were lower when compared with work done by (Remadevi *et al*., 2014). The ash content which informs the presence of mineral elements ranges from (2.68-2.52%) was almost the same when compared with the report (1.23-2.54%) by Odebunmi *et al*., (2010). It shows that ginger rhizome powder could supply an adequate, amount of minerals required for proper growth and development. The carbohydrate reduction was reported in a similar work reported by (Sahore *et al*., 2007). The carbohydrate content of yam tuber decrease during storage due to the conversion of starch to sugar and respiratory losses of sugar as carbon dioxide. The oleoresin content decrease after one month of storage this could be a result of the high temperature and the presence of oxygen during the time of storage reported by (Jamie Ayton *et al*., 2012) effect of storage on Olive Oil. Further decreased after three months of storage, could also be a result of moisture and longer storage.

CONCLUSION AND RECOMMENDATIONS

From the result obtained, we concluded that the most suitable organic material that had most suitable organic material that maintains the physiological and nutritional quality of ginger rhizome was grass, followed by wood shaving and palm bunch. Moreover, exposing the rhizome to environmental conditions/factors resulted in weight loss, sprouting and significant changes in the nutritional composition.

Following the high rate of deterioration during post-harvest, it is highly recommended that the use of organic materials should be adopted by the farmers because it helps in reducing loss during storage. However, organic materials are very cheap and affordable to acquire from our surroundings. It also serves as waste management in our society. Moreover, the variety that was covered with grass maintains the nutritional composition and it could be recommended for industrial purposes.

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Investigating the Factors Affecting Poultry Operators' Decision to Add Value in Abia State, Nigeria

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Abstract

The study assessed Value addition and factors affecting poultry operators' decision to add value in Abia state, Nigeria. Primary data were collected using a questionnaire from 120 poultry farmers selected using multistage sampling techniques. The data were analyzed using Simple descriptive tools, and probit regression models. The study revealed that 63% of the respondents were male with a significant proportion (72%) married with a household size of 1-5 persons. The majority (72 %) of the farmers had one form of education or the other. The result further showed that output size, years of experience, income level, and land availability positively affected this decision-making at 10%, 5%,5%, and 5% respectively while the amount of credit and cost of production negatively affected the same decision at 5% and 1% level of significance respectively.

INTRODUCTION

Agriculture in Nigeria has remained the largest sector contributing nearly 39% to the Gross Domestic Product for the past two decades and employing almost 60% of its workforce. Over 80% of the country's population living in rural areas is directly or indirectly dependent on agriculture for its livelihood (NBS. 2005). Agriculture provides a primary means of employment and accounts for more than one-third of the total Gross Domestic Product (GDP) and labor force in Nigeria (Evbuomwan, 2006). FOS (1996) reports that food production in Nigeria increased at a rate of 2.5% while food demand increased at a rate of more than 3.5% due to a high rate of population growth of 2.83%. Nigeria, like other developing countries, suffers from protein deficiency due to rapid population growth, low productivity in the agricultural sector, rural-urban migration, and a decline in productivity of the livestock subsector (Abubakar. 2000). Among livestock-based vocations, poultry occupies a pivotal position because of its enormous potential to bring about rapid economic growth. The importance of the poultry sub-sector is chiefly in the provision of meat and egg as well as the provision of employment either directly or indirectly and the contribution to the revenue (Gross Domestic Product) of the country. Recent studies have also added to this assertion. Thus, maximizing the production process to stabilize the economy, meet food security targets, and reduce poverty among practicing households will be a great development. To this effect, value addition has been discovered as a viable tool for reaching this height. From the definition of the value chain, it is easier to understand the value chain approach, which has been applied in different fields, especially very common in agriculture and rural development to analyze a certain commodity for management and development of the value chain (James *et al.,* 2010). Value chains allow operators to invest in different activities of a production process. As a result of large volumes of outcomes of output, the fixed and variable costs, when spread over the output of eggs, meat and other produced, hence achieving economies of scale. The producers are thus able to sell the produce at competitive prices (James *et al.,*2010). The factors affecting poultry operators' decision to add value form the core of this research paper

METHODOLOGY

This research was conducted in Abia State, the Southeast geopolitical zone of Nigeria. Primary data were employed in this investigation. A well-structured questionnaire was used to extract primary data from 120 poultry operators in the study area. A multi-stage sampling procedure was adopted in this study. The first stage involved the purposive selection of three Local Governments Areas (LGA) with relatively high involvement in poultry and poultry-related activities. Ikwuano, Bende, and Aba South were chosen from Umuahia, Ohafia, and Aba respectively. The second stage involves a random selection of 40 operators from the list of poultry operators in the selected LGAs. Thus, the sample size of the study is 120 respondents.

Method of Data Analysis

Simple descriptive tools like tables, percentages, and the probit regression models were used in data analysis. The probit model for factors affecting the decision to add value is stated as:

$$\text{Probit (Y)} = X^{I}\, B + E$$

Where, EnN (0,1)

Y = 0 or 1

Y Prob (Decision to add value) = Yes or no. Yes = 1, No = 0.

X_i = Vector of independent variables

X_1 = Size of output (No of eggs, broilers, layers)

X_2 = Experience (Years)

X_3 = Income level (Above minimum wage = 1. otherwise = 0)

X_4 = Educational status (Sec School completed and above =1, otherwise = 0)

X_5 = Amount of Credit used (Yes = 1, Otherwise = 0)

X_6 = Cost of production

RESULTS AND DISCUSSION

Socioeconomic characteristics of the respondents

The result on the socio-economic characteristics of the respondents revealed that the majority of the poultry entrepreneurs in Abia state are married men in their active years with a form of education and experience in the poultry business. Table 1 indicates that the majority (48%) of the respondents were within 40-49 years, 28% were between 20-39 years and 23% were more than 50 years, implying that the poultry farmers were within their economically productive age. The result revealed that 63% of the respondents were male with a significant proportion (72%) married. The Table further indicates that 71% of the respondents had a household size of 1-5 members; implying that poultry entrepreneurs would require hired labor (other than relying on family labor) for poultry activities. A vast majority of the poultry farmers in the state were educated and experienced in the poultry business. A notable share of the respondents (46%) had secondary education, 29% had primary education, 13% had tertiary education, and 13%

had no formal education. The table shows that 37% of the respondents had work experience of 6 to 10 years. This implies that the poultry farmers were well-groomed and experienced in their business. A significant proportion of poultry operators (63%) were members of cooperatives.

Factors affecting poultry operators' decision to add value

To determine the factors affecting poultry operators' decision to add value, seven (7) independent variables were chosen and six (6) of them were statistically significant at various levels. The result showed that output size, years of experience, income level, and land availability positively affected this decision-making at 10%, 5%, 5%, and 5% respectively while the amount of credit and cost of production negatively affected the same decision at 5% and 1% level of significance respectively. The sake of the sake of this study, value addition was captured by the number of poultry value chain-related activities carried out by a particular enterprise. The value of the intercept (Y = 0.620) means that 62% of the total changes in the dependent variable were accounted for by changes in the dependent variables included in the model while the remaining 38% occurred due to random variables not included in the model (error term).

The coefficient of variable output was positively signed at 10% indicating that the probability of adding value increased with an increase in output. This indicates that operators with higher outputs will seek to expand their frontiers as they would generate more income to do so. However, in certain conditions, an increase in output may not lead to an additional chain activity, but rather, an expansion of the existing arm. This is based on comparative and competitive advantage: thus, the fear of associated risks of introducing a new chain may scare off the operators from such decisions. This finding agrees with *a priori* expectations.

Years of experience on its own was positively signed and indicates that as operators advance in experience, the likelihood event of adding value to the existing enterprise increases. This follows that experience relates to knowledge about the intricacies of production and marketing, a proper understanding of seasons of glut and boom, correct decision-making, and others, thus, such farmers are in a better position to add more chain activities to the existing ones, especially related ones. Experience is deemed as one of the most important production factors as it relates to management. Experienced operators add flair and dynamism to their activities, make better profits, and can out-smart and out-compete less-experienced counterparts.

Income level was positively related to the operators' decision to add value at a 5% level of significance. This implies that as income increases, the probability of having an additional chain activity increases because the excess profit will be re-invested into the business and this time, a new and related activity in the poultry value chain. It is therefore clear that poultry operators who have a bogus income level would add value to the existing enterprise either by expansion of the existing one or by the introduction of a new one.

Poultry operators with access to land would most likely increase their frontiers. This is given by the positive sign of the variable's coefficient at a 5% level of significance. Land as a major production factor is an expensive asset and accounts for about 30% of the initial start-up money of any business except in the case where land is owned by the entrepreneur. When this is the case, the money that should have been spent on land is invested into the business and thus, operators may enjoy expanded value chain activities. This finding is in keeping with a priori expectations.

Credit use on the other hand negatively affected the likelihood event of expanding the business at a 5% significant level. This means that the more money the operators borrowed, the less likely they were to add value to their value chain activities. This may be a result of the high interest rate stated by banks that make firms aversive to borrowing and even those who insist on borrowing find it difficult to cover costs. With this in mind, value addition in terms of expansion or introduction of a new becomes extremely difficult.
Cost of production was negatively related to poultry operators' decision to add value at a 1% level of significance indicating that as cost of production increased with a lower commensurate increase in profit, poultry operators would not seek any kind of expansion.

CONCLUSION AND RECOMMENDATIONS

Years of experience, income level, amount of credit, and land availability are the most significant factors influencing the decision to add value. More experience and income increase the likelihood of value addition, while more credit and higher production costs have a negative impact. Land availability also has a marginally positive influence.

Table 1; Socio-economic characteristics of poultry operators

Age (Years)	Percentage
20 - 39	29
40 - 59	63
60 - above	8
Total	100
Sex	
Female	37
Male	63
Total	100
Marital status	
Single	17
Married	72
Divorced	11
Total	100
Household size	
1 - 5	71
6 - 10	26
11 - above	3
Total	100
Education	
No formal	13
Primary	29
Secondary	46
Tertiary	13
Total	100
Cooperative membership	
Yes	63
No	37
Total	100
Years of experience	
1 - 5	15
6 - 10	37
11 - 15	29
21 - 25	6
Total	100

Source: Field survey, 2016

Table 2: Probit Regression Result of Factors Affecting Poultry Operators' Decision to Add Value

Parameter	Estimate	Std. Error	Z	Sig
Output size	.094	.054	2.219*	0.27
Years of experience	1.841	.587	3.135**	.002
Income level	.000	.000	2.544**	.011
Years of education	.168	.609	.277	.782
Amount of credit	-.449	.138	-3.268**	.001
Cost of production	-365	.001	-6.722***	.267
Land availability	.0831	.022	3.012**	.0721
1intercept	.071	8.333	4.925***	.620

Source: Field Survey, 2016. *** = Significant at 1%, ** = Significant at 5%, *= Significant at 10%

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Comparative Performance of Rice Value Chain Actors in Qua'an Pan Local Government Area of Plateau State, Nigeria

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Abstract

The study compared the performance of rice value chain actors in Qua'an pan Local Government Area Plateau State, Nigeria with an objective: to compare the performance of selected rice actors along the value chain in the study area. A multistage sampling technique randomly selected 106, 83 and 50 respectively for farmers, marketers and processors. Primary data was obtained through the administration of a well–structured questionnaire. Net Income model and profitability indices were used to achieve the objective. The result reveals that the average revenue generated was ₦509,681.10, ₦46,187.50 and ₦273,000.00 for rice farmers, marketers and processors. Further, the TVC of the value chain actors were ₦157,664.55 (71.70), ₦23,353.00 (68.50) and ₦113,340.00 (84.20) respectively. Also, the values of the TFC were ₦61, 503.94 (28.10), ₦10,758.25(31.50) while the average TC among the value chain actors were ₦219,168.59, ₦34,111.25 and ₦159,660.00 respectively. The values of the NI or NFI were ₦290,512.69, ₦12,076.25 and ₦138,394.71 respectively for the Rice farmers, marketers and processors. The profitability indices were: PI:0.57, 0.26 and 0.58 respectively; ROI: 1.33, 1.12 and 1.03 respectively for the farmers, marketers and processors respectively; CTO or BCR:2.33, 1.35 and 1.71 respectively; percentage of gross margin received were 57%, 26.16% and 50.69% respectively. The recommended course of action is as follows: The profitability of value chain actors can be maintained by increasing production to benefit from economies of scale. ii. The government will establish marketing infrastructures to help marketers improve their profits. Processors should be helped through import duty waivers on machinery importation and subsidies.

Keywords: Comparative Performance, Rice Value Chain Actors, Plateau state, Nigeria

INTRODUCTION

The term value chain refers to the full range of activities that are required to bring a product (or a service) from conception through the different phases of production to delivery to final consumers (Kaplinsky and Morris, 2002, Thuzar, 2019) The concept of agricultural value chain was introduced to improve productivity and profitability of the actors in the sector. Value chain is an arrangement that describes the linkages of participants and their value-creating activities that enhance the movement of goods and services from production, and processing to the end user. Pertinently, the conduct of the participants along the value chain determines the efficiency, pricing, and return accruing to each participant. The notion of a value chain underscores the system approach to value-added activities where the action of one component in a system affects every other component within the system either directly or indirectly. Although the value chain idea is relatively new in the agricultural sector, it resides in sustainable initiatives focused on improving productivity, competitiveness, and growth of Small-Medium Enterprises (Ugwuonah, 2017; Ewuzie *et al.,* 2020). Rice is among the three leading food crops of the world, with corn and wheat being the other two. Rice is a plant that is well suited to tropical climate conditions. According to FAO (2004), rice is the important staple food for 17 nations in Asia and the Pacific, nine in North and South America and eight in Africa. Nutritionally, it contains 80% carbohydrates, 7-8% proteins, 3% fat, and 3% fibre (Juliano, 1985, cited by Thurza, 2019).

Rice provides 21% of global human per capita energy and 15% of per capita protein. In Nigeria, the combinations of many factors seem to have caused a structural increase in rice consumption resulting in excess demand over supply. The major reason for this increase in rice demand is because rice has changed from an elitist to a staple food for many Nigerians (Akpokodje, 2001, Ewuzie *et al.,* 2020). For instance, Nigeria's estimated annual rice demand is at 5.1 million metric tons, yearly production on average was 4.3 metric tons of paddies and total milled rice of 2.7 million metric tons based on a milling recovering rate of 63 per cent. Therefore, there is a deficit of 2.4 million metric tons of milled rice which is bridged by importation (United States Department of Agriculture (USDA) and Foreign Agricultural Services (FAS), 2017). Unfortunately, rice supply has not matched its demand notwithstanding the government's efforts to sustain its production.

Furthermore, rice importation constitutes one of the major sources that deplete the country's foreign reserve with over one billion naira spent daily on imported rice notwithstanding that the Nigerian government is discouraging rice importation. Based on empirical evidence in Nigeria, investors have not explored the investment opportunities in rice production because they are unaware of the performance of actors that engage in the rice value chain in Nigeria. Previous empirical studies by some scholars found that local rice production has not matched demand, rice farmers' productivity has not significantly improved, farmers do not have commensurate benefits from their activities and farm gate prices have not increased proportionately with costs of inputs over the past years (Nwaobiala & Adesope, 2012; Anuebunwa, 2007; Achike & Anaku, 2010; Aree & Yaovarate, 2001; and Ben-Chendo, Lawal & Osuji, 2017). According to these findings, there is no equality between value-added and value-received among the actors in the rice value chain. Although Ugwuonah (2017) found that investment opportunities exist among the three key agricultural value chains namely; rice, cassava and aquaculture. Therefore, this study seeks to close the gaps identified by using a quantitative value chain approach to compare the performance among some actors in the rice value chain using quantitative data on the key rice value chain actors, the performance of actors along the value chain and also to determine income distribution equal among the value chain actors in the study area. The specific objectives of this study were to; i. compare the performance of actors along the value chain in the study area and ii. determine income inequality among value chains in the study area.

METHODOLOGY

Study Area

Qua'an Pan is one of the seventeen Local Government Areas(LGAs) and it is situated in the southern region of Plateau State, Nigeria. It is located at 80 48′N and 90 09′E. Its headquarters is located in the town of Baap (or Ba'ap). It has a land area of 2,478 km² and an estimated population of 325,524 people in 2023 (NPC., 2006). It is bordered to the North by Bokkos, Mangu and Pankshin LGAs, to the East by Shendam Local Government LGAs and to the West and South by Nassarawa State. Qua'an Pan has eight districts, namely; Bwall, Doemak, DokanKasuwa (Jagatnoeng), Kwa, Kwalla (Kwagallak), Kwande (Moekwo), Kwang and Namu (Jepjan). There are two major tribes in Qua'an Pan namely; Pan and the Goemai. Various dialects are spoken in the area including Mernyang, Doemak, Bwall, Jagatnoeng, Kwagallak and Goemai. The main crops cultivated in commercial quantity include Yam, Cassava, Rice, Groundnuts, Guinea Corn, Beans, Oil Palm, Shea Butter, Groundnut, Bambarram nut and Olive Oil. The people of Qua'an Pan are predominantly farmers and engage in other trades like, blacksmithing, metal works, hunting, trading and fishing.

Sampling Procedure and Sampled Size

A multistage sampling technique was adopted for this study. In stage one, the purposive sampling technique was used to select Namu and Kwalla districts from the list of districts in the study area based on the quantum of rice production. The second stage involved random selection of four villages in the Namu district and three villages in the Kwalla district. Finally, a total number of 106 farmers; 83 marketers and 50 rice millers were randomly selected representing 10% sample frame of the value chain actors.

Method of Data Collection

Primary data was obtained using a structured open and close-ended questionnaire to the respondents that was designed based on the study's objectives and was complimented with oral interviews for illiterate respondents.

Analytical Techniques

Budgetary technique

The net farm income (NFI) model determines the return to invested capital and returns to management Olukosi & Erhabor (2008). It is represented in equation (1):

$$\text{NFI} = \sum P_y - \sum P_X - \sum P_K \qquad (1)$$

Where,

NFI = Net Farm Income (₦/hectare)
$\sum$ = Summation sign
$P =$ Unit price
$y =$ Output
$X =$ Input (Variable)
$K =$ Input (fixed)

According to Ronald *et al.* (2008), NFI should be considered more as a starting point for determining profitability than as a good measure of profitability. So, to conclude whether the enterprise is profitable or not, there is the need to compute the profitability index as follows;

i. Profitability Index (PI) – This is the Net Farm Income (NFI) per unit of Gross Revenue

(GR). That is;

$$PI = \frac{NFI}{GR} \quad (2)$$

Equation (2) shows the proportion of return per naira on Total Revenue. For a farm to be profitable, the PI should be greater than zero.

Other profitability measures were calculated:
ii. Return on Capital Invested or Return on Investment:

$$RoI = \frac{NFI}{TC} \times 100\% \quad (3)$$

Where: TC = Total cost, hence (TVC + TFC). Equation (3) shows the ratio of the accounting profit to the investment in the farm, expressed as a percentage. The ROI should be greater than the cost of capital for the investment to be worthwhile.

iii. Capital Turnover (CTO) BCR: $\frac{TR}{TC}$ (4)

Where: TR= Total Revenue and TC = Total Cost, CTO is defined as the total revenue divided by the total cost of production. It is also called the Benefit Cost ratio. This ratio should be greater than 1 for the investment to be profitable.

iv. Percentage of Gross Margin = $\frac{TR}{TVC}$ % (5)
This is the ratio of total revenue to total variable cost of production.

RESULTS AND DISCUSSION

Performance of Rice Value Chain Actors

The profitability of actors along the value chain is presented in Table 1. The result in Table 2 indicates the average revenue generated along the value chain was ₦509,681.10, ₦46,187.50 and ₦273,000.00 respectively for the rice farmers, marketers and processors; farmers had the highest, followed by processors and marketers. Further, the TVC of the value chain actors in the studied area were ₦157,664.55 (71.70), ₦23,353.00 (68.50) and ₦113,340.00 (84.20) respectively. Farmers had the highest, followed by processors and marketers. Also, the values of the TFC were ₦61,503.94(28.10), ₦10,758.25(31.50) and ₦ 134,605.29. The processors had the highest, followed by the farmers and the marketers. The average TC among the value chain actors were ₦219,168.59, ₦34,111.25 and ₦159,660.00 respectively for the rice farmers, marketers and processors. The values of the Net Income (NI or NFI) as shown in Table 2 were ₦290,512.69, ₦12,076.25 and ₦138,394.71 respectively for the Rice farmers, marketers and processors and the test of significance indicates a statistical difference in the income between millers and marketers in the studied area. The profitability indices were; PI;0.57, 0.26 and 0.58 for farmers, marketers and processors respectively. It is highest for the processors, and farmers and then lowest for marketers; ROI: 1.33, 1.12 and 1.03 respectively for the farmers, marketers and processors respectively. This is highest for farmers, and marketers and lowest for processors; the CTO or B-C ratio: is 2.33, 1.35 and 1.71 respectively for farmers, marketers and processors. This is highest for farmers, followed by marketers and lowest for processors; The percentage of gross margin received: 57%, 26.16% and 50.69% respectively for farmers, marketers and processors. This was found to be highest for the farmers, followed by the processors and the least marketers. The IRR indicate 2.23, 0.98 and 1.22 for farmers, marketers and processors. This was highest for farmers, followed by the processors and the least was markers. This result indicates a significant return on investment and solvency in the rice value chain in the study area, especially for rice farmers, compared to the other two actors for which the investment has paid off. This is consistent with the findings of Isa et al. (2022).

Table 1: Profitability Performance of Value Chain Actors

	Farmers		Marketers		Processors	
Revenue (₦)	**Average/Ha**	**%**	**Average/Cycle**	**%**	**Average/Cycle**	**%**
Total Revenue	509, 681.10		46, 187.50		273, 000.00	
Total Variable Costs (TVC)	157, 664.55	71.90	23, 353.00	68.50	113, 340.00	84.20
Total Fixed Costs (TFC)	61, 503.94	28.1	10, 758.25	31.5	134, 605.29	15.80
Total Cost of Production (TC)	219, 168.50	100	34, 111.25	100	159, 660.00	100
Gross Margin	352, 016.54		22, 834.50		138, 394.71	
Net income	290, 512.60		12, 076.25		159,660.00	
PI	0.57		0.26		0.58	
ROI	1.33		1.12		1.03	
CTO or B-C Ratio	2.33		1.35		1.71	
IRR	2.23		0.98		1.22	
% of GM received	57.00		26.15		50.69	

Source: Computation from field data 2024.

CONCLUSION AND RECOMMENDATIONS

Based on the findings of this study, it is concluded that rice production, marketing and processing enterprises were profitable and solvent among the value chain actors in the study. The following are recommended: i. Profitability can be sustained by the value chain actors through increased production to take advantage of economies of scale ii. The government will establish marketing infrastructures to aid marketers and iii. Processors should be helped through import duty waivers on machinery.

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Gender Perspectives in Potato Production in Jos Plateau Nigeria

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Abstract
This study was done in Jos South, Ryiom, Barkin-Ladi, Bokkos, and Mangu Local Government Areas of Plateau Nigeria to assess gender roles in potato production. 120 potato farmers were selected as respondents via a purposive and multi-stage sampling. A structured and pre-tested questionnaire was used to collect data on the socio-economic characteristics of respondents and gender roles in potato production. Descriptive (means, frequencies, and percentages) statistics were used to analyse the data generated from the study. Results indicated that men mostly carried out site selection and herbicide application. Women dominated planting, manual weeding, rouging, and food preparation for farm labour. Youths were the most involved in land clearing, gathering, and burning of trash and stumps, cultivation, earthing-up, and harvesting. Men had more access to and control of inputs required for farming and related activities. Gender gaps observed in this study can be addressed by allowing women greater access to inputs needed for production.
Keywords: Gender, Potatoes, Production, Men, Women, Youth

INTRODUCTION

Potato is an important staple food and a means of generating cash, especially in the cool mid-altitude areas of Nigeria where its growth can be sustained. It is a short-duration crop (90-120 days) and can therefore be grown multiple times within a year. It does well both under rain-fed and irrigated production. The production estimate for potatoes in Nigeria in 2022 is 1.22 million metric tonnes from 322,523 hectares (FAOSTAT, 2022). Over 90% of the potatoes grown in Nigeria are cultivated in the Jos Plateau (Okonkwo *et al*., 2009). The potato value chain holds substantial economic and nutritional importance, contributing to the food security and the livelihoods of millions. Gender has become a key issue in agricultural research and activities which mostly focus on differences in gender roles in agricultural production (Kalai and Devarani, 2018). Gender roles are responsibilities, social and cultural expectations, and norms, associated with men, women, girls, and boys. It is an acquired identity that is learned, changes over time, and varies widely within and across cultures (GICHD, 2014). These systematic differences influence the ability of men and women to access, adopt, and technology and innovations (March, *et al*., 1990). Historically, women and men have been assigned distinct roles in agriculture. Men are usually responsible for the heavier manual operations in crop production such as land preparation and tillage; and in high-risk operations involving machines and the application of herbicides. Women on the other hand were often responsible for tasks that require dexterity and attention to detail, such as raising seedlings in nurseries, transplanting, weeding, and harvesting (FAO, 2007, Nguyen, 2016). Understanding and analyzing gender roles in agriculture is crucial for achieving sustainable development and ensuring social equity. It helps address disparities in resource distribution, decision-making, and well-being among genders. Failure to recognize the roles, differences, and inequities between men and women poses a serious threat to the effectiveness of agricultural development (World Bank, 2012). Gender consideration is therefore critical for developing appropriate interventions and scaling up technology for women and men, respectively (Kawarazuka and Goswami 2019). The objectives of this study were to ascertain gender roles in potato production in Jos Plateau the main growing area for potatoes in Nigeria.

METHODOLOGY

A purposive and multi-stage sampling technique was used in selecting one hundred and twenty (120) potato farmers as respondents from five major potato-growing local government areas: Jos South, Ryiom, Barkin-Ladi, Bokkos, and Mangu in Jos Plateau Nigeria. This area is between Latitude: 9° 34' 0.00" N and Longitude: 9° 04' 60.00" E. The instrument for data collection was a set of structured and pre-tested questionnaires. The primary data gathered included the socioeconomic characteristics of respondents and gender roles in potato production. Descriptive (means, frequencies, and percentages) statistics were used to analyze the data generated from the study.

RESULTS AND DISCUSSION

Socioeconomic characteristic of potato farmers in Plateau State

The socioeconomic characteristics of the respondents in the study area are presented in Table 1. The majority of the respondents (66.3%) were within the age range of 31-50 years, had either secondary or tertiary education (81.7%), were married (80%), had large households (6-10 persons) implying that the respondents were still productive and vibrant, possess good knowledge of the phenomenon under study and had access to family labour for potato production. The result agrees with that of Onu *et al.,* (2020). Many respondents (63.3%) were vastly experienced with more than 10 years of experience in potato farming. Obinne, (1991), considered long farming experience as an advantage for an increase in farm productivity since it encourages rapid adoption of farm innovation. Most (74.1%) had farm size of less than 2ha and (50%) earned ₦300,000 or less per annum from their potato farm suggesting that they were small-scale farmers with low income. The result agrees with Ajaero and Onukala (2013) who reported low income by rural dwellers from their farming activity. A minority of the respondents (40.8%) belong to a cooperative society indicating poor participation in group activity.

Table 1: The distribution of the respondents according to their socio-economic characteristics

Variables	Frequency (n =120)	Percentage	Mean
Age			40.57
≤30	26	20.6	
31 – 40	29	22.1	
41 – 50	48	44.2	
51 – 60	16	12.3	
≥61	1	0.8	
Educational level			3.16
No formal education	7	5.8	
Primary education	15	12.5	
Secondary education	50	41.7	
Tertiary education	48	40.0	
Marital Status			
Single	18	15.0	
Married	96	80.0	
Widow	6	5.0	
Household size			6.42
≤5	48	40.1	
6 – 10	62	51.6	
≥11	10	8.3	
Farming experience			17.03
≤10	44	36.7	
11 – 20	41	34.2	
21 – 30	26	21.6	
≥31	9	7.5	
Farm size			2.19
≤2ha	89	74.1	
3ha – 4ha	24	20.2	
≥5ha	7	5.7	
Annual income			
≤300,000	60	50.0	
301,000-500,000	26	24.2	
≥501,000	28	25.8	
Membership of cooperative			
Yes	49	40.8	
No	71	59.2	

Source: Field survey, 2022

Gender roles in potato production

The distribution of respondents according to the gender they indicated that carried out different activities involved in potato production is presented in Table 2. Of the 12 potato farming activities assessed, men dominated site selection and herbicide application; women dominated 4 operations including planting, manual weeding, rouging, and preparation of food for farm labour; while youths were the most involved in operations associated with cultivation – land clearing, gathering, and burning of trash and stumps, and cultivation. Earthing-up and harvesting were also mostly carried out by youths. Children played no major role in potato farming. According to the survey result by Bakala, (2018), all household members participated in potato farming activities with men dominating in land preparation while women dominated weeding operations in Southwest Ethiopia. Women dominated fertilizer application, planting, and weeding, carrying farm produce home while men dominated land preparation and herbicide application, storage, and marketing in Nyandarua County in Kenya (Wamuyu, 2019). In the South Western Highland Agro-ecological Zone of Uganda, Etiang *et al*, (2019) found that men and women preferred to work jointly performing roles such as; land preparation, planting, weeding, and harvesting the crop and attributed that to the steep terrain which made such activity more difficult requiring joint cooperation to accomplish. However, men dominated bush clearing activity while women were left to spray pesticides.

Table 2: The distribution of the respondents according to gender roles in potato production

Variable	Men	Women	Youth	Children
Site selection	89(74.2)	21(17.5)	7(5.8)	3(2.5)
Land clearing	22(18.3)	29(24.2)	54(45.0)	15(12.5)
Burning	26(21.7)	24(20.0)	56(46.7)	14(11.7)
Gathering	19(15.8)	29(24.2)	49(40.8)	23(19.2)
Land preparation	37(30.8)	19(15.8)	58(48.3)	6(5.0)
Planting	30(25.0)	42(35.0)	39(32.5)	8(6.7)
Manual weeding	18(15.0)	48(40.0)	48(40.0)	6(5.0)
Herbicide/Fungicide application	58(48.3)	18(15.0)	40(33.3)	4(3.3)
Rouging	35(29.2)	56(46.7)	25(20.8)	4(3.3)
Earthing-up	31(25.8)	29(24.2)	54(45.0)	6(5.0)
Harvesting	30(25.0)	33(27.5)	48(40.0)	9(7.5)
Prepare food and bring water	11(9.2)	104(86.7)	3(2.5)	2(1.7)

Source: Field survey, 2022.Note: figures in brackets are the percentages (%)

The distribution of respondents according to their indication of which gender has access to and control inputs used for potato production is presented in Table 3. Many respondents indicated that men had the most access to farm inputs compared to other gender groups. Men also had greater control of farm inputs compared to other gender groups. This report aligns with Etiang, *et al*., (2019), who reported that men had more access to farm equipment, land, and stores and were found to be more engaged than women in the seed potato business. Allowing women equal access to farm inputs will raise their productivity and enhance the overall performance of agricultural production.

Table 3: Percentage Distribution of Respondents According to Gender they indicated that has Access to and Control of Inputs

Variable	Men	Women	Youth	Children
Access to Inputs	58.3	36.7	4.2	0.8
Controls of Inputs	66.7	31.7	0.8	0.8

Source: field survey, 2022

CONCLUSION AND RECOMMENDATIONS

This study shows that gender roles are firmly entrenched amongst potato farmers in the main potato-growing area of Nigeria. However, these roles were not mutually exclusive but were rather complimentary. Men selected farm sites and applied pesticides, women were most involved in planting, manual weeding, rouging, and preparation of food for farm labour; while youths dominated land clearing, gathering and burning of trash and stumps, cultivation, earthing-up, and harvesting operations. Children played no major role in potato farming. Gender gaps observed in this study can be addressed by allowing women greater access to inputs required for production. This can be achieved through the establishment of gender-based potato development programmes.

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Usage of Information and Communication Technology among Catfish Marketers in Selected Markets in Oyo State, Nigeria

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Abstract
The study assessed ICT usage among catfish marketers in Oyo State, and its importance for agricultural marketing, and development. Data were collected from 100 respondents in five major markets using a validated questionnaire. The analysis included descriptive and inferential statistics (Chi-square and Pearson Product Moment correlation). Results showed that most respondents were female (63.0%), married (69.0%), and Christians (67.0%). Many were aged (years) 31-40 (38.0%) and had completed secondary education (48.0%). Additionally, 66.0% were cooperative society members, 38.0% had 1-5 years of marketing experience, 66.0% lacked access to extension services, and 64.0% earned over ₦300,001 annually. Commonly used ICT tools included mobile phones ($\bar{x}$ = 1.71), radio ($\bar{x}$ = 1.58), television ($\bar{x}$ = 1.30), internet ($\bar{x}$ = 1.28), and social media ($\bar{x}$ = 0.18). ICT benefits included easier customer proximity ($\bar{x}$ = 1.36), finding new buyers ($\bar{x}$ = 1.25), access to market information, and capacity building. Constraints were poor power supply ($\bar{x}$ = 1.47), phone loss/theft ($\bar{x}$ = 1.33), and high ICT costs ($\bar{x}$ = 1.24). Significant factors affecting ICT usage were marital status, religion, gender, and education level ($p < 0.05$). Improving Nigeria's power sector could enhance ICT usage among farmers.
Keywords: ICT usage, Catfish marketers, Oyo State

INTRODUCTION

Information and Communication Technology (ICT) has revolutionised various sectors globally, enhancing creativity, information processing, and sharing (Tech Target, 2024). ICT encompasses devices and applications like radio, television, telephones, computers, and internet technologies that facilitate rapid information dissemination (Mdoda and Mdiya, 2022). In Nigeria, the catfish industry, a crucial part of the aquaculture sector, significantly contributes to the economy, ranking third in GDP after agriculture and livestock (Odioko and Becer, 2022). However, challenges such as lack of timely market information, insufficient industry expertise, and shortage of viable brood stock hinder production and profitability. ICT can address these issues (Nawab et al., 2020). ICT tools, including mass media, are vital for communicating agricultural innovations and techniques to rural farmers (Nawab *et al*., 2020). Farmers use ICT to share information on farming technology, management, processing, storage, marketing, and financial aid (Oke et al., 2021). Integrating ICT into catfish marketing broadens market reach, streamlines operations, and boosts profitability (Mdoda & Mdiya, 2022).

ICT advancements are linked to higher productivity and efficiency in catfish production and marketing (Adeosun et al., 2024). Despite these benefits, socio-economic and institutional factors can inhibit ICT usage among farmers (Amin-Dankwa, 2018). This study examines ICT usage among catfish marketers in Oyo State.

The objectives are;

i. Describe the socio-economic characteristics of catfish marketers in the study area;
ii. identify the different types of ICTs available and the level of usage by the respondents in the study area;
iii. identify the benefits of ICT usage among catfish marketers in the study area;
iv. identify the constraints to the usage of ICTs among catfish marketers in the study area;

Hypothesis of the study

Ho: There is no significant relationship between the socio-economic characteristics of the fish marketers and the level of usage of ICTS tools among the catfish marketers

METHODOLOGY

The study in Oyo State used a multi-stage sampling method, starting with the purposive selection of the Ibadan Agricultural zone due to its prominent markets. Five markets (Iwo Road, Sango, Bodija, Omi, and Oritamerin) were selected for their significant catfish seller presence. From each market, 20 fish marketers were randomly chosen, totalling 100 respondents. Data analysis involved descriptive statistics and hypothesis testing using Chi-square and Pearson Product Moment Correlation (PPMC). Results showed that over half of the respondents were male, married, Christians, cooperative members, had a household size of 4-6 members, and earned over ₦300,000 annually. About one-third were aged 31-40 (years), had 6-10 years of fishing experience, and had completed secondary education. This demographic suggests that respondents were young and educated, capable of utilizing ICTs effectively. These findings align with Efobi *et al*. (2023), who noted that farmers within a productive age range actively seek relevant information to enhance their agribusiness.

RESULTS

Table 1: Socio-economic characteristics of the respondents

Variables	Frequency	Percentage	Mean
Sex			
Male	63	63.0	
Female	37	37.0	
Age			
< 30	7	7.0	
31-40	38	38.0	34
41-50	26	26.0	
51 and above	29	29.0	
Marital status			
Single	25	25.0	
Married	69	69.0	
Divorced	4	4.0	
Widowed	2	2.0	
Religion			
Islam	33	33.0	
Christianity	67	67.0	

Variables	Frequency	Percentage	Mean
Educational status			
Primary	6	6.0	
Secondary	48	48.0	
Tertiary	42	42.0	
No formal education	4	4.0	
Household size			
1-3	33	33.0	
4-6	59	59.0	5
7-9	8	8.0	
Member of any cooperative society			
Yes	66	66.0	
No	34	34.0	
Fish marketing experience			
1-5	38	38.0	5
6-10	34	34.0	
11 and above	28	28.0	
Access to extension service			
Yes	34	34.0	
No	66	66.0	
Annual Income			
<100,000	16.0	16.0	
100,001-300,000	20	20.0	
300,001 and above	64	64.0	

Types and level of usage of ICT tools among the catfish marketers

Table 3 revealed that mobile phones (mean=1.71) had the highest usage among the respondents followed by radio ($\bar{x}$=1.58), television ($\bar{x}$=1.30), internet ($\bar{x}$=1.28) and social media platforms ($\bar{x}$=1.18) respectively.

Table 3: Level of usage of ICT tools among the catfish marketers

Level of usage	Always	Occasionally	Not at all	Mean	Rank
Mobile phone	71.0	29.0	0.0	1.71	1st
Television	37.0	56.0	7.0	1.30	3rd
Radio	64.0	30.0	6.0	1.58	2nd
Computer	37.0	39.0	24.0	1.13	6th
Internet	46.0	36.0	18.0	1.28	4th
Newspaper	35.0	33.0	32.0	1.03	7th
Magazines	16.0	40.0	44.0	0.72	8th
Social media platform	38.0	42.0	20.0	1.18	5th
Digital camera	7.0	30.0	63.0	0.44	11th
E-mail	11.0	41.0	48.0	0.63	9th
Print media	9.0	43.0	48.0	0.61	10th

Benefits of ICT usage among catfish marketers

Results in Table 4 revealed the greatest benefits of ICT usage among fish marketers as easy access to customers ($\bar{x}$ = 1.36) followed by finding new buyers ($\bar{x}$ = 1.25), market information access and capacity building and knowledge sharing ($\bar{x}$ = 1.24) respectively. This further supports the importance of ICTs for easy, profitable marketing, and agrees with the findings of Adeosun *et al*, (2024).

Table 4: Benefits of ICT usage among catfish marketers

Benefits	Highly beneficial	Beneficial	Not beneficial	Mean	Rank
Capacity Building and Knowledge Sharing	32.0	60.0	8.0	1.24	3
Easy access to customers	39.0	58.0	3.0	1.36	1
Finding new buyers online	31.0	63.0	6.0	1.25	2
ICT improve market performance	23.0	66.0	11.0	1.12	6
ICT enhance catfish marketing quality	5.0	75.0	20.0	0.85	12
Increase the income of the catfish marketers	12.0	66.0	22.0	0.90	11
Market Expansion	38.0	44.0	18.0	1.20	5
Market Information Access	42.0	40.0	18.0	1.24	3
Market Intelligence and Analysis	19.0	61.0	20.0	0.99	10
Proper linkage with the catfish buyers	32.0	41.0	27.0	1.05	8
Quality and Traceability Assurance	23.0	32.0	45.0	0.78	14
Reduced Transaction Costs	29.0	54.0	17.0	1.12	6
Reduction of marketing stress involved in catfish business transactions	25.0	55.0	20.0	1.05	8

Constraints to the usage of ICTs among catfish marketers

Table 5 showed the most constraints to the usage of ICTs among catfish marketers in the study area as poor power supply ($\bar{x}$=1.47) followed by lost/theft of phones ($\bar{x}$=1.33), high cost of ICT facilities ($\bar{x}$=1.24), poor communication policy by government ($\bar{x}$=1.18) and high data charges ($\bar{x}$=1.13) respectively. This partially aligns with the study of Efobi et al (2023), who found the constraints to the effective use of ICTs to be inadequate funds, the high cost of acquiring ICT tools, irregular power supply, and a poor time for farmers

Table 5: Constraints to the usage of ICTs among catfish marketers

Constraints	Very severe	Severe	Not severe	Mean	Rank
Poor power supply	48.0	51.0	1.0	1.47	1
lost/theft of phones	34.0	65.0	1.0	1.33	2
Language barriers	8.0	73.0	19.0	0.89	10
High cost of ICT facilities	37.0	50.0	13.0	1.24	3
High level of rural poverty	22.0	64.0	14.0	1.08	7
Poor communication policy by the government	43.0	32.0	25.0	1.18	4
Poor network reception	31.0	29.0	40.0	0.91	8
Marketers literacy level	19.0	52.0	29.0	0.90	9
Lack of credit	34.0	44.0	22.0	1.12	6
High data charges	25.0	63.0	12.0	1.13	5

Hypothesis showing the relationship between socio-economic characteristics and the level of ICT usage

The outcome of the chi-square analysis revealed that marital status, religion, sex and educational status were significant with a p-value < 0.05. This shows that these variables had a link with respondents' ICT usage in the study area.

Table 6: Chi-square and PPMC analysis showing the relationship between the socio-economic characteristics of the respondents and the level of ICT usage

Variables	Value	r-value	Df	P-value	Decision
Marital status	15.420		6	0.017	Significant
Religion	8.936		2	0.011	Significant
Sex	11.935		2	0.003	Significant
Educational status	18.355		6	0.005	Significant
Annual Income		-0.194		0.101	Not significant

CONCLUSION AND RECOMMENDATIONS

The study on ICT usage among catfish marketers in Ibadan, Oyo State, revealed that marketers primarily use mobile phones, radio, and television for information access. ICT is used for customer access, capacity building, and knowledge sharing. However, constraints include poor power supply, phone theft, and high ICT costs. Significant factors affecting ICT usage were marital status, religion, gender, and education level ($p < 0.05$). It is recommended that the government improve power supply and reduce ICT costs.

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Engagement of Small-scale Farmers in Community-based Extension Organizations and the Impact on Farm Income in Kaduna State, Nigeria

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Abstract
This study investigated farmers' engagement in community-based extension organizations (CBEOs) and the implications for increased farm income in Kaduna State, Nigeria. The study engaged both participants and non-participants of CBEOs. The respondents numbering 437 participants and their equivalent non-participants were drawn with the use of a multi-stage sampling technique from 6 local government areas in the State. Descriptive and inferential statistics were used to analyze the objectives and hypotheses of the study. Results showed that various activities were carried out by CBEOs and that most of the farmers were willing to participate in group activities. More of the farmers in CBEOs earned higher farm income from farm activities. The difference in average farm income was N119,908.46 and it was in favour of farmers participants. The study thus recommends that the executive of the group should put in place some kind of incentive that will help to encourage farmers' participation in group activities.
Keywords: farmers, participation, income, participants, productivity, community-based extension organizations

INTRODUCTION

Rural farmers play a significant role in the economic development of Nigeria. (Okwuokenye *et al*., 2023). They declared that the contribution of this rural sector towards food provision and income seems to be declining steadily. In revamping the trend, Ilori (2022) advised that rural farmers need to come together and participate in community-based extension organizations (CBEOs) where policy programmes and investments of the government can reach and impact them through inputs, cash, agricultural advice provision as well as training from the extension arm of agriculture. Farmers' participation in CBEOs provides participants with the opportunity to improve their livelihood, motivates the people to work together and allows the participants to address their needs and interests by themselves therefore impacting their productivity and farm income (Kuponiyi (2019). It is hoped that farmers' participation in such programmes would be a linkage to extension services and farm innovations, all of which will help to improve farmers' productivity and income. It is on this note that the study seeks to: assess the various activities carried out by CBEOs, determine farmers' willingness to participate in CBEOs, assess the effects of farmers' engagement in CBEOs on farm income and identify the factors constraining farmers from participating in CBEOs activities.

Hypotheses of the study

The hypotheses of the study were stated in their null forms:

i. There is no significant effect on the farm income of members and non-member farmers of CBEOs

ii. There is no significant difference between several farmers who are willing and those not willing to participate in CBEO.

MATERIALS AND METHODS

Area of Study

Kaduna State is located in the North West Geopolitical zone of Nigeria and it has 23 local government areas with the capital seat at Kaduna City. Its land area is 46,053 km^2 thereby ranking 4th in land area among other Nigerian States (Okwuokenye et al., 2023). The estimated population as of 2022 was 9.032,200 (NPC, 2023). Hausa is the major spoken language while English language stands as the official language. Agriculture is the mainstay of the people with about 80% of them participating actively in farming crops like ground nut, maize, millet, rice, cotton, yam, etc (Kaduna State of Nigeria Information and Guide, 2016). The state also has a tropical climate with an annual temperature and humidity of 25.2^{0}C and 1211mm respectively (Kaduna Climate, 2016).

Sampling techniques and sampling size

Multi-stage random sampling method was employed in selecting the respondents. Stage 1 involved the random sampling of 2 agricultural zones (Kaduna Central and Kaduna South) out of the three existing. In stage 2, there was a random selection of 3 local government areas (LGAs) from each of them, thus making it six (6) LGAs. Stage three involved the random selection of 3 from each of the LGAs, thus making it 18 communities that were randomly selected. In stage 4 there was a random selection of 25 farmers from each of the communities and this made the farmers used for the study to be four hundred and fifty (450) community-based extension farmers. An equivalent number (450) of non-participating farmers was also randomly selected in each case for comparison where necessary. About 437 question instrument was selected in each case thereby making it 874 question instruments suitable for analysis that was used for the study. Primary and secondary data were used to analyse the objectives and hypotheses of this study. Questionnaires and interview schedules were the tools used to source information from the farmers.

Data analytical techniques

Descriptive and inferential statistics were used for the study. Descriptive statistics was used to analyse the objectives of the study. Four Likert scale was used to analyse the factors limiting participation in groups. The factors limiting farmers' participation in CBEO activities were measured on a four (4) – point Likert scale which ranged from Strongly agree (coded 4), Agree (coded 3), Disagree (coded 2) and strongly disagree (coded 1). A weighted mean score of 2.50 and above indicated that it was a limiting factor, while factors with a mean score less than 2.50 were considered otherwise. Inferential statistics which include t-test statistics and binomial tests were respectively used to analyse hypotheses one and two. T-test was used to determine the difference in farm income of farmers members and non-farmer members of CBEOs. The formula for the t-test is as shown below:

T = $\underline{\bar{x}_1 - \bar{x}_2}$

$$\sqrt{(s_1^2/n_1 + s_2^2/n_2)}\ ; \tag{1}$$

Where;
$\bar{x}_1$ = the mean of group 1;
$\bar{x}_2$ = the mean of group 2
S_1 = standard deviation for group 1; S_2 = standard deviation for group 2
S_1^2 = variance of the first group; S_2^2 = variance of the second group
n_1 = size of the first group; n_2 = size of the second group; √ = square root

The decision rule for t - t-statistics
If the t – t-calculated is greater than the t – tabulated, we conclude that the estimate of the variable is statistically significant. In that case, we reject the null and accept the alternative hypothesis. The reverse is the case if otherwise.

Binomial test statistics were used to determine the significant difference in the proportion of farmers who are willing and those not willing to participate in CBEOs. The formula for binomial distribution is given as follows:

b(x;n,p) = nCx*px *(1-p) n-x (2)

Where: b = binomial probability; x = total number of successes (livelihood status before and during their membership); p = probability of success on an individual trial; n = number of trials

RESULTS AND DISCUSSION
Activities carried out by Community-Based Extension Organizations (CBEOs)
Table 1 displays the range of activities conducted by different CBEOs. The results indicate that the primary activity undertaken by the CBEOs, as reported by the majority (71.6%) of the group's participants, is savings and loans. Other activities include training and skill development (22.4%), livestock farming (2.5%), processing (1.8%), crop farming (1.4%), and input supply (0.2%). The primary activity conducted was the provision of savings and loans. This finding is supported by Faruk and Maharjan (2022), who noted that farmers in CBEOs receive credit from both formal and informal sources to alleviate household poverty.

Table 1: Community-Based Extension Organizations activities

CBEO Activities	Frequency	Percentage	Mean
- Savings & loans	313	71.6	
- Training/ skill development among members	98	22.4	
- Livestock farming	11	2.5	
- Processing	8	1.8	
- Crop farming	6	1.4	
- Input supply	1	0.2	
Total	437	100.0	Savings & loans

Source: Field survey, 2023

Farmers willingness to participate in Community-Based Extension Organizations
Table 2 reveals farmers' willingness to participate in CBEOs. Results revealed that most (80.55%) were willing to participate in CBEOs. About 15% and 4% were respectively not willing and undecided to participate in CBEOs. The willingness of the majority of the

farmers to participate in CBEO is likely to be connected to the benefits they seemed to be deriving from their groups. The findings of Okwuokenye and Akintoye (2016) are in line with this result as they found regular participation of farmers in similar groups they belonged.

Table 2: Farmers willingness to participate in Community-Based Extension Organizations

Farmers' level of willingness	Frequency	Percentage	Mean
- Willing	352	80.55	
- Not willing	67	15.33	
- Undecided	18	4.12	
Total	437	100.00	Willing

Source: Field survey, 2023

Effects of farmers' participation in Community-Based Extension Organization Activities

The study analyzed the income generated by farmers participating in Community Based Extension Organizations (CBEOs). Results showed that farmers with CBEO memberships earned significantly more income than non-participants, with most earning between N200,001 – N300,000 annually. This suggests that group participation in CBEOs enhances farmers' farm income, aligning with previous studies.

Table 3: Comparative analysis of impacts of participation on farmers

Income level	Participants			Non-participants		
(annual)	Freq.	%	Mean	Freq.	%	Mean
<100,000	4	0.92		21	4.81	
100,001-200,000	51	11.67		347	79.41	
200,001-300,000	210	48.05		69	15.79	
300,001-400,000	151	34.55		0	0.00	
400,001-500,000	20	4.58		0	0.00	
500,001+	1	0.23		0	0.00	
Total	437	100.00	280,892	437	100.00	160,984

Source: Field survey, 2023

Challenges limiting respondents' participation in Community-Based Extension Organizations (CBEOs)

The study reveals that farmers face several challenges that impact their participation and performance in their groups. These include low participation in management, political hijacking, and high illiteracy rates. Poor leadership and lack of awareness are identified as limiting factors. Other challenges include refusal to repay loans, insurgency/banditry/conflict, and high dues and levies. Additionally, lack of government assistance, corrupt leadership, and failure to distribute benefits among members are also significant issues.

Table 4: Challenges limiting farmers participation in CBEOs

Problems	Strongly disagree		Disagree		Agree		Strongly agree		Total	
	Freq	%	Freq	%	Freq	%	Freq	%	Mean*	SD
Low participation of members in the management of organization activities.	0	0.00	34	7.78	225	51.49	178	40.73	3.33*	0.6
Most of the organization's activities have been hijacked by Politicians	0	0.00	41	9.38	218	49.89	178	40.73	3.31*	0.6
High rate of illiteracy among members.	4	0.92	36	8.24	218	49.89	179	40.96	3.31*	0.7
Member's refusal to repay loans	4	0.92	34	7.78	228	52.17	171	39.13	3.30*	0.6
Insurgency/banditry / Conflict	2	0.46	45	10.30	224	51.26	166	37.99	3.27*	0.7
High dues and levies	3	0.69	77	17.62	255	58.35	102	23.34	3.04*	0.7
Lack of government assistance	19	4.35	18	4.12	351	80.32	49	11.21	2.98*	0.6
Corrupt and dishonest leadership	52	11.90	59	13.50	278	63.62	48	10.98	2.74*	0.8
Failure to distribute benefits among members	69	15.79	68	15.56	267	61.10	33	7.55	2.60*	0.8
Poor organization of group activities	36	8.24	230	52.63	133	30.43	38	8.70	2.40	0.8

*Serious (mean > 2.50); Source: Field survey, 2023

Test of difference in farm income of farmer members and non-farmers of Community-Based Extension Organizations (CBEOs)

The study found that there is a significant difference in farm income between farmer members and non-members of Central Bank of Ethiopian Oasis (CBEOs). The average income of CBEO farmers was higher than non-participants, with a difference of N119.908,467. This difference is significant at the 1% level, supporting Etwire's (2013) observation that membership in CBEOs increases farmers' access to production credit.

Table 5: Effects of participation in Community-Based Extension Organizations on income level of respondents

Participant Status	Income				T-test	Prob. level
	N	Mean	SD	Difference		
Participants	437	280,892.45	78004.8	119,908.467	27.97*	P < 0.05
Non-participants	437	160,983.98	44082.8			

*Significant at the 1% level (Critical t-value = 2.576); **Significant at the 5% level (Critical t-value = 1.96)

Test of difference between farmers- willingness to participate in community-based Extension Organizations

Table 6 shows that 83.75% of farmers are willing to participate in Community Based Enterprises (CBEOs), while 16.25% are not. This significant difference supports the alternative hypothesis that farmers are willing to participate due to benefits such as improved productivity, income, and standard of living, as supported by Faruk and Maharjan's 2022 findings.

CONCLUSION AND RECOMMENDATIONS

The study found that several activities were carried out by the CBEOs and these activities help to strengthen the farmers economically. It may be out of these activities that the farmers showed a high level of willingness to participate in group activities and this has resulted in a positive influence on farmers' income and this was manifested in the difference (₦119,908.467) in farm income in favour of participants farm income. Participation in groups would have been higher if not for the constraints. Based on the results, the study recommends that:

i. The executive of the group should put in place some kind of incentive that will help to ensure and encourage more participation of farmers in group activities, and
ii. There is a need to ensure that the CBEOs are not politically affiliated and bound in any way. Such assurance will make it difficult for any external influence and guarantee more participation in groups.

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PROCEEDINGS

Effect of Climate Change and Biodiversity Loss on the Livelihoods of Rural Farmers in Kogi State, Nigeria

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Abstract
This paper examines the impact of climate change and biodiversity loss on the livelihoods of rural farmers in Kogi State, Nigeria. It explores how erratic weather patterns, increased temperatures, changes in rainfall, and biodiversity decline have adversely affected agricultural productivity, food security, and economic sustainability in rural communities. Using a combination of field surveys and interviews from 200 rural farmers, the study highlights the perceived effects of climate change and biodiversity loss on the livelihoods of the rural farmers in Kogi State, Nigeria. The findings suggest that while some adaptive measures have mitigated the effects of climate change, a coordinated approach to environmental conservation and policy intervention is crucial to safeguard both the ecosystem and the livelihoods of farmers in Kogi State.
Keywords: climate change, biodiversity loss, livelihoods

INTRODUCTION

Climate change and biodiversity loss are increasingly recognized as critical global challenges, particularly for developing nations. Nigeria, like many other countries in Sub-Saharan Africa, is highly vulnerable to climate change. The country experiences rising temperatures, erratic rainfall, and more frequent extreme weather events such as droughts and floods. Kogi State, located in the north-central region, is particularly affected by these changes due to its location along the flood plains of the Niger and Benue rivers. Increased rainfall variability has resulted in severe flooding events, which devastate farmlands, destroy crops, and displace communities. Conversely, during dry seasons, the region experiences water scarcity, affecting irrigation and reducing agricultural yields (Ogbo, Nwankwo & Ibe, 2021). Rural farmers in Nigeria, particularly in Kogi State, are among the most vulnerable to the impacts of these environmental shifts. The state's economy largely depends on agriculture, and rural livelihoods are deeply intertwined with the ecosystem's health. Climate change, manifested in unpredictable weather patterns, rising temperatures, and changes in precipitation, exacerbates the challenges faced by rural farmers (Ibrahim, Ahmed, & Yusuf, 2021). Coupled with biodiversity loss, which diminishes the availability of natural resources and services that farming communities rely on, the combined impact is threatening the sustainability of agricultural practices and livelihoods in Kogi State (Abah & Petja 2020; Olaniyi & Lawal, 2020). This paper explores how climate change and biodiversity loss are impacting the livelihoods of rural farmers in Kogi State, with a focus on agricultural productivity, food security, and income.

METHODOLOGY

The study employed a survey research design, incorporating both quantitative and qualitative data collection techniques. A total of 200 rural farmers from six Local Government Areas namely Dekina, Ankpa, Ofu, Olamaboro, Lokoja, and Ajaokota—were selected using a stratified random sampling method to ensure representation from different agro-ecological zones. A structured questionnaire was administered to gather quantitative data on farmers' perceptions of climate change and biodiversity loss and their impacts on livelihoods. The survey covered topics such as observed changes in weather patterns, biodiversity, crop yields, income, and coping strategies. Quantitative data were analyzed using descriptive statistics, while qualitative data were analyzed thematically to extract key themes on the perceptions of climate change and biodiversity loss.

RESULTS AND DISCUSSION

The result in Table 1 shows the perception of the effect of climate change and biodiversity losses on the livelihoods of the respondents. The majority (85%) of farmers perceive climate change as having a detrimental effect on their farming activities. The key climatic changes observed by the farmers include irregular rainfall patterns (75%), prolonged dry seasons (65%), and increased occurrence of droughts and floods (50%). These findings align with previous studies that have reported significant climate variability in the region (Chinwe & Ibrahim, 2023). Farmers highlighted that unpredictable rainfall has affected planting schedules, leading to crop failure and reduced yields. For example, maize and yam, two of the region's staple crops, have seen significant declines in productivity due to these irregularities. Farmers also noted that the increased temperature has led to a proliferation of pests and diseases, further exacerbating the challenges of crop production. Climate change directly impacts agricultural productivity by altering growing seasons, reducing soil fertility, and increasing the incidence of pests and diseases. In Kogi State, many farmers rely on rain-fed agriculture, making them particularly vulnerable to changing rainfall patterns.

Table 1: Perception of rural farmers on the effect of climate change and Biodiversity Losses on their Livelihoods (n=200)

Perception	Percentage %	Frequency
Climate change negatively affects farming activities	85	170
Climate change has noticeable impact on irregular rainfall	75	150
Climate change negatively affects drought and flood	65	130
Biodiversity loss has noticeable impact on declined agricultural productivity	75	150
Climate change and biodiversity loss negatively affect income	90	180
Climate change and biodiversity loss have negative impact on crop yields	86	172
Climate change and biodiversity loss have negative impact on farm inputs cost	55	110
Climate change and biodiversity loss increase in pest and disease incidence	46	92
Climate change and biodiversity loss reduce indigenous crop varieties	60	120

Source: Author's computation from primary data.

Extended droughts have led to decreased yields in staple crops such as maize, rice, and yam, which are central to both food security and income for rural communities. Additionally, unpredictable flooding has resulted in crop destruction, leaving farmers without harvests in some years. A study by Abah and Petja (2020), (Sani & Eze, 2021) on the impacts of climate change on smallholder farmers in Kogi State found that farmers reported a 20-30% reduction in crop yields over the past decade due to erratic weather conditions.

About 75% of respondents believe that biodiversity loss has directly impacted their agricultural productivity. Key concerns include a reduction in the variety of crop species and the disappearance of beneficial insects, such as pollinators. Farmers also noted that the decline in soil fertility due to the loss of soil organisms has reduced the quality and quantity of their harvests (Agwu & Obiora, 2023). Farmers in the focus group discussions reported that the reduction in natural biodiversity has increased their reliance on chemical inputs, such as fertilizers and pesticides, which have further degraded the environment. The loss of biodiversity, particularly of traditional crop varieties, was also linked to reduced resilience to climate shocks.

The combination of climate change and biodiversity loss has had a profound impact on the livelihoods of farmers in Kogi State. About 90% of farmers reported reduced income due to lower agricultural productivity. Many farmers noted that they are increasingly unable to meet their family's food security needs, forcing them to seek alternative sources of income, such as petty trading or labour (Bello et al., 2022). Moreover, the increased cost of agricultural inputs, such as fertilizers, pesticides, and irrigation equipment, has further strained their financial capacity. Some farmers have been forced to abandon farming altogether due to the high costs of adaptation (Adeola et al., 2021). Many rural households in Kogi State rely on the sale of agricultural produce as their primary source of income. With reduced yields and increased crop failure, household incomes have been significantly impacted. For example, farmers growing cassava, one of the state's major cash crops, have reported declining production due to prolonged droughts and soil degradation (Okon, & Musa, 2022). Additionally, as biodiversity declines, opportunities for supplementary income activities such as foraging and artisanal fishing have diminished, compounding the financial strain on farming households.

As agricultural productivity declines, food security is threatened. Rural farmers in Kogi State often consume a portion of what they produce, and reduced harvests directly translate to less food availability. This situation is particularly concerning for households with limited alternative income sources, leading to increased food insecurity and higher rates of malnutrition, particularly among children and pregnant women. According to the Food and Agriculture Organization (FAO, 2019), the combination of climate-induced crop failure and biodiversity loss has led to a decline in the nutritional value of available food, exacerbating malnutrition in many rural communities.

CONCLUSION AND RECOMMENDATIONS

Climate change and biodiversity loss are having profound effects on the livelihoods of rural farmers in Kogi State, Nigeria. Reduced agricultural productivity, food insecurity, loss of income, and declining ecosystem services are all interconnected challenges that require urgent attention. While local adaptation strategies have been employed, more comprehensive interventions are needed to support farmers in building resilience to these environmental threats. By promoting sustainable farming practices, protecting biodiversity, and addressing the root causes of climate change, it is possible to safeguard the livelihoods of rural communities and ensure food security for future generations.

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Effect of Replacing Fish Meal with Maggot Meal in the Growth Performance of Juvenile Catfish (*Clarias gariepinus*) Using Indoor Plastic Aquaria

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Abstract
In this experiment, 90 catfish juveniles (Clarias gariepinus) aged 8 weeks and weighing 14-15g were studied over 4 weeks. They were distributed into 15 aquariums and fed diets with varying maggot meal (MM) inclusion levels (0%, 25%, 50%, 75%, and 100%). Significant differences (p < 0.05) were observed in body weight gain, with the highest gains at 100% and 75% MM (13.32g and 13.15g, respectively). The lowest gains were 0% and 25% MM (9.82g and 10.38g). Specific growth rates were highest at 100% MM (47.39) and 75% MM (46.78), and lowest at 0% MM (34.89). Body length increased most at 100% MM (2.97cm) and 75% MM (2.87cm), and least at 0% and 25% MM (1.67cm and 1.97cm). Feed conversion ratios were highest at 0% MM (14.43) and lowest at 100% and 75% MM (10.64 and 10.77). Protein efficiency ratios showed no significant differences, with the highest at 100% MM (0.47) and the lowest at 0% MM (0.33). Mean growth rates were highest at 75% MM (2.31%) and lowest at 0% and 25% MM (1.82% and 1.88%).

Keywords: catfish juveniles, maggot meal, body weight gain, specific growth rate, feed conversion ratio.

INTRODUCTION
Fish is highly digestible compared to other meats due to its higher muscle protein to connective tissue ratio, making it suitable for infants and adults, and recommended for patients with digestive disorders (Eyo, 2001). Fish is nutritionally superior to terrestrial meats, providing high-quality protein, essential amino acids, and digestible energy, making it ideal for supplementing high-carbohydrate diets (Amiengheme, 2005). The major cost in fish production is feed, accounting for over 60% of total production costs (Lamai, 2011). Successful fish farming requires affordable, locally available feed that meets all nutritional needs (Ayinla, 2007). However, the high cost of conventional feed ingredients used for livestock and human consumption necessitates alternative, non-competitive, nutrient-rich feed ingredients, known as unconventional feeds (Ali et al., 2008). Locally produced feed can reduce production costs, improve food security, and alleviate poverty. Alternative protein sources should focus on by-products and materials unsuitable for human consumption (Ali et al., 2008). African catfish (*Clarias gariepinus*) require about 40% crude protein with optimal results at 35-50% (Gabriel et al., 2007). Due to the high demand for fish meal in livestock production, substitutes are needed. African catfish are popular in Africa for their fast growth, disease resistance, and high

market demand (Adewolu *et al*., 2008; Adewolu *et al*., 2009). Despite their adaptability, commercial catfish farming has been slow to develop in Nigeria (Fagbenro *et al*., 2007). Many farmers rely on farm-made feeds due to the high cost of commercial feeds. Common ingredients for catfish feeds in Africa and Asia include chicken entrails, abattoir waste, fish market waste, maggots, termites, and various plant-based ingredients (Hecht, 2007). Maggots, the larvae of flies, are used in controlled settings for medical purposes and have antibacterial properties (Fasakin *et al*., 2003). They feed on dead tissue, leaving healthy tissue unharmed, and bacteria.

MATERIALS AND METHODS

The experiment was conducted at the University of Abuja teaching and research farm, with annual rainfall ranging from 1,145 to 1,631 mm, temperatures between 36-42°C in the dry season and 25.8-30.2°C during the rainy season, and relative humidity of about 60% during the rainy season and 30% during the dry season. Ninety catfish juveniles (*Clarias gariepinus*), aged 8 weeks and weighing 14-15g, were obtained from a fish farmer in Kuje, Abuja, and hardened for 5-7 days. The experiment lasted 4 weeks, with the fish cultured in 25-litre indoor plastic aquariums (24x21x44cm) covered with mosquito wire mesh and aerators for oxygen. Maggots were sourced from cattle blood and rumen digest, sundried for 2 weeks, and ground into maggot meal (MM). Other feed ingredients included maize, fish meal, groundnut cake, soybean meal, bone meal, salt, fish premix, vitamins, methionine, and lysine, sourced from a commercial feed mill and local market in Gwagwalada, Abuja. The 90 catfish juveniles were randomly distributed into 15 aquariums, labeled T1 to T5, with three replicates per treatment. They were fed diets with MM inclusion levels of 0%, 25%, 50%, 75%, and 100%, twice daily at 8 am and 5 pm. Weekly weight, length, survival rate, and mortality were taken using a sensitive balance and ruler.

Water quality parameters monitored temperature, dissolved oxygen, pH, conductivity, biochemical oxygen demand (BOD), total hardness, and alkalinity. Data on initial and weekly body weight, length, and feed intake were recorded. Specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), and mean growth rate (MGR) were calculated. Proximate analysis of MM was conducted using AOAC methods (2005). Data were analyzed using analysis of variance (ANOVA) with a Complete Randomized Design (CRD) and significant treatment means compared (SPSS, 2007).

RESULTS AND DISCUSSION

The study assessed the growth performance of *Clarias gariepinus* juveniles fed diets with varying levels of mealworm meal (MM). Significant differences ($p < 0.05$) were observed in body weight gain, specific growth rate, and feed conversion ratio among the diets. Juveniles fed 100%- and 75%-MM diets had the highest body weight gains of 13.32 g and 13.15 g, respectively, while those fed 0% (control) and 25% MM diets had the lowest gains of 9.82 g and 10.38 g. The highest specific growth rate was 47.39 for the 100% MM diet, and the lowest was 34.89 for the control diet. Feed intake showed no significant difference ($p > 0.05$) across treatments, with a consistent value of 5 g. Body length increased significantly ($p < 0.05$) with the highest increase of 2.97 cm in the 100% MM diet. The feed conversion ratio was lowest in the 100%- and 75%-MM diets (10.64 and 10.77, respectively) and highest in the control diet (14.43). The protein efficiency ratio showed no significant difference ($p > 0.05$) among diets, with the highest value of 0.47 at 100% MM and the lowest of 0.33 at 0% MM. The mean growth rate was highest at 75% MM (2.31%) and lowest at 0% MM (1.82%). Proximate analysis revealed significant differences ($p < 0.05$) in moisture, ash, and crude protein content. The highest moisture content was 7.46% at 0% MM, and the lowest was 6.87% at 50% MM. Ash content increased with MM inclusion, peaking at 3.80% for 100% MM. Crude protein was highest at 100% MM (39.43%) and lowest at 0% MM (37.13%). Crude fibre content showed no significant difference ($p > 0.05$), with the highest values at 75% and 100% MM (1.33%). Water quality analysis indicated no significant differences ($p > 0.05$) in temperature, pH, and ammonia levels across diets. However, significant differences ($p < 0.05$) were observed in water conductivity, dissolved oxygen, biological oxygen demand, total hardness, alkalinity, and carbon dioxide levels. The highest water conductivity was at 25% MM (2.07%), and the lowest was 75% MM (1.56%). Dissolved oxygen was highest at 75% MM (7.13 mg/L) and lowest at 25% MM (6.07 mg/L). Total hardness was highest in the control diet (1.4 mg/L) and lowest at 50% MM (1.08 mg/L). Alkalinity and CO_2 levels were highest in the control diet (100.04 mg/L and 10.37 mg/L, respectively) and lowest at 50% MM (66.33 mg/L) and 75% MM (8.27 mg/L), respectively.

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CONCLUSION AND RECOMMENDATIONS

The study concluded that African catfish (*Clarias gariepinus*) effectively used maggot meal in their diet. Higher inclusion levels of maggot meal significantly improved body weight gain and feed conversion ratio (FCR). Proximate analysis showed high crude protein (47.1%) and fat (25.3%) in maggot meal. Increased maggot meal levels also significantly enhanced body length.

The study recommends using 100% and 75% maggot meal in catfish diets for its low feed conversion ratios. The government should promote this through workshops and campaigns to encourage farmers to adopt this cost-effective feed alternative.

Table 1. Growth performance, proximate composition, physicochemical parameters, and experimental diet of juvenile catfish fed graded levels of maggot meal (MM) inclusion (%)

Parameters	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)	SEM
Growth Performance						
Initial body weight (g)	14.93bc	15.26a	14.92bc	14.42d	15.02bc	0.07
Final body weight (g)	24.82e	25.57d	26.94b	26.50c	28.27a	0.07
Body weight gain (g)	9.82e	10.38d	12.09c	13.15ab	13.32ab	0.07
Initial body length (cm)	14.57bc	14.67ab	14.37cd	14.27cd	14.47cd	0.07
Final body length (cm)	16.17e	16.57cd	16.67b	17.07b	17.37a	0.07
Increase in body length (cm)	1.67e	1.97d	2.37e	2.87ab	2.97ab	0.07
Specific growth rate (%)	34.89e	36.89d	43.00c	46.78b	47.39a	0.07
Mean growth rate	1.82cd	1.88cd	2.18ab	2.31ab	2.26ab	0.07
PER (Protein Efficiency Ratio)	0.33a	0.36a	0.41a	0.46a	0.47a	0.07
FCR (Feed Conversion Ratio)	14.43a	13.65b	11.72c	10.77de	10.64de	0.07
Proximate Composition (%)						
Dry Matter	7.46ab	7.29ab	6.87de	6.67de	7.03c	0.07
Ash Content	3.35cd	3.55cd	3.64bc	3.76bc	3.79ab	0.07
Crude Protein	47.13a	46.63cd	46.73bc	46.43cd	46.13e	0.07
Crude Fibre	1.22a	1.26a	1.29a	1.33a	1.33a	0.07
Ether Extract	11.13ab	11.19ab	11.33ab	10.13c	11.19ab	0.07
Nitrogen-Free Extract	33.07a	32.40b	31.50e	32.18cd	32.07cd	0.07
Physico-chemical Water Quality						
pH	7.40ab	7.43cd	7.29cd	7.59ab	7.55ab	0.07
Conductivity (mS/cm)	2.01ab	2.07a	2.01ab	1.56d	1.88bc	0.33
Dissolved Oxygen (mg/l)	6.93cd	6.07ef	6.73cd	7.13ab	6.07bc	0.07
BOD (mg/l)	5.13a	4.07cd	4.07cd	3.67e	4.43b	0.07
Total Hardness (mg/l)	1.46a	1.26b	1.08e	1.22cd	1.22cd	0.33
Alkalinity (mg/l)	100.03a	84.33b	66.33e	77.67d	81.67c	0.33
CO2 (mg/l)	10.37ab	8.87c	10.33ab	8.27e	8.67d	0.07
NO3 (mg/l)	0.39a	0.43a	0.44a	0.55a	0.46a	0.07
PO4 (mg/l)	0.18a	0.18a	0.23a	0.19a	0.21a	0.07
Proximate Composition of MM						
Dry Matter (MM %)	92.7	-	-	-	-	-
Crude Protein (MM %)	47.10	-	-	-	-	-
Crude Fibre (MM %)	7.50	-	-	-	-	-
Ash Content (MM %)	6.25	-	-	-	-	-
Fat Content (MM %)	25.3	-	-	-	-	-
Dietary Composition (kg/100kg)						

Parameters	**T1 (0%)**	**T2 (25%)**	**T3 (50%)**	**T4 (75%)**	**T5 (100%)**	**SEM**
Maize	30.00	30.00	30.00	30.00	30.00	-
GNC (Groundnut Cake)	24.50	24.50	24.50	24.50	24.50	-
SBM (Soybean Meal)	16.30	16.30	16.30	16.30	16.30	-
MM (Maggot Meal)	0.00	6.25	12.50	18.75	25.00	-
FM (Fish Meal)	25.00	18.75	12.50	6.25	0.00	-
Palm Oil	2.00	2.00	2.00	2.00	2.00	-
Bone Meal	1.00	1.00	1.00	1.00	1.00	-
Salt	0.25	0.25	0.25	0.25	0.25	-
Methionine	0.10	0.10	0.10	0.10	0.10	-
Lysine	0.10	0.10	0.10	0.10	0.10	-
Premix	0.25	0.25	0.25	0.25	0.25	-

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Effects of Poultry Manure and Plant Population on Growth and Vegetable Yield of Celosia (*Celosia argentea* L.) at Samaru Zaria

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Abstract

A field experiment was conducted at the Artemisia Garden, Institute for Agricultural Research (IAR) farm, Ahmadu Bello University, Zaria during the 2018 rainy season to study the Effects of poultry manure and plant population on growth and vegetable yield of Celosia (Celosia argentea L). The treatments consisted of four (4) rates of poultry manure (0, 1, 2, and 3t ha^{-1}) and 3 spacing (15x15, 20x20 and 25x25cm). The treatments were factorially combined and laid out in a Randomized Complete Block Design (RCBD) and replicated four (4) times. Results showed plant height, leaf area index, crop growth rate as well as total fresh weight were significantly (P > 0.05) higher with the application of 3 t ha^{-1} of poultry manure compared to other rates used. Similarly, results show that the use of 20x20cm spacing resulted in the highest increases in growth attributes such as plant height, leaf area index, and crop growth rate. In conclusion, based on the result of this study, it can be suggested that the application of 3 t ha^{-1} of poultry manure at the spacing of 20x20cm is adequate for better growth and yield of Celosia in Samaru.

***Keywords:* Celosia (Celosia argentea L.), Poultry Manure and Plant Population**

INTRODUCTION

Celosia (*Celosia argentea L.)* is an important pot herb. It is an edible species of the genus Celosia of the Amaranthaceae family, widely grown in home gardens in Nigeria and other parts of West Africa. It is cultivated during both the rainy and the dry seasons. Despite the enormous uses, economic importance, nutritional and medicinal benefit of Celosia (*Celosia argentea L.)*, its production in Nigeria is still not at significant level, especially in the northern part of the country due to inadequate knowledge about the crop. This is coupled with low market demand, resulting in generating low income. As such farmers rarely apply nutrients to meet the crop nutrients requirements. Poultry manure contains nutrient elements that can support crop production and enhance the physical and chemical properties of the soil. Poultry manure application like all other organic manure improves soil water retention and uptake of plant nutrients. It increases the number and diversity of soil microorganisms, particularly in sandy conditions. This enhances crop health by increasing water and nutrient availability, as well as suppressing harmful levels of plant parasitic nematodes, fungi and bacteria. Although, there is a wealth of information on dietary importance of *Celosia argentea* cultivation in West Africa, but little information are available on its ideal row spacing and organic nutritional requirements for improved growth and yield. The scarcity and high cost of obtaining mineral fertilizer also calls for alternative sources of the comodity (Akanbi *et al*., 2006). Plant population is one of the agronomic factors that determine crop growth and yield. Thus, plant spacing should be done to ensure that each crop has an equal chance to grow and allow for all necessary field operations to be implemented with ease. Base on the above reasons, the research work was conceived with the following objectives;

- To determine the effect of poultry manure on the growth and vegetable yield of *Celosia argentea*
- To determine the effect of plant population on growth and vegetable yield of *Celosia argentea*.

MATERIALS AND METHODS

A field experiment was conducted at the Artemisia Garden Institute of Agricultural Research (IAR), Ahmadu Bello University, Samaru Zaria. (Latitude: 11° 11 N, Longitude: 11° 7° 38' E, Elevation: 697 meters) in the northern Guinea savanna ecological zone of Nigeria during the 2018 wet season. Random soil samples from the experimental sites were taken at depths of 0-30 cm. The samples were bulked, air-dried, grounds passed through 2 mm mesh sieve and composite soil samples was analyzed for physical and chemical properties in accordance with the standard procedures as given by Black (1965). A sample of the poultry manure to be used for the experiment was analyzed to determine its chemical composition. Data on the climatic parameters such as temperature, relative humidity, and rainfall recorded was collected from I.A.R meteorological station, during the 2018 wet season (appendix I).

The trial consisted of a factorial combinations of 4 rates of poultry manure (0, 1, 2 and 3t ha^{-1}) and a spacing of 15x15cm (443, 5556 stands ha^{-1}), 20x20cm (250, 000 stands ha^{-1}) and 25x25cm (160, 000 stands ha^{-1}). The treatments were laid out in a Randomize Complete Block Design (RCBD) and replicated three (3) times. The seeds were local variety sourced from the market. It is an erect annual herb up to 2 m tall, glabrous, branches up to 25 per plant, and ascending. The leaves alternate. Seeds are reticular 1-1.5 mm long, black and shining, shallowly reticulate. The field was cleared on 18th June, 2018 and prepared into beds. Each replicate comprises of 12 plots which gives a total of 36 experimental plots. The plot size was 1.5m x 1m (1.5m^2) with 0.5m gap between plot and 1m between replicates. The total land area for the experiment was 11m x 7.5m (82.5m^2). The poultry manure was applied on 21st June, 2018 by spreading and mixing the manure with soil using a hoe, three weeks before transplanting. A bed was prepared with the use of hand hoe in a form of raised bed and the surface leveled. The seeds were sown in the nursery bed at Artemisia garden on the 25th June, 2018 by broadcasting method. The bed was mulched using dried grasses and was watered regularly. The seedlings were in the nursery for two weeks before transplanted to the field. Seedlings with 4-5 leaves were transplanted three weeks after sowing. All the recommended agronomic practices were duly observed.

Harvesting was done by uprooting the plant at 9 WAT, weighed as fresh shoot yield and expressed in kg ha^{-1}. Three (3) plants were randomly selected from the net plot and tagged and data on growth characters (plant height, number of leaves, and number of branches) were taken at 4, 5, and 6 and 7 WAT. Data collected was subjected to analysis of variance (ANOVA) as describe by Snedecor and Cochran (1967). Duncan Multiple Range test (DMRT) was used to separate difference among treatment means (Duncan, 1955).

RESULTS AND DISCUSSION

Effect of poultry manure

The result showed that the growth and yield parameters of celosia were significantly increased in response to application of poultry manure. This may be due to the beneficial effects of poultry manure on soil fertility and structure (Mario *et al.,* 1989). The enhancement in growth attributes in celosia due to increase in PM levels may be related to the direct addition of limiting plant nutrients (Micro and Macro). Poultry manure has high N content as well as other nutrients which are gradually released to the plant (Awodun, 2007). Nitrogen being a major food for plants is an essential constituent of protein (build from amino acids) it enables the process of photosynthesis. Nitrogen plays a most important role in various physiological processes, imparts dark-green color in plants, promote leaves, stem, fruit quality and other vegetative part's growth and development by stimulating root growth. It encourages the uptake and utilization of other nutrients including potassium, phosphorous and controls overall growth of plant. Deficiency of nitrogen causes reduced growth, chlorotic appearance in plants and appearances of red and purple spots on the leaves as well as restricted lateral bud growth.

The significant increases in the plant height leaf area index, crop growth rate and total fresh weight might be due to the improved soil fertility and soil water holding capacity. This corroborated the earlier assertions of Fallah *et al*. (2007) who noted that increase in plant height can be achieved by improving soil fertility. Also, Olaniyi and Ojetayo (2012) reported that Celosia plants increased in growth with increasing rate of nitrogen. They noted that nitrogen increases the cell size and cellular number resulting from cell division and expansion that leads to increased vegetative parts of the plants.

Effect of plant spacing

The study shows that plant spacing significantly affects plant height, leaf area index, crop growth rate and total fresh weight. Plants with ample space will compete less for environmental factors (Baloch *et al*., 2002). This observation also corroborates the report by Galanopoulou-Sendouka *et al*. (1980) that increase in plant density reduces individual plant performances especially morphological growth attributes. Also the more healthy and robust celosia plants produced by widely spaced plants as opposed to the closely spaced ones. This can be attributed to less competition for nutrients as also observed by Philip *et al*. (2010). Morrison *et al*. (1990) explained further that well-spaced plant received more solar radiation and are therefore more photo-synthetically efficient than closely spaced ones. Dense spacing also increases competition for water and fertilizers which results in inadequate vegetative growth (Knavel, 1988).

CONCLUSION

In conclusion based on the result of this study, it can be suggested that celosia can be produced by the application of 3t/ha of poultry manure and the use of 20x20cm spacing.

Table 1: Effect of Poultry manure and plant population on growth and yield of Celosia

	Parameters			
	Plant height at 6WAS	**Leaf Area Index (LAI) 6WAS**	**Crop growth rate at 6-7WAS**	**Total Fresh weight**
Treatments				
Poultry Manure t ha^{-1}				
0	54.7^{c}	1.4^{c}	2.5^{c}	360.0^{d}
1	60.2^{bc}	1.9^{b}	3.6^{bc}	480.3^{c}
2	67.9^{b}	3.3^{a}	4.3^{b}	582.2^{b}
3	81.1^{a}	3.4^{a}	8.7^{a}	785.6^{a}
SE±	2.89	0.09	0.54	23.69
Spacing (cm)				
15x15	66.4	2.4^{b}	3.8^{b}	455.8^{c}
20x20	69.1	3.0^{a}	7.7^{a}	549.4^{b}
25x25	62.4	2.2^{c}	2.9^{b}	650.9^{a}
SE±	2.51	0.09	0.47	20.51
Interaction	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not statistically different at 5% level of probability, using Duncan Multiple Range Test (DMRT). NS: Not significant.

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Appendix 1: Chemical composition of the poultry manure used in the experiment during the 2018 rainy season.

Chemical properties	Poultry manure
Total Nitrogen (%)	1.06
Phosphorus (%)	0.51
Potassium (%)	0.22

Poultry manure samples as analyzed at Agronomy Department analytical lab I.A.R/ABU, Zaria

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PROCEEDINGS

Efficacy of Granular Urea and Farmyard Manure on Chilli Pepper (*Capsicum annum* L.) in Northern Sudan Savannah Ecological Zone of Nigeria

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Abstract
A field experiment was conducted during the 2016/2017 irrigation farming at Ghude irrigation site, Kabo Local Government Area of Kano State 11.907^0N 8.230^0E to evaluate the bio efficacy of urea and farm yard manure on pepper (Capsicum annum L.) Serrano variety. The experiment was laid out in a Randomized Complete Block Design (RCBD) Control, Recommended dose of NPK (100% N) through Indorama Urea, Recommended dose of NPK (100% N) through Indorama Granular Urea 50% and FYM 50%, Full dose of P&K + 75% N through Indorama Granular Urea + 25% N through FYM , Full dose of P&K + 75% N through FYM and 25% N Indorama Granular Urea, Full dose of P&K + 75% N through Indorama Granular Urea and Full dose of P&K + 75% N through FYM.with seven (7) treatments and replicated three (3) times. Results show that application of P & K + 75% N though Indorama granular urea significantly increased the plant height compared to the other treatments. However, application of NPK 100%N through Indorama perform better than all other application among the treatments and were significantly higher compared to the control.

INTRODUCTION

Pepper (*Capsicum annum* L.) belongs to the *solanaceous* family and can be grown throughout the year (Kabura *et al*., 2008). The crop is ranked third most important vegetable crop after tomato and onion in the world (Islam *et al*., 2011; Belel *et al.,* 2011). Capsicum consists of approximately twenty-two wild species and five domesticated species. The five domesticated specie include, *C. annum L., C. baccatum L., C. chinensis L., C. pubescens L., and C. frutescens L.,* (Bosland and Votava, 2000). They include from mild to non pungent (sweet) varieties which are longer and have thicker flesh than the pungent ones (Aliyu *et al*., 1996). Pepper like other vegetable crops contributes nutritionally to the human diet. It is rich in nutrient that may be lacking in other food materials thereby making it more palatable and hence improves food intake and digestion. Sweet pepper also known as bell pepper can be cooked or eaten as raw salad. The leaves are also consumed as salad in soup or eaten with rice. It was also discovered to be a good source of medicinal preparation for black vomit, gout and paralysis (Khan *et al.*, 2010). Juroszek and Tsai, (2009) reported that sweet pepper fruits are good sources of many essential nutrients, including vitamins A, C, and E, carotenoids, minerals (e.g., calcium and iron), and other secondary plant compounds. The crop responds to both organic and inorganic fertilizers and has been shown to respond positively to nitrogen and phosphorus fertilizers (Aliyu, 2002).

The use of organic and inorganic fertilizers has amassed a great significance in recent years in vegetable production for two reasons. Firstly, the need for enhanced sustainable increase in production; and per hectare yield of vegetables requires an increased amount of nutrients. Secondly, the results of a many experiments on organic and chemical fertilizers managed in many countries detect that inorganic fertilizer alone cannot sustain productivity of soils heavy cropping system (Khan *et al*., 2010). Whereas the use of intensive artificial fertilizer in agriculture caused so many health problems and environmental pollution, to decrease and remove the reverse impacts of artificial fertilizers and pesticides on human health and environment, modern practices of agriculture were sophisticated in the so-called organic agriculture, ecological agriculture or agricultural sustainability (Malgorzata and Georgios, 2008). Maintaining soil fertility as well as sustainability of crop production using farmyard manure (vermicompost, green compost, farmyard manure phospocompost has attracted the farmers to replace the use of chemical fertilizers. Anburani *et al*.,(2003), reported that readily available nitrogen from application of FYM and biofertizer) are the prime factors for increasing fruit weight ,length and girth in brinjal. Yield parameters such as number of pods, pod yield, shelling percentage, kernel weight, fresh and dry weight were increased in compost treated field due to the supply of essential nutrient by continues mineralization of farmyard manure.

The high yield of chill pepper was recorded with the application of 7.5 t/ha FYM with half dose of recommended nitrogen and phosphorous, according to (Babhullak *et al.,* 2000). Boopathi *et al* (2010) reported that influence of organic and urea source for the cropping of sorghum +redgram +sunflower + coriander with application of four farm yard manure viz FYM biogas slurry, composted mushroom spend substrate, fish pond silt among these application of biogas slurry at 5t/ha enhanced productivity and soil fertility . Like many other vegetable crops Chilli is a nutrient loving plant and therefore prefer nutrient management in which can enhance the yield and improve the quality, however, indiscriminate use of chemical fertilizer has distinct detrimental effect on health and quality of produce. It is therefore necessary to homogenize the integrated nutrient management techniques for chilli grown in ecological zones. Peppers (*Capsicum annuum* L.) have been cultivated for over six thousand years and are considered important fruity vegetable crop.The peppers including sweet bell pepper belong to the *Solanaceae* family (Perry *et al*., 2007).

Sweet bell pepper contains minerals and vitamins and are valuable medicinal plants in pharmaceutical industry because active ingredients, capsaicin and capsanthin which confers high antioxidant characteristic in the fruit when consumed (Aminifard *et al*., 2012) It is included in medicinal preparation to manage vomit, gout and paralysis. Nitrogen fertilization can increase crop yields and N uptake compared with no Nitrogen. Nitrogen is a major limiting factor for sustainable and profitable crop production. However, excessive N application through fertilizers and manures can degrade soil and environmental quality by increasing soil acidification, N leaching, and emissions of ammonia (NH_3) and nitrogen oxide (NO, N_2O, and NO_2) gases, out of which N_2O is considered a highly potent greenhouse gas that contributes to global warming Franzluebbers, 2007) Nitrogen application more than crop’s need can also result in reduced yield (Eickhout *et al*., 2003). Fertilizers are materials containing one or more nutrients elements in the form of chemical compounds of the organic and inorganic nature. Organic fertilizers are natural materials of either plant or animal source, including livestock manure, green manures, crop residues, household waste, compost, and works directly as a source of plant nutrients and indirectly influences the physical, chemical and biological properties of soil (Basel, 2014). Microorganisms from the soil decay theorganic fertilizers to make its nutrients available for utilize by plants (Amujoyegbe *et al.,*2007) which added into the soil and have the characteristic nature of the slow release of nutrients.

Organic fertilizers have the following advantages to improve soil fertility: (i) Increasing organic matter content in soil, improve the soil structure, creating more air space and water retention within the soil and enhances soil nitrogen content, nutrient availability, improves nutrient mobilization (Akhtar et al., 2009). (ii) Organic fertilizer increase root growth due to enhanced soil structure, promoting soil aggregates, enhances cation exchange capacity (Lal, 2006). (iii) Organic fertilizer acts as a buffering agent against undesirable soil pH fluctuations (Olaniyi 2008). (iv) Organic fertilizers are the fastest-growing sectors of the agriculture and its main objective is to create a balance between the interconnected system such as soil organism, plants, animals and humans (Berova *et al*., 2010). (v) The organic fertilizers offer the biological process necessities of plants and conjointly suppress the plant pests' populations (Heeb *et al*., 2005). Organic fertilizers increase the quality and yield of crops (Bullock *et al.*, 2002). These occur either as natural deposits or are synthesized in a chemical factory. Fertilizers are two types (i) Organic Fertilizers (ii) Inorganic (chemical) fertilizers. In years to come, utilization of organic manure to meet crop nutrient requirement will be an unavoidable practice to enhance sustainable agriculture, this is because, the physical, chemical and biological properties of soil is generally improved by the addition of organic manures which in turn enhances crop productivity and maintains the quality of crop produce (Maheswarappa, 1999 *et al.,*). Although, in comparison to inorganic fertilizers, organic manures contain smaller quantities of plant nutrients.

The use of inorganic fertilizer to increase yield has been found to be effective as a short-term solution but demands consistent use on a long-term basis. The high cost of inorganic fertilizers makes it uneconomical and out of reach to poor farmers and it is also undesirable due to its hazardous environmental effects. Additional N inputs include dry and wet (snow and rain) depositions from the atmosphere, biological N fixation, and irrigation water fertilization.Integrated use of bio fertilizer, organic manure and chemical fertilizers resulted in crop yield increase in comparison with the exclusive application of chemical fertilizers. Moreover, higher yields were reported when a combination of chemical and organic fertilizer was applied, compared with the use of chemical fertilizer alone. But increased cost and uncertain availability and reliability of chemical fertilizer made the growers look towards renewable and organic sources of nutrients for their crops (Roe, 1998). Regular and unbalanced use of chemical fertilizers in the long run leads to decreasing base saturation and acidification of soil (De-Ridder and Van-Keulen, 1990).

Chemical fertilizers alone generate several deleterious effects to the environment and human health and they should be replenished in every cultivation season because, the synthetic N, P and K fertilizer are rapidly lost by either lettuce is more susceptible to nutrient deficiencies than most crop plants because of their shallow root system. Despite the enormous potentials of pepper fruits production, its yield per hectare and quality had been greatly hampered by the low fertility status and organic matter contents of the soils which translate into low productivity and consequently reducing income for the farmer either grown solely in a mixture of many vegetables crops. Therefore, this study investigate the effect of nitrogen fertilizer and farmyard manure on growth and yeild of pepper (*Capsicum annum* L.) in Northern Guinea Savanna zone of Nigeria.

MATERIALS AND METHODS

The experiment was conducted at Ghude Dam, Kabo Local Government area ($11^0$52N 8^0 10E) with an area of 341km^2 and population of 213,000 (NPC, 2006) all in the Sudan Savannah Ecological Zone of Nigeria. The soil of the experimental site was collected at a depth of 15cm prior to land preparation. Results of the soil analysis of the experimental site were indicated.The treatment contains: the cultural practices involved transplanting of two seedlings per hole with a spacing of 30cm x 30cm in each plot. All production practices were followed accordingly such as weed control, fertilizer application, pest control etc. The variety of pepper cultivated (F_2 Serenada) was during the dry season condition. Parameters on growth and yield were taken at 14 days intervals. Parameters taken include the followings, Plant height, Number of leaves, Number of branches, Weight of fruit per plant and Fruit yield per hectare (t/ha).Land preparation of the experimental site was plough, harrow, and ridge. After then the ridges were flatten into sunken beds. A 3x3m plot was used and a discard of 0.75cm was used between treatments. Application of (FYM) Farm yard manure was applied and incorporated to the soil according to the level of treatments after land preparation. Weed Control was done at two weeks after transplanting, the field was weeded manually using hoe in the morning and another hoe weeding was done after three weeks of transplant (WAT). Pest and Disease Control was done using Cypermethrin at the rate of 2.0 a.i/ha was applied at the sight of insect infestation. Assessment of Growth and Yield Parameters were recorded on measuring ruler was used to determine the Plant height from ground level to the tip of the plant at 10, 20, 30, 40 and 50 DAT, number of leaves of the sample plant was taken and recorded at 10, 20, 30, 40 and 50 DAT, 50% anthesis of each plot was taken and recorded and computed when the plots have reached 50% flowering and average yield of the fruit was taken and recorded in kg/ha. Data taken was analyzed using (ANNOVA) and the mean treatment was compared using (FLSD) at $P< 0.05$ significant level. The means were subjected to the analysis of variance ANNOVA using WASP Package version 1.0 to test significant effect among the treatment as described by Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

Mean effect of plant height on chilli was shown on Table 1 at Chiromawa during the 2018/2019 dry season. At 2 weeks after transplant, plant height perform better with the application of Full dose of 75% N and Farmyard manure and 25% and full dose of 75% through FYM and 25% Urea though they were statistically the same with Full dose 75% through FYM during the sampling period and application of Full dose of 75% N and Farmyard manure and 25%. Least mean plant height was obtained from control during the sampling periods. At 3 WAT (weeks after transplant), application of Full dose 75% through FYM produce highest mean plant height compared to other treatments though they are statistically at par with application of recommended dose of (100%N) and recommended dose of 50% N and 50% farmyard manure. Least plant height was observed in control.The mean effect of number of leaves at 2 WAT was shown in table 2. Lowest mean number of leaves was obtain at the control while all the other treatments were statistically at par. At 4WAT, application of recommended dose of (100%N) and a recommended dose of 50% N and 50% Farmyard manure produce significantly more number of leaves compared to other treatments. At 6 WAT, application of recommended dose of (100%N) has the highest mean number of leaves compared to the other treatments. Least was produce from control compared to also the other treatments. As shown in table 3, highest mean number of branches was obtain by the application of recommended dose of (100%N) during the period of sampling compared to all other treatments which were at par even with the control at 2 WAT. At 4WAT, application of recommended dose of (100%N) during the sampling periods produced highest mean number of branches though statistically the same with application of full dose of 75% Urea. Least number of branches was observed during the sampling period by application of recommended dose of 50% N and 50% Farmyard manure. At 6WAT, significant number of branches was observed during the application of recommended dose of (100%N) and a least number of branches was recorded during the sampling period by application of full dose 75% through FYM. Results in table 4 shows that application of recommended dose of 50% N and 50% Farmyard manure to chilli during the sampling periods at Chiromawa produce high mean significant Number of Fruits compared to all other treatments though they were statistically the same with the application of recommended dose of (100%N) and Full dose of + 75% through FYM and 25% Urea. Least mean fruit number among the treatments combination was observed during the sampling period at control. However, at 8WAT, least mean fruit number among the treatments combination was observed during the sampling period at control. At table 5, application of Full dose 75% through FYM shows high mean fruit yield during the sampling period though statistically at par with all other treatments combination except control which produce least fruit yield par hectare.

Table 1: Pre-cropping physico-chemical properties of the soil at the experimental sites in Kabo L.G.A. Kano State 2018/2019 dry season

Soil characteristics (Physical composition (%)	Values
Sand	67.1
Silt	19.2
Clay	13.8
Textural class	Sandy Loam
Chemical properties of soil	
Soil characteristics (Chemical composition (%)	**Values**
Nitrogen	0.30
Phosphates	5.45
Potassium	0.23
Sodium	1.28
Calcium	1.37
Organic Carbon	61.21
Magnesium	0.41

Pre-cropping physico-chemical properties of the soil

Table 2: Effect of Indorama Urea fertilizer and Farmyard Manure on Plant Height of Chilli at Kabo during the 2018/2019 dry season

Treatment	Plant Height	
	2WAT	**4WAT**
1	2.766^{c}	7.88b
2	8.233^{a}	8.74c
3	6.233^{ab}	12.04b
4	6.600^{ab}	8.70^{c}
5	6.366^{ab}	12.05a
6	6.800^{ab}	13.79ab
7	4.966^{bc}	10.16ab
CD (0.05)	2.99	3.12

Means followed by the same letter(s) in the vertical column are not statistically different using DMRT at 5% level of probability.

Table 3: Effect of Indorama Urea fertilizer and Farmyard Manure on Number of Leaves of Chilli at Kabo during the 2018/2019 dry season

Treatment	Number of Leaves	
	2WAT	6WAT
1	2.766[c]	11.166[c]
2	8.233[a]	14.933[ab]
3	6.233[ab]	18.066[a]
4	6.600[ab]	11.366[bc]
5	6.366[ab]	12.766[bc]
6	6.800[ab]	14.766[bc]
7	4.966[bc]	13.700[bc]
CD (0.05)1.304	4.994	2.99

Means followed by the same letter(s) in the vertical column are not statistically different using DMRT at 5% level of probability.

Table 4: Effect of Indorama Urea fertilizer and Farmyard Manure on Number of Branches of Chilli Kabo during the 2018/2019 dry season

Treatment	Number of Branches	
	2WAT	6WAT
1	2.766[c]	7.733[bc]
2	8.233[a]	11.333[a]
3	6.233[ab]	9.466[ab]
4	6.600[ab]	7.500[bc]
5	6.366[ab]	7.433[bc]
6	6.800[ab]	8.100[bc]
7	4.966[bc]	6.933[c]
CD (0.05)	1.415	1.448

Means followed by the same letter(s) in the vertical column are not statistically different using DMRT at 5% level of probability.

Table 5: Effect of Indorama Urea fertilizer and Farmyard Manure on Number of Fruits of Chilli Kabo during the 2018/2019 dry season

Treatment	Number of Fruits	
	8WAT	6WAT
1	0.866[c]	2.700[c]
2	17.266[a]	20.100[a]
3	12.100[ab]	17.100[b]
4	14.500[ab]	17.200[b]
5	11.433[b]	16.100[b]
6	12.600[ab]	18.266[ab]
7	4.400[bc]	6.266[a]
CD (0.05)	1.731	1.507

Means followed by the same letter(s) in the vertical column are not statistically different using DMRT at 5% level of probability.

Table 6: Effect of Indorama Urea fertilizer and Farmyard Manure on Yield/Hectare of Chilli Kabo during the 2018/2019 dry season

Treatment	Fruits Yield/hectare
1	3.666[b]
2	10.566[a]
3	9.066[a]
4	9.566[a]
5	9.666[a]
6	9.266[a]
7	8.266[a]
CD (0.05)	2.667

Means followed by the same letter(s) in the vertical column are not statistically different using DMRT at 5% level of probability.

The results in Table 1 show the physico-chemical properties of the soil the experimental site. The result showed that soils used for the experiment or trials were slightly acidic. The total N values of 0.30 recorded for the sites reveals that N was not lacking as it surpassed the critical level of 0.15% (Enwenzor *et al.,* 1979). The available P content of 5.45 and 6.21 was lower than the critical level of 8 – 10mg/kg (Agboola, 1982). The exchangeable K of 0.23 and 0.32 were not less than the critical level of 0.20 cmol/kg as reported by (Sobulo, 1969). Mean effect of plant height on chilli was shown on table 1 at Kabo during the 2018/2019 dry season cropping. At 2 weeks after transplant, plant height perform better with the application of Full dose of P & K + 75%N through FYM and 25%N through FYM at Kabo while at Kabo application of recommended dose of NPK (100N) through Indorama Urea shows significantly high mean effect of plant height during the sampling period. Control shows least mean plant height at both the sites while other treatments were statistically the same during the sampling period. At 4 WAT (weeks after transplant), application of full dose of P & K + 75%N through FYM shows significant mean plant high than the other treatments while at Kabo the mean effect of tall plant high was recorded with the application of full dose of P & K + 75%N through FYM and 25%N through Indorama Granular Urea. Least plant height was observed at control during the sampling periods. The mean effect of number of leaves at Kabo was shown in shown in table 2. Highest number of leaves was recorded at Kabo with the application of recommended dose of NPK (100% N) through Indorama Urea, recommended dose of NPK (100% N) through Indorama Granular Urea 50% and FYM 50%, full dose of P&K + 75% N through FYM and 25% N Indorama Granular Urea, Full dose of P&K + 75% N through Indorama Granular Urea and full dose of P&K + 75% N through FYM compared to all other treatments. However, at Kabo experimental site, application of recommended dose of NPK (100% N) through Indorama Urea performs better than all the other treatments though they are statistically at par except the control. At 6 WAT, application of recommended dose of NPK (100% N) through Indorama Urea shows high mean plant height than all other treatments at Kabo with least mean leaves recorded in the application of full dose of P&K + 75% N through Indorama Granular Urea. At Kabo however, high mean number of leaves was found with the application of recommended dose of NPK (100% N) through Indorama Granular Urea 50% and FYM 50% during the sapling period with least mean leaves recorded in control.

Table shows mean number of branches during the sampling period at the two experimental sites. Results shows that application of recommended dose of NPK (100% N) through Indorama Urea performs better than all other treatment, though all other treatments were at par with control at Kabo during the 2 WAT sampling periods. At Kabo, application of recommended dose of NPK (100% N) through Indorama Urea performs significantly better than all other treatments with control producing least mean number of branches. At 6WAT, application of recommended dose of NPK (100% N) through Indorama Urea at both the experimental fields produce highest mean number of branches during the 2018/2019 dry season cropping period. Results from table 5 depict the mean number of fruits during the sampling periods at the experimental sites. Application of recommended dose of NPK (100% N) through Indorama Granular Urea 50% and FYM 50% at Kabo performs significantly better than all other treatments. While at Kabo, application of recommended dose of NPK (100% N) through Indorama Urea produce significantly high number of fruits compared to all other treatments during the sampling periods at 6WAT. During the sampling periods of 8WAT, mean significant number of branches recorded was observed at Kabo with the application of all the treatments with the exception of control. At Kabo however, application of recommended dose of NPK (100% N) through Indorama Urea produce more significant number of fruits than all other treatments. Least mean fruits was recorded at control. All the remaining treatments were statistically at par. Fruits yield/hectare recorded during the sampling periods were shown at both experimental sites during the 2018/2019 dry season cropping period. Results shows that application of full dose of P&K + 75% N through FYM produces highest fruits yield per hectare than all other treatments, however least fruits yield was recorded at control. At Kabo, highest mean fruits yield was observed among all other treatments except control with least mean fruit yield.

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Fish Species Composition, Diversity, and Abundance in Kashimbila Dam, Taraba State, Nigeria

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Abstract
The Kashimbila Dam, located in Taraba State, Nigeria, is a crucial water body that sustains local fisheries. This research delved into the dam's fish species composition, abundance, and diversity to gain insights into its ecological well-being. Over three months from December 2021 to February 2022, 24 fish species belonging to 11 families and 17 genera were identified with Claroteidae family being the most diverse. Oreochromis niloticus was the most abundant species, making up 13.25% of the total catch, while Malapterurus beninensis and Malapterurus electricus were the least abundant, each accounting for 0.92%. These findings highlight the need for ongoing monitoring and sustainable management efforts to protect Kashimbila Dam's biodiversity and ecological balance.

Keywords: Aquatic ecosystem, Biodiversity, Kashimbila dam, Relative abundance, Sustainable management,

INTRODUCTION

Aquaculture and fisheries represent important aspects of ensuring global food security. These sectors provide the most significant source of animal protein and support the livelihoods of millions of people, especially in developing countries (FAO, 2019). In Nigeria, lakes, rivers, and reservoirs are critical in these subsectors. However, they are exposed to overfishing, environmental degradation and poor management. This has resulted in a decline in fish population and a reduction in the overall productivity of these aquatic ecosystems (Adamu *et al*., 2020). One of the significant water bodies affected is Kashimbila Dam, located in Taraba State, Nigeria. It plays a crucial role in the country for flood control, hydroelectric power production, irrigation, and fisheries (Oruonye and Ahmed, 2020). However, studies targeting the composition, abundance, and diversity of fish in the dam are limited. These ecological parameters are vital for assessing ecosystem health, identifying vulnerable species, and implementing management strategies for sustainable resource exploitation (Ekpo *et al*., 2016). This study aims to fill the gap by providing detailed information about the composition of the species, abundance, and variety of fish in the dam. This data will be valuable for resource management and conservation efforts.

MATERIALS AND METHODS

Study Area

This study was conducted at Kashimbila Dam, located in Kashimbila district, approximately 50 km southwest of Takum town in Taraba State, Nigeria. The dam is situated between latitudes 6°22'N to 7°30'N and longitudes 9°40'E to 10°20'E. The river originates from the Bamenda highlands in Northwestern Cameroon. The dam is 35m high and a buffer against floods from Lake Nyos, Cameroon (Oruonye, 2015).

Fish Sampling

Fish samples were taken every two weeks from December 2021 to February 2022 at a major landing site near the dam. Sampling was carried out using gill nets with a mesh size of 2.5 inches. The quantities of fish samples were recorded and species were identified in the field using the "Field Guide to Nigerian Freshwater Fishes" by Olaosebikan and Raji (2013), ensuring accurate species-level identification.

Relative Abundance

The species abundance was calculated as the percentage of each species represented in the total catch for each station. Adite and Thielen (1995) explained that the average monthly catch of the water body was calculated by dividing the catch data into monthly intervals. The relative abundance was calculated as follows:

$$Relative\ abundance = \frac{Number\ of\ individuals\ of\ a\ particula\ species}{Total\ number\ of\ individuals\ of\ all\ species}\ x\ 100$$

Species Biodiversity

The species biodiversity in this study was determined using the following indices in line with Okomoda *et al*. (2017):

Shannon-Weiner Diversity Index (H') calculated using the formula;

$$\text{H'} = -\sum_{i=1}^{s} PilnPi$$

Simpson's Diversity Index is calculated using the formula;

$$D = \sum \frac{ni\ (ni-1)}{N\ (N-1)}$$

Pielou Equitability Index (J') is calculated using the formula:

$$\text{J}' = \frac{\text{H'}}{\ln(S)}$$

Margalef's Diversity Index (d) is calculated using the formula:

$$d = \frac{S-1}{lnN}$$

Where,
H' = species diversity index
S = total number of species
P_i = proportion of individuals per species belonging to the ith species of the total individuals
n_i = number of individual species i
N = total number of individual species for that site

Data Analysis

The data was analysed using simple descriptive statistics including means and percentages. Analysis of Variance (ANOVA) was used to compare the means. The species diversity values for each index were computed using R programming software (version 4.4.1).

RESULTS AND DISCUSSION

Fish Species Composition

During the study period from December 2021 to February 2022, 24 species, spanning 11 families and 17 genera, were recorded (see Table 1). The family Claroteidae was the most diverse, represented by five species, including *Chrysichthys auratus*, *Chrysichthys nigrodigitatus*, *Clarotes laticeps*, *Auchenoglanis biscutatus*, and *Anaspidoglanis akiri*, followed by Mormyridae with four species and Cichlidae with three species. Bagridae Cyprinidae, Latidae, Tetraodontidae and Schilbeidae were represented by one species each; *Bagrus bajad, Labeo coubie, Lates niloticus, Tetraodon lineatus* and *Schilbe uranoscopus* respectively. The 24 Species identified in this study were also observed in other studies which concluded that these species constitute the major fisheries resources of Nigerian inland water, due to their adaptability to the physico-chemical conditions of these water bodies. The prevalence of these species in the 11 families throughout the study period in the Kashimbila dam could be attributed to the relative abundance of these species in Northern Nigeria (Allison and Okadi 2013; Oguntade *et al*., 2014).

Table 1: Fish Species Composition of Kashimbila Dam from December 2021 - February 2022

Family	Genus	Species
Alestidae	Hydrocynus	*Hydrocynus forskahlii*
	Brycinus	*Brycinus Intermedius*
Bagridae	Bagrus	*Bagrus bajad*
Clariidae	Clarias	*Clarias gariepinus*
	Heterobranchus	*Heterobranchus bidorsalis*
Cichlidae	Coptodon	*Coptodon guineensis*
		Coptodon zilli
	Oreochromis	*Oreochromis niloticus*
Claroteidae	Chrysichthys	*Chrysichthys auratus*
		Chrysichthys nigrodigitatus
	Clarotes	*Clarotes laticeps*
	Auchenoglanis	*Auchenoglanis biscutatus*
	Anaspidoglanis	*Anaspidoglanis akiri*
Cyprinidae	Labeo	*Labeo cubie*
Latidae	Lates	*Lates niloticus*
Malapteruridae	Malapterurus	*Malapterurus electricus*
		Malapterurus minjiriya
		Malapterurus beninensis
Mormyridae	Hyperopisus	*Hyperopisus bebe*
	Pollimyrus	*Pollimyrus isidori isidori*
	Mormyrus	*Mormyrus rume rume*
		Mormyrus hasselquistii
Schilbeidae	Schilbe	*Schilbe uranoscopus*
Tetraodontidae	Tetraodon	*Tetraodon lineatus*

Fish Species Abundance

A total of 981 fish were caught along the Dam during the sampling period along with the relative abundance of all species is reported in Table 2. *Oreochromis niloticus* was the most abundant (13.25%), followed by *Chrysichthys nigrodigitatus* (11.93%) and *Bagrus bajad* (9.17%). *Malapterurus beninensis* and *Malapterurus electricus* were the least dominant species, each consisting only 0.92% of the total catch. The dominance of *Oreochromis niloticus* may be attributed to its high adaptability, general feeding and prolific reproductive nature (Sani *et al.,* 2019). This is similar to the findings reported by many other studies including Oladipo *et al*. (2020) who reported the dominance of *Oreochromis niloticus* in Jebba Hydro-Electric Power, Niger state, and Nazeef *et al*. (2021) in Dadin-Kowa reservoir, Gombe State. *Malapterurus beninensis* and *Malapterurus electricus* being the least abundant species recorded could highlight the possible vulnerability of the fish in the dam. This is similar to the findings reported by Adadu *et al*. (2019) in river Okpokwu, Benue State, and this differs from the work of Okomoda (2017) who reported that *Malapterurus electricus* showed significant dominance in Lake Kalgwai, Jigawa State, Nigeria

Table 2: Fish Species Abundance of Kashimbila Dam from December 2021 - February 2022

Species	Number	Relative Abundance (%)
Oreochromis niloticus	130	13.25
Chrysichthys nigrodigitatus	117	11.93
Bagrus bajad	90	9.17
Anaspidoglanis akiri	65	6.63
Hyperopisus bebe	61	6.22
Coptodon guineensis	59	6.01
Chrysichthys auratus	58	5.91
Clarias gariepinus	51	5.2
Labeo coubie	47	4.8
Hydrocynus forskalii	45	4.59
Auchenoglanis biscutatus	38	3.87
Lates niloticus	38	3.87
Schilbe uranoscopus	34	3.47
Mormyrus rume rume	28	2.85
Clarotes laticeps	17	1.73
Tetraodon lineatus	16	1.63
Heterobranchus bidorsali	13	1.33
Coptodon zilli	12	1.22
Pollimyrus isidori isidori	12	1.22
Malapterurus minjiriya	11	1.12
Mormyrus hasselquistii	11	1.12
Brycinus intermedius	10	1.02
Malapterurus electricus	9	0.92
Malapterurus beninensis	9	0.92
Total	**981**	**100**

Fish Species Biodiversity

The values of fish species biodiversity calculated in this study for Kashimbila dam are presented in Table 3 below.

Table 3: Fish Species Biodiversity of Kashimbila Dam

Biodiversity Parameter	**Values**
Number of fish species identified	24
Number of fish families identified	11
The numeric volume of fish sampled	981
Shannon Weiner's diversity index (H′)	2.88
Simpson diversity index (1-D)	0.93
Pielou’s equitable index (J′)	0.904
Margalef’s diversity index (D_M)	3.48

The Shannon-Wiener’s diversity index (H′) measures the richness and distribution of individuals among species. An H value of 2.88 indicates that the ecosystem has significant diversity. This value is higher than that given by Okomoda *et al.* (2017) for Kalgwai Lake in Jigawa state but lower than that reported by Suravi *et al*. (2017) for Dekar Haor in Sunamganj of Bangladesh. The Simpson's Diversity Index measures the relationship between the number of species present in a habitat and the number of individuals within each species. It is often represented as 1 - D, where a value closer to 1 indicates higher diversity. The 0.93 value obtained from this study suggests high fish species diversity and distribution evenness in the dam. Pielou’s equitable index is how individuals are distributed among species in an ecosystem. The value ranges from 0 to 1 and the 0.904 value in this study indicates a fairly even individual distribution among the species. This value is higher than that of River Awach-Seme and River Kisian in Kisumu district, Kenya as recorded by Mwangi *et al.* (2012). Margalef’s diversity index of species richness, the 3.48 value obtained from this study indicates that the dam has significant species richness and diversity. The value is similar to the value reported by Nazeef *et al*. (2021) for Lake Kalgwai in Jigawa State.

CONCLUSION AND RECOMMENDATIONS

This study demonstrates that Kashimbila Dam has significant fish biodiversity indicating a healthy aquatic ecosystem with fish of economic importance. Therefore, it is recommended that continuous monitoring and implementation of sustainable management practices, including periodic closed seasons, be carried out to ensure sustainable use of the dam's resources.

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Prevalence and Consequence of Insurgency on Livestock Data: Implications for Enhancing Livestock Production and Income in North Central, Nigeria

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Abstract
The prevalence and consequences of insecurity and insurgency on livestock data and its implications for enhancing livestock production and income in North Central, Nigeria was examined in this study. A structured questionnaire and interview schedule were used for data collection from 3285 livestock farmers spread across three States (Benue, Kwara and Niger) and the Federal Capital Territory. The data were analysed using descriptive and inferential statistics (t-test). Findings show that the majority (83.84%) of the farmers indicated that insecurity/insurgency has affected their livestock production to a very high extent, and this is shown in the difference in livestock performance which was respectively 10 and 5 before and after insecurity/insurgency. Several strategies, such as the control of banditry, conflicts and insurgency, provision of working capital, and provision of infrastructural facilities were agreed to help improve livestock provision. The T-test showed a significant difference in the average number (5) of livestock produced at a 5% level. The findings suggest that there is an absolute need for the Nigerian government to take legitimate steps in combating the rate of insurgency in the country in general and the northern area of the country in particular.
Keywords: Insecurity, insurgency, livestock production, farmers, impact, performance, farmers household

INTRODUCTION

Livestock are those animals kept by man and they include Chickens, Goats, Sheep, Cattle, Donkeys, Camels, Horses, Turkeys, Pigs, Dogs, Cats, Rabbits, Guinea Pigs and Giant Rats (Bourn, 2012). The prevalence of insurgency or insecurity in Nigeria has been on the increase since 1999 (Oduehie *et al.,* 2023). Consequent to the activities of insurgents, there have been various forms of murder, rape, theft, car snatching, abduction, cultism, kidnapping, robbery of homes, etc. (Abdullahi, 2019). In addition, insecurity has resulted in the farming of only 32 million hectares out of the 92.4 million hectares of the country and this has led to poor production leading to household food insecurity. Nigeria now lacks the capacity and capability to cater for food and the sustainability of the livelihood of the populace (Mufutau *et al*., 2022). Most of the Nigerian rural farmers live in the rural areas and there they carry out their agricultural activities like fishing, crop production, livestock rearing, etc (Oduehie *et al.,* 2023). They lamented that the level of insecurity in Nigeria has resulted in an unwelcome consequence on the livelihood of many of the rural households as well as the lack of data especially in the livestock sector. This study was carried out to Ascertain the extent to which insecurity impacted livestock production in the study area, analyse the rate of growth of livestock production among households before and after the insurgency in the study area and identify strategies on how to improve livestock production in the study area. The hypothesis of the study is stated in the null form as the rate of growth of livestock production by households before the insurgency is not significantly different from the rate after the insurgency in the area.

MATERIALS AND METHODS

Area of Study

The study was carried out in 3 States and the Federal Capital Territory (see Fig 1). The States are Benue, Kwara and Niger State. and they are all in the North Central geo-political zone of Nigeria. They are described below as:

***Federal Capital Territory*: ** Federal Capital Territory (FCT) Abuja was carved out of its neighbouring or surrounding states like old Kwara, Niger, Kaduna and Plateau States. It has 6 Local Government Councils and its estimated population according to National Population Commission (NPC) as of 2023 was 3,840,000 with a land mass of 7,620 km2. Okwuokenye, *et al*. (2023) stated that the vegetation is guinea in nature and it also grows shrubs and is suitable for the rearing of animals. FCT has mineral deposits like clay, feldspar, tin, gold, iron, ore, etc.

Benue State: Benue State derived its name from the river Benue which is the second largest river in the country. The geographical coordinates are Latitude $7^0$20'N and Longitude $8^0$45'E. It has 23 Local Government Areas with its capital seat at Makurdi and the estimated population size as of 2023 was 6,141,300 and a land area of 30,783 Km^2. The State is rich agriculturally as it is known to grow crops like oranges, mangoes, sweet potatoes, yam, rice, cassava, soya bean, guinea corn, etc.

Kwara State: The State is an old State founded in 1967 with 16 LGAs and has its capital at Ilorin. The estimated population size as of 2023 is 3,551,000, while the land area size is 33,433 Km^2 (NPS, 2023) The geographical coordinates of the State are 8.9669^0N and 4.3874^0E (Kwara State Wikipedia). On economic trends, the inhabitants are mostly engaged in growing crops and rearing animals (Ayinde, 2008).

Niger State: Niger State is known to be the largest State in Nigeria. The State was created in 1967, it has 25 local government areas at the moment with the capital seat at Minna. The population size as of 2023 was 27,202,843 and a land area of 1,266,700 Km^2 (NPS, 2023). The monthly average temperature of the State is between 23^0C and 37^0C, while the annual rainfall is between 1100 – 1600mm with a -vegetation that is mainly composed of short grasses, shrubs and scattered trees.

Sampling technique and sample size

The study used a multi-stage sampling technique to select respondents from three northern central states in Nigeria. The first stage includes all agricultural zones and local government councils (LGCs), followed by a random selection of 30 LGAs/LGCs from each zone. The fourth stage involved randomly selecting 4 communities from each LGA/LGC, resulting in 120 communities. The fifth stage involved systematic random sampling, resulting in 3600 respondents.

Sources of data and data collection instrument

Primary and secondary sources of data were used for the study. The data of the study were collected with the use of a questionnaire and interview schedule.

Analytical techniques of the study

Descriptive (percentages, means and standard deviations) and inferential statistics were used to analyse the data of the study. Identified strategies on how to improve livestock production were analysed using a 4-point Likert scale. The scale ranged from "strongly agree" (coded 4), "agree" (coded 3), "disagree" (2) and "strongly disagree" (coded 1). The scale produced a weighted mean of 2.50 and it was asserted that if the mean ≥ 2.50, then the respondents agreed that the strategy or factor under consideration is capable of improving livestock production. On the other hand, if mean = < 2.50, then respondents disagreed that the strategy is capable of improving livestock production. Inferential statistics involved t-test statistics.

A T-test was used to determine the effect of insurgency on livestock production. This was carried out on a before and after basis. The formula for the t-test is as shown below:

$$T = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{(s_1^2/n_1 + s_2^2/n_2)}} \qquad df = n_1 + n_2 -$$

Where,

$\bar{x}_1$ = the mean for effect before insurgency

x_2 = the mean for effect after insurgency

S_1 = standard deviation for effect before insurgency; S_2 = standard deviation for after insurgency

S_1^2 = variance of the effect before insurgency; S_2^2 = variance of the effect after insurgency

n_1 = size of the first group; n_2 = size of the second group; √ = square root

Decision rule for t – t-statistics: If the t – t-calculated is greater than the t – t-tabulated, we conclude by rejecting the null and accepting the alternative hypothesis. If on the other hand, t – tabulated is greater than t – calculated, we accept the null and reject the alternative hypothesis.

RESULTS AND DISCUSSION

The extent to which insecurity/insurgency impacted livestock production

Table 1 shows the extent to which insecurity has impacted livestock production in the area. The results revealed that the majority (83.84%) of the respondents indicated that insecurity/insurgency has negatively impacted their livestock production to a very high extent. The others, notably 12.42%, 3.47% and 0.27% respectively indicated that insecurity/insurgency has a similar effect on their livestock farming activities to a high extent, average extent and low extent. This result is corroborated by the findings of Yau *et al.* (2021) who stressed that the incidence of insurgency has resulted in hike in the price of livestock farming and livestock products.

Table 1: Extent to which insecurity/insurgency impacted livestock production

Variable	Category	Frequency	Percentage
Extent of insecurity/insurgency impact on livestock production	Low extent	9	0.27
	Average extent	114	3.47
	High extent	408	12.42
	Very high extent	2754	83.84
	Total	3285	100.00

Source: Field survey, 2023

Rate of growth of livestock among households before and after insurgency
The results on the rate of growth of livestock among the farmers before and after insecurity/insurgency are shown in Table 2. It revealed that the majority (52.30%) of the livestock farmers had their livestock size increased at the rate of between 10 – 14 animals per annum before the occurrence of insecurity/insurgency. It was however observed that after insecurity/insurgency, the number of livestock produced by the majority (60.06%) of the livestock farmers decreased to less than 5 (<5) animals per annum. The average rate of growth of the animals produced by the livestock farmers before and after insecurity/insurgency on a per annum basis was 10 and 5 animals respectively. The result implies that insecurity/insurgency has adversely affected the rate of growth of animals produced by the farmers in particular and the nation in general. This finding corroborates with Awodola and Oboshi (2015) who reported that farm households have experienced food insecurity and poor production since the escalation of *Boko Haram* in 2013.

Table 2: Rate of growth of livestock amongst households before and after insecurity/insurgency

Variables	Category (per annual basis)	Freq	%	Mean
Livestock performance before insecurity	Increase by <5 animals	177	5.39	
	Increased by 5-9 animals	1118	34.03	
	Increased by 10-14 animals	1718	52.30	
	Increased by 15-19 animals	272	8.28	
	Total	3285	100.00	10
Livestock performance after insecurity	Increase by <5 animals	1973	60.06	
	Increased by 5-9 animals	1100	33.49	
	Increased by 10-14 animals	212	6.45	
	Total	3285	100.00	5

Source: Field survey, 2023

Strategies on how to improve livestock production
The study identifies four strategies to improve livestock production in areas of insecurity/insurgency: controlling banditry, conflict, insurgency, providing working capital, infrastructural facilities, and government assistance. Other strategies include controlling pests and diseases, providing farm inputs, implementing improved technology, training farmers, and encouraging integrated livestock farming systems. The results align with previous research, supporting the need for government efforts to restore peace and security in insurgency-affected areas. The study also supports the development and use of appropriate technology and encouraging farmers to engage in integrated crop farming systems.

Table 3: Strategies on how to improve on livestock production

Variables	SD Freq	%	D Freq	%	A Freq	%	SA Freq	%	Total Mean	SD
Control of banditry, conflicts and insurgency	0	0.00	0	0.00	0	0.00	3285	100.00	4.00*	0.0
Provision of working capital	0	0.00	1	0.03	1185	36.07	2099	63.90	3.64*	0.5
Provision of infrastructural facilities	0	0.00	366	11.14	832	25.33	2087	63.53	3.52*	0.7
Provision of government assistance	0	0.00	366	11.14	1300	39.57	1619	49.28	3.38*	0.7
Control of Pests and diseases	0	0.00	227	6.91	2561	78.01	495	15.08	3.08*	0.5
Provision of farm input	62	1.89	145	4.41	2621	79.79	457	13.91	3.06*	0.5
Application of improved technology in the production process	0	0.00	525	15.98	2306	70.20	454	13.82	2.98*	0.5
Training of farmers on improved livestock farming technology	0	0.00	432	13.15	2427	73.88	426	12.97	2.73*	0.6
Farmers' encouragement of integrated livestock farming systems into cropping systems	0	0.00	432	13.15	2239	68.16	614	18.69	2.61*	0.6
Provision of manpower	2097	63.84	1125	34.25	63	1.92	0	0.00	1.38	0.5

Source: Field survey, 2023; *Agreed factor (mean ≥ 2.50)

Effect of insecurity/insurgency on livestock production

The results (Table 4) showed that the average number of animals kept by the livestock farmers before insecurity/insurgency was 10. While after the insurgency, it dropped to 5 animals. The results showed that the number was higher than what it was after the insurgency. The difference in the number before and after the insurgency was 5 livestock. This was significant since the calculated t value (21.423) was greater than the tabulated t value at the 5% level (1.645). Based on this, the alternative hypothesis was accepted against the null. It thus states that the rate of growth of livestock production by households before the insurgency is significantly different from the rate after the insurgency in the area. This result is supported by the results of Awodola and Oboshi (2015) who reported a drop in food production due to insecurity. Hassan and Lawal (2023) also share the same view as they noted that insecurity/insurgency has resulted in a reduction of investments in animal production which has consequently led to negative impacts on supply chains and animals' productivity losses.

Table 3: Effect of insecurity/insurgency on livestock production (t-test)

Livestock performance	No.	Income (₦) Mean of animals	Difference	t	Decision
Livestock performance before insecurity	3285	10	5	21.423*	Significant
Livestock performance after insecurity	3285	5			

*Significant at the 5% level (critical t- value = 1.645)

CONCLUSION AND RECOMMENDATIONS

Insurgency significantly impacts livestock production, resulting in a low number of livestock in certain areas. Strategies such as controlling banditry, providing working capital, and providing infrastructure can increase livestock production. The study recommends the government to combat insurgency, especially in the northern region, to create a peaceful environment for farmers. Additionally, farmers should be organized into cooperative societies to share resources and access loans for larger-scale production.

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Analysis of Factors Influencing Micro Credit Access among Groundnut Women Processors in Ganjuwa and Warji LGAs of Bauchi State

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Abstract
*The study examined access to micro credit by groundnut (Arachis hypogeae **L**.) women processors in Bauchi State, Nigeria. Two Local Government Areas were purposively selected from the central agricultural zone with sample size of 122 groundnut women processors. Data were collected with the aid of well-structured questionnaire and analysed using descriptive and inferential statistics. The result of the Tobit regression showed that inadequate farm investment (80.64561), membership of cooperatives (131.5643), availability of processing technology (-1.86418), adoption of processing technology (-54.40501) were significant at P<0.01 influencing access to micro credit by the processors. While access to extension services (8.814243) was found to be significant at P<0.05 influencing access to credit in the study area. The major constraints faced by the respondents were inadequate capital, insufficient modern processing equipment and facilities, high cost of processing materials, high interest rate, and inadequacy of collaterals to access credit facilities, respectively. The respondents complained that the major constraints affecting their enterprises were inadequate capital, high cost of processing materials and limited access to extension services among others. The study recommended that soft loans should be made available at low interest rate by the government and non-governmental financing institutions. In addition, women groundnut processors should source modern processing equipment collective from cooperative societies and service providers in order to boost production in the study area.*

Keywords: Access, Groundnut, Micro-Credit, Processing, Women

INTRODUCTION

Groundnut (*Arachis hypogaea L.)* belongs to the genius Arachis in family *legiminosea (Fabacaea).* Groundnut seeds or nuts are a nutritional source of vitamin E, Niacin, Folacin, calcium, phosphorous, magnesium, zinc, iron, riboflavin, amino and potassium (Girei, Dauna and Dire, 2019). Groundnut, sometimes called Peanut, is majorly grown for its nut, oil or stem. Groundnut cake is often deep-fried or dried to make a Kuli-Kuli snack (Adamu, Yakaka and Dotti, 2023). Similarly, Groundnut haulms also provide excellent hay for livestock, while its flour is also used as an ingredient in soup, confectionaries and pudding (Taru, Kyagya and Mshelia, 2022). Groundnut is the 13th most important food crop in the world. It is the world's 4th most important source of edible oil and third most important source of vegetable protein (Muhammad-Lawal, Animashaun and Towoju, 2020). It contains 48-50% oil, 26-28% protein and 11-27% carbohydrates, minerals and vitamins (Madaki, Abba and Mary, 2016).

Groundnut production in Nigeria and the Bauchi State, in particular the study area, has suffered major setbacks from the groundnut rosette epidemics and foliar diseases, aflatoxin contamination and lack of sufficient and consistent supply of seed of improved varieties for particular ecologies, inappropriate crop management practices, pests and diseases, climate variability, poor access to production technology and inputs (Audu *et al.,* 2017 and Madaki *et a.,*2016). Similarly, crop productivity or yield is a function of environment, plant, management and socio-economic factors and their interactions; and maximum yield in a given environment is possible only when all these factors are at optimum levels (Kadurumba, Kadurumba and Umeh, 2020). However, most research works done on groundnut such as (Girei *et al*., 2019 and Taru *et al.,* 2022) were in different areas with different soil types for instance Madaki *et al.* (2016) study was in Ganjuwa where the soil type is alluvial and rocky.

The gender division of women in farm labor assigns women more works in the processing of groundnut as agricultural food products and yet, women have no access to improved methods of groundnut processing and depend mainly on the traditional methods, due to the constraints that are responsible for it, such as poor electricity supply, lack of credit facilities, high purchasing price of technologies increase in price of petrol, poor processing equipment's poor quality of groundnut and absence of sustainable policy for groundnut processing activities. Hence, agricultural credit is expected to play a critical role in groundnut processing and agricultural development as a whole (Taru *et al.,* 2022).

Objectives of the Study

The specific objectives were to:

i. Determine the factors that influenced access to credit by groundnut women processor's; and
ii. Describe the constraints faced by groundnut women processors in accessing micro credit in the study area.

METHODOLOGY

Study Area

Ganjuwa LGA is located on latitude 10.729^0 North and longitude 9.912^0 East with land mass of 5,059km^2. The estimated population was about 391,200 (NPC, 2021). The climatic condition is characterized by two distinct seasons, dry and wet seasons, with rainfall ranging from 850mm to 1000mm per annum which falls between April/May and October and dry season starts from November to April, while temperature ranges from 9.11^0 C to 40.55^{0}C (BSADP, 2015). Warji LGA is located on latitude 11.158^0 North and longitude 9.739^0 East with land mass of 625km^2. The estimated population was about 161,500 (NPC, 2021). The climatic condition is characterized by two distinct seasons, dry and wet seasons, It has an average daily high temperature 30^{0}C and rainfall range of 700mm which falls between April/May and October and dry season starts from November to April (BSADP, 2015). The vegetation types are conditioned by the climatic factors, which in turn determine the amount of rainfall received in the area. It has loosed soil and clay soil. The vegetation is typically Northern Guinea Savanna type made of grasses and herbaceous plants. Trees are scattered and do not form a canopy. The human settlement in the area is essentially of rural setting with few semi – urban environments (BSADP, 2015). The major economic activities of the area are farming, trades, cattle rearing, hunting, weaving, black smiting, art and craft practiced by the people. The major crops produced by most of the farmers in Warji LGA include rice, maize, millet, groundnut, cowpea, sesame, sorghum, while livestock include cattle, sheep and goat, and poultry.

Sampling Techniques and Sample Size

Multi-stage sampling was employed in the selection of respondents for the study. In the first stage, two Local Government Areas (Warji and Ganjuwa LGAs) were purposively selected because of large number of groundnut women processors. While in the second stage, two villages were randomly selected from each LGAs making a total of four villages. A response rate of 20% was considered adequate for analysis and reporting within the study; therefore, in the final stage, 20% respondents were proportionately selected from the sampling frame as sample size. The sampling procedure and sample size is presented in Table 1.

Table 1: Sampling Procedure and Sample Size

LGA's	Villages	Sample frame	Sample size @20%
Ganjuwa	Kafin Madaki	160	32
	Miya	100	20
Sub-total		**260**	**52**
Warji	Tudun Wada	200	40
	Ranga	150	30
Sub-total		**350**	**70**
Grand-Total		**610**	**122**

Source: Field Survey, 2022

Methods of Data Collection

The research used primary data that were collected through the administration of structured questionnaire to the respondents with the assistance of trained enumerators. The questionnaires will be administered to the women engage in Groundnut processing and have access to agricultural credit in the study area.

Methods of Data Analysis

The research used both descriptive and inferential statistics to achieve the research objectives. Descriptive and inferential statistics such as; mean, frequency distribution and percentages was used to achieve objectives i and ii

Tobit regression model: As specified by Agwu. (2014):

$$Yi = Yi^{*} \text{ if } \beta_0 + \beta X_i + \mu_i > 0 \quad \ldots (1)$$

$$Yi = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + U \quad \ldots (2)$$

where;

Y_i = Dependent variable (Access to credit (access = 1, otherwise = 2)

Yi^{*} = Latent variable (Unobserved)

X_i = Independent variable

β = Coefficient of the explanatory variable

μ_i = Error term

$X_1 – X_8$ = Independent variables, defined as:

X_1 = Access to extension service (access = 1, otherwise = 2)

X_2 = Inadequate farm investment (adequate = 1, otherwise = 2)

X_3 = Membership of cooperatives (member =1, otherwise = 2)

X_4 = Availability of processing technology (available =1, otherwise = 2)

X_5 = Awareness of processing technology (aware =1, otherwise = 2)

X_6 = Adoption of processing technology (number of technologies adopted)
X_7 = Years of experience (years)
X_8 = Education (years)
β_0 = Constant
$\beta_1 - \beta_8$ = regression coefficient
U = Error term.

RESULTS AND DISCUSSION

Factors Influencing Credit Access by Groundnut Women Processors

The Table 2 result shows that inadequate farm investment, membership of cooperatives, availability of processing technology, adoption of processing technology was significant $p > 0.01$ while access to extension services was also found to be significant at $p < 0.05$ influencing groundnut women processors access to credit in the study area. This agrees with Amaza *et al*. (2021), who reported a positive relationship between processing technology and inadequate investment. This means the presence of ultra-modern processing facilities was very important; especially the engagement of more women on the groundnut processing and adequate investment will enhance good productivity. Awareness of processing technology, years of experience and education was found not to be significant which showed that adoption of processing technology, access to extension service and membership of cooperatives, were significant influenced access to credit by women groundnut processors.

Table 2: Factors that influence access to credit by women groundnut processors

Variables	Coefficient	SE	T	p>/t/
Constant	4.014	1.130	3.64	0.000***
Access to extension service	8.814243	4.459096	1.98	0.048**
Inadequate farm investment	80.64561	21.58322	3.74	0.000***
Membership of cooperatives	131.5643	17.27938	7.61	0.000***
Availability of processing technology	-1.86418	0.5376613	- 3.47	0.001***
Awareness of processing technology	-17.233	35.74237	- 0.67	0.874^{NS}
Adoption of processing technology	-54.40501	7.418496	- 7.33	0.000***
Years of experience	-16.218	38.64136	-0.42	0.675^{NS}
Education	-0.499	1.488	0.112	0.739^{NS}
Log likelihood = -308.0546				
Pseudo R^2 = 0.0343				
LR chi2 (8) = 271.59				
Prob > chi2 = 0.000				

***Significant at ($P < 0.01$); **Significant at ($P < 0.05$); NS: Not Significant
Source: Field Survey, 2022

Constraints Affecting Groundnut Women Processors in Accessing Micro Credits

The Table 3 shows that (100.0%) of the respondents complained that the major constraint was inadequate capital followed by high cost of processing materials (95.1%), limited access to extension services (95.1%), inadequate extension agent visit and awareness (95.1%), poor rural infrastructures (86.9%), inadequacy of modern equipment and machineries (84.4%), lack of collateral to access credit (84.3%), limited access to credit (69.7%), high interest rate (60.7%) and poor working condition (40.2%). These problems highlighted coincide with the number of problems reported by Ani *et al*. (2020) and Abubakari *et al.* (2019) were major problems affecting groundnut processing in the study areas.

Table 3: Constraints faced by women groundnut processors access to micro credit (n = 122)

Constraints	*Frequency	Percentage	Ranking
Inadequate capital	122	100.0	1st
Inadequacy of modern equipment and machineries	116	95.1	2nd
Limited access to extension services	116	95.1	2nd
Poor rural infrastructures	106	86.9	3rd
Inadequate extension agent visit and awareness	103	84.4	4th
insufficient of collateral to access credit facilities	98	80.3	5th
Limited access to credit	85	69.7	6th
High interest rate	74	60.7	7th
Poor working condition	49	40.2	8th
Total	**985**		

Source: Field Survey, 2022 * Multiple Responses

CONCLUSION AND RECOMMENDATIONS

The study concluded that socio-economic factors had influence on access to micro agricultural credit by the groundnut women processors in the study area. Also the respondents complained that the major constraints affecting their enterprises were inadequate capital, high cost of processing materials and limited access to extension services among others. The study recommended that soft loans should be made available at low interest rate by the government and non-governmental financing institutions. In addition, women groundnut processors should source modern processing equipment collective from cooperative societies and service providers in order to boost production in the study area.

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Climate-Resilient Soybean Production in Bassa, Plateau State, Nigeria: A Study on Adaptation Strategies and their Effectiveness

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Abstract
This study assessed the effectiveness of climate change adaptation strategies on soybean production in Bassa Local Government Area, Plateau State, Nigeria. Specifically, it evaluated the efficacy of various climate-adaptive measures and identified constraints hindering their adoption. A purposive sampling method was used to select 140 respondents from two districts. Data collected through structured questionnaires and interviews were analyzed using descriptive statistical tools. Findings revealed that certain adaptive measures (crop rotation, cover cropping, mulching, and integrated pest management) were effective, while others (drought-tolerant varieties, irrigation systems, climate-smart agriculture, precision farming, and weather-index insurance) were not. Constraints to adoption included high costs, limited access to credit, inadequate climate information, insufficient extension services, and lack of knowledge, inadequate government support, restricted market access, and inadequate infrastructure. The study concludes that government support for drought-tolerant seeds, farmer cooperatives, regular extension services, and a comprehensive policy framework can enhance climate resilience in soybean production.
Keywords: Effectiveness, climate change, Adaptive-measures, Soybean production

INTRODUCTION
Soybeans are a vital crop in Nigeria, enhancing food security and economic growth (Nigerian Export Promotion Council, 2020; Siamabele and Moral, 2021). Soy protein is a comprehensive protein source containing all nine necessary protein building blocks and has a digestibility-adjusted protein quality score of 1.00, which is on par with proteins derived from animals (Pingxu, Taoran, and Yangchao, 2022). While slightly deficient in sulfur-containing amino acids like methionine, soybeans' versatility in food processing, animal feed, and biofuel has driven increased demand and production, generating employment and income for farmers. Additionally, the governments and investment have further elevated the significance of soybeans in Nigeria's agricultural sector. The nutritional benefits of soybeans, rich in protein, fiber, and essential vitamins and minerals, have increased their consumption, promoting better health and well-being (Saha and Mandal, 2019; Wakweya, 2023; Haritika, 2023). Research links soy consumption to reduced chronic disease risk, including heart disease, diabetes, and obesity (Dukariya et al., 2020). High-protein soy products have additionally been demonstrated to lower cholesterol levels (Harvard Health, 2019). As the soybean

industry grows, it is poised to contribute significantly to Nigeria's agricultural sustainability and development.

Furthermore, soybean cultivation has improved significantly through research and development, collaborations, and sustainable agriculture initiatives (Saikia & Laishram, 2023). Digital technologies enhance efficiency and market access, while innovative farmers contribute to a robust agricultural value chain. Nigeria's Plateau state is a top soybean producer, thanks to favorable conditions (NATIP, 2022; Fasusi et al., 2022; Saikia and Laishram, 2023).

However, climate change poses significant challenges to soybean production in Bassa Local Government Area, Plateau State, with unpredictable weather patterns, rising temperatures, and extreme weather events substantially reducing agricultural productivity. Research by Fasusi et al. (2022) reveals far-reaching impacts on soybean production, including agro-ecology shifts, nutrient loss, and deterioration of soil health. Adaptive measures such as drought-resistant varieties, improved irrigation, soil conservation, and agroforestry are essential for mitigating these effects (Prasad et al., 2023). This study aims to assess the effectiveness of climate change adaptation strategies on soybean production on soybean production in Bassa Local Government Area, Plateau State, Nigeria.

The study seeks to:

i. assess the effectiveness of climate change adaptation strategies in soybean production; and
ii. identify the constraints to the use of climate-adaptive measures in soybean production.

These will provide valuable information that can guide decision-makers in enhancing resilience and productivity within the local agricultural sector amidst changing climatic conditions. The findings from this study will contribute to a better understanding of effective strategies for sustainable soybean production under varying climatic conditions.

MATERIALS AND METHODS

This study was conducted in Bassa LGA, Plateau State, Nigeria. Two districts, Kishika and Mafara, were purposively selected as they are the major soybean-producing areas. A total of 140 soybean farmers were selected from the two districts (Seventy persons from each district). Data was collected using a structured questionnaire and interview schedule. A Descriptive statistical tool (mean) was used to analyze the data.

RESULTS AND DISCUSSIONS

The effectiveness of climate change adaptation strategies in soybean production is shown in Table1 above. The results indicate that strategies like crop rotation, cover cropping, and integrated pest management were effective, with mean scores of 3.0 and above. The findings align with Andy (2015) who noted that cover crops are one of the best ways to improve soil health, reduce off-farm inputs and protect natural resources. In contrast, farmers showed a poor attitude towards drought-tolerant varieties, irrigation systems, and climate-smart agriculture, with mean scores less than 2.5. This is likely due to high costs, complexity, and limited knowledge (Antwi-Agyei et al., 2021). The findings suggest that soybean farmers in Bassa LGA have not benefited from these strategies, highlighting the need for support and accessible solutions.

Table 1: effectiveness of climate change adaptation strategies in soybean production

Climate Change Adaptation Strategies	Very Effective (4)	Effective (3)	Less Effective (2)	Not Effective (1)	Mean (x̄)
	F (%)	F (%)	F (%)	F (%)	
Crop rotation and diversification	56 (40.0)	48 (34.3)	21(15.0)	15(10.7)	3.0
Drought-tolerant varieties	26 (18.6)	6 (10.6)	62 (44.3)	46(32.9)	2.1
Irrigation system	21(15.0)	4 (2.9)	67 (47.9)	48(34.3)	2.0
Agroforestry	15(10.7)	3 (2.1)	60 (42.9)	62 (44.3)	1.8
Cover cropping	71 (50.7)	43 (30.7)	21(15.0)	5 (3.3)	3.2
Climate-Smart Agriculture	3 (2.1)	21(15.0)	59 (42.1)	57 (40.7)	1.9
Soil mulching	80 (57.1)	39 (27.1)	13 (3.9)	8 (5.7)	3.2
Integrated pest management techniques	57 (40.7)	63 (45.0)	14 (10.0)	6 (4.0)	3.2
Precision farming	8 (5.7)	16 (11.4)	56 (40.0)	60 (42.9)	1.8
Weather-index insurance	16(11.4)	7 (5.0)	61(43.6)	56 (40.0)	1.9

Field survey, 2024. Mean score ≥ 2.50 = Effective, Mean score < 2.50 = Not Effective

Table 2 shows economic constraints to adopting climate-adaptive practices in soybean production, including high costs and limited access to credit, with mean scores of 4.3. The findings align with Ikyoosu et al., (2017) Siamabele and Moral (2021) identifying the high cost of improved soybean seed as a key constraint limiting farmers from adopting climate-adaptive practices in soybean production. Technical constraints include inadequate climate information, extension services, and knowledge, scoring 4.3, 4.2, and 4.1, respectively.

These findings (Table 2) align with Ncoyini et al., (2022) that limited access to reliable climate information can leave farmers unprepared for extreme weather events, impacting soybean yields. Institutional and policy constraints include insufficient government support, restricted market access, and inadequate infrastructure, with mean scores of 3.8, 3.7, and 3.2, respectively. The finding is in agreement with Ukaoha et al., (2022) and Wakweya (2023) which identified similar challenges as the primary constraint to soybean cultivation in the federal capital territory, Nigeria. These findings highlight the need for accessible and affordable climate-adaptive strategies, reliable climate information, and supportive policies to enhance soybean production resilience.

Table 2: Constraints to the use of Climate-Adaptive Measures in Soybean Production

Constraints	Extremely Severe Constraint (5)	Severe Constraint (4)	Moderate Constraint (3)	Mild Constraint (2)	Not a Constraint (1)	Mean (x̄)
Economic Constraints						
High cost of climate-adaptive inputs (e.g., drought-tolerant seeds, irrigation systems, precision agriculture)	71(50.7)	43(30.7)	21(15.0)	3 (2.1)	2(1.4)	4.3
Limited access to credit for climate-adaptive investments	80(57.1)	39(27.1)	13(3.9)	8 (5.7)	- -	4.3
Uncertainty about the economic benefits of climate-adaptive measures	16(11.4)	8 (5.7)	21(15.0)	39(27.1)	56(40.0)	2.2
Technical Constraints						
Lack of knowledge about climate-adaptive practices	54(38.6)	53(37.9)	25(17.9)	4 (2.9)	4 (2.9)	4.1
Limited access to climate \information and forecasting	71(50.7)	43(30.7)	21(15.0)	3 (2.1)	2 (1.4)	4.3
Inadequate extension services and support	60(42.9)	59(42.1)	15(10.7)	3(2.1)	3(2.1)	4.2
Social and Cultural Constraints						
Resistance to change from traditional farming practices	13 (3.9)	8 (5.7)	21(15.0)	59(42.1)	39 (27.1)	2.3
Limited social support from peers and community	14(10.0)	15(10.7)	6 (4.0)	48(34.3)	57(40.7)	2.2
Cultural beliefs and practices that hinder adoption	16(11.4)	13 (3.9)	8 (5.7)	60(42.9)	43(30.7)	2.3
Institutional and Policy Constraints						
Lack of government support and policies for climate-adaptive agriculture	39(27.1)	59(42.1)	21(15.0)	13(3.9)	8 (5.7)	3.8
Inadequate infrastructure for climate-adaptive practices (e.g., irrigation canals)	57(40.7)	15(10.7)	14(10.0)	6 (4.0)	48 (34.3)	3.2
Limited access to markets for climate-resilient soybean products	56(40.0)	39(27.1)	16(11.4)	8 (5.7)	21(15.0)	3.7

Field Survey, 2024. Mean score ≥ 3.0 = Constraint, Mean score < 3.0 = Not a constraint

CONCLUSION AND RECOMMENDATIONS

This study assessed the effectiveness of climate change adaptation strategies in soybean production in Bassa Local Government Area, Plateau State. The findings revealed that while certain strategies like crop rotation and diversification, cover cropping, and integrated pest management are effective in enhancing climate resilience, economic, technical, and institutional constraints hinder their adoption. Specifically, high costs, restricted access to credit and climate information, inadequate extension services, and insufficient government support and policies pose significant barriers to the widespread adoption of climate-adaptive measures.

The study recommends as follows:

- The government should ensure the availability of drought-tolerant seed at all times and at a reduced cost. This is to encourage and boost farmers interest on the continuous use of drought-tolerant seed
- The Government should establish a comprehensive policy framework and set up meteorological institute to address farmers need on climate variation and advice.
- Farmers should form themselves into a cooperative society to access a bulk purchase of agricultural input at a reduced cost
- Lack of knowledge about climate-adaptive practices extension training and campaign should be mounted to equip the farmers with the vagaries of weather, to enable them to prepare for solution in the coming farming season.
- Extension visit should be proactive at every forth night to provide the necessary and timely information required in soybean production.

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Impact of Sowing Methods and Time of Herbicide Application on the Productivity of Rice (*Oryza sativa* l.) in Lafia, Southern Guinea Savannah of Nigeria

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Abstract

A field experiment was conducted during the wet season of 2023 at the Teaching and Research Farm of the College of Agriculture, Science and Technology, Lafia Nasarawa State located on latitude 80.33`N and longitude 80.32`E with a mean elevation of 181.53 m above sea level. To investigate the impact of different sowing methods of rice in the Southern Guinea Savannah of Nigeria. The treatment consisted of five planting methods (dry-seeding broadcasting, wet-seeding broadcasting, dry-seeding dibbling, wet-seeding dibbling and row transplanting methods) and two times of herbicides application (2 and 3 weeks after sowing). The (10) treatment combinations were laid out in Randomized Complete Block Design (RCBD) and replicated three (3) times. The data on growth and yield parameters were collected on Plant height, Number of tillers, Day to 50% flowering, Day to maturity, Number of seeds per panicle, seed yield per panicle, 1000-grain weight and Grain yield per hectare. The result revealed that the Transplanting method consistently outperformed other sowing methods across growth and yield parameters. The dibbling (wet and dry) was the next best alternative. Broadcasting had the poorest outcomes. Applying herbicide at 2 weeks after sowing resulted in better outcomes in all parameters than at 3 weeks after sowing. In conclusion, the transplanting method of sowing demonstrated superior performance across all parameters, with dibbling wet and dibbling dry as alternative options. The time of herbicide application and minimal impact on most parameters. Combine transplanting with herbicide application at 2 WAS to boost rice growth, development, and yield, and maximize profits.

Keywords: Sowing, Herbicide, Broadcasting, Dibbling, Transplanting and Hectare

INTRODUCTION

Rice (*Oryza sativa* L.) a member of the Poaceae family, is a staple food for over 60% of the global population, serving as a primary source of nutrition (ICAR, 2006). In Nigeria, it plays a vital role in agriculture and daily food consumption, providing approximately 20% of the world's dietary energy. Rice is an excellent source of essential nutrients, including calories, protein, fat, and carbohydrates, accounting for two-thirds of the average Nigerian's caloric intake and half of their protein intake. To meet the demands of the growing global population, rice production must increase from 520 million tons to 880 million tons by 2025, as forecasted by CGIAR (2023). This can be achieved through the adoption of advanced farming techniques and high-yielding rice varieties. However, challenges such as water scarcity, rising fertilizer costs, and labor shortages necessitate the implementation of effective agronomic practices to ensure sustainable rice production.

Africa, despite accounting for only 2.6% of global rice cultivation area and 4.6% of the population, produces an average of 14.6 million tonnes of rice annually on 7.3 million hectares, as reported by AfricaRice (2022). West Africa dominates the continent's rice production, covering 56.5% of the land area, approximately 3.7 million hectares. In Nigeria, rice has become a staple food across all social classes, with demand surpassing other staples. The country's annual rice consumption is 5.4 million metric tons, worth over $9.2 billion. However, domestic production only reaches 2.3 million metric tons, resulting in a significant import deficit of 3.1 million metric tons. Nigerian farmers face substantial challenges in boosting productivity, including optimizing establishment methods, effective weed control, and fertilizer application, all of which significantly impact rice yields, as noted by Arouna *et al.* (2017).

Rice production faces numerous challenges, with weed growth being the most significant obstacle. Weeds can reduce rice yields by 75-100% due to competition for resources like water, nutrients, and light. (Akobundu, 2011; Imeokparia, 2011; Lavabre, 2011). No-tillage rice is more vulnerable to weed competition than transplanted rice, especially when using dwarf varieties and fertilizers. Poor weed control can lead to 40% production losses. Early weed control is crucial in direct sowing, where rice seeds and weeds germinate simultaneously. Farmers have various weed control methods, including chemical treatments, traditional practices, and manual weeding (Street and Lanham, 2016). Effective weed management requires precise timing and method selection, with herbicide efficacy being critical. Researchers have identified effective herbicides for different growth stages, including pre-plant, burn-down, pre-emergence, and post-emergence treatments. (Mahajan and Chauhan, 2022; Allen, 2012). Specific herbicides like thiobencarb, pendimethalin, and ethoxysulfuron have proven effective in controlling weeds in direct-seeded rice systems. (Kumar *et al*., 2018; Mahajan and Chauhan, 2022).

In Nigeria, rice farmers employ various planting techniques, including broadcasting, dibbling on ridges, and random or row transplanting (Fukagawa and Ziska, 2019). While row transplanting is touted as a means to increase rice yields in lowland areas, it demands substantial water and labor resources. To address these challenges, direct seeding is now being advocated as a more efficient and labor-saving approach that conserves water (Kamai *et al.,* 2020).

In Nigeria, manual weeding is the traditional method, but it's no longer viable due to labor shortages and increasing costs. Moreover, distinguishing between rice seedlings and weeds, particularly grasses, is difficult during the early growth stage, making manual weeding ineffective. (Kamai *et al*., 2020). Therefore, herbicides are considered the most effective solution for weed control in direct-seeded rice (DSR) (Sanjoy *et al.,* 2019). Pre-emergence herbicide application is crucial for efficient weed management in DSR. However, selecting the right herbicide is essential for cost-effective weed suppression. Environmental factors, such as soil moisture, can impact herbicide efficacy and crop safety by affecting absorption, translocation, or metabolism. To boost rice production and meet the growing population's demands, it's essential to optimize rice planting methods, nitrogen rates, and herbicide application timing based on prevailing conditions. (Sanjoy *et al.,* 2019).

Despite the importance of optimizing rice production, there is a lack of knowledge on the best planting method and timing of herbicide application or achieving high yields in this agro-ecological zone. This study aims to fill this knowledge gap by investigating the effects of different planting methods and herbicide application timings on rice productivity, with the goal of identifying the most effective practices for improving yields.

MATERIALS AND METHODS

Description of the Experimental Site

Field experiment was conducted during the wet season of 2023 at the Teaching and Research Farm of the College of Agriculture, Science and Technology, Lafia Nasarawa State located on latitude 80.33`N and longitude 80.32`E with a mean elevation of 181.53 m above sea level (Jayeoba, 2013).

Treatments and Experimental Design

The trials were carried out in 2021 wet season. The treatment consisted of five planting methods (dry-seeding broadcasting, wet-seeding broadcasting, dry-seeding dibbling, wet-seeding dibbling and row transplanting methods) and two time of herbicides application (2 and 3 weeks after sowing).The (10) treatments combinations was laid out in Randomized Complete Block Design (RCBD) and replicated three times. The gross plot size was 9m^2(3m x3m) and net plot size was 4m^2 (2m x 2m).

Land Preparation

The experimental field was prepared according to standard procedures, involving ploughing, harrowing, leveling, and manual bounding. In both locations, nursery beds were created for sowing seeds and raising seedlings, which were later transplanted to the field.

Seed/Seedling

Direct seeding and broadcasting were done using both dry and pre-germinated seeds. A nursery was established for the seedlings, which were later transplanted at 14 days after establishment at a rate of 2 seedlings per hole. Both transplanting and direct seeding were done with a spacing of 20 x 20 cm. The FARO 44 rice seed variety was used, with the following seeding rates: 25 kg/ha for transplanting, 50 kg/ha for direct seeding and 60 kg/ha for broadcasting.

Fertilizer Application

A basal application of NPK 15:15:15 fertilizer was applied on the day of sowing or transplanting, prior to sowing or transplanting. The first topdressing with Urea was applied 3-4 weeks after sowing or transplanting, followed by second topdressing with

Urea 6-8 weeks after sowing or transplanting, according to the specified fertilizer rates for each treatment.

Disease and Pest control
Throughout the experimental period, there were no occurrences of pest or disease outbreaks. As a result, no pesticides were applied during the experiment.

Harvesting
The rice field was harvested when 80-85% of the panicles had turned yellow or brown, which occurred around 14-16 weeks after sowing (WAS). Harvesting was done using a rice sickle.

Threshing and Winnowing
Threshing was done manually using a drum on a tarpaulin. The seeds were then separated from the chaff through winnowing, a process that uses air to blow away the lighter chaff, leaving the heavier seeds behind.

Growth and Yield Parameters
In each plot, five hills were randomly selected and tagged for data collection, and the following parameters were recorded:

Plant Height
This was collected at 10WAS and at harvest by measuring the height of the tagged plants using a meter rule from the ground level to the apical bud of the plant and mean recorded.

Number of Tillers
This was counted from the 10 selected tagged plants at 10WAS and the mean recorded.

Days to 50 % flowering
This was determined by counting the number of days from sowing to when half of the plant in a plot have flowered

Days to Maturity
This was counted from the sowing date to the date of harvesting for each treatment.

Number of Seeds per Panicle
The number of seeds per panicle from the selected tagged plants was threshed, counted and the mean recorded.

Seed Yield per Panicle (weight)
The seed from the selected panicles after threshing were weighed and the mean recorded.

Grain Yield
Total grain at harvest was determined by weighing the grains from each net plot with a Mettler scale Model 1210 and the value obtained was converted to per hectare basis.

Statistical Analysis
Data analysis was performed using GENSTAT software (2008 edition).Analysis of Variance (ANOVA) was conducted using the General Linear Model Procedure. Least

Significant Difference (LSD) was used to compare means at a 5% level of probability (P≤0.05).

RESULTS AND DISCUSSION

Table 1: showed the effect of planting methods and time of herbicide application on Plant height, Number of tillers, Days to 50% flowering, Days to maturity, Number of seeds per panicle, Seeds yield per panicle, 1000-grain weight and Grain yield per hectare at Lafia 2023 wet seasons.

Plant height result indicated that transplanting method of planting produced significantly tallest plants (86.59) compared to the other methods of planting, the timing of herbicide application on plant height revealed that applying herbicide at 2 WAS resulted in significantly taller plants (85.19) compared to 3WAS time of herbicide application. No significant interactions between planting methods and time of herbicide application, indicating that the effects of planting methods and herbicide application time were independent of each other.

Number of tillers result indicated that transplanting method of planting produced significantly highest number of tillers (17.55) compared to other planting methods. Time of herbicide application on the number of tillers showed that applying herbicide at 2WAS resulted in significantly higher number of tillers compared to 3WAS of herbicide application.

Days to 50% flowering result showed that the transplanting method of planting significantly attained late flowering (69.94) compared to others methods of planting. Broadcasting method of planting was the first to attain 50% compared to other methods. The time of herbicide application on days of 50% flowering revealed that there was no significant difference at 5% level of probability.

Days to maturity result indicted that all treatments showed statistically similar days to maturity, ranging from 115.94 to 116.50 days, though transplanting method of planting significantly influenced the day to maturity compared to other method of planting. Transplanting planting method of rice matured late compared to broadcasting and dibbling methods. The time of herbicide application on days to maturity revealed that 2WAS application significantly matured earlier compared to 3 WAS application.

Number of seeds per panicle result indicated that the transplanting method of planting significantly resulted in the highest number of seeds per panicle compared to other method of planting. The herbicide time of application on number of seeds per panicle revealed that 2WAS herbicide application significantly produced highest number of seeds per panicle compared to herbicide application at 3WAS.

Seeds yields per panicle result indicted that the transplanting method of planting significantly produced highest seed yield per panicle compared to other method of planting. The timing of herbicide application on seeds yields per panicle indicated that 2WAS significantly influenced the production of higher seed yield per panicle compared with 3WAS of herbicide application.

1000-Grain weight result indicated that the transplanting method of planting produced significantly highest 1000 grain compared to other methods of planting. The time of herbicide application on 1000-Grain weight indicated that 2WAS significantly influenced the production of 1000- grain compared the application at 3 WAS application.

Grain yield per hectare result revealed that the transplanting method of planting significantly produced highest yield (4882.5 ton/ha) compared to other methods of sowing. The time of herbicide application on grain yield per hectare indicated that 2 WAS significantly influenced the production of rice yield per hectare compared with 3WAS application of herbicide. There significantly interactions on grain yield between the sowing methods and time of herbicide application.

The Table 2 shows the interaction effects between sowing methods and herbicide application time on rice grain yield per hectare in 2021 wet season, the transplanting method of sowing with 2WAS significantly increased grain yields compared to other methods of sowing and time of herbicide application.

Transplanting method of sowing produced significantly better plant growth performance and increased in grain parameters and grain yield compared to other methods of sowing. This could be as a result of taller plants, increased tiller count, higher biomass and dry matter accumulation, more panicles, higher seed yield per hill, and greater photosynthetic capacity. These was consistent with findings by Kawure *et al*. (2023), emphasizing that transplanting and direct seed dibbling methods generally resulted in higher yields compared to seed drilling and broadcasting methods.

Application of herbicide at 2WAS produced significantly increased grain yield per hectare compared to 3WAS of herbicide application. This indicates that the superiority of transplanting sowing method for increasing rice grain yield per hectare in the study area. Herbicide application at 2WAS is the most effective time for enhancing grain yield when using the transplanting method Kawur e *et al*. (2023).

Table 2 results indicated the interaction on the grain yield revealed that, the transplanting method of sowing with herbicide application at 2weeks after sowing (2WAS) produced significantly higher grain yields compared to other sowing methods and herbicide application times.

CONCLUSION AND RECOMMENDATIONS

In conclusion the transplanting method of sowing demonstrated superior performance across all parameters, with dibbling wet and Dibbling dry as alternative options. The time of herbicide application had minimal impact on most parameters.

Based on the study's findings, the following recommendations are made:

- The farmer should adopt Transplanting as the primary sowing method for improved rice productivity in the study area.
- Farmers should consider dibbling wet and dibbling dry as alternative sowing methods if transplanting method is not feasible.
- Applying herbicides at 2 weeks after sowing (2 WAS) is recommended to enhance rice production.
- For optimal results, combine transplanting with herbicide application at 2 WAS to boost rice growth, development, and yield, and maximize profits.

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Table 1: Effect of Sowing Methods and Time of Herbicide Application on Plant Height, Number of tillers, Days to 50% flowering, Days to maturity, Number of seeds per panicle, Seeds yield per panicle, 1000-grain weight and Grain yield per hectare at lafia 2023 wet season

	Plant Height (cm)	Number of Tillers	Days to 50% Flowering	Days to Maturity	Number of seeds per panicle	Seed Yield per Panicle (Kg)	1000-Grain Weight (g)	Grain Yield per Hectare (tons)
Treatments								
Sowing Methods (S)								
Broadcast dry	82.82d	11.54e	67.11c	116.00c	176.24d	84.53d	22.79bc	2977.54c
Broadcast wet	82.21e	11.69d	67.28c	115.94d	177.49c	8777.56c	22.87bc	2638.47d
Dibbling dry	84.49c	13.99b	68.39b	115.56e	179.41b	89.38c	23.56b	3152.50c
Dibbling wet	85.67b	12.78c	68.33b	116.06b	179.39b	92.57b	23.92b	3495.69b
Transplanting	86.59a	17.55a	69.94a	116.44a	182.18a	105.13a	24.71a	4882.50a
SE±	0.03	0.04	0.29	0.25	0.06	0.07	0.05	110.10
Time of Herbicide Application (H)								
2 WAS	85.19a	13.93a	68.47	116.24a	179.65a	95.54a	23.76a	3576.91a
3 WAS	83.52b	13.09b	68.37	115.76b	178.65b	90.92b	22.73b	3201.78b
SE±	0.02	0.03	0.19	0.16	0.04	0.04	0.03	69.64
Interactions								
S x H	NS	NS	NS	NS	NS	NS	NS	**

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. [1]Weeks after sowing; [2]not significant difference at 5% level of probability

Table 2: Interaction Effect of Sowing Methods (S) x Time of Herbicide (H) Application on Rice Grain Yield per Hectare (kg/ha)

	Time of Herbicide Application	
Sowing Methods	**2WAS**	**3WAS**
Broadcast dry	2506.19h	2662.78
Broadcast wet	3144.44e	2132.50i
dibbling dry	3221.39d	3083.61f
Dibbling wet	4328.61c	3048.89f
Transplanting	5081.11a	4683.89b
SE (±)	64.6	

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. [1]Weeks after sowing; [2]not significant difference at 5% level of probability

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PROCEEDINGS

Performance of Maize (*Zea mays)* as Influenced by Nitrogen Rates and Stand Density at Gwagwalada Abuja

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Abstract
A field experiment was conducted at the Teaching and Research farm, Faculty of Agriculture, University of Abuja at Gwagwalada (latitudes $8^{0}39$` and $8^{0}5$N and $007^{0}8$`20` and $007^{0}11$`10E) during the 2021 wet season to study the "Performance of maize (Zea mays as influenced by nitrogen rates and stand density". The treatments evaluated consist of four nitrogen rates (0, 60, 120 and 180kgN/ha^{-1}) and two stand densities (1 plant/stand and 2 plants/stand) which were factorially combined and laid out in Randomized Completely Block Design (RCBD) and replicated three times. Results show that applying 180kg N/ha^{-1} per maize stand produces taller plants, a greater number of leaves, leaf area index, crop growth rate, and grain yield than other fertilizer rates at 2 plants/stand. 1plant/stand resulted in a higher leaf area index and grain yield (3.2t/ha) compared to 2 plants/stand which was not statistically significant on plant height, number of leaves and crop growth rate. In conclusion, applying 180kgN/ha^{-1} per maize plant resulted in better growth and higher yield of maize under the wet season in Gwagwalada and its environs.
Keywords: Maize, Nitrogen rate, Stand density.

INTRODUCTION

Maize (*Zea mays* L.), the most common cereal globally, was domesticated in Mexico around 1500 BC and introduced to Africa by 1500 AD (Eze *et al*., 2023). Nigeria cultivates white, yellow, and red maize, with white and yellow preferred (Eze *et al*., 2023). Despite high production, Nigerian maize yields average 2t/ha, below potential (Eze *et al*., 2023). Industrial uses include flour milling, brewing, baking, and animal feed (Eze *et al*., 2023). Proper fertilizer application and plant density are crucial for optimal growth and yield (Eze *et al*., 2023). A study in Gwagwalada evaluated maize varieties, nitrogen rates, and plant densities for improved cultivation (Eze *et al*., 2023).

MATERIALS AND METHODS

The field experiment was conducted at the University of Abuja's Teaching and Research farm during the 2021 rainy season in the Northern Guinea Savannah of Nigeria. It used a Randomized Completely Block Design (RCBD) with three replications, testing four nitrogen rates (0, 60, 120, 180 kg/ha) and two maize stand densities (1 and 2 plants/stand). The field was prepared by ploughing and harrowing, with ridges constructed 0.75m apart. Seeds were sown at 75cm x 25cm and 75cm x 50cm for 1 and 2 plants per stand, respectively. Fertilizer was applied at 3 and 5 weeks after sowing

(WAS). Manual weeding was done at 3 WAS, with additional hand pulling at 6 and 7 WAS. Fall Armyworm was controlled using Caterpillar force pesticide. Growth data were collected at 3, 5, 7, 9, and 11 WAS, and yield data were analyzed using ANOVA and Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

The study at Gwagwalada during the 2021 wet season evaluated the effects of nitrogen rates and stand density on maize growth. Significant responses were observed with 180 kg N/ha, resulting in taller plants, comparable to 60 and 120 kg N/ha. At 5 weeks after sowing (WAS), 120 kg N/ha produced the tallest plants. Stand density did not significantly affect plant height or the number of leaves. However, nitrogen rates significantly influenced the leaf area index, with 1 plant per stand showing a larger index than 2 plants per stand. The interaction of nitrogen rate and stand density was significant for the leaf area index. At harvest, 180 kg N/ha produced the highest crop growth rate, similar to 120 and 60 kg N/ha. Higher grain yield was recorded with 180 kg N/ha, especially at 1 plant/stand. The interaction between nitrogen rates and stand density significantly affected grain yield.

Table 1: Effect of nitrogen rates and stand density on plant height (cm), number of leaves, leaf area index and crop growth rate of maize at Abuja during the 2021 wet season

Treatment	Plant Height (cm) (9WAS)	Number of Leaves/ Plant (9WAS)	Leaf Area Index	Crop Growth Rate (11WAS)
Nitrogen (kg/ha^{-1})				
0	111.00b	11.70	11.214b	18.86b
60	130.28b	13.17	16.693b	28.61ab
Stand Density				
Maize Var. 1	137.04	14.55	28.19a	32.070
Maize Var. 2	140.72	12.83	11.20b	28.681
SE±	10.049	1.194	3.124	3.554
Interaction (N x D)	NS	NS	*	NS

Means within the same column followed by the same letter are not significantly different at a 5% level of probability according to Duncan's Multiple Range Test (DMRT). NS = Not Significant

Table 2: Interaction effect of nitrogen fertilizer rate and stand density on leaf area index during 2021 wet season at Abuja

Stand Density	0	60	120	180
1	12.12b	22.13b	26.02b	52.47a
2	10.31b	11.25b	11.57b	11.67b
SE±	6.247			

Means within the same column followed by the same letter are not significantly different at a 5% level of probability according to Duncan's Multiple Range Test (DMRT).

Table 3: Effect of nitrogen rate and stand density on grain yield of maize during 2021 wet season at Abuja

Treatment	Grain Yield (3.2t/ha)
0	1155.6b
60	1477.8b
120	1909.7b
180	3180.6a
SE±	357.502
Stand Density	
Maize Var. 1	2425.0a
Maize Var. 2	1436.8b
SE±	0.215
Interaction	
N x D	**

Means within the same column followed by the same letter are not significantly different at a 5% level of probability according to Duncan's Multiple Range Test (DMRT). **

Table 4: Interaction effect of nitrogen fertilizer rate and stand density on grain yield of maize during 2021 wet season at Abuja.

x	Nitrogen (kg/ha^{-1})			
Stand Density	0	60	120	180
Maize Var. 1	616.67c	1694.44b	2541.67b	4847.22a
Maize Var. 2	1694.44b	1261.11b	1277.78b	1513.89b
SE±	505.585			

Means within the same column followed by the same letter are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT).

The study revealed a significant response to nitrogen fertilization on maize growth and yield parameters, with 180 kg N/ha resulting in taller, more vigorous plants and higher grain yield. This confirms maize's high nitrogen requirement for efficient growth (Hammad et al., 2011). The number of leaves per plant, a key growth indicator, increased with higher nitrogen doses (Ali *et al*., 2013). The highest grain yield (3180.6) was recorded with 180 kg N/ha, while the lowest (1155.6) was with no fertilizer (Valero *et al*., 2005). Stand density significantly affected leaf area index and grain yield, with 1 plant/stand outperforming 2 plants/stand (Udoh and Ogunkunle, 2012; Iremiren *et al*., 2013).

CONCLUSION AND RECOMMENDATIONS

In conclusion, applying 180kgN/ha^{-1} and sowing at 1 plant/stand resulted in higher growth and yield of maize under rainfed conditions at Gwagwalada and environs.

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Appendix 1: Physical and Chemical Properties of Experiment Soil during the 2021 wet season at Abuja

Soil characteristics	0-30cm
Physical characteristics(g/kg)	composition
Sand	556.00
Silt	167.00
Clay	273.00
Textural class	Sandy loam
Chemical Properties	
pH H2O (1:1)	6.05
Organic carbon (g/kg)	7.43
Total Nitrogen (g/kg)	0.60
Exchangeable bases (cmol/kg)	
Calcium (Ca)	0.78
Magnesium (Mg)	0.78
Potassium (K)	0.20
Sodium (Na)	0.36
Cation Exchange Capacity (CEC)	**6.82**

Source; Soil sample analyzed at Soil Science Department, Faculty of Agriculture, University of Abuja.

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Measurement of Technical Efficiency of Maize Farmers under Cultivation of Hybrid and Open-Pollinated Seed Varieties in Oyo State, Nigeria

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Abstract
Choice of hybrid or open pollinated maize seed varieties among farmers under the cultivation of maize is prevalent in the cropping seasons. This study examined the technical efficiency of maize under hybrid and open pollinated seed varieties in Oyo State, Nigeria. Socioeconomic and input characteristics, farm technical efficiency, factors determining type of seed adopted and constraints to maize production were examined. A multistage sampling procedure was used to select 173 respondents that comprised 90 hybrid and 83 open pollinated seed variety users. Structured questionnaires were used to collect data. Descriptive and inferential were used to analysis data collected. The result of the descriptive analysis showed that farm size, labour, fertilizer, age, and experience were average of 1.5ha, 52.6 man-days, 250.34kg, 47.77years and 22.69years respectively. Mean Technical Efficiency scores for High Yielding Variety (HYV) and Open Pollinated Variety (OPV) are 0.77 and 0.74 respectively. The RTS are 0.82 and 0.58 respectively indicating that the two farmers operate in the stage II of the production surface. It is recommended that farmers should upscale their production efficiently through the adoption of HYV of maize seed.

Keywords: Maize, Seed Varieties, Stochastic Frontier, Technical efficiency

INTRODUCTION

Maize (Zea mays L.) is one of the most important staple crops in the world. Globally, it is a widely grown cereals which contribute to food security in most of the developing countries (Nepal *et al*., 2021; Gimire *et al*., 2016). It is one of the most widely planted cereals and the global production of maize has averaged greater than 1,000 million metric tonnes (MMT) over the past decades (Olaf *et al*., 2022; Food and Agriculture Organization, 2021).

With total production of 11m metric tonnes, Nigeria is arguably Africa's second largest producer of maize after South Africa while Ethiopia occupies the third-place position on the chart of largest producers of maize in Africa (Joanna *et al*., 2018). Consumption of maize in Nigeria is on the increase due to the advantage of being converted to other foods that are palatable and characterized with high palatability value. In order to attain the frontier of mass production that will fill the demand supply gap, hence the reduction price and raise the purchasing power of the households for food security attainment, production increasing technology is the way out. The use of improved or high yielding variety seed capable of withstanding the factors that can impede production in the quality and quantity terms must be adopted. Many studies had been done to address issues in this area but this study stands out in the area of efficiency differential in the use of hybrid and open pollinated maize seed varieties. The study seeks to achieve the following objectives which are to: (i) describe the socioeconomic characteristics of the maize farmers; (ii) compare the technical efficiencies of farmers under open pollinated and hybrid maize cultivation and to determine factors responsible for choice of the varieties cultivated by farmers.

METHODOLOGY

The study was carried out in Ibarapa East Local Government Area of Oyo State with its headquarters in Eruwa. It is bounded in the West by Ibarapa North and Ibarapa Central LGA, in the East by Ido LGA, in the North by Iseyin LGA and in the South by Ogun State. The population of the area is 118,226 (National Population Commission, 2006). Data used were derived from primary source and copies of structured, validated and pretested questionnaires were used for data collection using trained enumerators. A multistage sampling procedure was used in the selection of respondents used in this study. A total of 180 respondents being dis-aggregated into 50% (90) apiece for adopters and non adopters was selected. In the final, adopters of high yielding variety and open pollinated varieties selected were 83 and 90 respectively forming a total of 173 respondents that was finally used for the analysis. Tools of analysis employed were: Descriptive Statistics (DS), Stochastic Frontier Production Function (SFPF) and Probit regression. The Technical Efficiency model is simply expressed thus:

$$Y = f(X_i\beta) + e_i$$

Where,

Y_i = Output of the *ith* farm

X_i = Vectors of actual input quantities

β = Vector of parameter to be estimated

e_i = composite error term denoted as Coelli and Batesse (1996)

$e_i = V_i + U_i$

$$InY_i = \beta_0 + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + \beta_5 InX_5 + V_i + U_i$$

Where,

Y	=	Quantity of maize output (*ith* farm in kg)
X_1	=	Farm size (in hectare)
X_2	=	Labour (in man-days)
X_3	=	Quantity of seeds (in kg)
X_4	=	Quantity of fertilizer (in kg)
X_5	=	Quantity of herbicide (in litres)
V_i - U_i	=	As defined above. β_0 - β_1= Parameters estimates.

The model assumed that the inefficiency effect (u_i) is independently distributed with mean U_i and variance δ. The model is specified as:

$$U = \delta_1 InX_i + \delta_2 InX_2 + \delta_2 InX_2 + \delta_3 InX_3 + \delta_4 InX_4$$

Where,

U_i	=	Inefficiency effect
Z_1	=	Age (in years)
Z_2	=	Household size

Z_3 = Extension contact (no.)
Z_4 = Years of education.

Probit Regression Model: Gujarati (2004) who expressed the model as:

$$P_i = [y = 1] = [FR_i]$$

where, $Z_i = \beta_0 + \beta_i R_i$;
$$y_i = \beta_i + \beta_{2i} R_{2i} + \dots + \beta_k R_{hi} + U_i$$

Y = Farming method (1 = Hybrid; Open pollinated Variety = 0)
R_1 = Education (in years)
R_2 = Experience (in years)
R_3 = Extension Visits (No.)
R_4 = Household Size (No.)
R_5 = Gender (male=1, female=0)
R_6 = Farm Size (in hectares)
R_7 = Seed (in kg)
R_8 = Labour Use (in man-days)
R_9 = Fertilizer (in kg)
R_{10} = Herbicide (in litres).

RESULTS AND DISCUSSION

According to Table 1, farm size of 1.5ha revealed that the maize farmers are small scale in operation due to fragmentation of farm holdings. Labour(52.6md) showed the insufficiency of annual labour-use as a result of rural-urban drift. Fertilizer(250.35kg) was slightly sufficient indicating about five bags/farmer. Age(47.8years) revealed that farmers are in their productive age. Experience(22.7years) revealed the relatively high experience of the maize farmers which enhances better performance in the seasonal farm operations.

Table 1: Socioeconomic Characteristics of Maize Farmers

Variable	Mean	Variable	Mean	Variable	Mean
Farm size	1.5ha	Fertilizer	250.34kg	Experience	22.7years
Labour	52.6md	Age	47.8years		

Source: Field Survey, 2023. Note: *md- mandays*

Maximum Likelihood Estimate of Technical Efficiency of Maize Farmers

Efficiency score estimation of maize farmers' efficiency is presented in Table 2. The sigma and log-likelihood ratio for both the farmers using HYV and OPV revealed that the model used in estimating them were appropriate while the gamma value also revealed that both groups of farmers have so many production factors under their their control. Farmers using HYV maize seeds had their efficiency significantly influenced by labour and experience while the efficiency of farmers using OPV was was found to be significantly influenced labour, seed, herbicide and experience. The mean efficiency performance for HYV and OPV were 0.77 and 0.74 respectively.

Table 2:Maximum Likelihood Efficiency Estimation of Maize Farmers

Production Variable	**Category HYV**		**Category OPV**	
	Coefficient	**t-ratio**	**Coefficient**	**t-ratio**
Constant	4.1802***	7.76	0.5660	1.71
Farm size(in Ha)	-0.2857	-1.51	-1.1878***	-10.18
Labour(in manday)	0.5202***	5.46	0.9538***	16.57
Seed(in kg)	0.5490	0.38	0.1907*	2.26
Fertilizer(in kg)	-0.0426	-0.46	-0.0508	-0.79
Herbicide(in ltr)	0.0787	1.13	0.6760***	3.29
Inefficiency Variable				
Constant	7.9613*	1.98	-13.7511**	-3.62
Education(in years)	-1.6861	-1.35	0.6259*	1.76
Experience(in years)	-0.1431*	-1.70	-0.3788***	3.90
Extension Visit(No.)	4.4131**	2.45	0.1532	0.68
Sigma square	3.1069***	3.50	1.0910***	7.32
Gamma	0.9607***	698.72	0.9736***	149.40
Log-likelihood Ratio	598.171		31.688	
Likelihood Ratio	429.086		73.910	
Mean. Tech. Eff.	0.77		0.74	

Source: Field Survey, 2023.

Rate of Technical Substitution (RTS)/Elasticity of Production (EoS)

The RTS for the farmers using HYV (0.8196) and OPV (0.5819) were found to be in the stage II of the production surface as presented in Table 3. The result indicates that both groups perform productively but HYV seed users outperformed their OPV seed users counterparts. It is inferred that the HYV seeds are better and scale up production given all other favourable factors.

Table 3: Rate of Technical Substitution/Elasticity of Production

Variable	HYV	OPV
Farm size(in Ha)	-0.2857	-1.1878
Labour(in man-day)	0.5202	0.9538
Seed(in kg)	0.5490	0.1907
Fertilizer(in kg)	-0.0426	-0.0508
Agrochemicals(in ltr)	0.0787	0.6760
Total	0.8196	0.5819

Source: Field Survey, 2023

Frequency Distribution of Technical Efficiency of HYV and OPV Maize Farmers

Table 3 presents the efficiency distribution of HYV and OPV seed user farmers. About 44.4% of HYV farmers cluster between 0.70-0.80 range while 59.94% of the OPV farmers aggregate massively within the bracket of 0.51-0.60. The two groups performed relatively well but the result added further that HYV seed users performed better when it comes to factor combination.

Table 4: Distribution of Technical Efficiency Based on HYV and OPV Categories of Farmers

Eff. Range	HYV		OPV	
	Frequency	Percentage	Frequency	Percentage
0.51-0.60	03	3.60	54	59.94
0.61-0.70	08	9.64	04	4.88
0.70-0.80	37	44.40	21	23.31
0.81-0.90	32	38.40	02	2.22
0.90-1.00	03	3.60	09	9.99
Total	83	100.00	90	100.00

Source: Field Survey, 2023

CONCLUSION AND RECOMMENDATIONS

From the study, it could be concluded that farmers using HYV maize seed are technically more efficient than their counterparts that use OPV maize seed. Although, the difference in their performances is not so much, but, farmers are encouraged to use HYV for better yield.

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Evaluation of Selected Sweet Potato Genotypes for Early Bulking and Other Root Quality Traits

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Abstract
This study evaluated 24 sweet potato genotypes selected from the NRCRI clonal evaluation trial. Conducted at the NRCRI experimental field, the trial was arranged in a factorial randomized complete block design (RCBD) with three replications, each consisting of 24 plots. The study assessed growth parameters such as leaf area, root length, fresh root yield (FRYD), dry root yield (DRY), dry matter content (DMC), starch content, and marketable and non-marketable roots. Data were analyzed using ANOVA with Genstat software. Significant differences were observed among the genotypes for number of leaves, root length (P<0.01), and dry weight (P<0.05). Time progression (8, 10, 12, and 14 weeks after planting) significantly affected the number of roots, root weight, and yield traits. Genotype 87/OP/145 had the highest dry yield (9.9 t/ha), while NNWA/OP/247 produced the highest fresh yield (9.92 t/ha). Dry matter content ranged from 33.3-48.5%, with a mean of 40.35%. The results suggest that certain genotypes show promise for breeding programs targeting early bulking and yield improvement.

Keywords: Sweetpotato, evaluation, early bulking, genotype, yield

INTRODUCTION

Sweet potato (Ipomoea batatas) is a significant staple crop in many developing countries, valued for its high yield potential, nutrient density, and adaptability to diverse climatic conditions (Aswathy et al., 2020). A member of the Convolvulaceae family, sweet potato is a polyploid crop with a hexaploid genome (2n = 6x = 90) (Austin, 1977). Major producers include China, Malawi, Tanzania, and Nigeria, with Nigeria producing 3.87 million metric tons annually (FAO, 2020). Globally, sweet potato ranks as the 7th most important food crop, following staples such as wheat, rice, and maize (Tortoe et al., 2010). Sweet potato is particularly advantageous in tropical regions due to its ability to thrive under marginal environmental conditions, mature early, and produce a relatively high yield. However, many of these regions face challenges such as soil erosion, desertification, and nutrient depletion, which limit crop productivity and contribute to food insecurity (Esraa et al., 2021). To address these issues, the development of improved sweet potato varieties, particularly early bulking genotypes, is crucial. Early bulking cultivars allow for multiple cropping cycles within a single season, increasing food security and optimizing land use. This study was designed to evaluate selected sweet potato genotypes for their early bulking ability and root quality traits, to identify high-performing lines for breeding programs aimed at improving sweetpotato.

MATERIALS AND METHODS

Experimental Design: The study evaluated 24 sweet potato genotypes sourced from the National Root Crops Research Institute (NRCRI) clonal evaluation trial. The experiment was conducted in a well-maintained experimental field at NRCRI, Umudike, Nigeria, laid out in a factorial design within a randomized complete block design (RCBD). Each plot measured 5m x 3m, with a planting density of 0.3m x 0.3m. The experimental layout included three replications, resulting in a total of 72 plots (24 genotypes × 3 replications). Standard agronomic practices were followed throughout the growing season. This included land preparation, planting, weeding, and pest management to ensure optimal growth conditions for the sweet potato plants. The plants were irrigated as necessary, particularly during dry spells. Data were collected on various growth parameters and yield components throughout the growing period. The parameters assessed included:

Growth Parameters*:* Leaf area, number of leaves, root length. Fresh root yield (FRYD), dry root yield (DRY), harvest index (HI), dry matter content (DMC), and starch content. The formulas used to calculate the derivatives were as follows:

$$\textbf{Harvest Index (HI)} = \frac{\text{Root weight}}{\text{Root weight+Biomass}}$$

$$\textbf{Fresh Root Yield (FRYD)} = \frac{\text{Root weight}}{\text{Area of plot harvested}} \times \frac{10000}{1000}$$

$$\textbf{Dry Root Yield (DRY)} = \text{FRYD} \times \frac{\text{DMC}}{100}$$

The collected data were subjected to analysis of variance (ANOVA) using the general linear model (GLM) approach, expressed as:

$$Yijk=μ+Ai+Bj+ABij+ϵijkY;$$

where: Yijk = observed response, μ = overall mean, Ai = effect of the i-th genotype, Bj = effect of the j-th week, Bij = interaction effect, ϵijk = random error. The ANOVA was performed using Genstat software (12th Edition). Significant differences among the genotypes and weeks after planting (WAP) were further analyzed using the least significant difference (LSD) test at P < 0.05.

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences in the number of leaves and root length among the genotypes. Specifically, the number of leaves showed a significant variation at P < 0.01, while root length demonstrated significance at P < 0.01. The results indicated that genotype 87/OP/161 produced the highest average root length (21.5 cm), whereas genotype PO3/93 exhibited the shortest (8.73 cm). The leaf counts varied, with genotype 87/OP/208 yielding the highest number of leaves (216), while genotype P03/19 had the lowest (101). Yield analysis indicated significant differences in fresh and dry yields among the genotypes. NNWA/OP/247 recorded the highest fresh yield (9.92 t/ha), whereas PO3/19 had the lowest (4.5 t/ha). For dry yield, genotype 87/OP/145 yielded the highest (9.9 t/ha) compared to PO3/19, which again had the lowest yield of 4.5 t/ha. This consistency in performance across different yield parameters underscores the potential of these genotypes for commercial production. The dry matter content of the genotypes ranged from 33.3% to 48.5%, with a mean of 40.35%. Genotype 87/OP/132 exhibited the highest dry matter content, while TIS/87/008 recorded the lowest. In terms of starch content, values ranged from 22.61%

to 35.82%, with genotype NWA/OP/231 having the highest starch content, indicating its suitability for processing industries. The combined analysis of variance showed no significant differences among the genotypes concerning time (weeks). However, significant differences in dry yield were observed at $P < 0.05$, and significant variation was noted for the number of roots, root weight, marketable roots, non-marketable roots, fresh yield (t/ha) at $P < 0.001$, and dry yield (t/ha) at $P < 0.05$. The absence of significant genotype × week interactions suggests that the performance of these genotypes was consistent throughout the evaluation period.

CONCLUSION AND RECOMMENDATIONS

This study identified promising sweet potato genotypes for early bulking and yield performance. Genotype NNWA/OP/247 recorded the highest fresh yield (9.92 t/ha), while 87/OP/145 demonstrated superior dry yield (9.9 t/ha). These genotypes show strong potential for inclusion in breeding programs aimed at improving sweet potato productivity in Nigeria. The significant variation in dry matter content, starch content, and other yield-related traits across the genotypes underscores the potential for selecting superior cultivars. Continued evaluation and multi-location trials are recommended to assess genotype stability and adaptability, which will contribute to the development of improved sweet potato varieties that can enhance food security, economic empowerment, and land resource utilization.

1. **Breeding Programs**: It is recommended that breeding programs focus on the development of genotypes such as NNWA/OP/247 and 87/OP/145, which have demonstrated high fresh and dry yield potential, respectively. These genotypes can serve as parents in breeding programs aimed at enhancing early bulking and root quality traits.
2. **Multi-Location Trials**: Conduct further evaluation of the promising genotypes across diverse agroecological zones to assess their adaptability and performance stability. Multi-location trials can provide insights into how these genotypes perform under varying environmental conditions.

Table 1: Mean square of the analysis of variance of the selected sweet potato Genotypes, weeks, and interactions.

Source of variation	DF	LA	NL	NR	RL	RW	MKTBLE	NMAKTBLE	FRY	DRY
Genotype	23	1276	15096 **	11.66	64.17**	0.3	1.43	0.96	24.73	7.11*
Block	2	1647	21893	344.9	81.19	0.10	1.42	1.01	7.47	0.89
Time_wk	3	4505	233	24.93**	41.70	6.1 **	79.48**	29.07**	427.10**	73.17*
Genotype x time_wk	69	1258	5322.	6.55	26.45	0.29	1.48	0.89	20.81	3.72
Error	190	12923	6050	9.003	24.71	0.30	1.19	0.7	21.07	3.69
CV (%)		12.8	9.5	39.1	6.8	4.0	3.6	5.7	4.0	3.4
Total	**287**									

(P<0.05), ** (P<0.01), * (P<0.001), ns- not significant, LA: leaf area, NL: number of leaves, NR: number of roots, RL: root length, RW: root weight, MKTBLE: marketable roots. NMRKTBLE: non-marketable roots, FRY: fresh yield, DRY: dry yield tons/hectare.*

Table 2: Mean performance of selected sweet potato genotypes to yield and bulking parameters

Genotype	FRY (t/ha)	Dry (t/ha)	DMC (%)
87/OP/132	6.32	4.39	40.5
07/OP/210	8.26	8.6	40.6
PO3/11	6.94	6.94	40.8
NWA/OP/290	6.7	6.7	44.5
NWA/OP/287	7.1	7.1	43.7
PO3/95	6.3	6.3	40.3
MAX	6.31	6.3	40
PO3/38	6.10	6.1	37.5
PO3/82	9.09	9.1	41.5
PO3/93	4.7	4.7	48.5
PO3/19	4.5	4.5	46.5
87/OP/145	7.9	9.9	38.4
PO3/016	4.5	4.5	44.6
87/OP/161	7.70	7.7	33.3
PO3/40	5.6	5.6	34.1
PO3/01/14	7.35	7.35	42.4
87/OP/208	6.94	6.94	34.3
NWA/OP/247	9.92	9.9	43.6
87/OP/194	9.02	9.00	37.8
NWA/OP/28	6.24	6.2	43.3
PO3/92	7.0	7.08	45.3
NWA/OP/242	6.38	6.38	34.5
NWA/OP/231	9.16	9.16	33.8
TIS/87/0087	7.8	7.4	38.8
MEAN	**6.99**	**6.99**	**40.35**
CV (%)	**4**	**3.4**	**7.5**
LSD	**1.42**	**1.54**	

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Evaluation of Physiological and Nutritional Composition of Different Methods of Storage Ginger Rhizomes

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Abstract
Ginger production in Nigeria is faced with the challenge of high postharvest losses. The aim of this study was to evaluate the effect of different storage methods on the physiological and nutritional composition of ginger rhizomes. Ginger were separated and stored using four different methods: ginger stored in a pits and covered with river sand, Wood shaves, Ash's and Rice husk under shades. Buried under ground was used as the control treatment. Temperature and relative humidity of the environment was monitored, the rhizomes were weighed monthly to determine the weight loss, sprouting and rot were observed visually and nutritional content of the stored rhizomes were accessed using standard methods. The lowest percentage weight loss was observed in samples covered river sand and those covered with wood shavings and also samples stored in pits and covered with wood shaves and river sand had the lowest percentage of sprouting (3.61% and 4.29% respectively). The dry matter content increased with storage period in all the storage methods. The starch yield varied in the different storage methods with the samples.
Keywords: Temperature, rhizomes river sand and wood shaves

INTRODUCTION

Nigeria produces an average of 50,000 metric tons of fresh weight ginger per annum (Ezeagu, 2006). About 10 % of the produce is consumed locally as fresh ginger while the remaining 90 % is dried for both local consumption and export. The dried ginger is consume locally for various uses and 80 % is exported (Ezeagu, 2006). Ginger (Zingiber Officinale) is a very crucial cash crop in our country today, due to its vital oil and Oleoresin contents. Ginger processed into powder is used in the preservation of meat, soup making and also in making beverages such as ginger drinks. In Nigeria, among other spices, for instance, garlic, onion and pepper that are consumed, ginger is one of the majorly grown on a commercial scale for export and it is highly recommended in the international market due to its aroma and pungency that arises from its oleoresin (non-volatile) and essential oil (volatile) contents (Famurewa et al,.2011). However, ginger is grown by vegetative means. Ginger is planted during April-May and harvested about 7-8months from December- January after planting when the leaves turn yellow and gradually wither. Ginger is broadly utilized worldwide as a spice, flavouring agent and herbal remedy. It also helps in treating diseases in the traditional system for instance vomiting, palpitation, loss of appetite, digestion, inflammation and constipation (Singletary, 2010). Ginger contains 1-2% of essential oil, which provides a unique flavour to the spice (Lawrence B.M, 2000). In root and tuber crops, storage is one of the major challenges often beyond the usual farmer's control. In addition, it was reported that reducing post-harvest losses would be a valuable tool for preventing global food shortages (Ezeocha and Adamma, 2017). The main aim of storage is to prevent deterioration of the (physiological and nutritional) quality of the crops According to the United Nations Food and Agriculture Organization (2014), Nigeria was among the countries that the global production of ginger in 2008 was over 1.4 million metric tons (MT) and the major exporting country to the US in 2007, this implies that ginger is cheaply and/or readily available in Nigeria. Due to the extremely crowded henhouses and consequently poor hygiene, antibiotics are extensively used to maintain health and activate bird growth (Van Boeckel et al., 2015). This is a significant problem since antimicrobial resistance can be derived from the abusive usage of antibiotics, and thus greater regulatory efforts are needed (Landers et al., 2012 their roots contain several compounds which have biological activities such as antioxidation, antimicrobial and pharmacological effects (Ali et al., 2008). Ginger contains about 12 antioxidant constituents, the combined actions of which have been regarded as being more powerful than vitamin C (Davies, 2011). The nutrients found in ginger include lipids amino acids, minerals and vitamins especially phosphorus, potassium, riboflavin and vitamin C. Ginger has been shown to have several biological effects, exhibiting antiinflammatory, anti-oxidant and hypolipidaemic activities Reports exist indicating that it has been used in gastrointestinal and respiratory disorders (Ghosh et al., 2011). In Nigeria, gingers are readily available, however, the physiology and nutritional composition of ginger had only been extensively investigated; there is information on the physiology, proximate, mineral and anti-nutritional composition of the ginger. Therefore, this study investigated the evaluation of physiological, proximate, anti-nutritional different organic materials for storage of ginger rhizomes.

MATERIALS AND METHODS

The experiment was conducted between December, 2023 and March 2024. 10kg of freshly harvested ginger rhizomes of two varieties each obtained from field of the Minor Root Crops Programme of National Root Crops Research Institute Umudike Umugin 1 & 2, were randomly sampled. The experimental design was performed using randomize complete block design (RCBD) and each treatment was replicated three times. The treatments were set up as follows: Storage in pit (A) under shade with alternate layers of River sand. Storage in pit (B) under shade covered with alternate layers of ash Storage in pit (C) under shade covered with alternate layers of rice husk. Storage in pit (D) under shade covered with alternate layers of wood shavings. Spread on the ground (control) under shade. The temperature and relative humidity of the storage environment were monitored. The weight of the yam tubers were measured at monthly intervals using electronic balance and weight loss expressed as a % of the total weight stored. Sprouting (%) and rot (%) were assessed through visual observation using the method described by Maalekuu et al. (2014). The samples were stored for a period of 3 months. Physiological, proximate antinutritional and minerals was done at the beginning of the experiment and monthly storage using the AOAC 1990 method. Oleoresin content was determined using Onwuka (2005) method.

Proximate Analysis

Samples were collected at the beginning of the experiment and monthly, proximate analysis was conducted using the AOAC (1990) method to investigate the effect of the storage methods on the dry matter content, crude fibre, crude protein, ash and carbohydrate content. The starch yield was also evaluated using the method of

Krochmal and Kilbride (1996) previously described by Sofa-Kantanka and Osei-Minta (1996).

Statistics

Data generated during the study were subjected to Analysis of Variance (ANOVA) using statistics analysis system (SAS Version 25.0, 2021). Means were separated at Least Significant Difference (LSD) of 0.05%.

RESULTS AND DISCUSSION

Table 1 shows the average temperature and relative humidity of the storage areas during the period of storage. The highest temperature was recorded in February, while the highest relative humidity and temperature was recorded in January of the three storage areas.

Table 1: **Average monthly temperature and relative humidity in the storage areas**

Months	Temperature (^{0}C)	Relative. Humidity (%)
November	28.2	83.4
December	28	84.1
January	28.1	85.4
February	28.5	82.9

Table 2: Percentage Sprouting of Ginger rhizomes Stored with different Storage Method

Treatment	1st month	2nd Month	3rd Month
GRS	0	1.79	3.61
GA	0	10.12	20.65
GRH	0	5.43	18.45
GWS	0	2.14	4.29
GCT	0	1	2.63

Where GRS= Ginger covered with River Sand, GA-Ash, GRH=Rice Husk , GWS= Wood Shaving, GCT= Control

Table 3: Effect of Storage Methods on Nutritional Composition of Ginger rhizomes

Samples	MC %	CP %	CF %	ASH %	FAT %	CHO %	EV (kcal)	Oleo
Day 0	10.33	7.30	7.44	2.58	0.65	71.72	32173	7.86
			After one month of storage					
GRS	10.27e	7.35d	7.43b	2.59b	0.66b	71.72b	322.68a	7.83b
GA	11.55b	7.52b	6.87e	2.57c	0.63d	70.87d	318.69d	7.76d
GRH	11.75a	8.02a	7.62a	2.69a	0.58e	69.33e	314.66e	7.83b
GWS	10.36d	7.34e	7.36d	2.53d	0.65c	71.78a	322.29b	7.84a
GCT	10.43c	7.37c	7.41c	2.57c	0.68a	71.56c	321.80c	7.82c
LSD	1.04	0.10	0.08	2.27	0.03	4.16	26.73	0.32
			After three month of storage					
GRS	7.11e	7.02e	7.45c	3.02a	0.51d	70.02b	304.26a	7.23a
GA	8.44c	7.15b	6.90e	2.59c	0.54c	69.27c	278.14e	6.73d
GRH	9.71a	7.44a	7.65a	2.72b	0.49e	59.13e	288.94d	6.61e
GWS	9.63b	7.11c	7.44d	2.59c	0.56b	70.17a	301.75b	7.12b
GCT	7.99d	7.09d	7.46b	2.62d	0.57a	68.96d	296.19c	6.99c
LSD	0.23	0.11	0.14	0.12	0.03	2,54	24.77	0.17

Means with same superscripts in the same column are not significantly different at 5% level of significance

Where GRS= Ginger covered with River Sand, GA-Ash, GRH=Rice Husk , GWS= Wood Shaving, GCT= Control
MC= Moisture Content, CP= Crude Protein, CF= Crude Fiber, ASH- Ash, CHO= Carbohydrate, EV= Energy

The percent weight loss of ginger rhizomes stored with different storage methods for three months were shown in table 1. Weight loss is an indication of deterioration during storage. This usually occurs as a result of respiration of the stored roots and moisture loss which can be facilitated by high temperatures. This has direct impact on the quality of the stored rhizomes. The peels of ginger rhizomes are relatively thin which makes it easier for moisture loss. The lowest percentage weight loss was observed in stored in a pit covered with river sand and a pit covered with wood shade while the highest weight loss was observed in a samples covered with ash and rice husk with 62% weight loss after 3 months of storage. It was generally observed that samples which were covered lost less weight than the samples which were exposed. The high level of weight loss in the exposed samples may be a consequence of high sprouting and respiration rates caused by direct impact of environmental factors such as temperature and relative humidity.

The weight loss could have also been caused by loss of moisture through transpiration which could have been facilitated by high temperature. The percentage weight loss observed in this study was higher than what was reported by Treche and Agbor-Egbe (1996) and Maalekuu et al. (2014) for yams during storage. Sprouting is a major factor that leads to losses during storage. The rate of sprouting increased with length of storage and varied with storage method as shown in Table 2. After one month of storage, sprouting was observed only in the samples stored on wood shave, this could be due to free flow of air, conducive temperature and relative humidity. Samples stored in pits and covered with wood shavings and river sand started sprouting on the 3rd month of storage and had the lowest percentage of sprouting (3.61% and 4.29% respectively). Mozie (1984) reported that, high rate of ventilation reduces the growth rate of vines in stored tubers, the reverse was observed in (GA and GRH) this experiment as the samples that were well ventilated and had higher percentage of sprouting than the samples with poor ventilation (GRS and GWS). The highest percentage of sprouting (20.65%) was observed in GA (samples pit spread with ash), this could have contributed to the high weight loss observed previously on these samples as sprouting is one of the factors responsible for weight loss (Ravi et al. 1996).

The level of rot was generally low in the ginger rhizomes samples, this could be as a result of the low moisture content which can prevent an enabling environment for micro-organisms. However samples stored in all the pits had lower level of decay, which can be attributed to prevent with the soil with contains some pathogens. It could also be due to average ventilation in the pit thereby resulting to build up of low heat generated during respiration. A similar observation was made by Maalekuu et al. (2014) during yam storage. The low percentage rot (32.86%) was recorded on samples stored in pit and covered with rice husk. The dry matter content of ginger rhizomes subjected to different storage methods at different intervals. Dry matter content ranged from 18.06% in the freshly harvested samples to 28.16% in samples stored in a pit and covered with river sand after three months of storage. The dry matter content increased with storage period in all the storage methods; this could be attributed to moisture loss during storage through transpiration. A similar observation was made by Treche and Agbor-Egbe (1996) during yam storage. The dry matter content varied with storage methods. The dry matter portion of roots and tubers is mostly composed of carbohydrates which exist primarily in the form of starch and sugars. Starch yield increased after one month of storage in all the storage methods. This could be due to the fact that simple sugars in the roots were converted to starch after one month of storage, however, at the end of the three months storage period, the starch yield decreased. The decrease in the starch yield at the end of storage could be because starch was used as a respiratory substrate. The starch yield varied in the different storage methods with the samples covered with river sand (3.16%) and the samples buried with wood shaves (4.29%) giving the highest starch yield at the end of the storage period. The ash, fat and crude fibre contents varied significantly ($p<0.05$) with the storage methods. Table 3 shows the nutritional composition of ginger rhizomes before, during and after three months of storage. The ash and crude fibre contents increased after three months of storage in all the storage methods. This increase could be apparent due to the high percentage of moisture loss during storage. A similar observation was made by Maalekuu et al. (2014) and Osunde and Orhevba (2009). Samples stored under rice husk had the highest ash content (4.77%) after three months of storage. At the end of the storage period.

CONCLUSION AND RECOMMENDATIONS

The findings from this research, shows that river sand and wood shavings are the most suitable materials to maintain the physiological and nutritional quality of ginger rhizomes. Spreading on the floor or buried underground are not good storage methods for ginger rhizome because the rhizomes are not protected from environmental factors resulting in high weight loss, sprouting and significant changes in the nutritional composition.

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Morphological Diversity of Some Melon Accessions in Ibadan, Nigeria

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Abstract
This study evaluates the morphological diversity of selected melon accessions conserved in the National Centre for Genetic Resources and Biotechnology (NACGRAB) genebank. Fifteen melon accessions were evaluated in NACGRAB's research field, Ibadan in the year 2023. The field experiment was conducted in a randomized complete block design (RCBD) with three replications and multivariate analyses was done to evaluate the relationships and diversity among accessions. Principal component analysis revealed that fruit size, leaf shape, fruit colour, stem colour, leaf gloss and leaf colour contributed the most to the observed variation, with PC1 and PC2 explaining 69.9% of the total variance with these traits being significantly correlated. Cluster analysis grouped the accessions into three distinct clusters, indicating significant genetic diversity. The high variability observed across these accessions highlights their potential of being utilized in melon crop improvement.

INTRODUCTION

Melons (*Cucumis melo* L.), a member of the Cucurbitaceae family, are an essential fruit crop widely cultivated across the globe for their nutritional value and economic importance. The species exhibits significant genetic variability, which is reflected in its diverse morphological characteristics, such as fruit shape, size, rind pattern, and flesh colour (Pitrat, 2017). This diversity is critical for breeding programs aimed at improving yield, disease resistance, and adaptability to various environmental conditions (Monforte *et al*., 2014). The study of morphological diversity in melon accessions is vital, as it aids in understanding the genetic base and potential of the germplasm conserved in genebanks (Paris, 2016).

In Nigeria, melon cultivation has been gaining attention due to its adaptability to tropical climates and its contribution to food security. However, the extent of genetic diversity within melon accessions in national genebanks remains under-explored. This research aims to assess the morphological diversity of selected melon accessions conserved at the NACGRAB, genebank Ibadan, using phenotypic traits. Understanding this diversity is crucial for the development of improved varieties tailored to local agricultural needs and environmental challenges.

METHODOLOGY

The study utilized 15 accessions of Melon species sourced from NACGRAB genebank. These accessions were selected based on their genetic diversity and represent different geographical regions. The experiment was conducted under field conditions at NACGRAB research field, Ibadan (Longitude 7.3847^{o}N and Latitude 3.8403^{o}E), located in the southern rainforest of Nigeria with an annual average rainfall of 1467 mm and mean average temperature of between 25-29^{0}C between September and December 2023. The experiment was laid in a randomized complete block design with three replications. Each of the accessions were grown in two row plot of 5m per row with inter plot spacing of 5m to prevent intertwining between plots, intra plot spacing of 1m. Standard agronomic practices, including weeding, and pest control, were followed throughout the growing season to ensure optimal plant growth.

Morphological data were collected on five randomly selected plants per plot. The traits measured included: Plant size (PS), Number of nodes, (NN), Stem colour, (SC), Number of primary branches, Leaf shape (LS), Leaf colour (LC), Leaf glossiness (LG), Prominence of leaf vein (PLV), Flower size (FS) and Flower colour (FC) and Fruit size (FS).The collected data were subjected to principal component analyses (PCA), cluster analysis and Persons correlation to study the relationships and variability of the traits studied in the accessions.

RESULTS AND DISCUSSION

Principal component 1 and 2 with an eigenvalue of 4.94 and 1.36 (Table 1) respectively explained 69.94 % of the total variability in the dataset, highlighting their importance in summarizing the dataset's complexity. Additionally, the loadings of different variables on these principal components help in understanding the relationships between the traits measured. PC1 is primarily associated with leaf shape (0.84) and leaf gloss (0.97), which suggests that these traits are important in defining the major variations. On the other hand, PC2 is heavily influenced by plant size (0.82), showing its significance in distinguishing variations captured by this component. The negative correlation between leaf colour and PC1 (-0.84) and the strong positive relationship with fruit size (-0.93) in PC1 provide insights into which traits contribute inversely to the primary variation in the dataset. These loadings indicate a trade-off between leaf colour and fruit size, further illustrating the diversity within the dataset. The high contribution of leaf shape to the variance further emphasizes the role of vegetative traits in defining genetic diversity among melon accessions, which could also be indicative of differences in adaptability to environmental conditions (Paris, 2016).

Table 1. Principal component analysis of accessions of *Melon spp evaluated* under field condition, their eigenvalues, and variance

PC	1	2	3	4	5	6	7
Eigenvalue	4.93808	1.35677	1.13716	0.764486	0.452707	0.206132	0.124961
% variance	54.868	15.075	12.635	8.4943	5.0301	2.2904	1.3885
cumulative	54.868	69.943					
	PC 1	**PC 2**	**PC 3**	**PC 4**	**PC 5**	**PC 6**	**PC 7**
Plant size	-0.14769	**0.82128**	0.51804	0.019695	0.09386	0.14248	-0.05947
No of nodes	**0.63577**	0.53902	0.02128	-0.5105	-0.13146	-0.12925	0.080133
Stem colour	-0.34069	**0.48666**	-0.77405	0.17097	0.018505	0.1335	0.013433
NOB	**0.63332**	0.21881	0.23909	0.68306	-0.09765	-0.11307	0.051267
Leaf shape	**0.84482**	-0.19599	0.12127	-0.04089	0.40413	0.2329	0.11008
Leaf colour	**-0.83925**	-0.22176	**0.43925**	-0.06094	-0.19192	0.10212	0.023338
Leaf gloss	**0.96756**	-0.04949	-0.00247	-0.0333	0.17025	-0.16645	-0.029
Fruit size	**-0.93195**	0.09403	0.040059	0.034386	0.15802	-0.12602	0.27894
Flower colour	**0.87872**	-0.09013	-0.05263	0.000896	-0.40327	0.17395	0.14451

Table 2 presents diversity metrics across several plant traits: plant size, number of nodes, stem colour, leaf shape, fruit size, and flower colour, among others. The richness of the taxa (S = 15 for all traits) shows that 15 distinct taxa were considered for each trait, providing a robust comparison. The Simpson Index (1-D) is consistently above 0.90, indicating a high diversity across all traits, with slight variations—leaf gloss and fruit size have the highest diversity at 0.9324 and 0.9306, respectively. The Shannon-Wiener Index (H) also reflects a high diversity, with values ranging between 2.57 and 2.70. These figures are characteristic of complex ecosystems with balanced representation across individuals. The Evenness metric reveals how uniformly individuals are distributed across taxa for each trait, with values close to 1.0 indicating a well-balanced representation.

The Menhinick Index fluctuates across traits, showing higher values for traits such as leaf gloss (3.44) and leaf colour (2.69), suggesting these have a higher ratio of species richness to individuals. The significant diversity found among the accessions is consistent with findings from similar studies on Cucumis species, where genetic diversity has been linked to broader adaptation to environmental stressors and better performance in different agro-ecological zones (Monforte et al., 2014; Escribano & Lázaro, 2009). In tropical environments like Nigeria, where variations in rainfall and temperature can significantly affect crop performance, having a diverse genetic base is crucial for selecting varieties that are resilient to these fluctuations (Schippers, 2000).

Table 2: Diversity in 15 accessions of Melon explained by the diversity indices

	Plant size	No of nodes	Stem colour	NOB	Leaf shape	Leaf colour	Leaf gloss	Fruit size	Flower colour
Taxa_S	15	15	15	15	15	15	15	15	15
Individuals	29	324	31	83	59	19	25	36	31
Dominance_D	0.06778	0.07125	0.06764	0.0765	0.08015	0.07479	0.072	0.06944	0.08221
Simpson_1-D	0.9322	0.9287	0.9324	0.9235	0.9199	0.9252	0.928	0.9306	0.9178
Shannon_H	2.698	2.673	2.702	2.638	2.577	2.653	2.664	2.688	2.583
Evenness_e^H/S	0.99	0.9657	0.9936	0.9326	0.8774	0.946	0.9572	0.9798	0.8828
Brillouin	2.123	2.572	2.148	2.358	2.235	1.925	2.043	2.187	2.057
Menhinick	2.785	0.8333	2.694	1.646	1.953	3.441	3	2.5	2.694
Margalef	4.158	2.422	4.077	3.168	3.433	4.755	4.349	3.907	4.077
Equitability_J	0.9963	0.9871	0.9976	0.9742	0.9517	0.9795	0.9839	0.9925	0.954
Fisher_alpha	12.5	3.253	11.44	5.349	6.488	32.93	15.83	9.655	11.44
Berger-Parker	0.06897	0.09877	0.09677	0.1205	0.08475	0.1053	0.08	0.08333	0.09677
Chao-1	15	15	15	15	21	26	15.91	15	36

The grouping of various accessions was done into four distinct clusters. These clusters provide valuable information for selecting parent lines in breeding programs, as genetically distant accessions could be used to enhance heterosis or improve specific traits such as disease resistance and drought tolerance (Dhillon et al., 2007). The study also emphasizes the importance of phenotypic characterization, which, despite advances in molecular markers, remains a practical and cost-effective method for assessing genetic diversity in crops (Adebola & Morakinyo, 2006). The use of morphological descriptors, as done in this study, is particularly valuable in genebank management, where large numbers of accessions need to be evaluated for their potential in breeding and conservation efforts (Slabbert et al., 2004). This is especially relevant for melon, a crop where morphological traits such as fruit size and rind texture are often directly correlated with consumer preferences and market value (Dhillon et al., 2007).

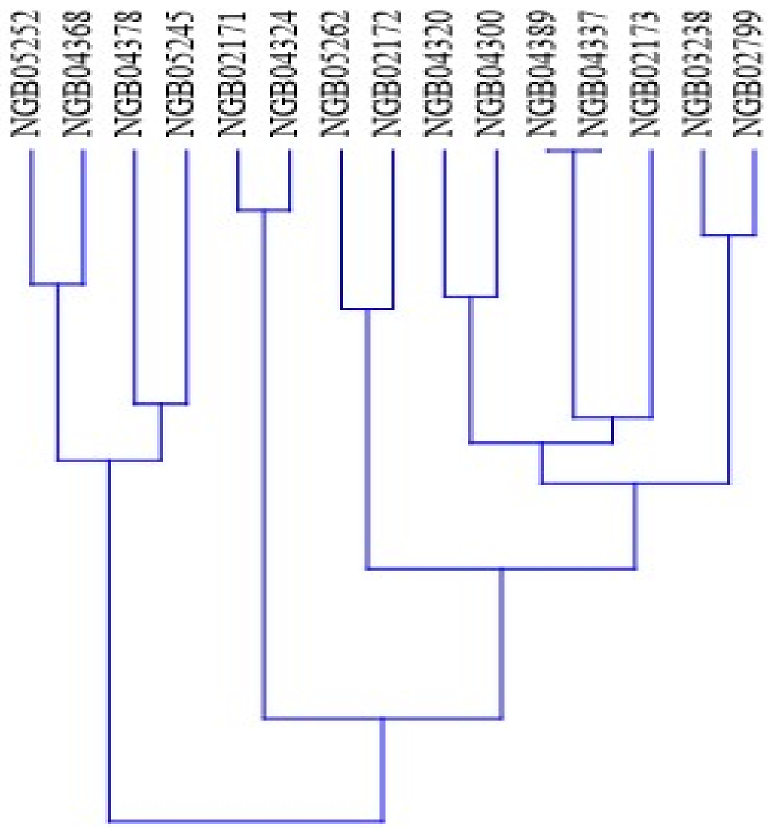

Figure 1: Dendrogram of 15 accessions of *Amaranthus spp* explained by complete linkage of 10 qualitative traits

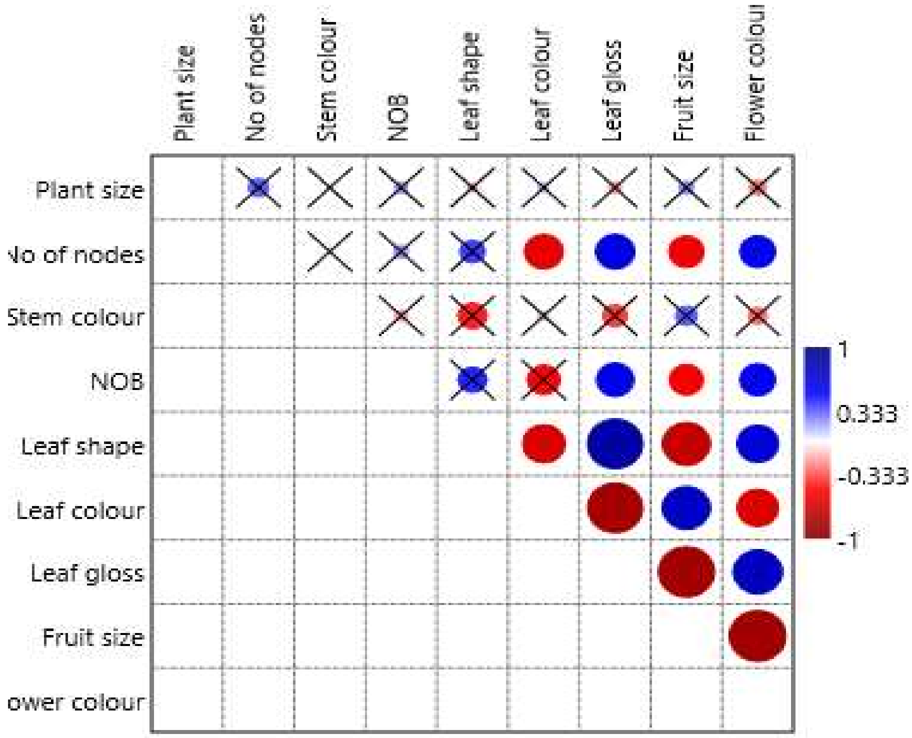

Figure 2: Correlations of traits in Melon

Traits like leaf gloss and leaf shape likely show a high positive correlation based on the high loadings seen in the PCA table. A positive correlation between these traits indicates that plants with a particular leaf shape are likely to exhibit similar gloss characteristics. Similarly, the positive correlation between flower color and leaf gloss suggests a relationship between aesthetic or surface-level traits of the plants. Intermediate or Low Correlations: Traits like stem color and number of nodes exhibit weaker or more moderate correlations, implying that while there may be some level of association, these traits do not directly influence one another as strongly. These weaker correlations indicate a more complex relationship or the potential influence of additional unmeasured factors. Traits like leaf color and fruit size likely show a strong negative correlation. The inverse relationship means that as leaf color intensity increases (darker or greener leaves), fruit size tends to decrease. This finding can be important in breeding programs, as selecting for one trait might lead to trade-offs in another.

CONCLUSION AND RECOMMENDATIONS

The significant morphological diversity observed among the melon accessions conserved in NACGRAB genebank presents a valuable genetic resource for breeding programs aimed at improving yield, resilience, and adaptability. The use of these diverse accessions could enhance the development of improved melon varieties that meet both local agricultural challenges and commercial demands. Future studies could integrate molecular tools with phenotypic characterization to further dissect the genetic basis of these traits, facilitating more targeted breeding efforts.

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Assessment of Heavy Metals Uptake in Soil and Water of River Ginzo Katsina under Controlled Experimental Condition

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Abstract
This study investigated the levels of toxic heavy metals (Cadmium, Chromium, Lead, and Zinc) in irrigation water, agricultural soils, and leafy vegetables (spinach, cabbage, and lettuce) cultivated along the Ginzo River in Katsina State, Nigeria. Thirty samples were analyzed using Atomic Absorption Spectrophotometry. The results showed high concentrations of Cadmium in soil samples, ranging from 1.30±0.00ppm to 2.11±0.00ppm. While Chromium, Lead, and Zinc levels in soil and irrigation water were within permissible limits, Cadmium exceeded the standard in water and vegetable samples. The highest Cadmium levels were found in spinach leaves, stems, and roots, with values of 0.50±0.01ppm, 0.59±0.0ppm, and 0.69±0.01ppm, respectively. Although the Ginzo River is suitable for agricultural purposes, the excessive Cadmium levels in soil, water, and vegetables pose a risk to human health and the environment. The study recommends regular monitoring and mitigation measures to reduce Cadmium contamination.
Keywords: Toxic heavy metals, soil, water, vegetables, irrigation sites, Cadmium, Chromium, Lead, Zinc, tap water, polluted water, Atomic Absorption Spectrometer.

INTRODUCTION

Heavy metals are defined as those with higher density than 5 mg mL[1] (Jarup, 2003) but the collective term now includes arsenic, cadmium, chromium, copper, lead, nickel, molybdenum, vanadium and zinc. Some interest also exists in aluminium, cobalt, strontium and other rare metals. Physiologic roles are known for iron (haemmoeties of heamoglobin and cytochromes), copper (amine oxidases, dopamine hydrolase and collagen synthesis), manganese (superoxide dismutase), zinc (protein synthesis, stabilization of DNA and RNA) with low requirements of chromium (glucose homeostasis). (World Health Organization).WHO, 2007. One of the consequences of the current stage of industrialization and the demand for improved quality of life has been increased exposure to air pollution coming from industrial activities, traffic and energy production (WHO, 2007).

Wastewater irrigation is known to contribute significantly to the heavy metal contents of soils (Mapanda *et al.,* 2005). Although problems occured in waterways when pollutants are leached out of the soil, if the plants die and decay, heavy metals taken into the plants are redistributed so the soil is enriched with such pollutants. Long-term wastewater irrigation may lead to the accumulation of heavy metals in agricultural soils and plants.

Crop yields are reduced due to the inhibition of metabolic processes in plants by metals. The sources of food contamination have often been traced to fumes from car exhausts (Fakayode, 2003). Potentially contaminated soils may occur at old landfill sites (particularly those that accept industrial wastes), old orchards that used insecticides containing arsenic as an active ingredient, excessive content of lead and cadmium metals in food is associated with etiology of a number of diseases especially with cardiovascular, kidney, nervous as well as bone diseases (Jarup, 2003).They have also been reported an agent for carcinogenesis, mutagenesis and teratogenesis. Copper toxicity induces iron deficiency, lipid peroxidation and destruction of membranes (Zaidi *et al.,*2005). In humans and animals, heavy metals can produce bone defects, they are also linked to increased blood pressure and affect the myocardium in animals. Periodic monitoring of concentrations of these heavy metals in food such as vegetables which are consumed by all and sundry is hence imperative to ensure that they are pollutant free.

World Health Organization (WHO) estimates that about a quarter of the diseases facing mankind have environmental pollution agents (Prüss-Üstün and Corvalán, 2006; Kimani, 2007). Heavy metals are pollutant of the environment, even at low levels, and their resulting long-term cumulative health effects are among the leading health concerns all over the world. Heavy metals are known as non-biodegradable, and they persist for long durations in aquatic as well as terrestrial environments. They might be transported from soil to ground waters or may be taken up by plants, including agricultural crops (Oluyemi *et al.,* 2008).

The soil contamination by heavy metals can be transferred to food and ultimately to consumers. For instance, plants accumulate heavy metals from contaminated soil without physical changes or visible indication, which could cause a potential risk for humans and animals (Osma *et al.,* 2012).

MATERIALS AND METHODS

Katsina is the capital city of Katsina state. It is located between latitude 12° 45' and latitude 13° 15' N, and longitude 7° 30' and 80° 00'E. The location is on the extreme Northern part of Nigeria, it is the administrative headquarters of Katsina emirate headed by *Magajin Garin* Katsina, District head of Katsina, and supported by Wards and Units heads.

According to the 2006 population census, the town was put at 507, 191. The 2020population estimates of Katsina State was put at about nine (9) million people (NPC, 2020). The major ethnic groups are Hausas and Fulani most of who are Muslims. The climate is semi-arid, tropical with distinct wet and dry seasons and these are controlled by two air masses of Tropical Maritime and Tropical Continental. Rainfall is between 700-800mm, with one peak which is usually observed around August. The mean monthly dry season temperatures are about 30°C with high diurnal temperature range.'

Preparation of Samples for Acid Digestion

Triplicate samples (0.5g) of each part (soil and water) of each were weighed in digestion flasks and treated with 5 mL of concentrated Nitric Acid (HNO_3). A blank sample was prepared applying 5 mL of HNO_3 into empty digestion flask (Sahito *et al.,* 2002). The flasks were heated for 2 hours on an electric hot plate (HP 220, UTEC Products Inc., Albany N.Y., USA) at 80-90°C and then the temperature was raised to 150°C at which the samples were made to boil. Concentrated HNO_3 and 30% Hydrogen peroxide (H_2O_2) were further added to the sample (3-5 mL of each was added occasionally) and digestion continued until a clean solution was obtained. After cooling, the solution was filtered with Whatman No. 42 filter paper and. It was then transferred quantitatively to a 25 mL volumetric flask by adding distilled water and forwarded to AAS for analysis and result.

Statistical analysis

Analysis of variance (ANOVA) was used to test the level of significance at $\alpha = 0.05$ (Miller *et al.,* 2010) using Social Package for Social Sciences (SPSS, version 16). Means were separated using the least significant difference test at 5% level of significance. Mean levels of heavy metals in samples was determined using descriptive statisitcs. A correlation test was carried out between the investigated metals for the water and soil materials, detected in the soil and water to associate their distribution and availability and accumulation in the samples at $\alpha = 0.05$

Table 1: Heavy Metals Concentration (ppm) in Soil and Water Samples

SS	Heavy Metals							
	Cd in Soil	**Cd in water**	**Cr in soil**	**Cr in Water**	**Pb in Soil**	**Pb in Water**	**Zn In soil**	**Zn in Water**
KM	1.30±0.02^{b}	0.89±0.01^{c}	1.12±0.01^{b}	1.13±0.01^{c}	0.52±0.17^{c}	0.52±0.01^{d}	0.25±0.15^{b}	0.22±0.05^{b}
KD	1.40±0.01^{c}	0.09±0.01^{a}	1.62±0.01^{c}	1.00±0.02^{b}	0.91±0.14^{d}	0.39±0.02^{c}	0.33±0.14^{c}	0.36±0.01^{c}
KS	2.11±0.01^{d}	1.11±1.01^{d}	1.47±0.02^{c}	1.38±0.01^{d}	0.30±0.05^{b}	0.35±0.01^{b}	0.25±0.04^{b}	0.22±0.01^{b}
Control	0.00±0.00^{a}		0.00±0.00^{a}		0.00±0.00^{a}		0.00±0.00^{a}	
WHO/FAO, (2008) Standard for Soil	1.00		50.00		10.00		250.00	
WHO/FAO, (1985) Standard for Water	0.01		0.10		5.00		2.00	

Source: Fieldsurvey, 2020. Values arerepresents as mean ±SD.Valuesin the same rowwith the same letter superscripts indicates no significant difference between them at $p > 0.05$ while values with different letters subscripts indicate significant difference between the values at $p < 0.05$. Cd = Cadmium, Cr = Chromium Pb = Lead Zn = Zinc. WHO = World Health Organization, FAO = Food and Agricultural Organizations. SS – Sampling Sites, KM – Kofar Marusa, KD – Kofar Durbi, KS – Kofar Sauri

Heavy Metals in Soil Samples

The result for laboratory analysis of soil contamination with heavy metals showed that the soil samples were contaminated with Cd, Cr, Pb and Zn as also reported by Raymond *et al.,* (2011).

The result of metals concentrations in the soil samples showed that Cd is the most concentrated heavy metal in the soil sample. In a similar study conducted by Jimoh and Mohammed (2016) on the transfer of heavy metals from soil to lettuce (*Lactuca sativa*) grown in irrigated twenty one (21) farmlands in Kaduna metropolis. Nigeria, levels concentration of Cd in all the farmlands reported were lower than the values reported in the present study. Similarly, Tahir *et al.,* (2007) reported highest mean value of Cd in agricultural soil of school community in New Orleans, USA, Levels of Cd in all soil samples have exceeded the WHO/FAO, (2008) permissible limit of 1.00ppm.

The mean values of Cr in all sampling areas were within the permissible limit of 50.00ppm.Health problems associated with Cr is its accumulation in the Kidney causing a disorder called renal tubular osteomalacia (Itai-Itai, in Chinese) and weakness of the bone (Vukojevic *et al.,* 2006; Ademorati, 1996 and Kjellstorm, 1979).

Heavy Metals in Water Samples

Concentration of Cd in the treatment groups exceeded the WHO/FAO (1985) permissible limit in irrigation water. Moreover, presence of Cd in the irrigation water was also reported by Hossien *et al.,* (2011), Olivares-Rieumont *et al.,*(2005) and Kaushik *et al.,* (2009)

Generally, the concentration of toxic heavy metals in water samples of Kofar Marusa and Kofar Sauri have the distribution pattern as Zn<Pb<Cd<Cr, although these concentrations exceeded the permissible limit (0.10ppm) set by WHO/FAO (1985).

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Growth Performance of Pearl Millet (*Pennisetum glaucum* L.) Varieties as Affected by Varying Fertilizer Rate and Intra-row Spacing in Katsina State, Nigeria

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Abstract
A field experiment was conducted during the 2023 growing season at Tambu-Daura Teaching and Research Farm School of Basic Vocational Agriculture, to investigate the growth performance of pearl millet varieties as affected by varying fertilizer rates and intra-row spacing. The experiment was conducted using three pearl millet varieties (SOSAT, JIRANI and DANDIGALI) two intra-rows spacing (50cm and 70cm) and two fertilizer rates (100kgN:50kgP:50kgK and 80kgN:40kgP:40kgK). The treatments were laid under randomized complete block design (RCBD) with three replications. Data on growth were recorded at 3, 6 and 9WAS during the experiment. The result indicated that variety DANDIGALI and SOSAT are statistically similar in growth but far better than JIRANI during the experiment. Intra-row spacing at 50cm recorded the highest value on several days to 50% flowering, plant height at 3, 6 and 9WAS, and number of plant tillers at 3, 6 and 9WAS. The fertilizer application rate had a significant (P>0.05) effect on the growth component and the application of fertilizer at the rate of 100kgN:50kgP:50kgK significantly (P>0.05) outperformed better than the application of fertilizer at the rate of 80kgN:40kgP:40kgK. Conclusively planting of pearl millet DANDIGALI or SOSAT at intra-row spacing of 50cm and 100kgN:50kgP:50kgK seem to be the best and recommended in the study area.
Keywords: fertilizer application, plant spacing, pearl millet, variety, yield component

INTRODUCTION

Pearl millet (*Pennisetum glaucum* L.) also known as Gero and Hatsi in northern Nigeria while in India is called bajra it's one of the most important cereal (grain) crops generally cultivated in Africa and Asia particularly India. It is the 4th most important food crop in Nigeria and India respectively. Anonymous, (2010) reported that Pearl millet is the 6th most important grain in the globe after rice, maize, wheat, sorghum and barley (Akinsuyi, 2011). Over 5 million hectares of land are cultivated in Nigeria with an annual production of 3.5 million metric tonnes (FAOSTAT, 2019). In West Africa, where the crop is considered of major importance Nigeria is the leading producer of pearl millet, with about 28% of the world production (FAO, 2014: Ismail, 2012). However, the estimated global production of pearl millet was 24.2 million hectares with approximately 45% of the production (FAO, 2015). The grain contains 13-14% protein, 5-6% fat, 74% carbohydrate and 1-2% minerals with slightly superior amino acid substance, it also contains a higher amount of carotene, riboflavin (Vitamin B2) and niacin (Vitamin B4).

(Harsh and Arvadiya2023). Regrettably, some factors responsible for low yield in pearl millet production are varietal effects, pests, diseases, fertilizer and agronomic practices. Fertilizer application rate and variety alone contribute to about 75% of poor yield production in Nigeria (FAO, 2014). However, the main objective of this study is to determine the productivity of pearl millet varieties as affected by plant spacing and application of fertilizer rate in the Sudan savanna, Nigeria.

MATERIAL AND METHODS

Description of the Experimental Site

Field experiments were conducted in the wet season of 2023 at the Teaching and research farm of Basic Vocational Agriculture School Tambu-Daura situated at 12^0 59'34 N, 8^0 16'58 E, and 549 meters above sea level) in Katsina State, Nigeria. The region has an estimated rainfall between 500 and 750 inches and 15^0 and 43^0C of average temperature yearly.

Treatments and Experimental Design

The treatment comprises three pearl millet varieties (DANDIGALI, JIRANI and SOSAT two plants Spacing 50cm and 70cm and two different rates of fertilizer application 100:50:50 and 80:40:40) and arranged in a 3x2x2 factorial combination with three replicates using randomized complete block design (RCBD). The fields were cleared, harrowed and ridged. The ridges were then separated into plots of six ridges each, measuring 3m by 4.5m (13.5m). The net plot of two inner rows spaced 75cm by 300cm long a pass-way of 1m was created. The seeds of the three varieties were sourced from the Katsina State Agricultural and Rural Development Authority (KTARDA). The seeds were also treated with apron star at 5g per 2.5kg seeds to guard against soil infections and pests. Seeds were planted manually and placed as per treatment at a depth of 5 cm. The seeds were sowed on 24th May 2023. 3WAS 1st weeding was conducted and the plant was thinned to three plants per stand. However, NPK fertilizer was applied as per treatment.

Data Collection

Data collected for each year on plant growth was recorded at 3, 6, and 9WAS from five tagged plants per plot while data on yield were also gathered immediately after harvesting. The data collected were subject to statistical analysis of variance using the General linear model (GLM), using SAS package 2002 version 9.0. Differences between treatment means were compared using the Duncan Multiple Range Test (DMRT) Duncan (Duncan, 1955). At the 5% level of probability ($P < 0.05$).

RESULT AND DISCUSSIONS

Plant height had a significant effect (($P \leq 0.05$) on variety and Dandigali was significantly higher than Sosat and Jirani. Although both Dandigali and Sosat are statistically the same two varieties outperformed better than Jirani. However, plant spacing had a significant effect ($P \leq 0.05$) on plant height and 50cm plant spacing performed better than 70cm this conforms with Emechebe, (2006) who revealed that intra-row spacing had a significant influence on plant height in pearl millet. Application of fertilizer at the rate of 100:50:50 recorded a significant ($P \leq 0.05$) increase in plant height than application at the rate of 80:40:40. The result confirmed Alhassan, et al., (2006) report that Fertilizer application is one of the limiting factors to pearl millet production in Sudan savannah Nigeria. All the interactions were not significant ($P \leq 0.05$) at both locations (Table 1). The number of leaves per plant at 6 and 9 WAS had a significant ($P \leq 0.05$) effect on millet variety and fertilizer rate at 6 and 9 WAS (Table 1). The result indicated that the

Dandigali significantly (P ≤ 0.05) performed better than the Sosat and Jirani varieties number of leaves per plant. The application of fertilizer at the rate of 100:50:50 recorded the highest number of leaves at 6 WAS, followed by an application rate of 80:40:40, while the rate was statistically the same at 3WAS. The result confirmed Alhassan, et al., (2006) report that Fertilizer application is one of the limiting factors to pearl millet production in Sudan savannah Nigeria. Plant spacing had no significant (P≤0.05) effect on the number of leaves throughout the measuring periods.

Table 1: Plant height per plat of millet as affected by variety, rate of fertilizer and plant spacing spacing at Tambu-Daura during the 2022 and 2023 wet season

	Plant height (cm)			Number of leaves per plant		
Treatments	**3WAS**	**6WAS**	**9WAS**	**3WAS**	**6WAS**	**9WAS**
Varieties (V)						
DANDIGALI	52.60a	131.28a	202.37a	5.83	9.61a	13.72a
JIRANI	45.00b	100.94b	130.06b	5.44	8.56b	12.17b
SOSAT	50.95a	97.05b	193.92a	5.27	9.05b	12.57b
S.E(±)	2.21	6.20	7.51	0.22	0.20	0.24
Significance	*	*	*	NS	*	*
Spacing (cm)						
50	57.35a	124.22a	183.79a	5.22	9.05	13.28
70	43.62b	106.87b	171.12b	5.53	9.00	13.37
S.E(±)	2.30	5.67	5.32	0.16	0.14	0.17
Significance	*	*	*	NS	NS	NS
Fertilizer rate (F)						
F1	51.97a	119.97	179.22	5.94a	10.26a	14.15
F2	50.90b	114.27	172.75	5.68a	8.41b	14.26
S.E(±)	2.30	5.67	5.32	0.20	0.18	0.21
Significance	*	NS	NS	NS	*	NS
Interactions						
V x S	NS	NS	NS	NS	NS	NS
V x F	NS	NS	NS	NS	NS	NS
S x F	NS	NS	NS	NS	NS	NS
V x S x F	NS	NS	NS	NS	NS	NS

Note: Means followed by the same letter(s) in each column, under each variety are not significantly different 5% level of significance (P < 0.05), using DMRT. *= Significant, NS= Not Significant at 5% level of probability.

Variety has a significant (P≤0.05) effect on the Number of Tillers per plant throughout the measuring period (P ≤ 0.05). The result revealed that Jirani outperformed Dandigali and sosat at 3 and 9 WAS but was statistically similar to Jirani at 6 WAS and higher than Sosat (Table 2). This corroborates the findings of Sheriff et al., (2019) and Bassi et al., (2020) who reported that the performance of pearl millet varieties was determined more by their inherent genetic characteristics. Spacing has a significant effect (P ≤ 0.05) throughout the measuring periods where 50cm is higher than 70 cm. Likewise, application at 100:50:50 resulted in a higher number of Tillers per plant than application at 80:40:40. Interactions were not significantly different at the same rate. Several stem girths per plant were observed at the sampling stages (Table 2). The result also indicated that variety had a significant effect (P ≤ 0.05) except at 9 WAS, spacing was significant at 3 and 9 WAS (P ≤ 0.05) except at 6 WAS where 70 cm provides thicker stem girth at 9 WAS This finding is in consonant with the report of Harsh and Arvadiya, (2023) That wider spacing (75cm) produced the highest grain yield, panicle length, yield per hectare and heavier 1000 grains. Fertilizer rate significantly (P ≤ 0.05) affected the stem girth at 3 and 6 WAS except at 9 WAS The result confirmed Alhassan, et al., (2006) report that Fertilizer application is one of the limiting factors to pearl millet production in Sudan savannah Nigeria

Table 2: Number of tillers per plant of millet as affected by variety, fertilizer rate and plant spacing at Tambu-Daura during the 2023 wet season

	Number of tillers per plant			Stem Girth Per Plant (cm)		
Treatments	**3WAS**	**6WAS**	**9WAS**	**3WAS**	**6WAS**	**9WAS**
Varieties (V)						
DANDIGALI	3.11b	3.22a	4.56b	3.41a	2.79a	3.39
JIRANI	3.61a	4.00a	6.28a	2.51c	2.31b	3.52
SOSAT	2.87b	2.95b	4.49b	2.80b	2.71a	3.36
S.E(+)	0.17	0.26	0.23	0.14	0.09	0.08
Significance	*	*	*	*	*	*
Spacing (cm)						
50	3.33a	3.58a	5.19a	3.30a	2.62	3.08b
70	2.97b	3.14b	4.74b	2.33b	2.73	3.78a
S.E(+)	0.12	0.18	0.16	0.10	0.07	0.05
Significance	*	*	*	*	NS	*
Fertilizer rate (F)						
F1	4.40a	5.85a	8.59a	2.99a	2.84a	3.41
F2	2.49b	4.90b	6.67b	2.98a	2.96a	3.45
S.E(+)	0.15	0.23	0.20	0.12	0.08	0.06
Significance	*	*	*	*	*	NS
Interactions						
V x S	NS	NS	NS	NS	NS	NS
V x F	NS	NS	NS	NS	NS	NS
S x F	NS	NS	NS	NS	NS	NS
V x S x F	NS	NS	NS	NS	NS	NS

Note: Means followed by the same letter(s) in each column, under each variety are not significantly different 5% level of significance (P < 0.05), using DMRT. *= Significant, NS= Not Significant at a 5% level of probability.

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Multivariate Analysis of Soybean Genotypes in the Southern Guinea Savanna of Nigeria

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Abstract
The studies were conducted at National Cereals Research Institute, (NCRI) Badeggi, Nigeria to evaluate both agronomic and proximate composition of sixteen soybean genotypes using multivariate analysis. The genotypes were evaluated for 16 characters and showed adequate variability for the components studied. Statistical software has been used to classify the divergent genotypes into different groups highlighting the most contributive traits. Two of the commonest multivariate analytical techniques (PCA & cluster) were used to subdue the multiple datasets. Following this analysis, seven component whose eigen values were greater than or equal to 1 accounted for 71% of the total variations of the data and were centered at; nutritional composition, yield and yield attributes and plant structure. Based on these traits, the sixteen soybean genotypes were divided into three clusters. All characters varied between the cluster especially for; days to maturity, plant height, fodder weight, crude fats carbon content and number of pods per plants. The genotypes showing great variation in cluster and principal component analysis can be used as parents in hybridization programs to maximize the use of genetic diversity and expression of heterosis and develop high yielding soybean varieties.

INTRODUCTION

Soybean has been described as a miracle crop because of it remarkable importance in the dietary and industrial purposes. It importance has never been over emphasized as it remained the cheapest source of quality protein and healthiest edible oil for humans and animals (Agada, 2015). The dietary protein source of soybean ranked it high above other protein sources such as; meat, egg, milk, fish and other members of it family (Mohammed *et al.* 2018). Despite the high nutritional advantages of soybean grains, much of the work on it improvement has been centered on manipulating agro-morphological characteristics for varietal advantages while little effort has been given to characterize cultivars along with their nutritional content. Nutritional characterization will enable the recommendation of highly nutritious lines for production or use in breeding programs (Nwosu *et al*. 2019). Exploitation of the proximate composition of soybean genotypes with respect to nutritional qualities becomes essential since the percentage nutrients of it composite are comparable to other legumes whose nutritional demands are highly viable between humans and livestock.

Soybean has high productive tendency even under minimum agricultural input (Khan *et al.* 2014), however, the ultimate yield of a crop depends on the interaction between the genetic makeup and it environmental factors on which it survive. Yield is determined by several traits therefore, a technique is required to identify and prioritize the important traits by minimizing the number of traits for effective selection and genetic gain (Dubey *et al.* 2018).

Multivariate analytical techniques that analyze multiple measurements for each genotype at the same time are widely used in the analysis of genetic diversity. Principal Component Analysis (PCA) and Cluster Analysis are currently the most widely used methods (Singh *et al*. 2020). They seem particularly well suited for analyzing components contributing to yield. Principal component analysis explains the contribution of the most important traits that account for the total genetic variability (Aondover *et al.* 2013). Principal component has been defined as reduced data forms which clarify the relationship between breeding materials into interpretable fewer dimensions to form new variables (Aremu, 2013). Important components analyzed will be effective to limit the number of primary variables, to describe the total variation of a population and to explain the traits contribution to total variation (El-Hashash, 2016). The eigen vectors and the corresponding loadings for each individual from the PCA can be used as covariates within a logistic regression framework to account for the underlying structure (Dubey *et al.* 2018). Cluster analysis, on the other hand, allows the classification of individuals into groups in order to maximize their homogeneity within a group and show heterogeneity among groups. The hierarchical method interconnects samples through their associations producing a dendrogram in which similar samples are grouped together. For this reason cluster analysis has been used efficiently to select genotypes and is complementary to PCA (El-Hashash, 2016).

This study was carried out to unravel the contribution of each trait to the total variation of sixteen soybean genotypes as well as grouping these genotypes on the basis of homogeneity within group and heterogeneity among them.

MATERIALS AND METHODS

The experiment was conducted at the soybean experimental field of the National Cereal Research Institute, Badeggi NCRI (Lat 9o 3’ 0”N, Long 6o 9’ 0”E and 70.5m above sea level), during the 2019 and 2020 rainy seasons. The site is of the Southern Guinea Savanna and bears an average annual rainfall of 1124mm (Gana and Adagba, 2013). A total of sixteen (16) genotypes were sourced from the NCRI germplasm. These include eight (8) local accessions [NCRI Soy; 32, 36, 38, 41, 47, 49, 58 and 16], three (3) others denoted as; Dina, Signal and JG of exotic pedigree and five National Released Varieties [TGx; 1987-10f, 1987-62f, 1835-10e, 1904-6f and 1448-2e] were used.

The experimental design was a randomized complete block design (RCBD) replicated 3 times. Each plot measured 2m x 3m with a total of four rows per treatment at 0.5m inter row spacing. Alleys of 1m separated each replication. Each experimental layout measured 26m x 13.5m, covering an area of 351m2 (0.0351ha) with a total of 48 plots (entries). This designed and layout was maintained for the two seasons the experiment was conducted. The field was cleared, ploughed and harrowed before planting. Seeds were planted using drilling method which was later thinned to 30 stands per roll at three weeks after emergence. Manual weeding was adopted and carried out at three (3) and six (6) weeks after planting.

Mixture of; 75g of NPK 15:15:15) and 90g of SSP were applied to each treatment in a

block based on Dugje et al. (2009) recommendations. Drilling method of application was adopted and the application took place immediately after the first weeding.
Agronomic data were collected on the following traits; Days to 50% flowering, Plant height (cm) at maturity, Days to 95% maturity, Number of pods per plot, First pod height, Seed yield per plot, Fodder weight and 100seed weight.

Proximate Composition and Gross Energy
The proximate constituents Moisture, ash, crude protein, crude fat and crude fibre of the oven-dried materials were determined by official methods of analysis of the AOAC, Association of Official Analytical Chemists (1998). All analyses were carried out in duplicate. Total percentage carbohydrate was determined by the difference method, subtracting all the other components from 100%. CHO = 100- (% ash+ %crude fibre + %crude protein + %moisture). This method involved adding the total values of crude protein, crude fat, crude fibre, moisture and ash constituents of the sample and subtracting it from 100. The value obtained was the percentage carbohydrate constituent of the sample.

Gross energy of the dry material was determined against thermocouple grade benzoic acid using a Gallenkamp ballistic bomb calorimeter (Model CBB - 330- 0104L).

Statistical Analysis
The data obtained from agronomic performance and proximate compositions in each replicated evaluation (field and lab) were subjected to analysis of variance (ANOVA) using STAR software version 7.2 (2002). Means were separated using the Tukey's Honest Significant Difference (HSD) test where noteworthy variations occurred among genotypes. All values were considered significant at P≤0.05.

RESULTS AND DISCUSSION
Principal Component Analysis (P.C.A)
Results of principal components analysis for these characters were shown in Table 1. The data revealed that the 7 principal components having greater than one Eigen values contributed 73.7% of the total variation among the 16 genotypes of soybean. Generally, if eigen value is higher than one, it can be used as an inclusion criterion (El-hashash 2016). In this study, the first seven PCAs extracted had eigen values more than one (Eigen value >1). Opkorei, (2008), Behnke *et al, (*2018) and El-hashash (2016) all reported 7 extracted PCAs with eigen values >1. The first component PC1 expressed 19.8% of the total variation and was occupied by; moisture (0.3858), Ash (0.4448) and Fibre (0.4455). PC2 contributed (13.7%) of the total variation which was highly influenced by; days to maturity (-0.3937) and Energy value (0.4277). The 11.5% contribution made from PC3 was implicated by; Yield per plot (0.3184), Fodder weight (0.322), number of branching per plant (0.2773), crude fat (0.4372) and Carbon content (-0.3557). However, PC4 made 8.4% of the total variation which was dominated by; First pod height (-0.4313) and Number of pods per plant (0.4794). PC5 (7.8%) was solely earmarked by Crude protein (0.6253). protein was also the sole variable in a PC analysis reported by, Dubey et. al; (2018). The (6.7%) contribution made by the sixth PC was influenced by Days to 50% flowering (0.6945) and 100 seed weight (-0.4053), while in the seventh PC, plant height at maturity (0.4733) supported the 5.8% contribution made to the total variation.

Among 16 genotypes, the top principal component scores (PC score) for all the traits were estimated in these seven components. These scores can be utilized to propose precise selection indices whose intensity can be decided by variability explained by each of principal component. High PC score for a particular genotype in a particular component denotes high values for the variables in that particular genotype.

PC1 generally represents the nutritional quality of the seeds. Genotypes with high mean values for these parameters can be targeted for breeding purposes. The overall means of these variables match the existing values reported by various investigators for this region Datti *et al*. (2019), and Nwosu *et al.* (2019).

Table 2: Eigen values, % variance and cumulative values of 16 soybean genotypes in Badeggi

Variables	PC1	PC2	PC3	PC4	PC5	PC6	PC7
D50F	-0.0443	-0.0607	0.054	-0.2325	-0.0322	**0.6945**	-0.1373
DTM	-0.0962	**-0.3937**	0.0994	0.2893	0.18	-0.0489	0.0059
PHAM	-0.1231	-0.2793	0.1567	0.0934	0.3345	-0.1061	**0.3355**
FPH	0.0435	0.0594	0.1563	**-0.4313**	0.332	-0.1069	0.1187
NPPP	-0.0705	-0.0924	0.2404	**0.4794**	-0.2294	-0.0462	0.1367
NBPP	-0.0465	0.1804	**0.2773**	-0.2044	0.0819	-0.1511	-0.3597
YPP	-0.1043	-0.2806	**0.3184**	0.0216	-0.1261	-0.3195	-0.102
FWPP	-0.2141	-0.1953	**0.322**	-0.0428	-0.1318	0.0945	-0.1635
100SW	0.0816	0.1976	-0.1849	0.1659	0.2655	**-0.4053**	-0.2532
W_0	**0.3858**	-0.1118	0.066	0.2236	-0.0285	0.0978	-0.4057
ASH	**0.4448**	-0.116	0.1734	-0.1512	-0.0749	-0.0491	0.2525
CF	0.1005	0.3905	**0.4372**	0.1076	-0.1433	0.0166	0.0391
CP	-0.0844	0.1504	0.0103	0.1481	**0.6253**	0.1454	0.0289
CFB	**0.4455**	-0.1298	0.1579	-0.1515	-0.0743	-0.0394	0.2498
CHO	-0.321	-0.2333	-0.3557	-0.1147	-0.2605	-0.0894	-0.0949
E.V	-0.2485	**0.4277**	0.264	0.149	-0.1136	0.0133	-0.0591
Proportion of variance	0.1978	0.1372	0.1154	0.0835	0.0784	0.0665	0.0583
Cumulative proportion	0.1978	0.335	0.4504	0.5339	0.6123	0.6788	0.737
Eigen Values	2.607	2.1933	1.586	1.4896	1.2629	1.1068	0.8393

where; D50F=days to 50% flowering, DTM=days to 95% maturity, STD C=stand count, PHAM= plant height at maturity (cm), FPH=first pod height (cm), NPPP= number of pod/plant, NBPP= number of branches/plant, YPP= yield/plot (g), FWPP= fodder weight/plot (g), 100SW= weight of 100 seeds (g), W_0 = moisture content (%), ASH= ash content (%), CF= crude fat (%), CP= crude protein (%), CFB= crude fibre (%), CHO= carbon content (%) and EV= energy value (K/cal).

On the other hand, the contributions of crude fats and proteins in their individual PCs will be ineffective in the selection of the corresponding genotypes. This is because; the highest mean values of these parameters were less than the trending values (genetic gain). As such, selection on the basis of these traits can only be for the purpose of it improvement.

PC3 and PC4 were compounded by yield and yield attributes. This only implies that, selection of corresponding genotypes for this component will positively improve yield while making crosses. Similarly, PC7 solely represents genotype selection to determine plant stature.

Clustering

The grouping of different soybean genotypes in clusters for quantitative traits is presented in table 4. Cluster I comprised of 7 genotypes, which represented 43.75% of the total genotypes. The Cluster II represented 37.5% with 6 genotypes. Cluster III comprised of 3 genotypes which represents 18% of the population. The results indicated the presence of high degree of divergence among the genotypes for almost all traits.
The cluster mean values for different plant characters in groups are presented in table 3. The mean values differed largely in for all the characters except for yield.

Table 3: Cluster performance of sixteen soybean genotypes grouped based on the studied characters

Variables	Cluster I	Cluster II	Cluster III
D50F	40	39.33	39.67
DTM	120.43	111.67	96
PHAM	47.56	51.35	40.9
FPH	9.33	11.22	11.53
NPPP	39.11	42.87	36.6
NBPP	4.24	5.07	6.33
YPP	411.29	431.17	408.33
FWPP	311.57	358.5	427
SW	13.5	14.67	13.67
MOISTURE	5.4	6.1	5.48
ASH	5.9	7.86	5.65
CRUDEFAT	17.17	18.45	20.7
CRUDEPROTIEN	30.93	33.38	32.92
FIBRE	3.89	5.19	3.73
CHO	36.58	28.9	31.26
ENERGYVALUE	424.62	414.03	444.09

Where D50F=days to 50% flowering, DTM=days to 95% maturity, STD C=stand count, PHAM= plant height at maturity (cm), FPH=first pod height (cm), NPPP= number of pod/plant, NBPP= number of branches/plant, YPP= yield/plot (g), FWPP= fodder weight/plot (g), 100SW= weight of 100 seeds (g), W_0 = moisture content (%), ASH= ash content (%), CF= crude fat (%), CP= crude protein (%), CFB= crude fibre (%), CHO= carbon content (%) and EV= energy value (K/cal).

Members of cluster II recorded the highest mean yield (431.17g/3m^2). This could be as a result of higher number of pods and seed weights recorded for this group. It also recorded higher protein (33.38%), fibre (5.19%), ash (7.86%) and moisture (5.48%). The least yielding genotypes were found in cluster III.

Table 4: Grouping of Sixteen soybean genotypes based on agronomic and proximate characters

Cluster I	Cluster II	Cluster III
Gen1 Gen2 Gen5 Gen6 Gen9 Gen16 Gen 11	Gen3 Gen4 Gen7 Gen8 Gen10 Gen 14	Gen12 Gen13 Ge

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Gen1 Gen2 Gen5 Gen6 Gen9 Gen16 Gen 11	Gen3 Gen4 Gen7 Gen8 Gen10 Gen 14	Gen12 Gen13 Ge

They were also characterized with shorter plants and lesser number of pods per plant. However, the members of this cluster exhibited the highest mean value for crude fats and energy level. The genotypes which have greater morphological similarities were grouped in clusters. Although, no cluster presented genotypes at zero dissimilarity level.

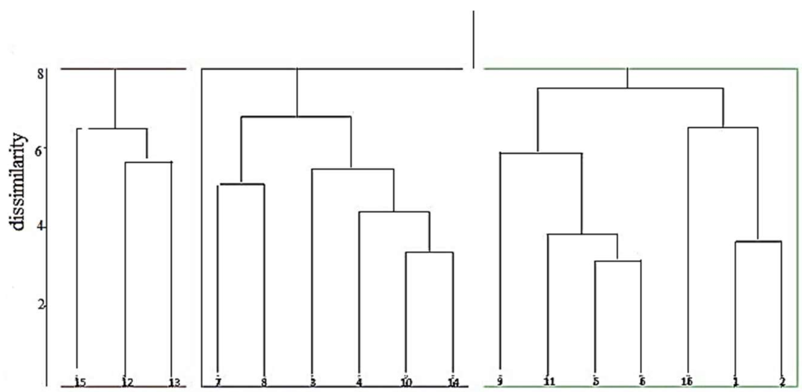

Figure 1: Dendrogram of 16 soybean genotypes based on 17 quantitative traits at Badeggi, Nigeria.

CONCLUSION AND RECOMMENDATIONS

Noteworthy variations were recorded for all traits harnessed in this study. However yield variation between clusters was not adequate enough and cannot effectively determine the basis for selecting parental material. More so, the percentage contribution of yield to the total variation in the PC analysis was meager compare to the yield contribution observed in other investigation. As such, emphasis should be shifted to other yield components like, number of pods for parent selection. However, improved crop husbandry techniques can also be employed to amend environmental influences and boost character expression in the genotypes. Multivariate analysis has proven instrumental in identifying relevant characters in differentiating genotypes in a germplasm. Based on this result, it can be concluded that selection of genotypes can be for gene introgression of characters like; days to 50% flowering and to curb pest and disease infestation, days to maturity to allow proper timing of farm operations, seed moisture content to improve storability and seed quality improvement through Ash, firbre and carbon content.

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Isolation and Identification of Fungi Associated with Postharvest Spoilage of Tomato (*Solanum lycopersicum* L.) in Wudil Kano State, Nigeria

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Abstract
This research aimed at isolating and identifying the fungal pathogens associated with tomato post-harvest spoilage in the Wudil vegetable market, Kano. A diseased tomato was collected from the Kwanar Gaya vegetable market along Kano road, in Wudil Local Government Area of Kano state. Five (5) diseased tomatoes from each of the available varieties in the market were selected and transported to the pathology laboratory in the Department of Crop Protection, Faculty of Agriculture, Bayero University, Kano in separate sample bags same day for further studies. Diseased tomatoes were sampled based on physical examinations. The findings of this research confirm the presence of fungal species that play a significant role in post-harvest spoilage of tomatoes in the Wudil vegetable market, Kano. Five (5) different fungi were isolated, and identified and their distribution and growth rate have been thoroughly examined across the spoiled varieties. Among the different tomato varieties sampled, variety Dan Niko had the highest fungal distribution (38.46 %) of the total fungal distribution. Followed by Dan Gombe (34.62%), and the lowest percentage was obtained from the variety Dan Zaria (26.92%). It is recommended that more research should be focused on the development of sustainable improved storage facilities that will help the farmers, traders, and stakeholders in the tomato supply chain to reduce postharvest spoilage of tomatoes.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is an important vegetable crop known for its nutritional and economic values. The crop is rich in vitamins and minerals and contains anti-oxidant compounds, like vitamin C and carotenoids that has a significant role in human health (Wang, 2016). Tomato is the world's most highly consumed vegetable due to its status as a basic ingredient in a large variety of raw, cooked or processed foods (FAOSTAT, 2020). It belongs to the family Solanaceae, which includes several other commercially important species. Tomato is grown worldwide for local use or as an export crop (FAOSTAT, 2020).The crop is a traditional vegetable crop commercially cultivated throughout the world on 4.02 million hectares with a production of 152.9 million tones and productivity of 37.83 tones/ha (Anon., 2011). Fresh tomato production reached 163,719,357 tons in the world in 2020, out of which about 4.5% are traded (FAOSTAT, 2020).

The crop is widely cultivated in Nigeria and are processed into a wide variety of products including paste, pulp and other more specialized sauces. Despite the importance of the crop to Nigeria economy, the tomato industry is faced with a myriad of constraints along the value chain which include incidence of pests, diseases and post-harvest losses among others (Gifoni *et al.,* 2020). The most devastating tomato diseases in Nigeria and entire part of the world that caused spoilage both at pre and post-harvest are *Fusarium* rot caused by *Fusarium oxysporum* f. sp. *lycopersici* , Tomato early blight caused by *Alternaria solani* and tomato late blight caused by *Phytophthora infestans* among others (Chauhan *et al.,* 2015). These diseases cause serious yield losses of 45% wherever tomato is produced. The pathogens are specific to tomato plant and fruits, highly destructive and difficult to control (Raut *et al.,* 2020). Attempts by scientist and farmers to control the diseases especially at post-harvest level have yielded limited success (Juliano and Bettiol, 2005). One of the limiting factors that influence the tomato economic value is the relatively short shelf life period caused by pathogen attack. It is estimated that about 20-25% of the harvested tomatoes are decayed by pathogens during post–harvest handling even in developed countries (Haruna *et al.,* 2024). Soil-infesting fungi that causes damage of fleshy tissue usually infect plants at the time of or just before harvesting. Infection of tomato may occur, during post -harvest handling or storage (Yusuf *et al.,* 2020). Some fungal species may gain entry into the susceptible fruit tissue and cause loss during packaging and transportation ((Raut *et al.,* 2020). Spoilage microorganisms can be introduced to the tomato fruits during the crop growth in the field, during harvesting and postharvest handling, or during storage and distribution (Barth *et al.,* 2009). Those same types of soil-borne spoilage microbes that occur on produce are the same spoilage microorganisms that are present on harvesting equipment, on handling equipment in the packinghouse and in the storage facility (Barth *et al.,* 2009). Thus, fruits spoilage refers to any change in the condition of fruit, in which the fruit becomes less palatable or even toxic; these changes may be accompanied by alterations in taste, smell, appearance or texture (Danila, 2005).

Post-harvest spoilage caused by different fungal pathogens is very common and destructive to tomato, causing significant reduction in the quantity and quality of fruit. Over 50 % of the tomato produced in Nigeria are lost in transit between farms and major urban markets (Yusuf and Salau, 2007), thus, there is need for an effort towards curtailing post-harvest losses in the country. Losses of up to 80 % have been attributed to several fungal spoilage of tomato under field conditions and after harvest (Haruna *et al.,* 2024). When left unidentified and uncontrolled, these pathogens may destroy huge tones of tomatoes during harvesting, transportation and handling within several days. For effective management of the aforementioned problems, there is need to identify the fungal pathogens responsible and associated with the spoilage of tomato fruits with view of finding lasting solution to the problem.

The objectives of this study is to; (i) Isolate and identify the fungal pathogens associated with tomato post-harvest spoilage in Wudil vegetable market (ii) To determine the percentage distribution of the identified fungal isolates in relation to spoiled tomato varieties in the study area and (iii) To determine the growth rate and colony characteristics of the identified fungal pathogen on nutrient media.

MATERIALS AND METHODS

Sample Collection

Diseased (spoiled) tomatoes were collected from the Kwanar Gaya vegetable market along Kano road, in Wudil Local Government Area of Kano state. The market is the main vegetable depot in Wudil town. Five (5) diseased tomatoes from each of the available varieties in the market were selected and transported to the pathology laboratory in the Department of Crop Protection, Bayero University, Kano in separate sample bags same day for further studies. Diseased tomatoes were sampled based on physical examination as used by (Bukar, *et al.,* 2009).

Isolation and Identification of the Fungi

Isolation and identification of the fungal pathogen associated with spoilage of tomatoes was carried out at the Plant pathology laboratory, Department of Crop Protection, Bayero University, Kano. To isolate the fungi, infected tomatoes were first rinsed gently using running tap water and sterilized distilled water respectively. A small portion of tissue from the tomato (5 mm) was cut using a scalpel from the advance margin of the spoiled tomato lesion and placed side up on 2.0 % sodium hypochlorite (NaOCl) for two minutes, and was rinsed in three changes of sterile distilled water (SDW). The samples was then dried with sterile filter paper and aseptically transferred to Potato dextrose agar (PDA) supplemented with streptomycin (100 µg/mL) to prevent the growth of bacteria. The Petri dishes were incubated for five days at room temperature (28 ± 2 °C) as described by (Muhammad *et al.,* 2018). Fungal mycelia was subcultured into freshly prepared PDAs to obtain pure cultures at seven days after inoculation.

To identify the fungi, a drop of lactophenol cotton blue stain was placed in a clean slide with the aid of a mounted needle, a small portion of the mycelium from the fungal cultures was removed and placed in the drop of the stain. The mycelium was spread thoroughly on the slide with the aid of two sterilized needles and cover the slide. The covered slide was examined under the microscope as described by (Fawole and Oso, 1995; Muhammad *et al.,* 2018). The observation was done at high power resolution of the microscope (×40) for clarity. The cultures observed were identified by microscopic and morphological examinations using identification manual (Barnett and Hunter, 2006).

Data analysis

Fungal pathogens associated with spoilage of tomato identified from each of the sample was summarized and tabulated using descriptive statistics (frequency and percentages).

RESULTS AND DISCUSSION

Isolation and identification of fungal species associated with postharvest spoilage of tomato

Five different fungal species were isolated and identified from the spoiled tomato samples obtained from Wudil vegetable market and the result presented in Table 1. *Fusarium* spp, *Pythium* spp, *Colletotrichum* spp, *Alternaria* spp and *Rhizoctonia* spp were identified. Two varieties, Dan Gombe and Dan Zaria had the same number of fungal isolates of four each, while variety Dan Niko had five number of isolates (Table 1).

Table 1: Fungal species isolated from the spoilt tomato from Wudil vegetables market

Variety	Fungal Pathogen Identified
Dan Niko	*Fusarium* spp*, Pythium* spp*, Colletotrichum* spp *,Alternaria* spp*, Rhizoctonia Spp*
Dan Gombe	*Fusarium* spp*, Pythium* spp*, Colletotrichum* spp *,Alternaria* spp
Dan Zaria	*Fusarium* spp*, Pythium* spp*, Colletotrichum* spp *,Alternaria* spp

Percentage of fungal distribution across the spoiled tomato varieties

Table 2 shows the percentage distribution of the fungal isolates identified across the spoiled varieties. Variety Dan Niko had the highest fungal distribution (38.46%) of the total fungal distribution. Followed by Dan Gombe (34.62%), and the lowest percentage was obtained from variety Dan Zaria (26.92%) respectively (Table 2).

Table 2: Percentage distribution of fungal species on the varieties of spoiled tomato

Variety	Fungal pathogen distribution					
	Fusarium	***Pythium***	***Collectotrichum***	***Rhizoctonia***	***Alternaria***	**Percentage (%)**
Dan Niko	2	3	2	2	1	38.46
Dan Gombe	3	2	2	0	2	34.62
Dan Zaria	2	2	1	2	0	26.92
Total	**7**	**7**	**5**	**4**	**3**	**100.00**

Percentage fungal distribution per isolates

Table 3 shows the percentage fungal distribution of the isolates identified. *Fusarium* and *Pythium* spp had the highest isolates number of 7 each (26.92%), followed by *Colletotrichum* spp with 5 (19.23%), and the least isolates was *Alternaria* spp (11.54%) (Table 3).

Table 3: Percentage distribution of fungal spp from the spoiled Tomato

Fungi	Number of Isolates	Percentage (%)
Fusarium spp	7	26.92
Pythium spp	7	26.92
Colletotrichum spp	5	19.23
Rhizoctonia spp	4	15.39
Alternaria spp	3	11.54
Total	26	100

Growth rate and colony characteristics of fungal isolates associated with spoilage of tomato on PDA culture media

All the isolated five fungal pathogens were cultured in potato dextrose agar (PDA) media and its growth rate and colony characteristics were observed and recorded (Table 4). *Fusarium* and *Pythium* had rapid growth rate compared to *Colletotrichum* and *Rhizoctona* that were moderate. Their colony also varied among the isolates ranging from silky, fluffy and cottony appearance (Table 4).

Table 4: Growth rate and colony characteristics of fungal isolates associated with spoilage of tomato on PDA culture media

Fungi	Growth rate	Colony characteristics
Fusarium spp	Rapid	Silky or cottony colonies with whitish color
Pythium spp	Rapid	Cottony to fluffy colonies usually white or grey
Colletotricum spp	Moderate rapid	Silky or cottony colonies with dare to brown
Rhizoctonia spp	Moderate rapid	Cottony and web take colonies tan to brown color
Alternaria spp	Moderate	Fluffy or cottony, usually whitish to grey color

Tomato (*S. lycopersicum*) is a highly perishable and economically vital crop in the agricultural and food industry. However, their post-harvest spoilage due to fungal infection poses a substantial challenge, resulting in economic losses and reduced food availability.

Our research focuses on the isolation and identification of fungi responsible for post-harvest spoilage of tomatoes. And different fungal isolates were isolated and identified from other tomato varieties. *Fusarium, Pythium, Colletotrichum Alternaria,* and *Rhizoctonia* spp, were found to be associated with the postharvest spoilage of tomato fruits in the study area. This is similar to the findings of (Yusuf *et al.,* 2020), where fungal isolates were isolated from spoiled tomato fruits. The aforementioned fungal pathogens were also distributed across the varieties of tomatoes sampled from the Wudil vegetable market. Furthermore, Akintobi *et al.,* (2011), reported a similar fungal distribution among different fruits and found responsible for postharvest spoilage. The importance of this study is highlighted by the economic significance of tomatoes in global agricultural markets and the critical need for improved post-harvest management practices to reduce losses (FAO, 2021). Understanding the specific fungal culprits behind tomato spoilage is essential for targeted interventions that enhance both the economic and food safety aspects of tomato production.

CONCLUSION AND RECOMMENDATIONS

This research also observed the growth rate and colony characteristics of the isolated fungal pathogens, which is a typical replica of how the pathogens grow in their natural host. Understanding this would contribute to the broader knowledge in the fields of plant pathology and postharvest spoilage. By identifying the fungal species associated with tomato spoilage, and understanding its growth rate pattern we aim to offer insights for reducing spoilage, improving food safety, and ensuring the availability of high-quality tomatoes in the market (Yusuf *et al.,* 2020). This could be achieved by careful handling and transportation of tomatoes by the growers and marketers.

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Phenotypic Evaluation of Latin American Cassava Genotypes for Genetic Variability into Nigerian Breeding Populations

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Abstract
Cassava improvement is crucial to satisfy the world's demand amidst different challenges like climate change, increasing population growth and hunger. A major challenge to breeding for improvement and productivity of cassava in Nigeria is that the genetic base has narrowed down and further improvement in the crop becomes unlikely. To combat this challenge, the Root, Tubers and Banana (RTB) cassava project in collaboration with the National Root Crops Research Institute (NRCRI), Umudike is continuously striving to increase yield, enhance root quality and resistance to biotic and abiotic stresses of cassava through introducing Latin American (LA) lines into Nigeria breeding programme. The LA germplasm comprises; superior genotypes with cassava mosaic disease (CMD) resistance and high root quality. Our study aimed to evaluate 200 genotypes of LA origin introduced to NRCRI. The genotypes were established in a clonal evaluation trial using an augmented experimental design assessed based on vigour, CMD severity, dry matter content (DMC), fresh root yield and dry root yield. The analysis of variance showed the presence of considerable amount of variability ($P < 0.01$, $P < 0.05$) among the genotypes for all the traits. High genotypic and phenotypic coefficient of variation were found in all the traits, indicating that, direct selection could be effective for yield improvement. High heritability estimates with high genetic advance were recorded for cassava green mite (CGM), vigour and DMC, suggesting that phenotypic selection for the traits would be effective.
Keywords: cassava improvement, Latin American cassava germplasm, genetic variability, genotypic and phenotypic coefficient of variation

INTRODUCTION

Cassava is crucial for the food security of millions of people in sub-Saharan Africa (Mbanjo *et al*., 2021). The crop has great potential to contribute to African development, it has moved from a subsistence crop to a full commercial crop for its income-generating capacity. Although cassava has great potential as a cash crop, limited breeding work has been conducted to understand the genetic architecture of the crop. The narrow genetic base of the crop and limited efforts have not resulted much in genetic improvement. Only local types or a few high-yielding varieties are being cultivated, in the last decade the adoption of a variety TMEB419 has shown a significant impact on productivity enhancement. However, the sustainability of single-variety cultivation is always questionable. Henceforth, varietal development programme should always be taken in a continuous mode by utilizing primitive and newly evolved genotypes altogether concerning the present need. Genetic variation available in the germplasm collection of a species is the basic requirement for a crop improvement programme. The first step in any breeding programme must be a quantitative assessment of the available variability concerning the important yield contributing characters. Such information can be gathered by comparing a large number of genotypes. Phenotypic diversity is a basic criterion for crop improvement, through natural selection or by directed plant breeding approaches (Bairwa et al., 2015). Recombinants between diverse lines generally display greater chances of getting transgressive segregants than those between closely related parents. Genetic variability studies help to identify promising genotypes and key component traits for designing or developing high-yielding genotypes for commercial cultivation. The present study was conducted to generate basic information on the nature and magnitude of genetic variability for important agro-morphological traits in cassava. Hence, the germplasm was collected germplasm from a Latin American Cassava programme and maintained at NRCRI, Umudike.

MATERIALS AND METHODS

The present study was conducted at the National Root Crops Research Institute, Umudike, Abia State, Nigeria. The experimental material for the present investigation consisted of 200 clones derived from the LA cassava gene pool and three checks (IITA-TMS-IBA98O581, IITA-TMS-IBA30572, TMEB419). These checks are famously high-yielding improved varieties. The experiment was laid in an augmented block design (ABD) with 20 blocks, each block consisted of 10 test entries and two checks in replicated mode. All recommended packages of practices were followed, each entry was planted in a single row of 10 plants spaced 1m apart, plant to plant distance was maintained at 0.8m for each entry. Data on cassava mosaic disease (CMD), cassava green mite (CGM), vigour (vig), fresh root yield (FRY) and dry matter content (DMC) were collected from the inner eight plants to avoid border effects (Table 1). Cassava green mite was evaluated at the peak of the dry season (January) at six months after planting (MAP) while cassava mosaic disease (CMD) was assessed at 3, 6 and 9 MAP, visual rating of the symptom severity on the scale from I = no symptoms to 5 = extremely severe. Vigour was scored at 6 and 6 MAP at the visual rating of the vigour; 3 = poor vigour, 5 = moderate and 7= very vigorous Harvesting was done at 12 MAP and data were collected on yield (FYLD was estimated according to (Kamau *et al*., 2011) ((fresh storage root weight per plot/ no harvested) *10000)/1000. and DMC. DMC is Determined by the specific gravity method (Kawano, 1980) (measured in %) = (158.2* (weight in air/ (weight in the air – weight in water))-142).

Genetic variability analysis, broad sense heritability and analysis of variance (ANOVA) were computed using the R package 'augmentedRCBD' (Aravind *et al*., 2023).

RESULTS AND DISCUSSION

The assessment of observation recorded for these important agro-morphological traits signified the presence of an ample amount of variability within the population studied as per the ANOVA (Table 1) and variability parameters estimated (Table 2). FYLD (GCV = 47.29) followed by DMC (GCV = 41.2), vigour (GCV = 41.18), CGM (GCV = 38.40) and CMD (GCV = 34.54) showed high values of genetic coefficient of variation (GCV) suggesting that these traits have a high amount of genetic variability. Similar results were also reported by Ewa *et. al*., (2017) for DMC and Mulualem *et. al*., (2013) for high GCV for fresh root weight in ccassava. The differences in phenotypic coefficient of variation (PCV) and GCV were less for the traits viz., DMC and CGM suggesting that phenotypic variation is a good indicator of genetic variation; hence, genetic improvement through phenotypic selection for these traits would be quite effective. An insight into the magnitude of variability present in the crop species is of utmost importance as it provides the basis for the selection response. In crop improvement, only the genetic components are transmitted to the next generation. Heritability indicates the effectiveness with which the selection of genotypes could be based on the phenotypic performance. This could be achieved through the estimates of heritability and genetic advance under selection. The heritability (broad sense) estimates were high for the traits viz., CGM (73.09%), vigour (71.60%) and DMC (95.18%). Moderate values were estimated for CMD (35.62%) and FYLD (33.60%). Contrary to the present findings Ezenwaka *et al*., (2018, 2020) reported low heritability for CGM. This might be due to a narrow variation in the parents used in the crossing programme. Similar results were also reported by Akinwale *et. al*., (2010) for moderate heritability for FYLD and CMD in cassava. Traits showing high heritability values were relatively less influenced by the environment and can be easily fixed in the population as they are governed by additive genes. Traits having high heritability values coupled with high GCV should be chosen for effective criteria for selection programmes viz., CGM, vigour and DMC. In the present study, high heritability estimates coupled with high genetic advance mean (GAM) were recorded for CGM (H^2b = 73.09, GAM = 67.22), vigour (H^2b = 71.60, GAM = 71.89) and DMC (H^2b = 95.18, GAM = 93.88) indicating that direct selection for this character would be fruitful (Akinwale et al., 2010). CMD and FYLD recorded moderate heritability coupled with high genetic advance; this can be attributed to non-additive gene action. Traits with moderate to high broad sense heritability coupled with high genetic advance can be improved upon through direct selection using phenotypic information.

CONCLUSION AND RECOMMENDATIONS

The overall results on variability parameters revealed that the traits contributed substantially to high genetic variability in ccassava. Selection practised for these characters would lead to an improvement in the desirable direction. In recombination breeding, genotypes diverse concerning important yield contributing traits are likely to play an important role as potential parents to produce a high level of variability important for varietal development in ccassava.

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Table 1: Mean squares of the traits evaluated

Source	Df	Mean.Sq				
		CGM	CMD	VIG	DMC	FYLD
Treatment (ignoring Blocks)	200	1.13**	0.42ns	5.5**	120.48**	64.56ns
Treatment: Check	2	0.26ns	5.26**	4.93ns	26.22*	15.02ns
Treatment: Test vs. Check	1	5.39**	6.95**	14.31**	306.19**	1012.03**
Treatment: Test	197	1.12**	0.34ns	5.46**	120.5**	60.26ns
Block (eliminating Treatments)	8	0.68ns	0.53ns	3.6ns	164.29**	198.1**
Residuals	16	0.3	0.22	1.55	5.8	40.01

** Highly Significant at 0.01% level, * Significant at 0.05% level, ns not significant, CGM = cassava green mite, CMD = cassava mosaic disease, VIG = vigour, DMC = dry matter content, FYLD = fresh root yield

Table 2: Genetic variability estimates of the traits evaluated

Trait	Mean	Min	Max	PV	GV	GCV	PCV	H^2b	GA	GAM
CGM	1.35	1.03	3.5	1.12	0.82	38.4	44.91	73.09	1.59	67.72
CMD	1.22	1	3	0.34	0.12	34.54	57.88	35.62	0.43	42.53
VIG	5.64	3	7	5.46	3.91	41.18	48.67	71.6	3.45	71.89
DMC	26.99	18.52	41.2	120.5	114.6	46.65	47.81	95.18	21.5	93.88
FYLD	9.52	5.8	27.5	60.26	20.25	47.29	81.58	33.6	5.38	56.55

PV = Phenotypic variation, GV = Genotypic variation, GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient variation, H^2b = broad sense heritability, GA = genetic advance, GAM = GA as %age of Mean

Determinants of Credit Accessibility amongst Subsistence Yam Farmers in Ikwuano Local Government Area of Abia State, Nigeria

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Abstract

The research work examined the determinant of credit accessibility amongst subsistence yam farmers in Ikwuano Local Government Area of Abia State. A multistage random sampling procedure was utilized to select 120 yam farmers for the study. Primary data were generated through a structured questionnaire and interview schedule, and analyzed with descriptive and inferential statistics such as frequency, mean, percentage and logit multiple regressions. Results revealed that the majority of the yam farmers in the area are male, literate, and married, with a mean age of 45 years, a mean household size of 7 persons and a mean farming experience of 15 years. Eight variables namely sex, age, household size, farm size, net farm income, interest rate, collateral and guarantor were significantly related to the credit accessibility of yam farmers. Farm size, net farm income, collateral and guarantor were positively significant to the credit accessibility of yam farmers, sex, age, household size and interest rate were negatively significant to the credit accessibility of yam farmers in the area. The study therefore recommended that major trust in policy formulation for credit access for yam farmers in this area should focus on reduction in interest rate and collateral charged, which will help to increase access to credit.

Keywords: Credit accessibility, Subsistence, Yam farmers, Abia State

INTRODUCTION

Yams are members of the family Dioscoreaceae and genus Dioscorea. Yam is one of the most significant food crops grown in Nigeria. Nigeria accounts for over 71% of global yam production, making it the world's top producer (FAO, 2021). The importance of yams as a food crop in Nigerian cuisine cannot be overstated. Access to agricultural credit is one of the elements of yam production, and it is crucial to examine these factors critically (Okafor, 2022). Farmers' limited access to credit is one of the causes contributing to the sector's declining productivity. Because farmers with limited capital typically employ fewer inputs in their production operations, access to funding has a major impact on yam productivity. Obtaining and applying finance for agricultural purposes increases production, which enhances a nation's food security. Growing economic activity is leading to a rise in the demand for credits. This explains why farm credit has emerged as a key component in scenarios predicting increases in agricultural production and the growth of rural economies, the majority of which are centred around agriculture (Nwaru, 2020). Like in most other countries, credit is a crucial component of many agriculture enterprises in Nigeria. One of the biggest challenges farmers face when attempting to improve their living conditions is the lack of financial facilities. Agbor

(2004) states that the limited availability of credit services has weakened rural income-generating activities due to a lack of capital for investments and a barrier to farmers implementing better farming techniques. Most of Nigeria's agricultural production, especially in Ikwuano local government area, is controlled by smallholder farmers. A significant ($p < 0.05\%$) number of farmers operate within limitations imposed by their available resources, which often hinders their ability to adopt the most highly recommended agricultural technologies (Ifenkwe, 2021). Due to this, these smallholders cannot produce as much food as possible for household needs and generate income. This study is necessary because there seems to be a knowledge gap in the field of this subject matter related to the study area. The production of farm products is negatively affected by the difficulty of obtaining credit, even though credit is essential to farmers. Most farmers lack knowledge that they have the option of loaning money, thus they cannot secure one. For this reason, it is essential to assess the subsistence yam producers' loan accessibility. Generally, this study examined credit accessibility among subsistence yam farmers in the Ikwuano local government area of Abia State. Specifically, it examined the socio-economic characteristics of the subsistence yam farmers and analyzed the determinants of credit accessibility among yam farmers in the study area.

METHODOLOGY

The study was conducted in Ikwuano Local Government Area of Abia State, Nigeria. Ikwuano Local Government Area is one of the seventeen (17) local governments in Abia State. It is located within the southeastern zone of Nigeria. It is bounded north by Umuahia North and Bende, west by Umuahia South and Isiala-Ngwa North, in the east by Ini, and the south by Obot-Akara. It lies between latitudes 5^0 24'N and $5^0$30'N and longitudes 7^0 32'E and 7^0 37'E. The population of Ikwuano is about 175,078 (Ikwuano Local Council, 2019). It has a land area of 281 km^2. The region experiences an average rainfall of 2351 mm, with an average temperature of 28˚C and an average humidity level of 62%. It has two distinct seasons: rainy and dry. Agriculture is the major occupation in this region is the cultivation of arable crops including yam, cassava, cocoyam, maize and vegetables (NAERLS, 2020). A multiple random sampling technique was employed to select the respondents for the study. The first stage was the random selection of three (3) banks out of the ten (10) banks in the local government area as provided by CBN in Umuahia. The second stage was the random selection of 40 yam farmer-beneficiaries from the list provided by each bank i.e., Access Bank, Microfinance Bank and Union Bank in the Ikwuano local government area. This gave a sample size of 120 yam farmer-beneficiaries. Data were obtained with a structured interview schedule and analyzed using descriptive and inferential statistics such as frequency, mean, percentage and logit multiple regressions.

The Logistics regression model was specified as:

$$LnY = In\ (Pi/1\text{-}Pi) = B0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + \ldots\ B_{10}X_{10}$$

Where,

Y = binary variable defined as 1 if the farmer has access to credit and 0 if not.

Pi = Probability of access to credit

B_o = Constant

$B_1 – B_{10}$ = Logistic regression coefficients

$X_1 – X_{10}$ = Explanatory variables explained below

X_1 = Sex (dummy: male = 1, female = 0)

X_2 =Age of the farmer (years)
X_3 =Educational status (years)
X_4 = Household size (number)
X_5 = Farming experience (years)
X_6 = Farm size (ha)
X_7 = Interest rate (%)
X_8 = Net farm income (naira)
X_9 = Guarantor (dummy: yes =1, no = 0)
X_{10} = Collateral (naira)

RESULTS AND DISCUSSION

Results in Table 1 showed that a higher percentage (57.5%) of the respondents were males while 42.5% were females. This makes sense given that yam farming is an energy-intensive endeavour and that yams have a unique cultural meaning for men. The mean age of the farmers was 45 years. This indicates that the majority of the farmers in the study area were middle-aged. This suggests that the farmers are productive and engaged members of the workforce who can access more loans. A higher percentage (88.3%) of the farmers were married, with a mean household size of 7 persons. This suggests that the farmers have large family sizes, which is anticipated to have a good contribution to yam production. The size of the home indicates the availability of family labour. Njoku *et al* (2020) stated that large household sizes in farming communities provide free family labour on the farm. The findings revealed that the Majority (98.4%) of the yam farmers were literate. It is anticipated that education will positively impact the utilization of new technology.

Table 1: Socio-Economic Characteristics of Yam Farmers in Ikwuano Local Government Area, Abia State

Variables	Frequency	Percentage (%)	Mean
Sex			
Male	69	57.5	
Female	51	42.5	
Age			
21 – 30	12	10.0	
31 – 40	60	50.0	45
41 – 50	40	33.3	
Above 50	8	6.7	
Marital status			
Single	7	5.83	
Married	106	88.3	
Widowed	5	4.2	
Divorced	2	1.7	
Household size			
1 – 5	19	15.8	
6 – 10	91	75.8	7
Above 10	10	8.3	
Educational status			
No formal	2	1.7	
Primary	26	21.7	12 years
Secondary	63	52.5	
Tertiary	29	24.2	
Farming experience			
1 – 10	20	16.7	
11 – 20	71	59.2	15
21 – 30	15	12.5	
Above 30	14	11.7	

Source: Field survey, 2023

Table 2 shows that the binary logistics model predicted 72.52% of the sample. The likelihood ratio test showed a significant value of -53.21 and a chi-square value of 57.22, implying that the estimated model is statistically significant. Hence, the model is considered a good fit and equally consistent with the theory. Four variables farm size, net farm income, guarantor and collateral were positively significant to credit accessibility of yam farmers at 10%, 5%, 5% and 1% levels respectively. Furthermore, four variables sex, age, interest rate and household size were negatively significant to credit accessibility of the farmers at 5%, 5%, 1% and 10% levels respectively. The logit coefficients of farm size, net farm income, guarantor and collateral are 0.23, 0.37, 0.51 and 0.12 respectively which indicates that controlling the effect of other independent variables, the log odds of accessing credit by yam farmers in the study area increases by 0.23, 0.37, 0.51 and 0.12 for each unit increase in farm size, net farm income, guarantor and collateral value respectively. Nonetheless, the outcome showed that the likelihood of not being able to obtain credit increases with each unit increase in interest rates. This is consistent with the assumption that farmers are less likely to procure credit based on higher interest rates paid. Results also revealed that being a female reduces the probability of having access to credit by 71.4%. An increase in age reduces the chance of credit access. This is consistent with the Okafor (2022) report, which found that younger people have a high propensity to take on hazardous endeavours. Younger people are more adaptable to changes, innovations, and credit terms than older people, who tend to be more rigid in their ways. The size of a farmer's household has an adverse effect since larger households are more likely to utilize credit for family expenses to support a larger family, which lowers the likelihood of getting credit. The availability of collateral and guarantors has a good impact on farmers' access to credit. This validates a previous theory that the possibility of obtaining credit increases when these elements are available.

Table 2: Logistic Estimate of Factors Affecting Yam Farmers' Access to Credit in Ikwuano Local Government Area of Abia State

Variables	Coefficient	Standard error	Z-statistics	P-value
Constant	0.5014*	0.97929	0.51200	0.56212
Sex	-0.71409**	0.33693	-2.11940	0.03626
Age	-0.29543**	0.12206	-2.42036	0.01135
Education	-0.037824	0.04365	-0.86652	0.33153
Household size	-0.21124**	0.08859	-2.38446	0.02164
Farming experience	-0.00521	0.00181	-2.87845	0.74297
Farm size	0.22614*	0.32254	-0.70112	0.05321
Interest rate	-1.94228***	0.28717	6.76351	0.00079
Net farm income	0.37189**	0.37862	0.98222	0.03421
Guarantor	0.512381**	0.24855	2.06148	0.03251
Collateral	0.120115***	0.33499	-0.35856	0.00874
Log-likelihood: -53.21				
McFadden R^2: 0.756				
Chi^2: 57.22				
Sample predicted correctly: 72. 52%				

Source: Field Survey, 2023. Note: *** = value significance at 1%, ** = value significance at 5%, * = value significance at 10%.

CONCLUSION AND RECOMMENDATIONS

Men predominate yam farming in the study area due to high energy requirements. The farmers were middle-aged, energetic, and literate, all of which were favourable traits for accessing loans. The accessibility of credit for yam farmers in the area was found to be favourably correlated with farm size, net farm income, collateral, and guarantor, which was adversely linked with sex, age, family size, and interest rate. It is therefore recommended that measures be taken to ensure farmers have better access to credit, including laws ensuring loan availability and accessibility. Among these include cumbersome loan processing procedures and exorbitant interest rates. The regulatory lending institutions should inform farmers about the opportunities to obtain loans.

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Microbial Load Evaluation of Chickens Fed Dietary Supplement of Ginger (*Zingibe officinale*) Meal and Synthetic Premix

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Abstract
This study was conducted to evaluate the effect of dietary inclusion of ginger meal (Zingiber officinale) on the microbial load of broiler compared with the synthetic premix. One hundred and twenty arbor acre day old broiler chicks were used. They were divided randomly into 5 treatment groups designated as T_1, T_2, T_3, T_4 and T_5 comprising twenty-four birds each in three replication. Each group was fed one of 5 formulated diets containing ginger meal at levels of 0.0, 0.05, 0.10, 0.15 and 0.2g/100kg, for eight weeks in a completely randomized design. At the termination of the experiment, three birds per treatment were used for the evaluation of microbial load. Results showed significant ($P < 0.05$) effects of dietary ginger meal inclusion on microbial load in favour of T_3 than in T_2, T_4 and T_5, whereas higher inclusion (T_5) was deleterious to all the evaluated indices. The result of this study showed that the total coliform count (TCC) and the total viable count (TVC) were significantly ($p<0.05$) higher in T_1 than in T_2, T_3, T_4, and T_5. This suggest that ginger at increasing inclusion level behaved as probiotics by reducing the total coliform count in the caecum, while no significant ($p>0.05$) difference occurred in the TVC across the ginger groups (T_2 and T_3) compared with the non-ginger group (T_1) in the gizzard. There was reduction in the TCC and TVC of the microbial load in the duodenum across the treatment group, although not significant compared with the control which showed an increase in the TCC and TVC although not significantly ($p>0.05$) different from the ginger group. It can be concluded that ginger could be an alternative growth promoter for antibiotics, and can also be used to improve feed utilization when included at moderate dose of 0.1g/100kg. It is therefore recommended for use in formulating poultry diet for optimal production benefit.

Key words: Ginger, Vitamin/Mineral Premix, Microbial load and broiler chicken

INTRODUCTION

The major importance of poultry production is for the production of egg, meat etc. and for the provision of protein to the human. Feeding constitutes up to 75%-80% of the total cost in monogastric production and is a major factor limiting production of livestock. Minerals and vitamins supplements may contribute up to 2-3% of total cost of feed. The essence of animal protein will be compromised if livestock production is limited to synthetic mineral/vitamin which is basically for vitality, acid-base balance, proper metabolism, and muscle contraction and relaxation etc. Synthetic vitamin and mineral supplements in the diet contains synthetic antibiotic which possess negative effect on the farm animal and beneficial microorganism, and its residues in the carcass of animal could be detrimental to the human system, as well as contributes to cost of production in animal husbandry. (Bamidele and Adejumo, 2012; Attia *et al*., 2014; Sa'aci *et al*., 2018). Therefore, on this note, the interest of nutritionist, Veterinarian, farmers, and other key players in recent years are directed towards the search for cheaper, locally and organic mineral/vitamins additive that will be nutritionally viable, non-toxic to beneficial microbes as well contribute to health benefits to the animal for optimum production. (Al-Kassie and Witwit, 2010). Ginger (*Zingiber officinale*) is an important spice. It is a monocotyledonous herbaceous perennial plant that lives longer than two years, belonging to the family of *Zingiberaceae*, its flavouring type is classified as *Zingiber officinale* which is the most popular hot spice in the world (Dhingra and Kumar, 2005). The main important compounds of ginger (*Zingiber officinale*) are Gingerol, gingerdiol, borneol, conphel, citfral, penllandiene and resin. These compounds have the ability to stimulate digestive enzymes, affect the microbial activity (Dieumou *et al*., 2009). Also it acts as an antioxidant, antimicrobial and has various pharmacological effects (Ali *et al.,* 2008). It enhances animal nutrient digestion and absorption because of the positive effects on the gastric secretion of enterokinesia, and digestive enzyme activities (Platel *et al*., 2000). Furthermore, ginger compound have shown various pharmacological effects including Immuno-modulatory, Anti-lipidemic, Anti-inflammatory, Anti-hyperglycemic and antiemetic effects (Ali *et al*., 2008). However information is lacking on effect of ginger in comparison to synthetic vitamin/minerals premix on the microbial load. This study is designed to investigate the response of broiler fed dietary supplement of ginger in comparison to synthetic vitamin/mineral premix, and its assessment in terms of microbial load count and the growth performance.

MATERIALS AND METHODS

Location of the study

This study was done at the Poultry section of the Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike, which is located at Latitude 5^0 28' N and Longitude 7^0 32' E lines at an altitude of 122 meters above sea level. The environment of study is situated within the rainforest zone of Nigeria and is characterized by annual rainfall of about 2167. 8mm in 148 to 155 days, average relative humidity during the rainy season is over 72%. It's has environmental temperature average 22^0C to 30^0C (National Root Crops Research Institute-NRCRI, 2004).

Experimental birds, design and management

A total of 120 day-old broiler chicks were purchased locally within Nigeria for this experiment. Prior to the arrival, the experimental pens and equipment were washed and disinfected. On arrival, the broiler chicks were vaccinated then allocated to experimental pens for brooding for 4 weeks, then, they were allocated to five (5) dietary treatment T_1, T_2 T_3, $T_4$and $T_{5.}$ The birds were fed diets with ginger meal at 0.00, 0.05, 0.10, 0.15 and 0.20 g/100kg which was supplemented with the synthetic vitamin-mineral premix at 0.25, 0.20, 0.15, 0.10 and 0.05 kg/100 kg, respectively.

During the brooding stage, heat was supplied with the use of brooding devices such as kerosene stove and lanterns. The temperature was regulated by the rule- of- the- thumb (watching the broilers behavior whether to increase or decrease the heat source), routine vaccinations and medications were given across the groups. The experimental design was a completely randomized design. During the brooding stage, the broiler chicks were fed *ad-libitum* with the formulated mash in rubber feeding stray for 4 weeks to enable the chicks have access on the feed. After brooding the feeders were changed to metallic container and raised using ropes to a certain height such that they do not have the chance to spill the feed on the litter. Water was given *ad-libitum* throughout the period of brooding in plastic drinkers. The broiler birds were randomly distributed to five (5) treatments. Each treatment diets was replicated 3 times.

Processing of ginger meal

The ginger was purchased fresh from National Root Crops Research Institution, (NRCRI) Umudike, their rings and husks was peeled off using knife. The peeled ginger was washed and dried (air and sun dried). The essence of air drying was basically to preserve the aromatic compounds, vitamin/mineral nutrients and later ground and sieved the meal that was incorporated into the diets.

Microbial load determination

The method of serial dilution as described by Aneja, (2005) and modified by Booth, (2006) was used for microbial load determination. On day 42, three chickens were randomly selected from each treatment, stunned and slaughtered. The effluence from the gizzard, duodenum, and caecum were gently stripped into sterile sample tubes and immediately transferred on ice to the laboratory for microbial load and culture study. Procedure: 2.5g each of the gizzard, duodenum and caecum samples from each chicken were collected immediately after slaughter, cut into small sizes with a flame sterilized knife under aseptic conditions and transferred into sterile screw-capped bottles and appropriately labeled. 22.5ml of sterile physiological saline solution was added to each sample bottle. The bottles were shaken vigorously to homogenize its contents before being diluted in the serial dilution technique. Test tubes of 9ml sterile physiological saline were set up and labeled from10^{-1} to$10^{-4.}$ Ten-fold serial dilutions were performed by pipetting 1ml from the original bottle containing the respective samples into the tube labeled 10^{-1}. From this tube, 1ml was transferred to the next tube labeled 10^{-2} and mixed properly. This was repeated until the 4th tube for all the samples. After the dilutions, standard microbiological technique was used to spread the inoculums from each sample into freshly prepared nutrient agar plates. A sterile bent glass rod was used to spread out each inoculum. The plates were labeled accordingly and incubated at 37^0c for 72 hours. The colony count was performed after 48 hours of incubation. The total aerobic count was expressed as Colony Forming Unit per gram (CFU/g).

RESULTS AND DISCUSSION

Table 1: Microbial load count of broiler chickens fed diets replacement with ginger

Caecum Colony Count	T1	T_2	T_3	T_4	T_5
TCC (cfu/mL $\times10^6$)	6.37 ± 4.19^a	2.83 ± 0.48^b	0.00 ± 0.00^c	0.00 ± 0.00^c	0.00 ± 0.00^c
TVC (cfu/mL $\times$ 10^6)	8.37 ± 0.69^a	2.43 ± 0.81^b	0.00 ± 0.00^c	0.00 ± 0.00^c	0.00 ± 0.00^c
Sig. df	0.035			0.339	

Note: Values are presented as Mean ± SEM. Means with different superscripts across rows are significantly different at p<0.05.TCC: Total Coliform Count; TVC: Total Viable Count.

The result of the microbial load of the cecum harvested from the experimental birds fed with the treated diet is presented in Table 1. There were significant ($p< 0.05$) differences in the total coliform count (TCC) and total viable count (TVC) across the ginger groups compared with the non-ginger group (T_1). The TCC and TVC were significantly ($p<0.05$) higher in T_1 than in T_2, $T_{3,}$ T_4, and T_5. This suggest that ginger at increasing inclusion behave as probiotics, reduced the total coliform count in the caecum significantly from 6.37 ± 4.19 cfu/mls in T_1 to 2.83 ± 0.48cfu/mls (55.57% reduction in bacterial load) in T_2, and 0.00 ± 0.00cfu/mls (100% elimination) in T_3, T_4 and T_5, which means complete destruction of the coliform bacteria in the ginger group (as the inclusion level was increased). Similarly, the viable bacteria count was significantly ($p<0.05$) reduced by 70.97% in T_2 and 100% in T_3, T_4, and T_5. This effect could be attributed to the fact that the susceptibility of coliform bacteria to the antibacterial components of ginger are higher than that of the physiological desirable intestinal bacteria. This bactericidal effect at increased inclusions, strongly agreed with Reeds *et al.,* (1993); Amanduruonye *et al.* (2018), who reported simultaneous decrease in *Escherichia coli* populations, and Faghani *et al.,* (2014) who reported significant decrease in *Lactobacillus* spp. counts. Also, the inclusion of ginger in diet produced a remarkable inhibition of duodenal coliform bacteria, yeast and mold in the caecum and all viable microbes in the ileum (Sama-rasinghe *et al.,* 2003), and this in agreement with our finding. Windisch *et al.* (2007) reported a significant decrease in caeca microbial loads for birds fed 1.5% and 3.0% ginger supplemented diets compared to the control. This strongly confirms the antimicrobial property of ginger. These antimicrobial property of ginger might be attributed to the presence of Alkaloids, Camphene, Glycosides, Saponins, Terpenoids, Methoxymethyl, Propionate, Phenllandrene, gingerol, borneol, gingerdiol and many more compounds found in ginger-- phenolic compounds that have antiseptic, bactericidal and disinfectant properties as reported by Gong *et al.*(2004); Zhan *et al*. (2008). The antimicrobial mode of action is considered to arise mainly from the potential of the hydrophobic essential oils in these plants to intrude into the bacterial cell membrane, disintegrate membrane structures and cause ion leakage (Lee *et al.,* 2004; Windisch *et al.,* 2007) thus suggesting that ginger can effectively be used in animal production to reduce the population of pathogenic micro-organisms thereby reducing the prevalence of disease occurrence. Auta *et al.* (2011) and Ibrahim *et al*. (2011) also reaffirmed the efficacy of ginger as an effective antimicrobial agent against the growth of both gram-positive and gram- negative bacteria, such as *Salmonella, E. coli, Salmonella typhinurium, Shigella spp, Proteus vulgaris, Haemophilus influenzae, Pseudomonas aeruginosa and Streptococcus* species. In contrast, Amaduruonye *et al.* (2018) reported that ginger did not have any detrimental effect on the intestinal micro flora resident at the caecum, but supported the activities of the micro-organisms that aid digestion in the gastro-intestinal tract, hence, not in line with our findings.

Table 2: Microbial load count of broiler chickens fed diets replacement with ginger

Gizzard Colony count	T_1	T_2	T_3	T_4	T_5
TCC (cfu/mL X 10^6)	3.20 ± 0.60^a	3.53 ± 0.29^a	3.23 ± 0.29^a	2.57 ± 0.74^a	5.17 ± 1.79^a
TVC (cfu/mL X 10^6)	6.93 ± 0.38^b	4.57 ± 0.81^b	3.63 ± 0.58^b	1.07 ± 0.61^b	3.53 ± 0.60^b
Sig. df	0.293	0.129	0.388	0.527	0.276

Note: Values are presented as Mean ± SEM. Means with the same superscripts across rows are not significantly ($p>0.05$) different. TCC: Total Coliform Count; TVC: Total Viable Count

There was no significant ($p>0.05$) difference in the total viable count (TVC) across the ginger groups (T_2 and T_3) compared with the non-ginger group (T_1). The result of the colony count in the gizzard harvested from the experimental birds showed that although there were reduction in the TCC and TVC across the treatment groups compared with the control, the reduction observed were not significant ($p>0.05$) compared with the control. This suggest that coliform resident at the gizzard did not respond (bacteria resistance) to the ginger included diet significantly. This is in agreement with Yarru *et al.* (2009); Ahmadi (2010); Zhang *et al.* (2009) and Amaduruonye *et al.* (2018) who in different study locations reported that ginger at 5, 10, 15 and 20% had no detrimental effect on the coliform bacteria resident on the gizzard and duodenum, but supported the activities of the micro-organisms that aid digestion in the gastro-intestinal tract. This observations supported our findings.

Table 3: Microbial load count of broiler chickens fed diets supplemented with ginger

Duodenum Colony count	T_1	T_2	T_3	T_4	T_5
TCC (cfu/mL X 10^6)	7.70 ± 0.38^a	4.97±1.27^a	3.13±0.42^a	3.93±1.49^a	3.53±1.10^a
TVC (cfu/mL X 10^6)	7.17±1.24^b	2.53±0.73^b	1.63±0.17^b	2.70±1.15^b	1.47±0.09^b
Sig. df	0.221	0.295	0.094	0.721	0.033

Note: Values are presented as Mean ± SEM. Means with the same superscripts across rows are not significantly (p>0.05) different. TCC: Total Coliform Count; TVC: Total Viable Count

The result presented in Table 3 showed that there was reduction in the TCC and TVC of the duodenum across the treatment group, although not significant compared with the control. In the control group, the microbial load in the duodenum showed an increase in the TCC and TCV although not significantly (p>0.05) different from the ginger group. This implies that there is no observable antimicrobial activity of the included treatment in the duodenum. This bacterial resistance effect could be also attributed to the fact that the susceptibility of coliform bacteria to the antibacterial components of ginger were lower than that of the physiological desirable duodenal bacteria, hence supported by Cullen *et al.,* (2005) and Chen *et al.* (2010).

CONCLUSION AND RECOMMENDATIONS

The result of this study revealed that replacing some vitamins with ginger at moderate (T_3: 0.1g/100kg) inclusion significantly improved the growth parameters and carcass characteristics evaluated in this study better than the low (T_2) and higher (T_4, T_5) inclusions, which also generated higher revenue and gross margin profit as a result of the significantly higher weight gain per kilogram. This could be attributed to increased feed efficiency and utilization in T_3due to increased activity of digestive enzymes such as trypsin, chymotrypsin, and amylase which increased the digestibility of the nutrients contained in the formulated feed. The implication is that considering the very high demand for better carcass quality of broiler chicken, formulating poultry diet with ginger at 0.10/100kg could reduce the cost of production and enhance the growth performance as little quantity of the diet consumed will improve the carcass quality (more meat) of the broiler chicken. It can be concluded that ginger could be an alternative growth promoter for antibiotics, and can be used to increase growth, survival rate, improve feed utilization, with better meat quality and higher income generation at low production cost, hence, highly recommended for use in broiler production.

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Effect of Cooperative Society on the Farm Output of Farmers in Southeast Nigeria

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Abstract
The effect of agricultural cooperatives on the farm output of farmers in the Southeast of Nigeria is being examined in this study. Specifically, it estimated the farm produce and farmers' income before and after joining the Cooperative Society compared to the farm output of farmers before and after joining the Cooperative Society. Data for the study were collected through a structured questionnaire and results were analyzed using both descriptive (such as frequency counts, percentages and mean scores) and Z-test analysis. The result showed that Cooperative farmers obtained pooled mean farm produce of 15,969.67Kg (before) and 16,735.99Kg (after) in the three States. Z-test analysis results found that the mean output of the farmers before and after joining the Cooperative Society with a Z-test value of 2.0782> 0.05. The result concluded that the farm outputs of farmers differed significantly in the study areas. It is, therefore, recommended that farmers should be encouraged to participate in cooperative activities to enhance their farm output.

***Keywords: Effect, cooperative society, far*m output, farmers**

INTRODUCTION

Over the years, agricultural cooperatives have been instrumental in bringing about a radical structural shift in agriculture that will ensure food security and improve the socioeconomic standing of farmers (Mbagwu, 2018). In Nigeria, the country's population is growing faster than its food output. This has resulted in a significant gap between the supply and demand of food, which brought about a higher price of food commodities. Over the years, Nigeria has struggled to feed its expanding population despite the various policies and programs established by succeeding administrations. Nwaobiala *et al*., (2019) asserted that the majority of Nigeria's agricultural output is dependent on low-productivity resources, such as gradually less fertile land, unskilled labourers (the hoe matched), low-yielding planting material and seed varieties, low-yielding agricultural and traditional farming practices, low yields, and high food prices. By joining groups, farmers can address challenges like lack of access to credit, input supplies, and timely agricultural information, which are difficult to tackle individually. This collective strength helps them escape poverty and powerlessness. Therefore, organizing into cooperatives is essential. Cooperatives, as member-owned business organizations, provide the necessary institutional framework for members to manage both production and marketing activities effectively (Gidey, 2019). The role of agricultural cooperatives has been neglected by our farmers and the government, making it difficult for the few farmers to struggle to meet production needs, which are not yet determined. This research gap necessitated this study that analyzed the effect of agricultural cooperatives on the farm output of farmers in South-East Nigeria. The study specifically estimated the farm output of farmers before joining the cooperative society, estimated the farm output of farmers after joining the cooperative society; and compared the differences in farm output of farmers before and after joining the cooperative society in the study area.

METHODOLOGY

Study Area

The study was carried out in Southeast Nigeria. Three states namely: Abia, Enugu and Imo were selected for the study. Three hundred and ninety-nine (399) cooperative farmers were chosen using a multi-stage random sampling procedure (Abia=133, Enugu=133, and Imo=133). Data for the study were collected using a well-structured questionnaire and were analyzed using descriptive statistics and Z-test analysis.

Estimation of the farm output of farmers before and after joining cooperative society

The result in Table 1 revealed that Abia cooperative farmers realized a mean output of 17888Kg and 2165.51Kg before and after joining the cooperative respectively. However, Enugu State cooperative farmers had a mean farm output of 19666Kg before joining and 6017.13Kg after joining the cooperative society. Again, Imo State cooperative farmers realized 10355Kg (before) and 8553.35Kg (after) joining the cooperative society. The grand mean farm outputs for the three States were 15,969.67 (before) and 16,735.99 (after) joining the cooperative society in the study areas. The study area's agricultural cooperative farmers saw a rise in farm output due to the inclusion of cooperatives, as suggested by the result. This result is in tandem with the findings of Chijioke-Okoro and Eze, (2021), and Nwaobiala *et al*., (2022) as they affirmed that cooperative membership tends to enhance access to production inputs, thereby contributing to increasing farm output

Comparison of the differences in farm output of farmers before and after joining cooperative society

The results in Table 2 presented the Z-test of significant difference between farm output before and after joining cooperative society in southeast Nigeria. In Enugu State, the study showed the mean output of the farmers before and after joining cooperative society with a Z-test value of 0.5113 which was not significant (> 0.05). The data indicates that the farmers' output in Enugu State did not significantly differ before and after they joined the cooperative society. Consequently, the null hypothesis could not be rejected. For Abia State, the study showed the mean output of the farmers before and after joining cooperative society with a non-significant z-test value of 1.1295 (> 0.05). These indicate that there are no significant differences between the farmers' output in Abia State before and after joining the cooperative society, therefore we failed to reject the null hypothesis. For Imo State, the study also showed that the mean output of the farmers in Imo State before and after joining cooperative society with a Z-test value of 1.6963 is significant at a 5% level. (< 0.05). These indicate that there are substantial differences between the outputs of farmers in Imo State before and after joining the cooperative society, therefore we reject the null hypothesis. The pooled results found that the mean output of the farmers before and after joining cooperative society with a Z-test value of 2.0782> 0.05. Thereby, implying a significant difference between the farmers' output before and after joining the cooperative society.

Table 1: Frequency distribution of farm output of farmers before and after joining cooperatives in the study areas

States	Before (Kg/ha)		After (Kg)/ha	
Abia (n=133)				
Output (Kg/ha)	**Frequency**	**Percentage**	**Frequency**	**Percentage**
100 – 600	19	14.28	19	14.28
601 – 1100	28	21.05	17	12.78
1101 – 1600	20	15.03	24	18.04
1601 – 2000	27	20.30	20	15.03
2100 – 2600	28	21.05	35	26.31
2601 – 3000	11	8.29	18	13.56
Mean ($\bar{x}$)	**17888**		**2165.51**	
Enugu (n=133)				
100 – 600	62	46.61	62	46.61
601 – 1100	41	30.82	19	14.29
1101 – 1600	12	9.02	4	3.01
1601 – 2000	3	2.25	2	1.50
2100 – 2600	6	4.51	26	19.56
2601 – 3000	9	6.79	20	15.03
Mean ($\bar{x}$)	**19666**		**6017.13**	
Imo (n=133)				
100 – 600	63	47.37	61	45.86
601 – 1100	23	17.29	27	20.30
1101 – 1600	17	12.78	3	2.25
1601 – 2000	11	8.27	6	6.77
2100 – 2600	10	7.52	16	12.03
2601 – 3000	6	4.51	20	12.79
Mean ($\bar{x}$)	**10,355**		**8553.35**	
Grand mean ($\bar{x}$)	**15,969.67**		**16,735.99**	

Source: Field Survey, 2023

Table 2: Z-Test of difference between farm output before and after joining the cooperative society across the Southeast State of Nigeria

States	Mean	Std. deviation	Std. error	Z test
Enugu				
Output Before	1788.19	236.14	2723.31	0.5113
Output after	2165.50	699.11	8062.58	
Abia				
Output Before	1965.92	1503.69	17341.48	1.1295
Output After	6017.132	3256.33	37553.89	
Imo				
Output Before	1035.43	325.64	3755.44	1.6963*
Output After	8553.45	4419.89	50972.72	
Pooled				
Output Before	1596.5100	517.9459	10345.9600	2.0782*
Output After	5578.6610	1844.8130	36850.1000	

Source: STATA Result, 2023. ** p≤ 0.05

CONCLUSION AND RECOMMENDATIONS

The study concluded that farmers increased their farm output after belonging to a cooperative society in the study area. The study therefore recommended that farmers should be encouraged to join cooperatives to enjoy the benefits accruing to the group.

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Assessment of Cocoyam Processing Technologies and Consumption Pattern in Ebonyi State, Nigeria

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Abstract

Cocoyam, an essential staple crop in Ebonyi state, is processed using primarily traditional methods such as peeling, boiling, drying, and pounding. This study assesses cocoyam processing technologies and consumption patterns in Ebonyi State, Nigeria. Primary data was collected from 120 cocoyam farmers using a multi-stage sampling procedure. The instrument used for data collection was interview schedule. Descriptive statistics was used for analyzing the collected data. The result showed that the most common methods of cocoyam processing are peeling, slicing, and drying (14.29%) and boiling/precooking, peeling, slicing, and drying (14.29%) are dominant techniques, reflecting a focus on extending shelf life and preparing cocoyam for varied culinary uses. It also shows that a significant portion (39.29%) of the farmers prefer cocoyam in a combination of processed forms like chips and flakes, showcasing the versatility of the crop in both its raw and processed states. Using cocoyam as a soup thickener is also prevalent, accounting for (35.71%) of the responses. Boiling cocoyam and eating it with red oil constituted (17.85%), reflecting a traditional consumption pattern tied to cultural practices. There is minimal commercial exploitation, with most cocoyam being consumed domestically rather than processed into high-value products. The findings suggest that improving cocoyam processing technologies, alongside initiatives to educate farmers and processors, could increase the crop's economic potential. This would not only reduce post-harvest losses but also expand cocoyam's role in enhancing food security, boosting incomes, and diversifying the agricultural sector in Ebonyi State.

Keywords: Cocoyam, Processing, Technologies, Consumption

INTRODUCTION

Cocoyam (*Colocasia and Xanthosoma* spp.) plays a significant role in food security, nutrition, and rural livelihoods in many tropical regions, including Nigeria. In Ebonyi State, where agriculture is a primary source of income for the rural population, cocoyam serves as a staple crop and farmers, especially women, engage in cocoyam cultivation. It provides essential nutrients such as carbohydrates, dietary fiber, and vitamins, contributing to household food consumption and income generation (Chukwu, 2012). Despite its importance, cocoyam has traditionally been underutilized in terms of its processing potential, with many farmers and processors relying on manual, labor-intensive methods.

Traditional cocoyam processing methods, such as manual peeling, boiling, drying, and milling, are not only labor-intensive but also prone to post-harvest losses, inefficiencies, and lower product quality (Ezeocha *et al.,* 2021). The traditional methods of cocoyam processing, including peeling, boiling, drying, and milling, often result in significant post-harvest losses and limit the crop's market potential. Moreover, these manual techniques are time-consuming and inefficient, especially for large-scale production. However, technological innovations in food processing can enhance the value chain, improve product quality, and expand market opportunities for cocoyam-derived products, such as flour, chips, and paste. The introduction of mechanized processing technologies could also address issues related to product standardization, shelf-life, and safety, which are critical for both local and international trade.

Farmers engage in various processing techniques, such as drying, pounding, and milling, to transform cocoyam into different food products, which are then sold in local markets or consumed within households. It can be converted to fufu, soup thickeners, porridge, and specialty food for gastrointestinal disorders, among others. They are either eaten boiled or fried to make crispy chips (Adeosun *et al.*, 2017). The leaf stalks can be prepared like other vegetables and consume with solid foods. These activities not only add value to the raw crop but also create opportunities for rural farmers to participate in value chains, improve their financial stability, and reduce poverty. Moreover, cocoyam processing helps in preserving the crop, reducing post-harvest losses, and ensuring year-round availability, which is crucial in a region where food insecurity remains a pressing challenge.

In recent years, there has been a growing awareness of the need to modernize agricultural practices in Nigeria, particularly in root and tuber crop processing. Advances in food processing technologies, including mechanization and improved preservation techniques, hold significant potential for enhancing the efficiency, safety, and profitability of cocoyam processing (Okonkwo & Okoye, 2020). However, the adoption of these technologies in rural areas like Ebonyi State has been slow, due to several factors including the high cost of equipment, lack of technical knowledge, and insufficient infrastructural support (Nwankwo *et al*., 2019). Cultural practices and perceptions influence both the processing methods and consumption patterns, with cocoyam often consumed as a side dish or in traditional soups. Assessing the current cocoyam processing technologies and consumption pattern in Ebonyi State is therefore crucial for identifying the challenges and opportunities for upgrading these processes, thereby boosting local food security and rural incomes. This study aims to examine the status of cocoyam processing technologies in Ebonyi State, with a focus on identifying gaps in current practices and exploring potential solutions to enhance processing efficiency. It also examines different ways cocoyam is consumed in the area.

METHODOLOGY

Multistage sampling technique was employed for the study. At the first stage, two out of three agricultural zones of Ebonyi state were used for the study. Ebonyi north and Ebonyi central. This is because they are more in cocoyam production. In the second stage, two (2) Local Governments Areas each in two (2) Agricultural zones of the study area were selected. For Ebonyi north, Ohaukwu and Ebonyi LGAs were selected while for Ebonyi central, Ikwo and Ezza north were selected making a total of four (4) LGAs for the study. In third stage, three (3) communities were purposively selected. Twelve (12) Communities were therefore selected to represent four (4) Local Government Areas in the two (2) Agricultural Zones selected for the study. In the final stage, Ten (10) respondents each were systematically selected in 12 communities bringing a total of one hundred and twenty (120) respondents for the study. Data was collected with the use of interview schedule. Analysis was done using descriptive statistics.

RESULTS AND DISCUSSION

Result from table 1 showed cocoyam processing methods and several approaches used to prepare the crop in Ebonyi State. The most common methods are peeling, slicing, and drying (14.29%) and boiling/precooking, peeling, slicing, and drying (14.29%), which suggest that cocoyam is typically processed for longer shelf life and easier storage. These methods allow the product to be preserved, especially in the form of chips or flour, which is important in areas where preservation is necessary due to lack of refrigeration.

Another common method includes slicing and peeling and slicing, both used by (10.71%) of respondents. These methods are likely foundational steps for preparing cocoyam for further processing, such as drying or cooking. Boiling/precooking (7.14%) and boiling/precooking combined with peeling and slicing (7.14%) are also notable, reflecting the importance of thermal preparation in cocoyam processing, which likely enhances digestibility and flavor. The combination of slicing and drying (7.14%) also points to a drying process that preserves cocoyam for longer storage, which is essential in regions with limited refrigeration. The data suggests that while cocoyam is processed using diverse techniques, simpler methods like slicing and boiling dominate. Other methods such as boiling/precooking, slicing, and drying (7.14%) and boiling/precooking, drying, milling, and pounding (3.57%) reflect more complex processes, possibly used to create smoother textures or prepare cocoyam for specific recipes, like pounded cocoyam for thickening soups.

Less frequently used methods include drying (3.57%) and milling (3.57%), suggesting that while processed forms like cocoyam flour are known, they are less commonly produced in this context. This could be due to infrastructural limitations or the labor-intensive nature of these methods. Also peeling, drying, and sieving (3.57%), indicate specialized techniques aimed at refining the product for further use in processed forms such as flour or powder.

Overall, the data reveals that drying and slicing, often paired with boiling or precooking, are dominant techniques, reflecting a focus on extending shelf life and preparing cocoyam for varied culinary uses.

Table 2 reveals several ways cocoyam is consumed in the study area. A significant portion (39.29%) of the farmers prefer cocoyam in a combination of processed forms like chips and flakes, showcasing the versatility of the crop in both its raw and processed states. Using cocoyam as a soup thickener is also prevalent, accounting for (35.71%) of the responses, indicating its importance in local cuisines as a staple thickening agent for various soups. This result is in tandem with the findings of Osahon (2019) who discovered that cocoyam soup thickener (3.62), was the only important value added technology above the mean benchmark of 3.0 across the three south eastern states studied.

Boiling cocoyam and eating it with red oil is another favored method (17.85%), reflecting a traditional consumption pattern tied to cultural practices. However, fewer people (7.14%) consume cocoyam with beans, suggesting it is a less popular, but still notable, pairing in the diet. According to Enwelu *et al.* (2014), consumption of mixture of cocoyam and beans is fairly good and should be encouraged because most people in rural areas eat unbalanced diets usually made up of carbohydrates. This data highlights cocoyam's flexibility and its integration into both traditional and modern meals, though processing for chips and soup thickening remains the dominant consumption approach.

CONCLUSION AND RECOMMENDATIONS

In conclusion, the assessment of cocoyam processing technologies and consumption patterns in Ebonyi State, Nigeria, reveals significant insights into the agricultural and dietary landscape of the region. While cocoyam remains an important staple food, its processing technologies are often rudimentary, limiting its potential for higher productivity and market expansion. Traditional methods, such as peeling, drying, and boiling, dominate, though there is a growing need for modern, efficient techniques to enhance value addition and shelf life. Consumption patterns show that cocoyam is mostly utilized in home meals and local delicacies, with limited commercial exploitation. Improving processing technologies, along with targeted interventions such as education and support for farmers, could enhance both the economic viability and nutritional impact of cocoyam in the state. These developments could also foster broader acceptance and integration of cocoyam into national and international markets.

Table 1: Method of processing Cocoyam

Method of Processing	Frequency	Percentages
Boiling/precooking	8	7.14
Slicing	12	10.71
Drying	4	3.57
Milling	4	3.57
Peeling and slicing	12	10.71
Slicing and drying	8	7.14
Boiling/precooking, peeling and slicing	8	7.14
Boiling/precooking, peeling and pounding	4	3.57
Boiling/precooking, slicing and drying	8	7.14
Peeling, slicing and drying	16	14.29
Peeling, drying and sieving	4	3.57
Boiling/precooking, peeling, slicing and drying	16	14.29
Boiling/precooking, drying, milling and pounding	4	3.57
Peeling, slicing, drying and milling	4	3.57

Source: Field Survey, 2023

Table 2: Consumption Pattern of Cocoyam

Consumption Pattern of Cocoyam	Frequency	Percentages
Boiled and eaten with red oil	20	17.85
Soup thickener	40	35.71
Eaten with beans	8	7.14
Combination of soup thickener chips and flakes	44	39.29

Source: Field Survey, 2023

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Variability Studies among Some Sugarcane (*Saccharum officinarum*) Accession at Badeggi, Nigeria

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Abstract
The study at the National Cereals Research Institute (NCRI) in Badeggi, Niger State, Nigeria, aimed to reveal the variability of 35 sugarcane accessions for breeding purposes. Using a Randomized Complete Block Design (RCBD) with three replications, significant differences were found among the clones. NCS 003 had the highest cane yield (91.57 t/ha), and CP 72-2086-1 had the best brix (23.4%). Principal component analysis showed that the first five components accounted for 89.42% of the total variation. Single Linkage Cluster Analysis (SLCA) revealed two major clusters, with Cluster I showing better sprouting, more malleable stalks, and higher yield. This variability can be exploited in future breeding programs.
Keywords: Sugarcane, Variability, Sugarcane, Accessions

INTRODUCTION
Sugarcane is a vital cash crop in Nigeria, crucial for food and income security (Mohammed *et al*., 2019). High-yielding, disease-resistant clones are essential for socio-economic growth (Etefia *et al*., 2019). Genetic variability is key for breeding programs to improve desirable traits (Ongala *et al*., 2016). Efficient manipulation of genetic variability is critical for crop improvement (Gana *et al*., 2013). Traits with high variability enhance gene transfer during breeding (Gana, 2006). Genetic diversity aids in identifying diverse germplasm (Aitken and McNeil, 2010). Multivariate analysis, including PCA and cluster analysis, is used to estimate genetic variability (Malik *et al*., 2014). Correlation studies reveal relationships between yield and other traits (Salahuddin *et al*., 2010). This study aimed to show variation among sugarcane accessions and their trait relationships.

MATERIALS AND METHODS
This study was conducted at the National Cereals Research Institute (NCRI) in Badeggi, Niger State, Nigeria, to evaluate the variability of 35 sugarcane accessions. The experiment, using a randomized complete block design with three replications, involved planting 3-budded setts in single rows with 1-meter inter-row spacing. Data on germination, tiller counts, plant height, stalk length, malleable stalks per plot, cane yield, and brix (sugar content) were collected. Analysis of variance (ANOVA) was performed using the Crop Stat package, and multivariate analyses (PCA, Cluster, and Correlation)

were conducted using the Statistical Tool for Agricultural Research (STAR) to identify significant differences and relationships among the genotypes.

RESULTS AND DISCUSSION

The study revealed significant differences (P< 5%) among sugarcane accessions for various traits. NCS-009 had the highest germination rate, while CP 72-2086-1 had the lowest. NCS-007 recorded the maximum number of tillers. D 8687 had the tallest plants at 6 months, and B 9054 was the shortest. NCS-003 had the most stools per line, and NCS-009 and NCS-002 produced the most malleable stalks. CP 72-2086-1 had the highest brix percentage. NCS-003 recorded the highest cane yield. Principal component analysis showed that the first five components accounted for 89.42% of the total variation, with stem girth contributing positively to PC 1 and PC 2. Cluster analysis indicated that B 9054 and BOO 270 had similar traits.

Table 1: Mean values of growth and yield performance of 35 sugarcane accessions at NCRI Badeggi (2019-2020 and 2020/2021)

Accession	Germ %	Tiller	Plant Height (6)	Stalk Girth (cm)	Brix %	Yield (t/ha)
NCS-002	56.95	43.33	221.00	1.65	20.10	89.43
B 85266	56.57	39.33	184.10	1.60	20.03	46.67
KNB 9218	39.93	36.50	227.67	2.03	20.68	57.22
BR 00001	59.27	26.67	213.00	2.00	21.65	59.15
NCS-003	49.35	39.33	226.43	1.67	21.12	91.57
NCS-009	62.73	39.33	230.82	1.85	20.02	87.52
SE +	5.48	4.32	9.35	0.10	0.58	8.23

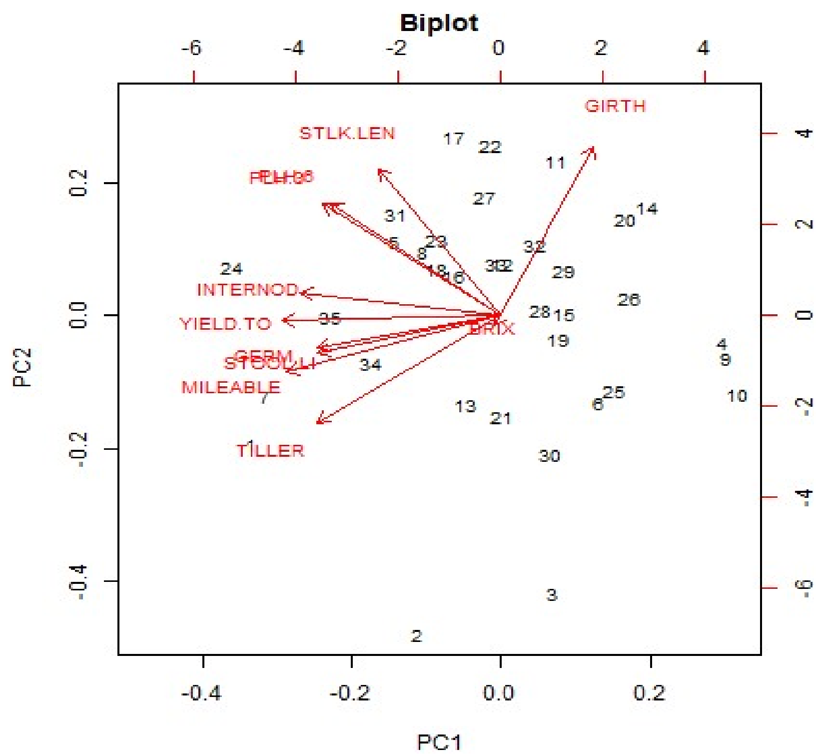

Figure 1: Biplot of (PC1) versus (PC2) for 11 traits and 35 Sugarcane genotypes

Table 2: Eigen value, Factor scores and contribution of the first five axes to variation in sugarcane accessions

Variables	PC1	PC2	PC3	PC4	PC5
GERMINATION	-0.3255	-0.1042	-0.0852	0.4424	-0.6476
TILLER	-0.3255	-0.3522	-0.0607	0.2631	0.014
PLANT HEIGHT 3	-0.3131	0.365	0.2179	0.1541	0.1046
PLANT HEIGTH 6	-0.3015	0.3697	0.1005	-0.3085	0.031
STOOL/LINE	-0.3245	-0.122	0.2547	0.4496	0.3633
MILEABLE STALK	-0.379	-0.1852	0.0721	-0.1181	0.2567
INTERNODE LENGTH	-0.3556	0.0735	-0.2925	-0.3215	-0.1691
STALK GIRTH	0.1642	0.5539	0.0851	0.4189	0.2177
STLK LENGTH	-0.216	0.4821	-0.209	0.02	-0.2817
BRIX	-0.0121	-0.0326	0.8512	-0.2186	-0.3667
YIELD	-0.3873	-0.0163	-0.0211	-0.2701	0.2843
Proportion of Variance	0.4963	0.182	0.1101	0.0596	0.0462
Cumulative Proportion	0.4963	0.6783	0.7884	0.848	0.8942
EigenValues	5.4595	2.0014	1.2115	0.6559	0.5082

The cluster analysis, using a dendrogram, grouped the sugarcane accessions into two major clusters based on trait variations, with a cophenetic correlation coefficient of 0.458. Cluster 1, consisting of 22 members, showed better average means for all traits except girth and brix. Members of Cluster 1 include NCS-002, NCS-007, B 85266, KNB 9218, NCS-003, BR 00001, B-2, BBZ 951034, SP81-3250, D 8687, N 27, NCS-005, SP71-618, RB 86-3129, NCS-006, NCS-009, RB 86-7512, B 47419, NCS 008, O535, BBZ 92653, and B 245/B 0197. Cluster 2, with 13 members, includes B 9054, B 51410, BOO 270, B 881602, DB 75159, NCS-001, B 96399, RB 94-2291, CP 72-2086-1, B 93220, BR 971007, BBZ 921101, and RB 82-5211.

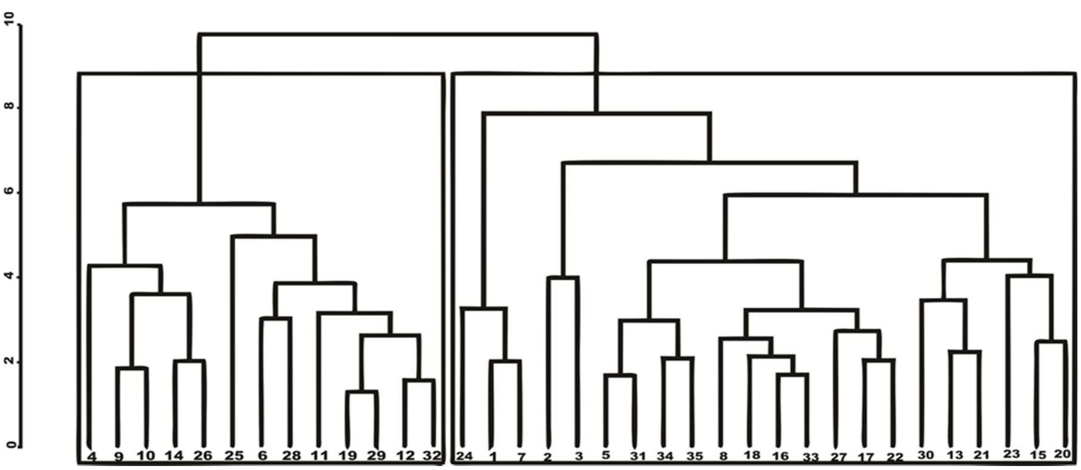

Figure 1: Dendrogram of the 35 sugarcane accessions based on combined crop cycle (plant and ratoon) performance

Table 3: Cluster membership performances of 35 sugarcane accessions

Variable	Cluster	Min	Max	Mean	Standard Deviation
GERMINATION	1	29.07	62.73	46.28	8.88
TILLER	2	14.00	26.83	20.10	4.76
PLANT HEIGHT 3	1	122.62	179.88	154.54	15.25
MALLEABLE STALK	1	15.67	41.83	27.14	8.35
BRIX	2	18.43	23.35	20.54	1.41

Based on the correlation analysis, it was found that there was a positive correlation between germination percentage and all traits except girth and brix, with significant correlations for all traits except brix. Tiller count showed a significantly high positive correlation with stool/line, malleable stalk, internode length, and cane yield. Plant height at 3 MAPS had a high significant positive correlation with germination percentage and tiller count. Stool/line had a significantly high positive correlation with germination percentage, tiller count, and plant height at 6 MAPS. The correlation between germination percentage, tiller count, plant height, stool/line, and millable stalks was highly significant. The germination percentage, tiller count, stool/line, and malleable stalks were all negatively correlated with stalk girth. The relationship between stalk length and plant height (3 and 6 MAPS) and internode length was highly positive and significant. Brix percentage had no significant correlation with any parameter. Cane yield showed a highly significant positive correlation with all traits except girth and brix, which correlated negatively with yield.

Table 5: Correlation analysis of agronomic traits of 35 sugarcane access

	GERM..	TILLER	PLH.3	PLH.6	STOOL.LI	MILEABLE	INTERNOD	GIRTH	STLK.LEN	BRIX	YIELD.TO
GERM..	1.0000										
TILLER	0.6948***	1.0000									
PLH.3	0.4736**	0.3447*	1.0000								
PLH.6	0.3764*	0.2356	0.7746***	1.0000							
STOOL.LI	0.5719**	0.6458***	0.5334**	0.3999	1.0000						
MILEABLE	0.5682**	0.7783***	0.49**	0.4573**	0.7397***	1.0000					
INTERNOD	0.5984**	0.5368***	0.5775***	0.5832***	0.3815*	0.7125***	1.0000				
GIRTH	-0.3529*	-0.5865***	0.1994	0.0168	-0.3033	-0.4935**	-0.3205*	1.0000			
STLK.LEN	0.3391*	0.0497	0.5568***	0.6326***	0.2377	0.2666	0.542***	0.2492	1.0000		
BRIX	-0.0184	-0.0499	0.1644	0.0932	0.1556	0.1101	-0.1814	-0.0349	-0.1549	1.0000	
YIELD.TO	0.565**	0.6312***	0.627***	0.6642***	0.6303***	0.8445***	0.7707***	-0.3823*	0.3705*	-0.0088	1.0000

The study revealed significant variations among sugarcane accessions for various traits, as shown by ANOVA, aligning with findings by Aamer *et al*. (2018) and Saleem *et al*. (2023). Principal component analysis (PCA) indicated different contributions of each trait to total variation, consistent with Al-Sayed *et al*. (2012). Correlation analysis demonstrated significant associations between yield and other traits, supporting Saleem *et al*. (2023) and Chaudhary and Joshi (2005). The study emphasized understanding trait relationships for breeding improvements, as noted by Million *et al*. (2018). NCRI varieties mostly clustered together, except NCS 001, similar to findings by Olaoye (1999) and Shahzad et al. (2016).

CONCLUSION AND RECOMMENDATIONS

The accessions exhibit high variations in their performance as revealed by the different statistical tools (ANOVA, PCA, SLCA, and Correlation) used in this study. The accessions had different genetic make-up due to the differences noted in the population thus providing better chances for sugarcane improvement. PCA, Dendrogram and Biplot revealed how each trait contributes to variation, distinctiveness and relatedness among the accessions depending on their performance. Based on our findings, we conclude that many characteristics should be considered when selecting parents to be used in sugarcane hybridizations and variety development for higher cane yield. Better progenies can be developed through the hybridization of different parents between the cluster groups (groups with higher variability) on the dendrogram.

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Impact of Plant Spacing and Different Fertilizers on Tuber Yield of Sweet Potato (*Ipomea batata. (L.)* Lam) in Savanna-Forest Zone of Nigeria

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Abstract
The concerted efforts by researchers to combat low yield imposed by native soils and plant density among other factors in sub-Sahara Africa have been of great concern. Therefore, this study assessed the impact of different nitrogen sources and plant densities on the yield of the UMUSP-3 variety of sweet potato in Jos, Plateau State, Nigeria. The experiment was laid out in a Randomized Complete Block Design (RCBD) replicated three times in a 4 x 4 factorial design, the experiment consisted of four plant densities (P1=20,000, P2= 25,000, P3= 33,333 and P4= 50,000 plants ha^{-1}) and four different fertilizers (Control, poultry manure, cattle manure and NPK). The data were subjected to analysis of variance (ANOVA) using the split-plot model. Significant means were separated using Fisher's protected least significant difference ($p < 0.05$). The findings unveiled significant variation between plant densities and different fertilizers on yield plant^{-1} and ha^{-1}. The highest tuber yield plant^{-1} of (632.00) was obtained at the lowest density (P1=20,000 plants ha^{-1}), while the highest yield ha^{-1} of (34.02 t. ha^{-1}) was obtained at the highest density (P4= 50,000 plants ha^{-1}). This research showed that higher plant density increases the total yield ha^{-1} but decreases the yield plant^{-1} in sweet potatoes. Poultry manure consistently emerged as a potential champion, demonstrating impressive yield plant^{-1} and ha^{-1} of 1013.30 and 51.98 respectively. In conclusion, the author recommends using a higher plant density to maximize yield ha^{-1} and prioritizing poultry manure as it significantly improves tuber yield plant^{-1} and ha^{-1}.

Keywords: Sweet potato, mineral fertilizer, plant density, organic fertilizer

INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam) a member of Convovulaceae family (the morning glory) is one of the most widely grown root crops in the world (Claudio *et al.,* 2020). The crop is widely cultivated for its enlarged edible storage roots which provide a high amount of starch to staple diets. Sweet potatoes have multiple uses as a regular food and cash crop, as raw materials and for livestock feed. It is also an important source of income especially in the rural areas. Despite the numerous uses and benefits of sweet potatoes in Nigeria, the production is below the nation's potential. Sweet potato has a yield potential of 20–50 tons per hectare wet weight in the tropics (Caliskan *et al.,* 2007). Farmers in Sub-Sahara Africa produce below 10 tons per hectare wet weight on average (Aneneokeakwa *et al.,* 2021), while farmers in Nigeria recorded one of the world's lowest average potato yields of less than 3.1 tons per hectare. In the United States of America and Japan, yields of 22.8 and 21.7 tons per hectare have been recorded respectively

(FAO, 2015). Despite the availability of high-yielding varieties of sweet potato in Nigeria, its yields are mostly limited by progressive declining soil fertility combined with low use or no fertilizers as well as lack of good agronomic practices such as lack of proper weed control, insect pest knowledge, improper use of fertilizer, and sub-optimal plant density (Muamba *et al.,* 2021), Socio-economic and demographic pressures also continue to compete and deprived agricultural sector of arable land leading to continuous cultivation of available land which depletes soil fertility status. Unfortunately, the intensive use of limited arable land is expected to produce enough to satisfy the ever-increasing population and raw materials for industries. This could be achieved by adopting many strategies including proper planting density and using organic and inorganic inputs as a prerequisite for good yield. Planting density is an important factor in regulating yield formation crop lifespan. However, the planting density of sweet potatoes is low in most areas of Nigeria at approximately 20,000 plant ha^{-1}. Therefore, increased planting density is a vital cropping measure to realize the maximum sweet potato yield potential (Qiggan L, *et al.,* 2023). Hence, this research aimed to determine the effect of plant density and different fertilizers on the yield of sweet potato variety and ascertain the appropriate plant density and fertilizer type for the optimum productivity of sweet potato.

MATERIALS AND METHODS

Field experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture, University of Jos, Jos, Plateau State, Nigeria. Located on latitude 09° 55.00" N and longitude 08°53.25" with an elevation of 1238m above sea level a mean annual rainfall of 1411 mm and a daily temperature of 20.4^{0}C. UMUSP-3 variety of sweet potato was obtained from Root and Tuber Research Institute Umudike, Abia State Nigeria, Fertilizer (NPK) was purchased from the Agricultural Development Program (ADP), Dogon, Dutse, Jos North, Plateau State, cow dung was obtained from abattoir, Jos North, Plateau, State. poultry manure was obtained from the poultry unit of the University of Jos farm. The experiment was laid out in a 4 × 4 factorial arrangements fitted into a Randomized Complete Block design (RCBD) and replicated three times. Each replicate consisted of sixteen ridges each carrying a treatment. The plot treatment consisted of four densities (50 x 100 cm (20,000 pph), 40 x 100 cm (25,000 pph), 30 x 100 cm (33,333 pph) and 20 x 100 cm (50,000 pph)) and four different fertilizers (Control 0 t. ha^{-1}, Cow dung at 5 t. ha^{-1}, Poultry manure at 5 t. ha^{-1} and NPK at 120 kg ha^{-1}). A total land size of 777 m^2 (37 x 21 m) was marked out for the study and Each ridge was measured 5 × 1.5 m. An alley of 0.5 m and 1.0 m respectively was left between plots and blocks to prevent treatment drift to adjacent plots.

Measurements on yield plant^{-1}and ha^{-1}

Tuber Yield Plant^{-1} (g plant^{-1}): Tubers harvested from plants within each net plot were weighed in grams. The fresh tuber yield in grams per plant was calculated as;

$$\text{Tuber yield plant}^{-1}\ (\text{g plant}^{-1}) = \frac{\text{Weight of tubers from harvested plants in net plot (grams)}}{\text{Plant population per plot}}$$

Tuber yield per ha^{-1} (t. ha^{-1}): Tuberous roots of six randomly selected plants were dung out, weighed, summed up and calculated based on t. ha^{-1}

$$\text{Tuber yield plant}^{-1}\ (\text{t. ha}^{-1}) = \frac{\text{Weight of tubers from harvested plants in net plot (kilogram)}}{\text{Area of the land harvested}}$$

Statistical analysis

The data collected were subjected to analysis of variance (ANOVA) using the split-plot model. Significant means were separated using Fisher's protected least significant difference at a 5% level of probability

RESULTS AND DISCUSSION

Impact of plant spacing and different fertilizers on yield of UMUSP-3 variety of sweet potato

Plant density and different fertilizer types significantly influenced tuber yield plant^{-1} and yield ha^{-1}, there was a decrease in tuber yield plant^{-1} (from 632.00 to 349.00) with an increase in plant density of P1 to P4, lower plant density resulted in a commensurate increase in tuber yield plant^{-1} owing to optimal utilization of nutrient by relative lower number of plants. This could, also, be due to reduced competition, improved light penetration, and enhanced root development among others. The author's findings are in tandem with (Muamba *et al.,* 2022 and Masarirambi *et al.,* 2012) who reported that maximum yields are obtained at a closer density which means lower plant densities due to reduced competition and better resource availability. The enhanced growth conditions at lower densities lead to more productive plants showing significantly higher yields compared to higher plant densities. Different fertilizer types significantly influenced tuber yield plant^{-1}, with the highest yields observed in plots treated with poultry manure, followed by cow dung, and the lowest in plots without amended inputs. This significant increase in yield plant^{-1} with organic fertilizers (poultry manure) can be attributed to several factors such as nutrient availability, soil structure, fertility and enhanced microbial activity. These results agree with the findings of (Abdissa *et al.,* 2012), who observed increased sweet potato yields with poultry manure, attributing it to better soil physical properties and enhanced nutrient uptake. On the other hand, these findings contrast with the results of Emmanuel Anedo (2020), who found that mineral fertilizers at high plant densities could also result in high yields plant^{-1}, indicating the effectiveness of fertilizer types can vary with different crop management practices. Tuber yields ha^{-1} differed significantly among the plant density treatments. On average, tuber yield ha^{-1} increased (from 20.09 to 34.02 t. ha^{-1}) with an increase in plant density (from P1 to P4).

The increase in tuber yield ha^{-1} with higher plant densities can be attributed to more efficient use of available land and resources, despite the lower yield per individual plant. The author's observation agrees with Masarirambi *et al.,* (2012), who reported that increased plant density leads to higher overall yield ha^{-1} due to more efficient land use and resource optimization. However, these results contrast with the findings of Emmanuel Anedo (2020), who noted that mineral fertilizers at high plant densities could also result in high yields per hectare. The variation in findings might be due to differences in soil type, climate, and crop management practices, indicating the need for site-specific fertilizer and density management strategies.

This research showed that higher plant density increases the total yield ha^{-1} but decreases the yield plant^{-1} in sweet potatoes. These findings are consistent with previous research that suggests organic fertilizers improve tuber yield by enhancing soil fertility and structure (Cheng *et al.,* 2020). This trend underscores the need for balancing plant density and fertilizer type to optimize the yield of both plant^{-1} and ha^{-1}. These results align with the findings of (Agyarko *et al.*, 2014, and Nwanne 2020), who emphasized the importance of optimizing plant density and fertilization for maximum yield. The yield of 34.02 t. ha^{-1} obtained at P4 densities ha^{-1} conforms with Law-Ogbomo *et al.,* (2019) who submitted that high-yielding potato varieties could produce up to 50 t ha^{-1}. The highest yield of (51.98 t. ha^{-1}) was observed in plots treated with poultry manure, followed by cow dung (35.67 t. ha^{-1}), and the lowest yield (12.07 t. ha^{-1}) in plots without amended inputs. The reasons for this are similar to those for yield plant^{-1} including; the enhanced nutrient availability and improved soil conditions provided by organic fertilizers result in more vigorous plant growth. This leads to more productive plants per unit area, and higher overall yields ha^{-1}. Organic fertilizers improve soil moisture retention and reduce nutrient leaching, ensuring plants have the necessary resources throughout the growing season. This efficiency is particularly beneficial in high-density planting systems where competition for resources is intense. These observations align with the findings of (Masarirambi *et al.,* 2012, and Akpan and Oladunmoye 2020).), who reported that increased plant density combined with organic fertilizer (poultry manure) application leads to higher overall yield ha^{-1} due to more efficient land use and resource optimization. (El-Hlamy 2011, and Szarvas *et al.,* 2019) also found that optimal plant density combined with organic fertilizer application significantly boosts yield ha^{-1} by improving soil fertility and plant health.

CONCLUSION AND RECOMMENDATIONS

The study's findings suggest that optimal plant density combined with the application of organic fertilizers, particularly poultry manure, can significantly improve the growth and yield of sweet potatoes. These results have practical implications for sweet potato farmers in Jos South, Plateau State, who aim to maximize yield while maintaining soil health. Farmers are recommended to adopt plant densities of (50,000 plants ha^{-1}) and incorporate organic fertilizers to achieve the best balance between growth and yield. The long-term benefits of organic fertilization on soil properties should be considered in developing sustainable farming practices.

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Table 1: Influence of plant density and fertilizer types on the yield of UMUSP-3 Variety of sweet potato in Jos South

	Tuber yield plant-1 (g) Fertilizer types					Tuber yield per hectare (t. ha-1) Fertilizer types				
Treatment	Control 0 t. ha^{-1}	CM 5 t. ha^{-1}	PM 5 t. ha^{-1}	NPK 120 kg ha^{-1}	Mean	Control 0 t ha^{-1}	CM 5 t. ha^{-1}	PM 5 t. ha^{-1}	NPK 120 kg ha-1	Mean
Plant density (pph)										
P1	98.80	645.20	1453.60	330.40	632.00	3.22	20.93	47.11	10.71	20.49
P2	134.80	441.20	1392.40	311.20	569.90	6.44	21.42	67.69	15.12	27.67
P3	310.00	707.20	749.20	195.60	490.50	20.09	45.85	48.58	12.67	31.80
P4	190.40	560.00	458.00	191.20	349.90	18.55	54.46	44.52	18.55	34.02
Mean	183.50	588.40	1013.30	257.10	510.56	12.07	35.67	51.98	14.26	28.50
LSD (0.05) plant density					67.31					3.85
LSD (0.05) Fertilizer type					93.33					3.85
LSD (0.05) density x fertilizer type					114.6					3.71

Ns= non-significant, PPh= plant population per hectare, WAP= weeks after planting, P1= 20,000, P2= 25,000, P3= 33,333, P4= 50,000, CM= Cattle manure, PM= Poultry manure

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Development and Performance Evaluation of an Acha (*Digitaria iburua jarab*) Dehulling Machine

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Abstract
Acha (Digitaria Iburua Jarab) is one of the world's important crops because it is a major source of food for some countries. Presently, it has emerged as a remarkable plant that has the potential to enhance economic growth and improve public health. Research on the mechanization of paddy Acha seeds production, however, is very low, especially in the area of dehulling and currently, there are few mechanical Acha dehullers in Nigeria. Therefore, the main objective of the study is to develop and evaluate the performance of the Acha dehulling machine, which will reduce the drudgery involved in manual dehulling of Acha and encourage increase productivity. Consequently, some physical properties of Acha seeds were determined for the design of some of the dehuller components. The dehuller consists of a frame, hopper, Acha seed metering device, delivery spout, collecting chamber, blower housing, delivery chute as well as a 1hp electric motor which aids power transmission to the metering device through belt and pulley arrangements. The machine dehulled paddy Acha and separated the grains from the chaffs. Machine parameters (dehulling speed, drum clearance and fan speed) and a process parameter (feed rate) of the Acha dehuller were varied to determine their effects on the machine performance. The machine dehulling efficiency, cleaning efficiency, seed recovery efficiency and percentage losses were used as performance variables. A central composite rotatable design (CCRD) was used in carry out the experiment. The results of the experiments revealed that the dehulling speed had positive significant effects on dehulling efficiency. All the independent variables; dehulling speed, feed rate, dehulling clearance and the fan speed had considerable positive effects on machine dependent variables (dehulling efficiency, cleaning efficiency, seed recovery efficiency and percentage loss). A 125 kg/h paddy Acha Dehulling Machine has been successfully developed using locally sourced construction materials. The developed paddy Acha Machine performed optimally with dehulling efficiency of 91.97 %, cleaning efficiency of 90.52 %, seed recovery efficiency of 94.60 % and percentage loss of 5.16 % at a machine speed of 400 rpm, drum clearance of 1.5 mm. fan speed of 1400 rpm and a feed rate of 20 kg/minutes.
Keywords: acha, dehulling machine, dehulling efficiency, cleaning efficiency, seed recovery efficiency, percentage loss and performance.

INTRODUCTION

Acha (*Digitaria Iburua Jarab)* has the potential of providing enough food for the increasing population of the poor people in Nigeria. Acha (*Digitaria Iburua Jarab*) also known as fonio, is a cereal crop of West African where it is the staple food crop for several millions of tribal people and it is considered to be the tastiest of all cereals

(Kaankuka *al.,* 2015). Acha is a very hardy crop and grows well on poor soils, it can even produce seed on soils with Aluminum levels that are toxic to other crops and can be relied on in dry savannah lands, where rains are brief and unreliable. Acha grains are very tiny with length and width dimensions of 1.84 mm and 0.864 mm respectively, and a weight of 0.529 g for one thousand grains, thus making it difficult to remove the brittle outer shell referred to as the hulls (Kaankuka *et al.,* 2015).Acha is sometimes regarded as the “grain of life” as it provides food early in the farming season, when other crops are yet to mature for harvest. After being sown, depending on the variety, Acha takes just 6 or 8 weeks to produce grains and 75 to 150 days to be matured for harvest. This crop fits into the low–input farming systems as it has unique ability to tolerate poor and marginal soils and can withstand the effect of drought. According to Idris *et al.* (2018a), Acha is the most nutritious of all grains, although it contains 7 % crude protein which is similar or slightly lower than that of other grains, Acha contains some essential amino acids like leucine (19.8 %), methionine and cysteine of about 7 % and valine 5.8 % which are vital to human health and are deficient in most major grains (Cruz, 2004; Idris *et al.,* 2018b). Acha digests easily and for its nutritional values, it is traditionally recommended for children, aged, women after delivery, people suffering from diabetes, stomach diseases and also as diet for weight loss off. Acha is grown in various parts of Nigeria, Sierra-Leon, Ghana, Guinea Bissau, Senegal, Togo, Mali, Benin Republic and Cote devoir (Gyang and Wuyep, 2005). In Nigeria, Acha is grown in commercial quantities in some states such as Bauchi, Kaduna Kebbi, Plateau, Nassarawa, Niger, Gombe and the FCT with Plateau state being the highest producer with an estimated production of 20,000 tons per annum (Gyang and Wuyep, 2005).

Dehulling is the process of removing the hulls (or chaff) from Acha and other seeds. This is sometimes done using a machine known as a dehuller. Hulls are removed by dehulling to get whole white grains, and the hull constituted about 23 % of the Acha weight Cruz *et al.* (2011). Traditionally, dehulling paddy Acha is accomplished by pounding using a pestle and mortar. The productivity of this work is very low, accompanied with dirt, sand and other foreign materials that have to be removed. It takes nearly one hour to pound just one or two kilograms of Acha paddy. Thus, mechanizing the processing and cleaning of Acha is essential both to reduce the painstaking work for women and to improve the productivity, quality and availability of the product in the market.

MATERIALS AND METHODS

Design analysis

The following design analyses were carried out to determine and select the various machine parts and the level of the performance of the Acha dehuller:

Physical dimension (major, intermediate and minor diameter) of Acha seeds: In order to determine the axial dimensions, one hundred Acha seeds (Digitaria Iburua Jarab) were randomly selected. For each Acha seeds, the three principle dimensions, namely major, intermediate and minor diameter were measured using a Nano instrument with accuracy of 0.001 mm. The major (L = 1.84mm) was defined as the distance from the tip cap to kernel crown. Intermedia meter (W = 0.85mm) was defined as the widest point to point measurement taken parallel to the face of the kernel. Minor (T = 0.75mm) was defined as the measured distance between the two kernels faces.

In order to determine the level of the performance of the dehuller, some factors; machine efficiency, output, throughput, cleaning efficiency, grain loss, Acha recovery efficiency and percentage undehulled acha were measured.\

Evaluation of machine efficiency: The efficiency of the machine was computed from the expression in Equation to know the exactly performance of the machine in this developed Acha dehuller.

The efficiency of the machine was calculated from the expression;

$$E = 100\frac{W_c - W_u}{W_c} \quad (1)$$

Where: E = Efficiency of the machine (%), W_c= Weight of Acha collected after passing between the roller (kg) and W_u = The Weight of undehulled Acha grains (kg)
3. Determination of throughput (F_r): Throughput is the ratio of the mass of undehulled Acha fed into the Acha dehuller to the time taken to dehull it. Equation 2 was referring to determine the throughput (F_r).

$$F_r = \frac{Q_t}{T} \quad (2)$$

Where: F_r = through put (kg/hr), Q_t = total weight of Acha fed into the dehuller (kg) and T = time taken to dehull Acha (hr).
4. Machine output: Machine output is the product of the resistance force and the distance through which the force is applied to dehull the paddy Acha with the time taken. The machine output was calculated from the expression Equation 3.

Output, $$P = \frac{60W_c}{t} \quad (3)$$

where: P = Machine output (kg) and t = Time to dehull the paddy Acha (h)
5. Determination of percentage undehulled Acha (P_i): Percentage undehulled Acha is the measured of weight of undehulled Acha received at the grain and chaff outlets to the total weight of Acha fed into the dehuller as shown in the expression in Equation 4.

$$P_i = \frac{100\,Q_u}{Q_t} \quad (4)$$

Where: P_i = percentage of undehulled Acha (%), Qu = mass of undehulled Acha received at the grain and chaff outlets (kg) and Q_t = total mass of Acha fed into the dehuller (kg)
6. Determination of percentage blown Acha (r): Percentage blown Acha also measured the mass of dehulled Acha received at chaff outlet and the total mass of Acha fed into the dehuller. This was computed by Joshi (1981) express in Equation 5.

$$r = \frac{100Q}{Q_t} \quad (5)$$

Where: r = percentage of blown Acha (%), Q = mass of dehulled Acha r (kg) and Q_t = total mass of Acha fed into the dehuller (kg)

Determination of the effects of the independent variable on the machine performance

The overall performance of the machine was evaluated on the basis of dehulling efficiency, cleaning efficiency, recovery efficiency, and the percentage loss by varying the independent variables.

7. Determination of dehulling efficiency (η_D): This is the percentage by mass of dehulled Acha received from all outlets of the dehuller with respect to total seeds input.

$$\eta_D = (100 - W_{DA})\ \% \tag{6}$$

Where: W_{DA} = mass of dehulled Acha received (%)

8. Determination of Cleaning Efficiency (η_c)

This is the percentage by weight of dehulled grains with respect to all products collected at the grain outlet (NIS, 1997). This is expressed in Equation 7, by Joshi (1981).

$$\eta_c = \frac{Q_S}{Q_A} \tag{7}$$

Where: Q_S = mass of foreign matter received at Acha outlet (kg) and Q_A = mass of all products collected at Acha outlet (kg)

9. Determination of Acha Recovery Efficiency (η_A): This is the percentage by mass of dehulled seed collected from grain outlet with respect to the total seed input. This is expressed in Equation 8.

$$\eta_A = \frac{Q_o}{Q_t} \tag{8}$$

Q_t = total mass of Acha fed into the dehuller (kg)

Q_o = mass of dehulled Acha received at Acha outlet (kg)

10. Determination of Total Acha Seeds Loss (T_L): Total Acha seeds loss is a measure of the percentage of undehulled Acha with the percentage of breakage Acha seeds from the Acha dehuller which is expressed in the Equation 9 by Joshi (1981).

$$T_L = P + r \tag{9}$$

Where: T_L= total Acha seeds loss, P = percentage of undehulled Acha (%), and r = percentage of breakage Acha (%)

Description of the Acha Dehulling machine with it component parts

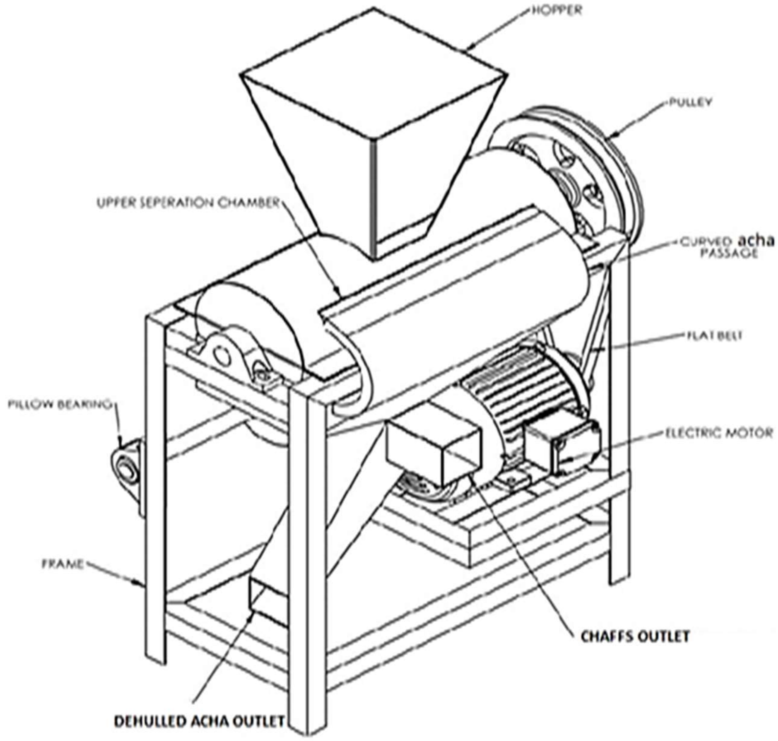

Figure 1: Assemble Dehuller

Plate I: Developed Acha Dehuller

RESULTS AND DISCUSION

Machine performance evaluation

After the design and construction of the machine were completed, the effects of the independent variables on the dependent variables were analysed. The results of the effects of the dehulling speed, drum clearance, fan speed, and feed rate on the machine performance are shown in Table 1. The values of dehulling efficiency ranged from 49.11 % to 93.13 % statically analysis The combination of dehulling speed of 400 rpm, drum clearance of 1.5 mm, fan speed of 1400 rpm, and feed rate 20 kg/min yielded the highest efficiency of 93.1 3 %, while the interaction of dehulling speed of 450 rpm, drum clearance of 3 mm, fan speed of 1300 rpm, and feed rate 30 kg/min yielded the lowest efficiency of 49.11 %.

The value of cleaning efficiency ranged from 55.4 % to 94.60 % during the analysis. The highest value of 94.60 % was obtained from the combination of dehulling speed of 500 rpm, drum clearance of 2.5 mm, fan speed of 1400 rpm, and feed rate of 20 kg/min, while the interaction between dehulling speed of 500 rpm, drum clearance of 1.5 mm, fan speed of 1200 rpm, and feed rate of 40 kg/min yielded a cleaning efficiency of 55.4 %. The value of seeds recovery efficiency ranged from 88.87 % to 97.42 %. The combination of dehulling speed of 450 rpm, drum clearance of 2 mm, fan speed of 1100 rpm, and feed rate of 30 kg/min yielded the highest seeds recovery efficiency of 97.42 %, while the interaction of dehulling speed of 500 rpm, drum clearance of 2.5 mm, fan speed of 1400 rpm, and feed rate of 40 kg/min yielded the lowest recovery efficiency of 88.87 %.The value of the percentage loss ranged from 2.58 % to 12.55 %.

The combination of dehulling speed of 450 rpm, drum clearance of 3 mm, fan speed of 1300 rpm, and feed rate of 30 kg/min yielded the highest percentage loss of 12.55 %, while the interaction of dehulling speed of 450 rpm, drum clearance of 2 mm, fan speed of 1100 rpm, and feed rate of 30 kg/min yielded the lowest percentage loss of 2.58 %.

Table 1: Results of Effects of Dehulling Speed, Drum Clearance, Fan Speed and Feed Rate on the Machine Dehulling Efficiency, Cleaning Efficiency, Recovery Efficiency and Percentage Loss

Std	Run	Speed of Dehulling **(Rpm)**	Drum Clearance **(mm)**	Fan Speed **(rpm)**	Feed Rate **(kg/min)**	Dehulling Efficiency **(%)**	Cleaning Efficiency **(%)**	Seed Recovery **(%)**	Grain Losses **(%)**
17	1	350	2	1300	30	90.54	67.42	95.32	4.68
20	2	450	3	1300	30	49.11	70.12	87.45	12.55
26	3	450	2	1300	30	79.36	71.34	93.56	6.54
4	4	500	2.5	1200	20	73.87	81.91	92.67	7.33
18	5	350	2	1300	30	71.33	70.12	91.6	8.43
13	6	400	1.5	1400	40	81.98	69.23	94.43	5.57
29	7	450	2	1300	30	80.76	68	93.97	6.03
12	8	500	2.5	1200	40	63.22	60.12	90.05	9.05
7	9	400	2.5	1400	20	75.5	92	92.33	7.64
30	10	450	2	1300	30	81.41	67.56	93.54	6.46
2	11	500	1.5	1200	20	72.81	71.56	95.8	4.2
22	12	450	2	1500	30	80.32	81.54	95.05	4.95
21	13	450	2	1100	30	73.22	63.45	97.42	2.58
6	14	500	1.5	1400	20	76	93.48	94.34	5.66
25	15	450	2	1300	30	78.49	67.9	93.43	6.57
27	16	450	2	1300	30	76.08	68.11	93.25	6.75
11	17	400	2.5	1200	40	63.98	61.21	92.86	7.14
15	18	400	2.5	1400	40	65.55	64.82	91.65	8.35
5	19	400	1.5	1400	20	93.13	91.35	94.72	5.28
24	20	450	2	1300	50	72.51	60.26	92.56	7.54
28	21	450	2	1300	30	82.98	67.89	93.12	6.88
3	22	400	2.5	1200	20	73.53	69.24	94.32	5.68
8	23	500	2.5	1400	20	71.55	94.6	90.64	9.36
1	24	400	1.5	1200	20	91.42	68.76	95.65	4.35
10	25	500	1.5	1200	40	70.96	55.4	94.78	5.22
9	26	400	1.5	1200	40	82.38	59.86	96.98	3.12
14	27	500	1.5	1400	40	72.78	63.52	92.33	7.67
23	28	450	2	1300	10	85.61	92.34	95.43	4.57
19	29	450	3	1300	30	65.56	78.92	92.64	7.36
16	30	500	2.5	1400	40	64.53	62.99	88.87	11.13

Capacity of the Acha Dehuller

The research on development and performance Evaluation of an Acha (*Digitaria Iburua Jarab*) dehulling machine was successfully developed using locally sourced construction materials with capacity of 125 kg/h. The Machine performed optimally with a machine speed of 400 rpm, drum clearance of 1.5 mm. fan speed of 1400 rpm and a feed rate of 20 kg/minutes at dehulling efficiency of 91.97 %, cleaning efficiency of 90.52 %, seed recovery efficiency of 94.60 % and percentage loss of 5.16 %

CONCLUSION AND RECOMMENDATIONS

From the investigation, the following conclusions were drawn on the developed Acha dehuller which is capable of dehulling paddy Acha grain has been developed and tested with a capacity of 125 kg/h and dehulling efficiency of 49.11 % to 93.13 %, cleaning efficiency of 55.4 % to 94.60 %, seed recovery of 88.87 % to 97.42 %, and percentage loss of 2.58 % to 12. 55 % are affected by machine parameters (dehulling speed of 350 rpm to 500 rpm, drum clearance of 1.5 mm to 3 mm, fan speed of 1100 rpm 1500 rpm, and feed rate of 10 kg/min to 40 kg/min).

The higher the machine parameters, the more difficult it becomes to separate the Acha seed from the chaffs. Furthermore, the drum clearance has a significant impact on dehulling efficiency, percentage loss efficiency, and seed recovery efficiency.The model developed for the performance indices of Acha dehuller performed optimally with dehulling efficiency of 91.97 %, cleaning efficiency of 90.52 %, seed recovery efficiency of 94.60 % and percentage loss of 5.16 % at a machine speed of 400rpm, drum clearance of 1.5 mm. fan speed of 1400 rpm and a feed rate of 20 kg/minutes.

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PROCEEDINGS

Effect of Potassium Fertilizer on Early Growth of Maize (*Zea mays l.*) in Continuously Cropped Soils of Okpala, Imo State

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Abstract
Potassium traditionally, is one of the major soil nutrients in the tropics but has not always been a major problem to crops. However, with intensive and continuous cropping, potassium depletion may occur, leading to potential deficiencies. This study is to evaluate the effect of potassium fertilizer on the early growth of maize (Zea mays L.) in a continuously cropped soil in Ngor Okpala, Imo State, Nigeria in 2022 and 2023 in a randomized complete block design. Five potassium levels (0, 20, 40, 60, and 80 kg/ha) were applied to maize (Oba supper 2) at two weeks after planting (WAP). Early growth parameters such as plant height, number of leaves, leaf area, stem girth and biomass accumulation were collected at 4 and 8 weeks after planting (WAP). Results indicated that potassium application significantly enhanced all measured growth parameters. The highest values were observed in the 80 kg K/ha treatment. The difference between the early growth yield of 60 kg K/ha and 80 kg K/ha were not significant and therefore, 60kgK/ha was recommended as an optimal rate to balance input costs with growth benefits.
Keyword: Potassium, Fertilizer, maize, Soils

INTRODUCTION

The inherent low fertility of most soils in the tropics is a major factor limiting the development of sustainable agricultural system in these region. Consequently, maintenance of soil fertility and management of upland soils for sustained and continuous crop production with economic input levels remain essential component of the overall management of tropical soils. (Balemi, 2021; Khan *et al.,* 2023).

Maize (*Zea mays L.*) is a staple crop in Nigeria, playing a critical role in food security and serving as a primary source of income for many smallholder farmers. However, the continuous cropping of maize without adequate nutrient replenishment has led to significant soil nutrient depletion, particularly potassium (K), which is essential for plant growth and development.

Intensive agricultural practices have increasingly led to potassium deficiencies (Ayodele & Omueti, 2019). This is particularly disturbing in areas like Ngor Okpala, Imo State, where continuous maize cultivation has further exacerbated nutrient depletion. Potassium (K) is one of the essential macronutrients for early plant growth, playing a crucial role in various physiological and biochemical processes, including photosynthesis, enzyme activation, water regulation,insects and disease resistance, control of stomata opening and promotion of microbial activities (Yawson,et al.2011; Obasi & Eze, 2022; Farooq *et al.,* 2023). Soil potassium distribution and availability could be altered due to changes in soil management and land use practices (Ayele, 2013). Recent studies have shown that potassium supplementation can significantly enhance crop growth, particularly in potassium-deficient soils, thereby improving yield and overall crop performance. This study was therefor to evaluate the effect of potassium fertilizer on the early growth of maize (Zea mays L.) in a continuously cropped soil in Ngor Okpala, Imo State, Nigeria.

MATERIALS AND METHODS

The experiment was conducted in Ngor Okpala, Imo State Nigeria in 2022 and 2023. The region lies between Latitudes $5^0.02^1$ and $5^{0.}07^1$ N and Longitudes 7^010^1 and 7^013^1E. It has a land area of about 635.73km^2 with a mean annual rainfall range of 2202.32206.2mm, relative humidity of 70.62 - 81.08% and temperature of 27.81-39 .22^{0}C (IPEDC,2006). Soil type is Ruptic Hapludult and Tpic Paleuduit (Soil Survey Staff, 1999). which has been subjected to continuous cropping over several years, leading to nutrient depletion, particularly potassium. The experiment was arranged using a Randomized Complete Block Design (RCBD), with three replications .The potassium (K) fertilizer (muriate of potash) treatments were applied as follows:K0 (0 kg K/ha Control), 20 kg K/ha, 40 kg K/ha, 60 kg K/ha and 80 kg K/ha. Two seeds of maize variety (Oba *Super2)* were planted per hole at a spacing of 75 cm × 25 cm.

Pte-composite soil samples were collected from the experimental sit from 0-30 cm depth. These samples were subjected to laboratory analysis to determine initial soil chemical properties. Soil pH (measured using soil water ratio of 1:1 electrode method by Mclean, (1982) and 1N KCL), Total Nitrogen (was determined by the macro-Kjedahl distillation method (Bremnar, 1965).), Organic carbon was determined using the Walkley and Black (1934) wet oxidation method as modified by Juo (1979).Organic matter content (Van Bremeden factor, 1982), Available phosphoru**s** (extracted using the Bray-1 method), Exchangeable cations (Ca, Mg, K, and Na) measured using an Atomic Absorption Spectrophotometer (AAS), exchangeable cations (Black, 1965).) and base saturation (calculated from the cation exchange capacity). Other agronomic practices were carried out.

Plant height, Number of leaves per plant, leaf area, stem girth and Biomass data were collected at 4 and 8 weeks after planting (WAP).The data collected were subjected to statistical analysis using Analysis of Variance (ANOVA). Treatment means were compared using the Least Significant Difference (LSD) at 5% level. .

RESULTS AND DISCUSSION

The initial soil chemical properties of the experimental site prior to treatment application of 0 - 30 cm depth 2022 is shown in Table 1. The soil pH (5.5) indicates slightly acidic conditions, typical of many tropical soils, and within the pH range (5.05 - 5.40 conducive for maize growth. The low pH of less than 5.5 indicate that the soils may suffer from aluminium toxicity. It has been indicated that aluminium toxicity occur in soils with pH values less than 5.50 and increases in intensity as the pH decreases below 5.0 (White *et al*, 2006). Organic matter content (1.2%) is relatively low, reflecting poor soil fertility likely due to continuous cropping over the years. Soils in this class are low in calcium, magnesium, phosphorus and base saturation which are normally available to plants. Potassium is low (0.2) and falls within the rang of critical limits for soils of southeastern Nigeria (Enwezor et al., 1990) which is indicating low fertility of soils of the study area

Table 1: Initial soil properties of the experimental site

Parameter	Value
Soil pH (H2O)	5.5
Total Nitrogen (%)	0.07
Organic Carbon (%)	0.7
Organic Matter (%)	1.2
Available Phosphorus (mg/kg)	8.5
Exchangeable Potassium (cmol/kg)	0.08
Exchangeable Calcium (cmol/kg)	2.0
Exchangeable Magnesium (cmol/kg)	0.6
Exchangeable Sodium (cmol/kg)	0.12
Base Saturation (%)	42.5

The two years mean soil data was significant ($P<0.05$) and indicated that treatment 80 kg K/ha gave a better effect to the soil than the other treatments and followed by the 60 kg K/ha treatment when compared with the initial soil property and the control Table2 and 3. Generally, the data indicated that the order was 80 kg K/ha > 60 kg K/ha > 40kgK/ha > 20kgK/ha > 0kgK/ha muriate of potash Control (no application). 80kgK/ha also increased the soil pH (5.8 and 5.7) when compared with initial soil properties and control (5.5,5.2 and 5.1 relatively) thereby reducing the soil acidity more than the other treatments and the order was also 80 kg K/ha > 60 kg K/ha > 40kgK/ha > 20kgK/ha > 0kgK/ha muriate of potash Control (no application). From the above soil data for the years and weeks, treatment 80kgK/ha also gave the highest NPK nutrient content. Generally, potassium fertilization significantly ($p<0.05$%) improved the soil chemical properties.The consistent increases in pH, organic carbon, nitrogen, phosphorus, and exchangeable potassium in 4 WAP and 8 WAP confirm the essential role of potassium in promoting nutrient availability in continuously cropped soil as reported by(). The application of potassium fertilizer at 80 kg K/ha though may have given the most significant improvements in soil chemical properties. However, the difference between 60 kg K/ha and 80 kg K/ha is relatively small and comparing with the cost effects, 60kgK/ha could be choosen as an optimal rate to balance input costs with growth benefits.

Table 2: Mean soil chemical properties at 4 weeks after planting (WAP) in 2022 and 2023

Potassium Level (kg/ha)	pH (H2O)	Organic Carbon (%)	Total Nitrogen (%)	Available Phosphorus (mg/kg)	Exchangeable Potassium (cmol/kg)	Exchangeable Calcium (cmol/kg)	Exchangeable Magnesium (cmol/kg)
0	5.2	1.12	0.09	8.5	0.08	2.3	1.1
20	5.4	1.15	0.1	9.2	0.1	2.5	1.2
40	5.5	1.18	0.12	10	0.13	2.7	1.3
60	5.7	1.2	0.13	11.5	0.15	2.9	1.4
80	5.8	1.23	0.14	12	0.16	3	1.5
Mean	**5.5**	**1.18**	**0.12**	**10.2**	**0.12**	**2.7**	**1.3**
LSD (0.05)	**0.2**	**0.03**	**0.01**	**1**	**0.02**	**0.4**	**0.2**

Table 3: Soil chemical properties at 8 weeks after planting (WAP)

Potassium Level (kg/ha)	pH (H2O)	Organic Carbon (%)	Total Nitrogen (%)	Available Phosphorus (mg/kg)	Exchangeable Potassium (cmol/kg)	Exchangeable Calcium (cmol/kg)	Exchangeable Magnesium (cmol/kg)
0	5.1	1.1	0.08	8	0.07	2.2	1
20	5.3	1.13	0.09	8.8	0.09	2.4	1.1
40	5.4	1.16	0.11	9.6	0.12	2.6	1.2
60	5.6	1.18	0.12	11	0.14	2.8	1.3
80	5.7	1.21	0.13	11.6	0.15	2.9	1.4
Mean	**5.42**	**1.16**	**0.11**	**9.8**	**0.11**	**2.58**	**1.2**
LSD (0.05)	**0.18**	**0.02**	**0.01**	**0.9**	**0.01**	**0.3**	**0.1**

Generally, potassium fertilization treatments had significant (P<0.05%) effects in a continuously cropped soil in Ngor Okpala, Imo State. At 4 and 8 after planting, potassium fertilizer application significantly enhanced the early growth parameters of maize, as reflected in plant height, number of leaves, leaf area, stem girth, and biomass accumulation. Each of these parameters showed consistent upward trend with increasing potassium levels. Treatments 80kgK/ha significantly gave the highest plant height (42.3 cm) and (76.0cm) respectively than the other treatments while the control gave the lowest (25.4 cm) and (50.6 cm) respectively. The increase in plant height demonstrates the critical role of potassium in promoting early vegetative growth in maize, with the mean height being (36.06 cm) and (66.64 cm) respectively. The number of leaves was observed with higher potassium rates, starting from 5 leaves in the control and rising to 8 leaves at (80kg K/ha and 60kg K/ha) and 8 leaves to 11leaves at (80kg K/ha and 60kg K/ha) respectively. The data on leave area were also significant with (80kg K/ha) treatment giving the highest number of leave area while control gave the lowest. The stem girth had the highest while control gave the lowest. Biomass yield data showed an increase in biomass accumulation. The order was control < 20kgK/ha < 40kgK/ha < 60kgK/ha < 80kgK/ha which is an indication that potassium fertilization can improve maize yield in Ngor Okpala Imo State. These findings are consistent with other research indicating the necessity of potassium for optimal crop development in potassium-depleted soils (Hossain *et al.,* 2022; Farooq *et al.,* 2023).

Table 4: Effect of potassium fertilizer on early growth yield of maize at 4 weeks after planting (WAP)

Treatment	Plant Height (cm)	Number of Leaves	Leaf Area (cm²)	Stem Girth (cm)	Biomass (g/plant)
K0	25.4	5	110.2	1.2	18.3
K20	32.6	6	145.8	1.5	24.7
K40	38.2	7	170.3	1.7	30.4
K60	41.8	8	190.7	1.9	36.1
K80	42.3	8	195.5	2	37.8
Mean	**36.06**	**6.8**	**162.5**	**1.66**	**29.46**
LSD (0.05)	**3.5**	**1**	**20.5**	**0.2**	**4.8**

Table 5: Effect of potassium fertilizer on early growth parameters of maize at 8 weeks after planting

Treatment	Plant Height (cm)	Number of Leaves	Leaf Area (cm^2)	Stem Girth (cm)	Biomass (g/plant)
K0	50.6	8	210.4	1.8	40.2
K20	61.4	9	250.8	2.1	48.6
K40	70.3	10	290.5	2.4	55.9
K60	74.8	11	320.7	2.6	61.5
K80	76.0	11	325.2	2.7	63.8
Mean	**66.62**	**9.8**	**279.52**	**2.32**	**53.2**
LSD (0.05)	**5.4**	**1.2**	**30.6**	**0.3**	**6.7**

CONCLUSION AND RECOMMENDATIONS

The result showed that Potassium fertilization significantly enhanced the early growth and yield of maize in continuously cropped soils in Ngor Okpala, Imo State, with the most substantial effects observed at (60 kg K/ha and 80 kg K/ha). Potassium application also improve soil fertility of soils of Ngor Okpala, Imo State. .

The (80 kg K/ha) gave the highest early maize growth and yield. The difference between 60 kg K/ha and 80 kg K/ha data was minimal and comparing the cost effects, 60kgK/ha was recommended as an optimal rate to balance input costs with growth benefits.

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Gender Differences in the Adoption of Ginger Production Technologies in South-East and South-South, Nigeria

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Abstract
This study investigated the factors influencing the adoption of ginger production technologies among male and female farmers in South-east and South-south Nigeria. Using a multistage sampling procedure, 95 ginger farmers were selected from Abia and Rivers states. Data was collected through structured questionnaires and analyzed using descriptive statistics and inferential statistics. The findings revealed that male farmers have higher adoption rates of improved technologies such as seed treatment (84.9% males; 59.5% females) and fertilizer application (94.3% males; 78.6% females). Socioeconomic factors, particularly extension contact and farm size, significantly influenced technology adoption, with males showing a stronger correlation. Regression analysis showed that socioeconomic variables explained 71.4% and 65.6% of the variation in technology adoption for males and females, respectively. The study underscores the need for gender-sensitive interventions, including targeted extension services and land tenure reforms, to address the disparities in technology adoption.

INTRODUCTION

Ginger (*Zingiber officinale*) is a valuable crop extensively cultivated in Nigeria for its rhizome, which has various applications, including as a spice, medicine, and in industrial processes. The crop plays a crucial role in generating revenue, foreign exchange, and job opportunities, particularly for smallholder farmers, with women significantly involved in its production, processing, and marketing (Sodangi, 2020a; Onwunali et al., 2023). Nigeria ranks among Africa's leading ginger producers, contributing to over 20% of global production, with the industry experiencing growth due to increasing domestic and international demand (FAOSTAT, 2020; AgroNigeria, 2020). However, despite this growth, ginger production in Nigeria faces several challenges, including low yields, limited access to credit and markets, and significant gender disparities in the adoption of production technologies (Ibeneme, Igwe, & Akwuegbu, 2022). Gender differences in the adoption of agricultural technologies are particularly notable, as women—who play essential roles in agriculture—often face limited access to resources, credit, and technologies compared to their male counterparts (World Bank, 2019). Addressing these disparities is crucial for promoting gender equality and improving the livelihoods of smallholder farmers, especially in the ginger industry. This study explored gender differences in the adoption of ginger production technologies in the South-East and South-South regions of Nigeria. It specifically: (1) described the socioeconomic characteristics of farmers by gender, (2) assessed the level of adoption of ginger production technologies by gender, and (3) ascertained the factors influencing the adoption of ginger production technologies by gender.

METHODOLOGY

This study employed a multistage sampling procedure to select ginger farmers from the South-east and South-south zones of Nigeria. In the first stage, one state from each zone was purposively selected based on the effectiveness and activeness of the ginger cooperative society in the state. Abia state was selected from the South-east zone, while Rivers state was selected from the South-south zone. In the second stage, 50 active members were randomly selected from the Nigeria Ginger Farmers Association (NGAN) - Rivers state chapter, while 45 active members were randomly selected from NGAN - Abia state chapter. This gave a total sample size of 95 ginger farmers (53 males and 42 females). A structured questionnaire was administered to the selected farmers to gather information on their demographic characteristics, ginger production practices, technology adoption, and gender-related factors affecting ginger production. The data collected was analyzed using descriptive statistics, frequency distributions, and inferential statistics (Linear regression) to determine the gender differences in ginger production technologies and factors influencing adoption of ginger production technologies.

Model specification

The implicit form of regression model is specified as follows:

$$Y = F\ (X_{1,}\ X_{2,}\ X_{3,}\ X_{4,}\ X_{5,}\ e)$$

Y = Adoption of ginger production technologies by gender
The independent variables are:
X_1 = Age of respondents (No. of yrs of age); X_2 = Level of education (No. of years of schooling); X_3 = Extension contact (No. of extension visits received by farmers in a yr); X_4 = Ginger farm size (Ha); X_5 = Ginger farm experience (Yrs); e = error term.

RESULTS AND DISCUSSION

Socioeconomic Characteristics of the Respondents

This section discussed the socio-economic characteristics of farmers which are known to influence adoption of agricultural technologies. The study found that most ginger farmers in Nigeria are within the productive age range and have a relatively high level of education. However, a significant portion lacks access to extension services, hindering their ability to adopt improved practices. Women farmers, in particular, are disadvantaged in terms of farm size and access to resources, leading to lower incomes and productivity. For instance, while 75.5% of male farmers had more than 1 hectare of land, only 50% of female farmers did. Additionally, 26.4% of male farmers earned over N400,000 annually, compared to just 10% of female farmers. To address these disparities, it is crucial to provide targeted support to farmers, improve access to extension services, and promote gender equality in the agricultural sector. By implementing these measures, Nigeria can enhance agricultural productivity, improve food security, and empower its rural communities.

Table 1: Socioeconomic characteristics of the respondents

Variable	Male (N=53)			Female (N=42)		
	Frequency	%	Mean	Frequency	%	Mean
Age						
21 – 40	5	9.43		7	16.67	
41 – 60	40	75.47		29	69.05	
61 – 80	8	15.10	**51.7**	6	14.28	**50.6**
Total	53	100		42	100	
Marital Status						
Married	50	94.34		39	92.86	
Single	3	5.66		1	2.38	
Widowed	-	-		2	4.76	
Total	53	100		42	100	
Household size						
1 -5	37	69.81		23	54.76	
6 – 10	16	30.19	**5**	19	45.24	**6**
Total	53	100		42	100	
Formal Education						
No formal Education	-	-		-	-	
Primary Education	1	1.89		1	2.38	
Secondary Education	22	41.51		13	30.95	
Tertiary Education	30	56.60		28	66.67	
Total	53	100	**14.6**	42	100	**15.7**
Years of farming ginger						
1 – 5	47	88.68		32	76.19	
6 – 10	6	11.32		10	23.81	
Total	53	100	**3.2**	42	100	**3.8**
Ginger Farm Size (ha)						
0.1 – 1.0	13	24.53		22	52.38	
Above 1.0	40	75.47	**2.7**	20	47.62	**1.4**
Total	53	100		42	100	
Extension Contact						
Yes	7	13.21		15	35.71	
No	46	86.79		27	64.29	
Farm income (N)						
No income	2	3.76		1	2.38	
1 - 100,000	3	5.66		2	4.76	
100,001 – 200,000	4	7.55		13	30.95	
200.001 – 300,000	17	32.08		11	26.19	
300,001 – 400,000	13	24.53		11	26.19	
>400,000	14	26.42		4	9.52	
Source of land						
Personal	3	5.66		7	16.67	
Rented/Leased	8	15.09		12	28.57	
Family	3	5.66		2	4.76	
Cooperative	39	73.59		21	50.00	
	53	100		42	100	

Source: Field Survey, 2023

Adoption of Improved Ginger Production Technologies by Gender

Technological Innovation if properly understood from the gender perspective can foster increase in agricultural productivity (Tavya et. al. 2013).

Table 2: Percentage Distribution of Farmers according to their Adoption of improved ginger production technologies by Gender

		Male (%)		Female (%)	
S/N	**Technologies**	**Yes**	**No**	**Yes**	**No**
1	Treatment of seeds before planting	84.91	15.09	59.52	40.48
2	Recommended planting distance	96.23	3.77	90.48	9.52
3	Mulching	96.23	3.77	97.62	2.38
4	Fertilizer Application	94.34	5.66	78.57	21.43

Source: Field Survey, 2023

Table 2 reveals high adoption rates of improved ginger production technologies among male and female farmers, with 84.91% of males and 59.52% of females adopting seed treatment, 96.23% of males and 90.48% of females using recommended planting distances of 20 x 20cm, nearly equal adoption of mulching (96.23% males, 97.62% females), and 94.34% of males and 78.57% of females applying fertilizers, highlighting the need for gender-sensitive interventions to address gaps in seed treatment and fertilizer use to boost agricultural productivity.

Factors Influencing Adoption of Improved Ginger Production Technologies by Gender

Linear regression analysis of factors influencing adoption of improved ginger production technologies is presented in Table 3.

Table 3: Linear regression analysis of socioeconomic factors influencing adoption of improved ginger production technologies by gender

Variable	**Male**		**Female**	
	Coefficient	**t-value**	**Coefficient**	**t-value**
Constant	0.7485	6.80 ***	1.0053	5.26 ***
Age	0.0021	1.60	-0.0017	-0.59
Education	-0.0319	-1.10	-0.0521	-1.28
Ext. Contact	0.1604	3.06 **	-0.1112	-1.77 *
Ging Farm size	0.0063	5.91 ***	0.0052	3.78 ***
Ging Farm Exp	-0.0238	-2.20 **	0.0013	0.11
R^2	**0.7135**		**0.6555**	
Adjusted R^2	**0.6830**		**0.6063**	
F-Statistic	**23.41**		**13.32**	

N: Male- 53, Female - 42; *significant at 10%,**significant at 5%, *** significant at 1%

The regression analysis revealed that socioeconomic factors significantly influence the adoption of improved ginger production technologies among both male and female farmers in Nigeria. For males, 71.35% of the variation in technology adoption can be explained by these factors, while for females, is 65.55%. The F-statistics of 23.41*** for males and 13.32*** for females indicate that the results are statistically significant and normally distributed.

Male farmers who had more contact with extension agents were more likely to adopt new technologies. However, for females, the relationship was less clear, potentially due to resource constraints and competing priorities. Farm size was positively associated with technology adoption for both genders while farm experience was negatively associated with adoption for males, it did not significantly influence female adoption.

These findings suggest that providing targeted extension services, supporting land tenure reforms, and addressing gender-specific challenges are crucial for promoting the adoption of improved ginger production technologies among farmers. By improving access to resources and support for female farmers, Nigeria can enhance ginger productivity, reduce gender inequality, and bolster rural development

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Biochar and Zinc Rate Interaction Effects on Nutritional Composition of Fenugreek (*Trigonella foenum-graecum* L.) Fresh Shoot Yield in Lowland Tropics, Umudike, Southeast Nigeria

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Abstract
A field-pot experiment was conducted at the Department of Agronomy, Michael Okpara University of Agriculture, Umudike, Research and Teaching Farm (latitude 5°29' N, longitude 7°33' E and altitude 122 m above sea level) in 2022. The study assessed the effect of zinc rate, biochar rate and their interaction on growth, fresh shoot yield, and proximate and nutritional composition of fenugreek (Trigonella foenum-graecum) shoot. The treatments comprised all combinations of three rates of zinc (0, 3, 6 kg ha^{-1}) and biochar (0, 5, 10 kg ha^{-1}), which gave nine treatment combinations. The experiment was laid out in a 3 × 3 factorial arrangement in a completely randomized design with three replications. The data collected were subjected to analysis of variance using the GenStat statistical package and the significant means were separated using Fisher's least significant difference at $P<0.05$ probability level. The results showed that zinc, biochar rates and the interaction significantly affected several leaves, fresh shoot yield, and nutritional quality of fenugreek. Applying 10 kg biochar ha^{-1} gave the highest fresh shoot yield compared to the other treatments. Furthermore, the interaction between 3 kg zinc ha^{-1} and 10 t biochar ha^{-1} exhibited the highest number of fresh leaves per plant, the highest amount of ash, crude protein, crude fibre and carbohydrate while the interaction between 6 kg zinc ha^{-1} and 10 t biochar ha^{-1} gave the highest β-carotene, zinc, nitrogen, phosphorus and potassium contents in fenugreek shoot compared to the other treatments. The highest amount of chlorophyll, chlorophyll, vitamin C and vitamin B_3 was recorded under 3 kg zinc ha^{-1} by 5 t biochar ha^{-1} interaction compared with the other treatments. This implied that the interaction between 3 kg zinc ha^{-1} and 10 kg biochar ha^{-1} positively impacted the nutritional quality of fenugreek shoots. The study requires further investigation under the Umudike condition.

Keywords: Fresh shoot yield, proximate analysis, nutritional composition, chlorophyll

INTRODUCTION
Fenugreek (*Trigonella foenum-graecum* L.) is an annual, herbaceous forage legume crop belonging to the Fabaceae family and widely cultivated in the Mediterranean region, Asia and the highlands of Ethiopia. According to Ecocrop (2017), fenugreek grows well in dryland areas and the plant shoot and seeds have a characteristic strong odour. The shoots have strong medicinal values because they are rich in antioxidant and antimicrobial properties and can significantly reduce blood glucose and cholesterol levels (Kooti, 2017; Kandhare, 2019). Fenugreek, a culinary spicy crop is used to

enhance the flavour, colour and taste (Jakhar *et al*., 2013). It provides green fodder palatable to ruminants. Biochar, a burnt product of plant or animal waste or a combination of both contain nutrients that can enhance the growth of plants and improve the soil ecosystem (Wijewarden and Yapa, 1999). The nutrients from biochar are slowly released in the soil, hence they last longer and are more efficient because the nutrients are contained in complex molecules that do not easily leach away with the rains (Verma, 2014). Also, according to Loneragan (2016), biochar is used to improve soil nutrient content and sequester carbon from the environment.

Micronutrients are important for crop growth and development but are required in small amounts. However, it is involved in critical enzymatic reactions such as photosynthesis and plant respiration. Zinc, a micro-nutrient in cells throughout the body plays a key role in the body's defensive (immune) system to properly work. It enhances cell division, cell growth, wound healing, and the breakdown of carbohydrates according to Sandstead (2000) and Hunt (2002). Zinc deficiency retards the growth and yield of plants and has a strong effect on human beings, especially children between zero to five years of age and lactating mothers (Gong *et al*., 2016). Studies have shown that zinc significantly increased the shoot and seed yield (Kordas and Stoltzfus, 2004). Previous studies have shown that fenugreek is a new crop in the humid tropics and there is gross inadequate information on the effect of zinc or biochar on the performance of fenugreek in the humid tropics. Therefore, an investigation on this herbaceous forage legume crop was carried out to assess the effect of biochar, zinc rate and their interactive effects on the performance, proximate composition, nutritional contents and the amount of chlorophyll in fenugreek shoot.

MATERIALS AND METHODS

A pot experiment was conducted in 2022 at Michael Okpara University of Agriculture, Umudike, Nigeria, to study the effects of zinc and biochar on fenugreek growth. Zinc was applied at three rates (0, 3, 6 kg/ha) and biochar at three rates (0, 5, 10 t/ha) in a 3 × 3 factorial design. Fenugreek seeds were primed and sown, with treatments applied seven days after planting. Data on leaf count, fresh shoot yield, and dry matter yield were collected, and the dried plant shoots were analyzed for vitamin and chlorophyll contents

Determination of Ascorbic Acid (Vitamin C): The method described by Okwu and Josiah (2006) was used to extract and measure Vitamin C content. A 10 g sample was extracted with 50 mL EDTA/TCA solution, filtered, and made up to 50 mL. A 20 mL extract was then treated with 10 mL of 10% KI, 50 mL distilled water, and 2 mL of 1% starch indicator, and titrated with 0.01 $CuSO4$ solution to a dark endpoint. The Vitamin C content was calculated using the formula: Vitamin C [mg/100 g] = 0.88 × 100 / 5 × Vf / 20 × T / 1.

Determination of Niacin (Vitamin B_3): The spectrophotometric method by Onwuka (2005) was used to determine niacin content. A 5 g sample was treated with 50 mL of 1 N sulphuric acid, shaken, and filtered after adding ammonia. The filtrate was treated with potassium cyanide and acidified, and absorbance was measured at 470 nm. Niacin content was calculated using the formula: Niacin (mg/100 g) = (100/W × AU/AS × C × Vf / Va) D.

Determination of chlorophyll: This was determined using the spectrometric method. Each sample was weighed into a mortar and 200 mL of 80 % acetone was added before crushing. The paste was diluted to a 100 mL mark with the acetone solution. The absorbance readings of the test sample solutions were read at different wavelengths of 662 mm, and 645 mm. The chlorophyll contents were calculated thus: Chlorophyllα = 11.75 A662 – 2.35 A645; Chlorophyllβ = 18.61 A645 – 3.96 A662.

Statistical analysis

The field pot experiment and laboratory data were analyzed using a factorial design in a completely randomized design with GenStat Discovery, Edition 4.23. Significant means were tested using LSD at $P \leq 0.05$ (Obi, 2002). Pearson correlation analysis was performed with SPSS Ver. 25 to assess correlations of fenugreek fresh shoot yield with other attributes (Singh and Chaudhury, 1985), and significance was tested by the t-test (Vencovsky and Barriga, 1992).

RESULTS AND DISCUSSION

Meteorological data showed that August had the highest rainfall, lowest sunshine duration, and mean air temperature, along with the highest wind speed. Soil analysis indicated a moderately acidic pH (McLean, 1982), low organic carbon and manure, but moderate cations. Organic carbon and organic matter were determined by Nelson and Sommers (1996), nitrogen by Bremner (1996), available phosphorus by Olsen and Sommers (1982), and exchangeable bases by Thomas (1982). The soil texture was sandy loam, and biochar analysis revealed low levels of several nutrients but high organic carbon and manure.

Table 1: Meteorological data of the experimental site in 2021 cropping season

Months	Rainfall (mm)	Max RH (%)	Min RH (%)	Sunshine duration (hr/day)	Mean Temperature (°C)	Wind speed (km/day)
January	9.10	58.30	36.70	4.80	30.30	669.60
February	40.12	69.80	30.20	4.70	29.90	643.20
March	86.60	76.75	46.25	4.60	29.70	736.80
April	192.40	80.10	56.90	4.30	28.20	736.80
may	248.30	81.60	72.40	4.00	27.70	638.40
June	312.50	85.00	66.00	4.00	26.70	669.60
July	325.30	86.50	69.50	2.60	26.80	686.40
August	350.70	84.75	74.25	2.60	25.60	849.60

Source: Meteorological Unit, National Root Crops Research Institute, Umudike

The analysis of variance showed that zinc rate significantly affected the number of leaves, β-carotene content, chlorophyll contents (α and β), and vitamins (ascorbic acid and niacin), but not cumulative fresh shoot yield (Table 3). Biochar rate and the interaction between zinc and biochar rates significantly influenced all variables. The highest number of leaves was observed with 3 kg zinc ha-1, while 6 kg zinc ha-1 resulted in the highest chlorophyll contents and vitamins. Biochar at 10 t ha-1 led to the highest number of leaves, cumulative fresh shoot yield, and higher levels of chlorophyll α, β, and vitamins C and B3. The interaction of 3 kg zinc ha-1 and 10 t biochar ha-1 produced the freshest fenugreek leaves, while 6 kg zinc ha-1 with 10 t biochar ha-1 yielded the highest β-carotene content. The interaction of 3 kg zinc ha-1 and 5 t biochar ha-1 resulted in the highest chlorophyll, vitamin C, and vitamin B3 levels. Similar findings were reported by Swarnakar et al. (2014) and Petropoulos (2002). Bochalia (2008) and Lal et al. (2015) also noted positive responses of fenugreek to sulphur and zinc applications. Correlation analysis (Table 4) showed significant positive relationships between fresh shoot yield and dry shoot yield ($r = 0.83$), and fresh shoot yield and carbohydrate content ($r = 0.58$).

Vitamin C had positive correlations with carbohydrate and zinc contents, but negative correlations with crude protein and nitrogen (r = -0.88 and -0.44, respectively). Chlorophyll α content was positively correlated with chlorophyll β (r = 0.48) and zinc content (r = 0.55), while carbohydrates were positively related to zinc.

Table 2: Physico-chemical analysis of the soil and biochar used in the experiment

	Soil	Biochar
pH (H_2O)	6.2	-
Phosphorus	18.9 (mg/kg)	1.65 (%)
Nitrogen	0.226 (%)	0.78 (%)
Potassium	0.234 (cmol/kg)	1.06 (ppm)
Organic carbon	1.53 (%)	18.5 (%)
Organic matter	2.64 (%)	31.89 (%)
Calcium	6.4 (cmol/kg)	0.64 (%)
Magnesium	0.80 (cmol/kg)	0.47 (%)
Sodium	0.147 (cmol/kg)	0.28 (%)
Zinc	-	0.21 (%)
Exchangeable acidity	0.82 (cmol/kg)	-
Base saturation	90.25 (%)	-
Sand	73.4 (%)	-
Silt	13.7 (%)	-
Clay	12.9 (%)	-
Soil texture: Sandy loam		

Table 3: Summary of Zinc and Biochar Effects on Fenugreek Growth and Nutrients

Treatment	Number of Leaves	Fresh Shoot Yield	Key Nutrients (β-carotene, Chlorophyll, Vitamins)
Zinc Rate	Increased with higher zinc, max at 7.67 leaves (3 kg ha-1)	Max yield: 1136 kg ha-1 (3 kg ha-1)	β-carotene: Max 1136 µg g-1 (3 kg ha-1)
Biochar Rate	Max 7.39 leaves (10 t ha-1)	Max yield: 931 kg ha-1 (10 t ha-1)	Vitamin C: 55.94 mg 100 g-1 (10 t ha-1)
Interaction	Best results with 3 kg Zn + 10 t Biochar (8.33 leaves)	Max yield: 1283 kg ha-1	High chlorophyll and niacin content

Table 4: Pearson's Correlation Matrix Summary

Parameter	Correlation with Fresh Shoot Yield
Dry Shoot Yield	Strong positive (0.83**)
Carbohydrate	Positive (0.58**)
Vitamin C	Weak positive (0.12)
Crude Protein	Weak negative (-0.182)
β-carotene	No significant correlation (-0.05)

Key correlations: Strong positive correlation between fresh and dry shoot yield, carbohydrate, and moderate impact of protein and β-carotene.

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An Analysis of Technology Dissemination, Utilization, Awareness, and Adoption by the National Root Crops Research Institute in the Umuahia Agricultural Zone, Nigeria

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Abstract
The study examined NRCRI on Technology Dissemination, Utilization, Awareness and Adoption in Umuahia Agricultural Zone, Abia State, Nigeria. Data was collected from 100 farmers using a multistage sampling method. A series of questionnaires was employed in order to gather data. For data analysis, basic descriptive statistics were employed. The study's findings revealed that the majority of respondents were married and that the mean age of those surveyed in the study area was 49. The respondents' households were larger than usual. The bulk of research staff members have a very positive attitude toward sharing research findings with farmers, and the majority of respondents had farms that sized no more than two hectares. Farmers were aware of the caliber of research results (better technologies). This suggests that small, dispersed, and non-contiguous farm holdings are the study area's defining characteristics. Their low farm income and low farm output may also be impacted by their small farms. Out of the five statements pertaining to research staff attitudes toward sharing research findings with farmers, three were viewed favorably by the staff. As a result, it was suggested that the Research Institute strengthen its innovation dissemination strategies and capacities. Specifically, this should include raising awareness of new technologies through local village chiefs, churches, clubs, and cooperative societies and effectively distributing technology to target farmer's groups through rallies. Research organizations should work to improve farmers' low adoption of NRCRI-developed agricultural innovations.
Keywords; Technology dissemination, Utilization, Awareness, Adoption.

INTRODUCTION

The National Root Crops Research Institute (NRCRI) was established with the mandate of conducting research on the genetic improvement, production, processing, storage and socioeconomics of economically significant root and tuber crops, such as yams, cassava, potatoes, sweet potatoes, cocoyam, ginger, Hausa potatoes and addressing issues in their production (Egesi, 2023).

Additionally, NRCRI's Zonal Mandate encompasses the South-East Agro-Ecological Zone's whole farming system. The zone includes the Nigerian states of Abia, Anambra, Ebonyi, Enugu, and Imo (Egesi, 2023). NRCRI, Umudike, has substantially contributed to the National Food Security and Sufficiency through research and extension activities on root and tuber crops. Nigeria is now ranked first in the world production of cassava, yam, and cocoyam with total annual productions of over 60, 40, and 4 million metric tonnes for cassava, yam, and cocoyam, respectively (FAOSTAT, 2021). The production of Irish Potatoes in Nigeria has witnessed a significant increase, rising from 523,000 metric tonnes in 1975 to surpassing 1 million metric tonnes. Productions have also expanded from Jos Plateau to Sokoto, Kaduna, Kebbi, Kano Jigawa, Bauchi, Yobe, and Borno states where potato is produced under irrigation during the harmattan months (November to February). Also, the Institute has developed a technique for the use of true potato seed (botanical seed) instead of the traditional seed tubers for seed potato production.

Agricultural technology encompasses the use of advanced engineering, scientific breakthroughs, and farming practices to manage the growth, development, and health of crops and livestock (Nnodim et al., 2020). Technology transfer in agriculture occurs when individuals acquire, adapt, or replicate innovations developed elsewhere to boost agricultural productivity. The effective use of such technology is a primary indicator of the success of research and development (R&D) and reflects its broader impact through increased adoption (Mgendi et al., 2019).

Despite the existence of organizations dedicated to agricultural research, the region continues to grapple with food insecurity. This raises a critical question: why does the government continue to allocate a significant portion of its foreign exchange earnings to importing food crops when improved root and tuber crops could serve as effective substitutes? Researchers are expanding the understanding of root and tuber crops, which offer substantial potential for enhancing food security, health, and nutrition. Therefore, this study seeks to examine the role of the National Root Crops Research Institute (NRCRI) in the dissemination, utilization, awareness, and adoption of technology in the Umuahia Agricultural Zone, Nigeria.
The study specifically:

i. Describe the demographic characteristics of the respondents:
ii. Examine research staff attitudes to dissemination of research findings:
iii. Examine farmer's attitudes to utilization of research findings:
iv. Ascertain the level of farmer's awareness of technology innovation: and
v. Ascertain the adoption level of agricultural innovation by farmers.

METHODOLOGY

The study was carried out in Umuahia Agricultural zone, Abia State, Nigeria. Abia state lies between longitude 7°30'00"E and latitude 5°25'00"N of the equator and has a tropical and humid climate all year round. The rainy season ranges from March to October while the dry season occurs from November to February. The mean annual rainfall ranges from 2000mm to 2500mm with the southern areas receiving more than the northern areas. The temperature ranges between 22° C and 31° C. The state has 17 Local Government Areas and is divided into three Agricultural zones namely, Aba, Ohafia, and Umuahia (Maduka et; al, 2023). Umuahia agricultural zone is made up of six Local Government Areas; Umuahia North, Umuahia South, Isiala Ngwa North, Isiala Ngwa South, Ikwuano and Umunneochi. About 60 – 70% of the population is engaged in agriculture primarily crop production and animal rearing (Nnamerenwa, 2012).

Sampling Procedure and Data Collection

The study made use of primary data that were collected through a multistage random sampling technique in selecting a sample of 120 respondents. The first stage involved the purposive selection of Umuahia and Ikwuano Local Government Areas. In the second stage, three communities were purposively chosen from Umuahia North Local

Government Area, namely Umuohu, Ahiaeke, and Ndume Autonomous Community. Similarly, in Ikwuano, three communities were purposively selected: Umudike, Amawom, and Umuariaga Autonomous Community. From each of these selected communities, 20 farmers were randomly chosen, resulting in a total sample size of 120 farmers for the study.

Measurement of variables

Objectives i, iv, and v were realized using frequencies and percentages while objectives ii and iii were realized using means scores derived from a four-point Likert-type rating scale of strongly agree (4 points), agree (3 points), disagree (2 points), and strongly disagree (1 point), a benchmark mean of 2.5 was used in decision making.

RESULTS AND DISCUSSION

Demographic Characteristics of the Respondents

A frequency distribution of the respondents based on different demographic variables is shown in Table 1. The majority of sampled respondents (62.2%) were female, whereas men (37.8%) made up the majority of respondents. These findings suggest that women are more involved in the production of root and tuber crops in the study area than men. The study area's respondents' average age is 49, suggesting that middle-aged individuals dominate the agricultural industry. The outcome additionally demonstrates that 64.5% of the respondents were married. This could be an added benefit in that encouraging spouses might be a significant source of inspiration and drive to make sure that innovations are implemented in the research field. The result also shows that 61.1 percent of the respondents have households with between 6 and 10 people. According to this finding, the respondents' households were larger than usual. This number of household members may lead to increased output and income generation from their farms. In terms of education, about (37.8%) of the respondents attained primary, or secondary (32.2%), 20% had tertiary education and 10 percent had no formal education. The farmers may thus be considered literate. This is an advantage in that education should assist these farmers to understand better the farming innovations being introduced to them. This is consistent with the findings of Adedoyin et al. (1999), who identified education as a foundation for farmers' use of agricultural innovations. The result shows that the mean farm size is 1.8 hectares. The majority of the respondents (86.7%) had farm sizes of 2 hectares or less, implying that the study area is characterized by small, fragmented, and noncontiguous farm holdings. The small farm sizes may also affect their farm output and hence low farm income. Only 28.9% had less than 5 years of farming experience, 53.3% had between 6-10 years of experience, 10.1% had between 11-15 years of experience, and 6.7 percent had above 16 years of farming experience in the study area.

Table 1: Demographic characteristics of the Farmers: (n=120)

Variables	Frequency	Percentage
Sex:		
Male	34	37.8
Female	56	62.2
Age:		
≤30	21	23.3
31-40	35	38.9
41-50	28	31.1
<51	6	6.7
Mean	48.8	
Marital status:		
Single	3	3.3
Married	58	64.5
Divorced	9	10
Widowed	20	22.2
HH size:		
≤5	27	30
6-10	55	61.1
>11	8	8.9
Ed**ucational Level:**		
No formal Edu.	9	10
Primary	34	37.8
Secondary	29	32.2
Tertiary	18	20
Farm Size:		
≤1	27	30
1.01-2	51	56.7
2.01-3	8	8.9
>3	4	4.4
Years of experience in business:		
≤5	26	28.9
6-10	48	53.3
11-15	10	10.1
>16	6	67
Mean	16.5	

Source: field survey, 2023

Research Staff attitudes to Dissemination of Research findings

Research staff attitudes to the dissemination of research findings are presented in Table 2. Research staff expressed a positive attitude towards 3 statements out of the 5 statements bordering on research staff attitudes towards the dissemination of research findings to farmers. Specifically, the following statements elicited favourable (positive) attitude from the research staff: Dissemination of research findings has made agricultural services to be more relevant and responsive to farmers' needs (x = 3.5); Most research staff are not willing to participate in the dissemination of research findings due to lack of funds (x = 3.2); Participation in dissemination of research findings is a prerequisite to effect agricultural development (x = 2.85). However, the research staff disagreed with the following statement; Farmer's stand to lose as a result of poor participation of research staff in the dissemination of research findings (x = 2.23); Participation in dissemination of research findings by research staff is not the best alternation to creating agricultural extension institute within the locality (x = 1.68). These findings show that the majority of the research staff has a strong positive attitude towards dissemination of research findings to farmers.

Table 2: Research staff attitudes to dissemination of research findings:

Research staff attitudes to dissemination of research findings	Strongly Agree	Agree	Disagree	Strongly Disagree	Sum of Scores	Mean Score
Dissemination of research findings has made agricultural services to be more relevant and responsive to farmers' needs.	20	20	-	-	140	3.5*
Most research staff are not willing to participate in the dissemination of research findings due to lack of funds.	20	12	4	4	128	3.2*
Participation in dissemination of research findings is a prerequisite to effect agricultural development.	17	10	3	10	114	2.85*
Farmer's stand to lose as a result of poor participation of research staff in the dissemination of research findings.	-	20	10	10	90	2.23
Participation in dissemination of research findings by research staff is not the best alternation to creating agricultural extension institute within the locality.	2	3	15	20	67	1.68

Source: field survey, 2023. * Represent acceptance of statement

Farmer's Attitudes to Utilization of Research Findings

Table 3 shows the farmer's attitudes to utilization of research findings, to as farmers expressed positive attitude towards 4 statements out of the 5 statements bordering on farmer's attitudes towards their utilization of research findings. Specifically, the following statement elicited favourable (positive) attitude from the farmer's: Most research findings are usually less time consuming (2.75); Most research findings make one feel socially relevant (3.45); It requires more capital outlay (3.03); No much difference exists between research findings and local technology (1.33) and Most research findings do not conform with land tenure system (2.45). However, farmers disagreed with 1 statement out of 5 statements bordering on farmers attitudes towards their utilization of research findings, specifically, no much difference exists between research findings and local technology elicited unfavourable (negative) attitudes from the farmer's. These indicate that the farmers understand the quality of research findings (improved technologies) and will stick to its use rather than utilizing local technologies in positively improving their agricultural activities and productivity.

Table 3: Farmer's attitudes to utilization of research findings

Farmer's attitudes to utilization of research findings	Strongly Agree	Agree	Disagree	Strongly Disagree	Sum of Scores	Mean Score
Most research findings are usually less time consuming	10	10	20	-	110	2.75*
Most research findings make one feel socially relevant	20	18	2	-	138	3.45*
It requires more capital outlay	15	13	10	2	121	3.03*
Not much difference exists between research findings and local technology	-	-	13	27	53	1.33
Most research findings do not conform with land tenure system	12	4	14	10	98	2.45*

Source: field survey, 2023. *Represent acceptance of the statement

Level of farmer's awareness of Technology Innovation

Table 4 shows the level of farmers awareness of Technology Innovation, that majority (86%) of the farmers were aware of the technology being introduced to them. This high level of awareness is an advantage for the research institute developing the technologies in the sense that it makes the work of acquainting the farmers with the technology much easier. For farmers, being aware of the technology might result in either indifference or a lack of motivation to adopt and apply it in practice.

Table 4: The level of farmer's awareness of technology innovation

Awareness of innovation	Frequency	Percentage
Not aware	14	14.0
Aware	86	86.0
Total	**100**	**100.00**

Source: field survey, 2023.

Adoption level of agricultural innovation by farmers

Table 5 shows that majority (47.0%) of the farmers adopted at most four agricultural innovations in the last farming season. The mean level of adoption of agricultural innovation by the respondents was approximately three (3). About 47 percent of the respondents were only able to adopt at most four (4) NRCRI, agricultural innovations in the last farming season. This is quite low and may imply that the end-users do not really understand the innovations. It may also mean the end-users do not have the resources to acquire and adopt the innovations as well as lack of interest or determination to abandon old traditional agricultural practices for new and modern ones. More so, farmer's unawareness of the technology findings of the research institute (NRCRI) may be an irrefutable factor that influenced the level of adoption of technology findings of the research institute (NRCRI) by the end-users. This low level of adoption of NRCRI agricultural innovations by the farmers in the study area implies that the desire for higher levels of output from these farmers may not be achieved thus putting a delay on the much-desired increased national agricultural production as well as the development of agricultural practice and productivity in the study area.

Table 5: adoption level of agricultural innovation by farmer's

Level of adoption	Frequency	percentage
1 – 2	40	40.0
3- 4	47	47.0
5 – 6	10	10.0
7 – 8	3	3.0
Total	100	100.0
Mean	2.60	

Source: field survey, 2023

CONCLUSION AND RECOMMENDATIONS

The majority of the respondents in the study area were married, with a mean age of 49 years. The respondents' households were larger than usual. This number of household members could result in higher farm output and revenue generation. This is advantageous since education ought to help these farmers better comprehend the agricultural innovations that are being offered to them. Farmers may therefore be regarded as literate, as women are more involved in the production of root and tuber crops than men are, and over half of the respondents have households with six or more people. People in their middle years dominate the agricultural industry. This could be an added benefit in that encouraging spouses might be a significant source of inspiration and drive to make sure that innovations are implemented in the research field. Most respondents owned farms with two hectares or less, and most research staff members have a very positive attitude toward sharing research findings with farmers. Farmers were aware of the caliber of research results (better technologies). It is implied that the study area is made up of small, dispersed, and irregular farm holdings. The small farm sizes may also affect their farm output and hence low farm income. Research staff expressed positive attitude towards 3 statements out of the 5-statement bordering on research staff attitudes towards the dissemination of research findings to farmers.

The following recommendations where proffer:

- The research institute should strengthen its capacity and methods for disseminating innovations, particularly in the areas of educating the public about new technologies through local village chiefs, churches, clubs, and cooperative societies and effectively distributing technology to targeted farmer's groups through rallies and seminars.
- The institute should develop technologies that, when given to farmers, will enable them to sufficiently increase their output, regardless of the small farm size that requires them to farm at a particular scale.
- Research institutions ought to work to improve farmers' meager adoption of agricultural innovations created by NRCRI.

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Constraints Militating Youth's Engagement in Agribusiness Activities in Niger State, Nigeria

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Abstract
The study identified the constraints militating youth's engagement in agribusiness activities in Niger State. A multistage random sampling technique was used to select one hundred and twenty respondents for the study. Data were obtained using structured interviews scheduled and analyzed with descriptive statistics. Results revealed that the youths were mostly engaged in the transportation business ($\bar{x}$ = 2.5), crop farming ($\bar{x}$ = 2.1) and marketing of agricultural produce ($\bar{x}$ = 2.0). The findings indicated that the major constraints to youths' engagement in agribusiness activities were lack of interest ($\bar{x}$ = 2.63), inadequate capital/credit facilities ($\bar{x}$ = 2.41), poor marketing channels ($\bar{x}$ = 2.23) and poor technical skill ($\bar{x}$ = 2.10). Therefore, the study suggested that every stakeholder at play, particularly legislatures, religious leaders and community leaders, should provide youths with training and retraining to enhance their knowledge of the significance of their engagement in agribusiness.
Keywords: Agribusiness, Youth, Engagement Activities and Niger State.

INTRODUCTION

The development of the agricultural sector of the Nigerian economy depends largely on the young people, especially the rural youths. This is because a large population of youths represents the link between the present and the future and a reservoir of labour (Hassan, 2020). Because young people are found to have certain qualities desirable for sustainable development, such as innovative behaviour, greater physical strength, and quick learning, their integration into agribusiness is therefore crucial to the development of the agricultural sector (Bello, 2021). The low percentage of youth engagement in agriculture has been a major cause for concern, particularly because millions of youths have no prospect of finding white-collar jobs or starting their own business (Mark, 2021). According to Njoku *et al.* (2022), there has been an increasing commitment to engage youths in agricultural activities throughout Nigeria and Africa. Some of these initiatives include N-power, also known as N-agro, which was launched in 2016 and is still ongoing; the Fadama Guys program; the African Union adopted the African Youth Charter (AYC) in 2006; the Youth Decade Plan of Action, which was launched in 2009 and runs through 2018; the creation of the Youth Desk within the New Partnership for Africa's Development (NEPAD, 2017) and the Comprehensive African Agriculture Development Program (CAADP) (Oguh, 2022). A few governments have tried to promote youth involvement in agriculture, but the outcomes have not been entirely satisfactory. This study aims to identify the constraints that impede youths from engaging in agribusiness activities.

METHODOLOGY

The study was carried out in Niger State which is located within 8^0 22'N and 11^0 30'N and Longitudes 3^0 30'E and 7^0 20'E with an average annual rainfall in the State is 1,219 mm. The State covers an estimated total land area of 76,363sq.km, which is about 8% of Nigeria's total land area with a population of 3,954,772, comprising 2,082,725 males and 1,867,524 females (National Population Commission (NPC), 2006). The State's projected population as of 2021 was 5,644,139, with a 3.2% population growth (NBS, 2022). The study used a multistage sampling technique to select the respondents. The three agricultural zones in the state were involved in this study namely Niger East, Niger North and Niger South. Two circles were randomly selected in each of the agricultural zones. Ten individuals, each aged thirty (30) or younger, were randomly chosen from each selected group. This gave a sample size of one hundred and twenty (120) respondents. Primary data was collected through interviews and structured questionnaires. The data collected were analyzed using descriptive statistics, such as percentages, means, and an engagement index. Engagement index using a 3-point Likert type rating scale of Not engaged = 1, Rarely engaged = 2, Engaged = 3. The mean score for each activity was calculated; any mean score equal to or above 2.0 means full engagement. Constraints were also assessed using a 3-point Likert-type rating, with the scores weighted as follows: never = 1, mild = 2, and severe = 3. Mean score responses equal to or above the calculated mean score of 2.0 were regarded as serious constraints.

RESULTS AND DISCUSSION

Level of Youth Engagement in Agribusiness Activities

Table 1 shows the level of youth engagement in agribusiness activities in the study area. From the results, the youths were fully engaged in transportation ($\bar{x}$ = 2.5), crop farming ($\bar{x}$ = 2.1) and marketing ($\bar{x}$ = 2.0). The distribution of agricultural goods has benefited significantly by the full engagement of youths in the transportation of agricultural produce from one place to another. Good soil fertility in the study area may be one of the causes of youths' full engagement in crop farming by allowing them to boost yield. Youth's full engagement in marketing could be attributed to the highly business-savvy population in the study area, so youths are also involved. The results also show that the youths were not fully engaged in weeding ($\bar{x}$ =1.0), tillage ($\bar{x}$ =1.4), bush clearing ($\bar{x}$ =1.6), processing produce ($\bar{x}$ =1.7) and livestock rearing ($\bar{x}$ =1.8). The youths' low level of engagement in agribusiness activities was indicated by the grand mean (1.8) of the engagement index analysis. This could be due to the lack of capital and credit facilities for youths engaged in agriculture. This is in line with the report of Tunde *et al.* (2021) that there is a low level of youth engagement in agribusiness in Kwara State due to inadequate capital.

Table 1: Engagement Index Result showing Level of Youth Engagement in Agribusiness Activities

Activities	Mean scores
Livestock rearing	1.8
Crop farming	2.1
Processing produce	1.7
Marketing	2.0
Transportation	2.5
Bush clearing	1.6
Tillage	1.4
Weeding	1.0
Mean	1.8

Source: Field Survey, 2023. Full Engagement ≥ 2, Low level of Engagement < 2.

Constraints to Youths' Engagement in Agribusiness Activities

Table 2 shows the constraints to youths' engagement in agribusiness activities. From the results, there are many constraints hindering youths' engagement in agribusiness activities and serious among them were lack of interest ($\bar{x}$ = 2.63), inadequate capital/credit facilities ($\bar{x}$ = 2.41), poor marketing channels ($\bar{x}$ = 2.23) and poor technical skill ($\bar{x}$ = 2.10). This agrees with the report of Mazza (2016) that the major constraints faced by youths in participating in agricultural activities were inadequate fund, poor technical skill and lack of government support. Other non-serious constraints impeding youths' engagement in agribusiness were lack of agricultural inputs ($\bar{x}$ = 1.38), pest and diseases ($\bar{x}$ = 1.33), poor storage facilities ($\bar{x}$ = 1.30), cultural and religious belief ($\bar{x}$ = 1.28), inadequate farm tools ($\bar{x}$ = 1.25), low yield of crops ($\bar{x}$ = 1.23) and lack of awareness ($\bar{x}$ = 1.19).

Table 2: Constraints to Youths Engagement in Agribusiness Activities

Constraints	Never	Mild	Severe	Total	Mean	Rank
Poor Technical skill	34(34)	40(80)	46(138)	252	2.10	4
Lack of agricultural inputs	91(91)	13(26)	16(48)	165	1.38	5
Lack of Interest	17(17)	11(22)	92(276)	315	2.63	1
Cultural/ Religious belief	97(97)	13(26)	10(30)	153	1.28	8
Lack of awareness	104(104)	9(18)	7(21)	143	1.19	11
Low yield of crops	100(100)	12(24)	8(24)	148	1.23	10
Inadequate farm tools	102(102)	6(12)	12(36)	150	1.25	9
Pest and diseases	95(95)	10(20)	15(45)	160	1.33	6
Poor storage facilities	93(93)	18(36)	9(27)	156	1.30	7
Inadequate capital/credit facilities	15(15)	41(82)	64(192)	289	2.41	2
Poor Marketing channels	25(25)	43(86)	52(156)	267	2.23	3

Source: Field Survey, 2023. Serious constraints ≥ 2, not serious constraints < 2.

CONCLUSION AND RECOMMENDATIONS

The engagement index analysis revealed that there is a low level of rural youth engagement in agribusiness activities in Niger State. However, the youths were fully engaged in a few agribusiness activities such as agricultural goods from one place to another, crop farming and marketing agricultural produce. Numerous constraints hinder prog youth's engagement in agribusiness activities: lack of interest, inadequate capital/credit facilities, poor marketing channels and poor technical skills. The study recommended that all parties involved — legislatures, religious authorities, and community leaders in particular, should offer youths training and retraining to enhance their knowledge of the importance of their engagement in agribusiness.

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Effect of Time of Application of Organic Foliar Fertilizer on Yield and Quality Rhizome Seed of Turmeric

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Abstract
Two year experiment was carried out at the National Roots Crop Research Institute (NRCRI), Umudike to investigate the time of application of organic foliar fertilizer on yield of Turmeric. The trail was laid out in randomized complete block design (RCBD) with three replications. Treatments consisted of two species of Turmeric; Curcuma Xanthorhiza and Curcuma longa. Organic foliar fertilizer (Boost extra), time of foliar application (0 ,4 ,8 and 12WAP) respectively with eight treatments combinations. Growth and yield data were collected as at when due and were subjected to analysis of variance (ANOVA) ,means were separated using least significant difference (LSD).Results showed that growth parameters increased as growth proceeds during the months of observation, time of application significantly (P<0.05) affected the Harvest index ,yield and yield component except the number of primary rhizome which gave the highest yield in t/ha at application of 8WAP for both; Curcuma Xanthorhiza (4.7t/ha) and Curcuma Longa (4.2t/h). In Xan 47% increase in yield was achieved at 8WAP and 33% yield reduction over the control while at 4 and 12WAP recorded 32 and 14.4% increase in yield respectively. Similarly the highest yield in t/ha was achieved in application at 8WAP (11.7t/h) in longa while 33% reduction in yield was recorded over the control (7.8t/h). It was concluded that the two species used in this work showed production potential in Turmeric rhizome yield due to application of Boost extra foliar organic fertilizer. Therefore for the optimum production of Turmeric using Boost extra it is recommended for application at 8WAP.
Keyword; Rhizome, seed, organic fertilizer, yield and harvest index

INTRODUCTION

Time of supplemental nutrition is considered to be an efficient method required by plant at different critical stage of growth. Foliar application is credited with the advantage of quick and efficient utilization of nutrient, elimination of losses through leaching, fixation and regulating uptake of nutrients by the plant .Since foliar nutrients usually penetrate the leaf cuticle or stomata and enters the cell facilitating easy and rapid utilization of nutrients. (Sobulo and Osiname, 2006) Organic fertilization can be used in place of inorganic fertilizer due to its acidity and adverse effects on soil Ph (Ukoje, 2012). The disadvantages of inorganic fertilizer are high cost and long term environmental damage which perhaps outweighed the advantages and this also affects the poverty level of Nigerians and fragility of ecosystem (Adesina, 2012). Turmeric (Cucuma longa) production requires fertilization to improve yield. The work done by Obasi *et al* (2021) revealed that organic foliar application like boost extra can increase both growth and yield development. The objective was to determine the actual time of application on growth and yield of Turmeric. There is dearth information on the time of application of organic fertilizer in Turmeric South Eastern Nigeria,

MATERIALS AND METHODS

The experiment was conducted in the research farm of NRCRI .The experimental area was cleared of the existing vegetation, ploughed, harrowed and ridged. Plot size was 2mx3m with plant spacing of 30cmx50cm all laid in randomized complete block design. Treatments consisted of two species of Turmeric; *Curcuma Xanthorhiza* and *Curcuma longa* .Organic foliar fertilizer (Boost extra) ,Time of foliar application (0 ,4 ,8 and 12WAP).The foliar was applied at 100ml per 20 liters of water. The number of treatments combination is as follows:

X+0 ,X+4WAP,X+8WAP,X+12WAP,L+0,L+4WAP,L+8WAP and L+12WAP.Where ,X=*Xanthorhiza*, L=Long, WAP=Weeks after planting (Application of foliar fertilizer WAP). Zero application = (control).Boost extra nutrient analysis; Nitrogen 20%, Phosphate (20%) Potassium (20%) and 40% micro nutrients additive**.**

Growth data was collected as follows; plant height, Number of leaves, plant girth and number of tillers. They were collected at 4, 8 and 12 WAP .Yield data was collected at harvest by weighing. Other cultural practices like weeding were done and data was collected as at when due and was subjected to analysis of variance. Means were separated using least significant difference at 0.05 probability level.

Effect of Time of Application of Organic Foliar Fertilizer on Growth parameters of Turmeric (Figures 1, 2, 3 and 4)

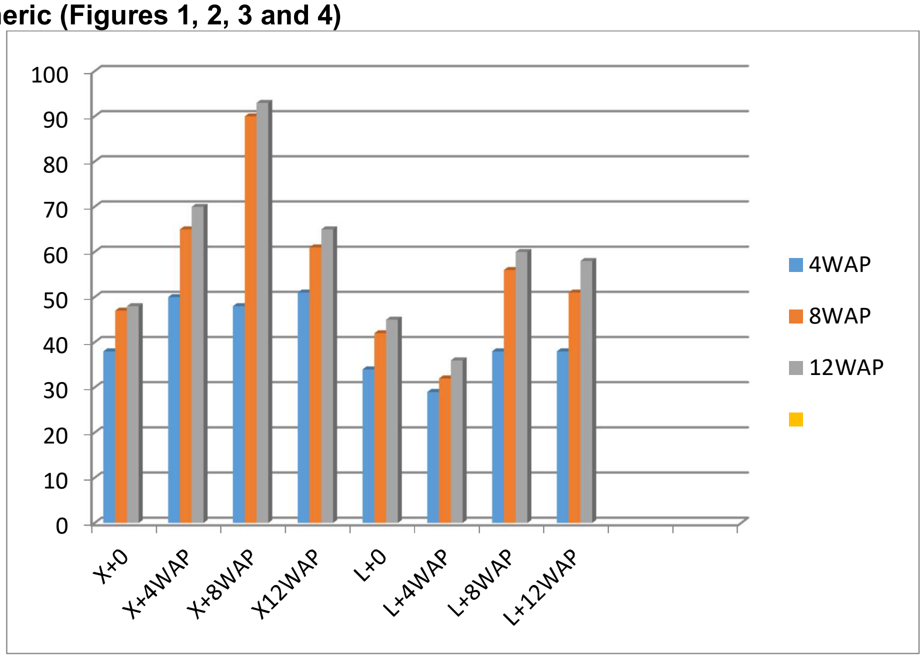

Figure 1: Plant height 2022/23 mean

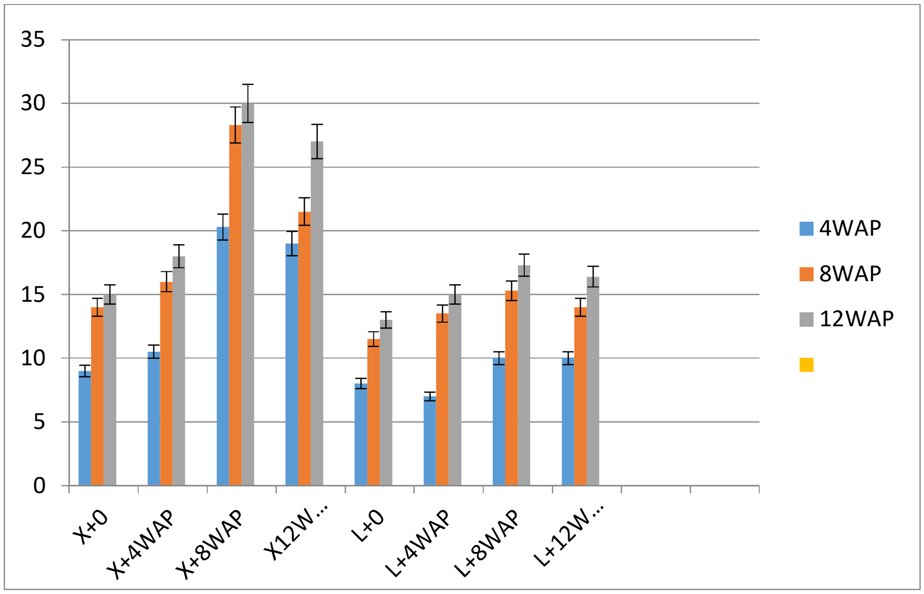

Figure 2: Number of leaves 2022/23 mean

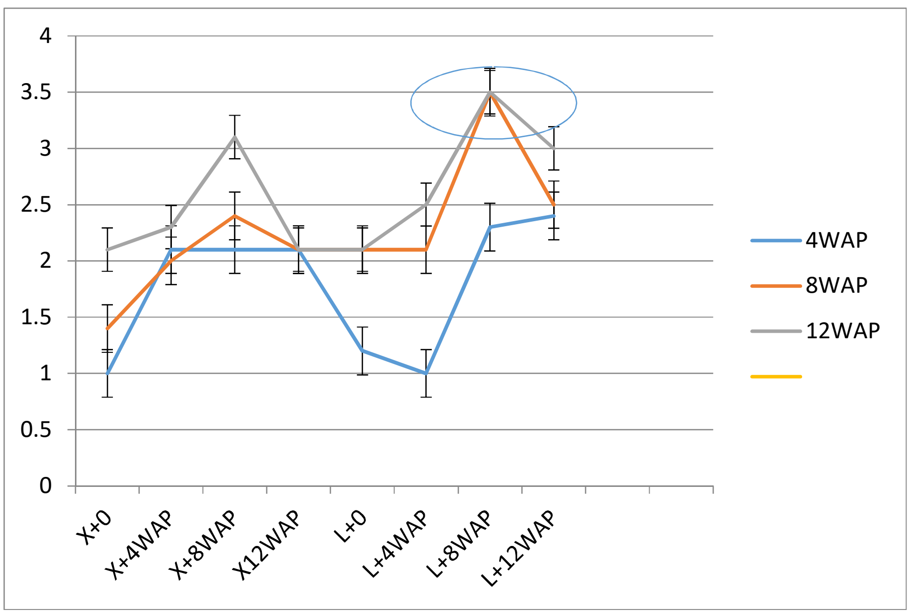

Figure 3: Tiller number.2022/23 mean

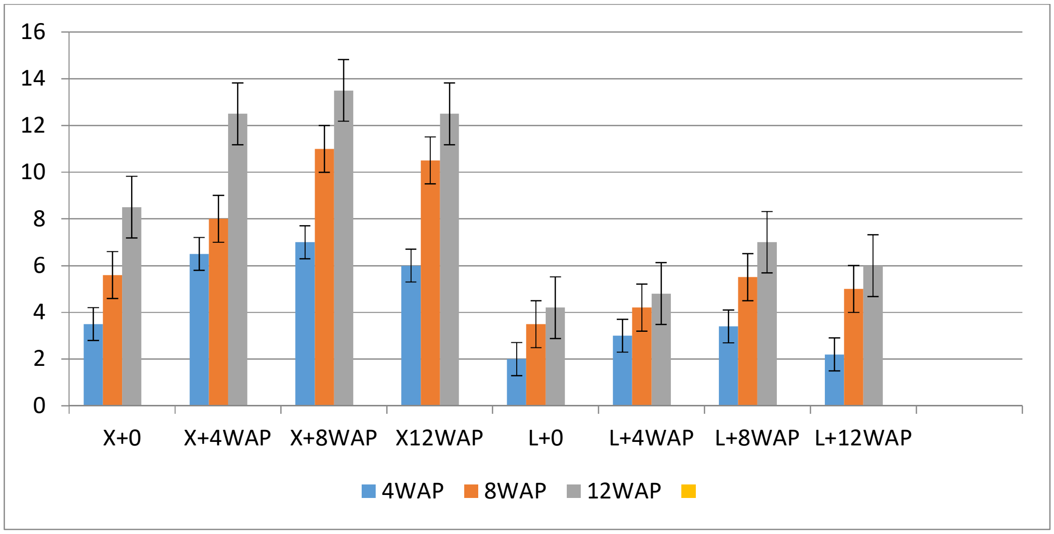

Figure 4: Stem girth 2022/23 mean

Table 1: Effect of time of Application of Organic Fertilizer on the Yield of Turmeric 2022/23.

	Primary	**Rhizome**	**Secondary**	**Rhizome**	**Mother**	**Rhizome**		
Treatments	**No/clump 2022/23 mean**	**Wt tonnes/ha 2022/23 mean**	**No/clump 2022/23 mean**	**Wt T/ha 2022/23 mean**	**No T/ha 2022/23 mean**	**Wt T/ha 2022/23 mean**	**HI(%) 2022/23 mean**	**Yield T/ha 2022/23 mean**
X+0	15	3.2	23.3	3.1	7.0	3.4	0.23	9.7
X+4WAP	23	3.8	36.2	3.6	13.0	3.7	0.50	11.1
X+8WAP	18	4.7	29.0	4.1	15.3	5.5	0.82	14.3
X+12WAP	15	3.5	30.0	3.2	12.4	4.1	0.61	10.8
L+0	16	2.8	24.5	2.5	7.2	2.5	0.21	7.8
L+4WAP	24	2.6	31.0	3.4	5.3	3.8	0.35	9.8
L+8WAP	21	4.2	34.0	3.2	8.1	4.3	0.55	11.7
L+12WAP	24	3.4	30.0	3.0	9.0	4.0	0.61	10.4
LSD 0.05	**NS**	**1.12**	**2.11**	**1.21**	**2.40**	**1.34**	**0.02**	**2.34**

RESULTS AND DISCUSSION

The growth parameters increased as growth proceeds during the months of observation. The two species responded more to foliar application at 8 and 12 WAP while the lowest height was obtained in the control check of Xanthorizae (47cm) and longa 42cm at 12WAP.(Fig 1). The same trend was also observed in the formation of leaves. Higher values on leaf production was achieved in foliar application of 8WAP (30 and18) for Xanthorizae (X) and Longa (L) respectively.(Fig 2). Longa produced the highest (3.5) tillers at the time of application of 8 and 12WAP and X+8WAP (3.0) (Fig 3). Foliar application significantly (P<005) affected the stem girth ,the highest girth of X was obtained in the time of application at 8WAP and recorded the lowest value in zero application 4cm for L+0 and 8.3 for X+0.(Fig.4). The mean values obtained on the effect of foliar application on harvest index yield and yield component are shown in Table 1.TIme of application significantly (P<0.05) affected the HI ,yield and yield component except the number of primary rhizome which gave the highest yield in tonnes per ha at application of 8WAP for both Xan (4.7t/ha) and Longa (4.2t/h). The same observation was also made in both secondary and mother rhizome. The mother rhizome gave the highest values of 5.5 t/ha at 8WAP for Xan,4.3 and 4.0t/ha in longa at 8 and 12WAP respectively. The mean yield in t/ha obtained in 2022 and 2023 constantly occurred in 8WAP.

However, in *Xan* 47% increase in yield was achieved at 8WAP and 33% yield reduction over the control while at 4 and 12WAP recorded 32 and 14.4% increase in yield respectively. Similarly the highest yield in tonnes per ha was achieved in application at 8WAP (11.7t/h) in longa while 33% reduction in yield was recorded over the control (7.8t/h).The consistence higher yield obtained in 8WAP could have resulted due to early absorption and stomata opening which occurred at early stage of vegetation between 4 to 8WAP this observation was made by Obasi, *et al (*2021)

CONCLUSION AND RECOMMENDATIONS

The experiment revealed that both the growth and yield data responded more to time of application at 8WAP than 4 and 12 WAP .The two species used in this work showed production potential in Turmeric rhizome yield due to application of Boost extra foliar organic fertilizer. Therefore for the optimum production of Turmeric using Boost extra it is recommended for application at 8WAP.

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Investigation of Physical Properties of Soils Affected by Erosion in Ideato North, Imo State Nigeria

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Abstract
Soil erosion is a significant environmental challenge in southeastern Nigeria, affecting soil productivity and land use sustainability. This study investigates the physical properties of soils impacted by erosion in Ideato North, Imo State, Nigeria. Three pedons were analyzed at varying depths (A, AB, Bt1, Bt2) to assess their texture, bulk density, porosity, and silt-clay ratio. Results show that the soils are predominantly sandy, with sand content ranging from 76.24% to 86.24%, while clay content varies between 10.76% and 16.76%. The silt content is consistently low, with a maximum of 8%. The silt-clay ratio is below 0.7 across all pedons, indicating low soil cohesiveness and high erosion susceptibility. Bulk density values range from 1.48 g/cm³ to 1.62 g/cm³, with corresponding porosity values between 18.75% and 24.22%. The variation in physical properties suggests that soil erosion has led to structural degradation, particularly in the deeper horizons, where compaction and reduced porosity are evident. The findings highlight the need for effective soil conservation strategies to mitigate erosion and enhance land productivity. This study provides a baseline for understanding soil degradation patterns in the region, contributing to informed land management practices and sustainable agricultural development.
Keywords: Soil erosion, soil physical properties, soil productivity, Ideato North

INTRODUCTION

Soil physical properties, including texture, structure, bulk density, and porosity aid in determining the soil's ability to support plant growth, regulate water infiltration, and resist erosion (Brady and Weil, 2016). Erosion, a natural process accelerated by human activities such as deforestation and poor land management, impacts soil health, particularly in areas like Southeastern Nigeria, where tropical rainfall and slope variations exacerbate the problem (Lal, 2019). Understanding the changes in these properties due to erosion is essential for effective land use planning and sustainable agriculture. Imo State, Nigeria, particularly Ideato North, has been significantly impacted by soil erosion, causing poor soil productivity and environmental degradation (Nwajiuba, 2001). Studies have shown that soil erosion in this region alters the physical properties of soils, leading to the loss of topsoil, reduced water-holding capacity, and increased soil compaction (Obalum *et al*., 2012). This investigation aims to assess the erosion effect on the physical properties of soils in Ideato North, contributing to the ongoing efforts to develop sustainable soil management practices in erosion-prone areas.

MATERIALS AND METHODS

Location

The study area is Umualaoma, in Ideato North Local Government Area of Imo state. Ideato North local government headquarters is located in the sub-locality, Urualla locality, district and its administrative headquarters is in Urualla, other towns in this Local Government include Obodoukwu, Akokwa, Isiokpo, Umualaoma, Uzii, Osina, Akpulu etc. The latitude of Ideato North Local Government is 5° 86' 18" and the longitude is 7° 10' 12". The latitude 5° 86'18" and longitude 7°10' 12" Ideato North local government area, Nnewi-Okigwe Road, Urualla, Nigeria.

Climate

Two main climatic seasons exist in Ideato North L.G.A, Imo state. The dry season and the rainy season may also be referred to as the wet season; the rainy season begins in March and ends in September and it`s characterised by the high volume of rainfall ranging from 1,750 to 2,500mm annually. It is characterised by high temperature and low relative humidity. The dry season begins in October and ends in February and it`s been characterised by low volume of rainfall, temperature in the dry season ranges from 20°C-38°C and during the rainy season it ranges from 16°C-28°C.

Existing information on soil

Most tropical soils are usually described as inherently infertile and fragile, weakly structured which encourages erosion, and high soil acidity leads to nutrient imbalance and toxicity (Oparandi and Oranekwulu, 1988).

Agricultural Activities

The major occupation of the people of Umualaoma in Ideato North is farming (about 50% are subsistence farmers) with food crops dominating the practice. The agricultural type is usually mixed cropping or mixed farming where food crops predominantly planted are cassava, yam, and vegetables, some engaged themselves in palm oil production because of the palm plantation established in that area some people also do hunting and so many other agricultural activities.

Field studies

Soil sampling was carried out where sheet and rill erosion was predominantly affected. Locations, where gully erosions had been affected drastically, were avoided since agricultural activities in the areas had been halted. A transect sampling technique was used to sink a three-profile pit. Core samples were collected for bulk density determination.

Laboratory Analysis

The particle size distribution was determined using the hydrometer method, (Gee and Bauder, 1979). Bulk density was obtained by core procedure (Lichter and Costello, 1994).

Statistical Analysis

The coefficient of variation was used as wilding (1985 was used in this study to estimate the degree of variability among soil properties in the study site). The comparison was drawn from the results obtained from the laboratory analysis of the pedons.

The percentage coefficient of the variation was determined using the equation.

$$^{C}/_{O}\ \text{cv} = \frac{SD}{\times} \times \frac{100}{1}$$

Where
S.D = Standard deviation
× = Mean

The co-efficient of variables was ranked according to Wilding (1985) as follows:
Level % Ranking
Co-efficient < 15 little variation
Co-efficient variation 15-39 moderation variation
Co-efficient > 35 High variation

The results to be obtained from the laboratory analysis will be presented in tables and represented graphically in straight-line charts and histograms.

RESULTS AND DISCUSSION

Table 1 below presents data on the physical properties of soils, including sand, silt, clay content, silt-clay ratio, textural class, bulk density, and porosity at different depths across three pedons (Pedon 1, Pedon 2, and Pedon 3). Each pedon represents a soil profile, with observations taken at varying depth intervals (horizons: A, AB, Bt1, and Bt2). The data provides valuable insights into the variation of these properties and their impact on soil behaviour, especially in an erosion-prone area like Ideato North.

Table 1: Physical properties of investigated soils

Location	Depth	Sand %	Silt %	Clay %	Silt Clay Ratio	Textural Class	Bulk Density	Porosity
Pedon 1								
A	0 - 21	86.24	1.0	12.76	0.08	LS	1.56	21.88
AB	21 - 35	84.24	1.0	14.76	0.07	LS	1.60	23.44
Bt1	35 - 84	78.24	7.0	14.76	0.47	LS	1.60	23.44
Bt2	84 - 145	76.24	7.0	16.76	0.42	SL	1.62	24.22
Means		81.24	4	14.76	0.27		1.60	23.44
CV		5.9	86.6	11.1	7.801		1.6	
Rank		LV	HV	LV	LV		LV	
Pedon 2								
A	0 - 16	82.24	7.0	10.76	0.65	LS	1.48	18.75
AB	16.45	80.24	8.0	11.76	0.68	LS	1.52	20.31
Bt1	45 - 71	80.24	6.0	13.76	0.44	LS	1.56	21.88
Bt2	71 - 153	78.24	6.0	15.76	0.38	LS	1.53	20.70
Mean		80.24	6.8	13.01	0.52		1.52	20.31
CV		2	14.2	17.1	0.830		2.2	
Rank		LV	LV	MV	LV		LV	
Pedon 3								
A	0 - 18	85.24	2.0	12.76	0.16	LS	1.50	19.53
AB	19 - 49	80.24	5.0	14.76	0.23	LS	1.51	19.92
Bt1	49 - 87	79.24	7.0	13.76	0.51	LS	1.58	22.66
Mean		81.57	4.7	13.76	0.34		1.53	20.70
CV		3.9	53.9	7.3	7.384		2.8	
Rank		LV	HV	LV	LV		LV	

LS = Loamy sand, SL = Sandy loam, TC = Textural class, MV = Moderate variability, HV = High variability, LV = Low variability, SCR = Silt/clay ratio

Textural Class

Sand content is high across all pedons, ranging from 76.24% to 86.24%. This indicates that the soils are predominantly sandy. Clay content shows moderate variation, with values between 10.76% and 16.76%. The silt content is generally low, with 1% and 8%. Based on the USDA soil classification, the textural class across most horizons is loamy sand (LS), except for the Bt2 horizon of Pedon 1, which shows a sandy loam (SL) texture due to a slightly higher clay content (16.76%).

Silt-Clay Ratio
The silt-clay ratio helps understand the soil's ability to resist erosion. Lower values indicate less cohesive soils, which are more prone to erosion. The table reveals that: The silt-clay ratio is generally low across all pedons, with a maximum of 0.68 (Pedon 2, AB horizon). This low ratio indicates weak structure and higher susceptibility to erosion, which is consistent with the erosion problems in the area.

Bulk Density
Bulk density values range from 1.48 g/cm³ to 1.62 g/cm³, showing moderate variation. The highest values are found in the Bt horizons, which generally consist of more compacted soil, while the lowest values are observed in the surface horizons (A and AB). Bulk density is a critical factor affecting soil porosity, root penetration, and water movement. Higher bulk density values indicate more compact soils, which can restrict plant root growth and decrease water infiltration.

Porosity
Porosity, which inversely relates to bulk density, ranges between 18.75% and 24.22%. The higher bulk density in the deeper horizons (Bt) correlates with lower porosity, while surface layers tend to have higher porosity due to less compaction. Low porosity values, especially in Pedon 1, suggest limited soil aeration and drainage, which can lead to increased surface runoff and exacerbate erosion problems.

Coefficient of Variation and Ranking
The coefficient of variation (CV) provides insight into the variability of each soil property within a pedon: Sand content shows low variation (LV) in all pedons, with CV values ranging from 2% to 5.9%. Silt content shows high variation (HV) in Pedons 1 and 3, indicating a greater inconsistency in silt distribution across horizons. Clay content shows low to moderate variation (LV to MV), with CV values ranging from 7.3% to 17.1%. Bulk density and porosity show low variation (LV) across all pedons, indicating relatively stable soil structure and compaction within each pedon.

CONCLUSION AND RECOMMENDATIONS
This study demonstrates that the soils across all pedons in Ideato North are predominantly sandy, with low silt-clay ratios and moderate bulk density. These characteristics suggest a high susceptibility to erosion due to poor soil structure and low cohesion. The relatively high sand content and low porosity contribute to reduced water retention, making the soils prone to surface runoff, which likely exacerbates the erosion problem in the area. Effective soil management strategies, such as increasing organic matter content and implementing erosion control measures, are necessary to improve soil quality and reduce erosion risk.

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Effect of Weed Control on Three Improved Cassava Varieties in Southeast Nigeria

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INTRODUCTION

Cassava (*Manihot escclenta* Crantz) is an important staple food and cash crop in several tropical African countries, especially Nigeria, where it plays a principal role in the food economy (Akpan, 2012). The production of cassava increased to 63 million tonnes in 2021 - growing at an average annual rate of 4.28% (FAO 2021). Cassava, a staple food source for most Nigerians is susceptible to weed interference during the first 10-16 weeks after planting (WAP) (Akobundu, 1987), because of slow canopy development for ground cover and weed suppression. Plant canopy cover which is related to highest and leaf distribution is a critical factor determining the relative competitiveness of plant species (Barnes *et al.* 1990). The crop canopy alters both light intensity and quality (Croster and Witt 2000), thereby influencing the survival of the other competing plants. Maximizing light interception by the crop is therefore a valuable tool for weed suppression. Therefore, the study focused on the determination of the potential of three newly improved cassava varieties to suppress weeds in the southeast agroecology of Nigeria.

MATERIALS AND METHODS

The experiment was conducted on the National Root Crops Research Institute farm at Umudike, Abia State in the 2022 and 2023 cropping seasons. The experiment was laid out as a split-plot treatment arrangement in a randomized complete block design (RCBD) and was replicated three times. The main plots were occupied by cassava varieties and the sub-plots by weeding regimes. The improved cassava varieties are GAME CHANGER, BABA 70 and OBASAJO 2. Each plot measured 3 m x 4 m, consisting of 4 ridges with plant spacing of 1 m x 1 m inter and intra row, respectively. Weeding regime treatments were; No weeding (NW), Weed free (WF), one weeding (WX1), and two weeding (WX2). Relevant agronomic practices were carried out as when due. Growth data were collected at four and eight weeks after planting (WAP), and the parameters obtained included; Plant height (cm), Number of leaves/plants, Girth (cm), Number of branches/plant, and Leaf area (cm^2). All data collected were subjected to analysis of variance (ANOVA) for a split plot in RCBD, using the GenStat Discovery Edition 3 (Genstat, 2007). Significant treatment means were separated using the least significant difference at a 5% probability level.

RESULTS AND DISCUSSION

Leaf area was significantly ($P < 0.01$) influenced by variety at 4 WAP, but did not at 8 WAP (Table 1). Baba 70 (V2) recorded the highest leaf area (116.7 cm^2) and Obasanjo 2 (V3) the least (68.5 cm^2). The weeding regime significantly affected ($P < 0.05$) the leaf area of the cassava varieties at 4 and 8 WAP. Weeding twice (WX2) at 4 WAP gave a higher leaf area (109 cm^2) which did not differ significantly from the value obtained when weeded once (WX1) (104.4 cm^2). Lesser leaf area was recorded by No weeding (78.6 cm^2) and weed-free (80.7 cm^2), which did not differ significantly from each other. The weeding regime similarly influenced the leaf area of the cassava varieties at 8 WAP. The highest leaf areas of 501 and 440 cm^2 were recorded from WX1 and WX2, respectively which did not differ significantly. No weeding resulted in the least leaf area (320 cm^2) at 8 WAP. Variety x weeding regime interaction significantly influenced the leaf area of cassava varieties only at 4 WAP. Baba 70 x WX2 gave the highest leaf area (181.8 cm^2), followed by Baba 70 x WX1 (125 cm^2) and Game changer x WX1 (115.1 cm^2) which did not differ significantly from each other. Obasanjo 2 performed poorly on leaf area (64.1-73.1 cm^2) across the weeding regimes tested.

Effects of variety, weeding regime and variety x weeding regime interaction on plant height/plant at 4 and 8 WAP are shown in Table 2. Variety and variety x weeding regime interaction did not significantly ($P > 0.05$) influence plant height at 4 and 8 WAP. The weeding regime significantly affected ($P < 0.05$) plant height at 4 and 8 WAP. Weeding once (WX1) at 4 WAP produced significantly taller plants (12.59 cm), while weed-free (WF) gave the lowest plant height (9.0 cm). This poor performance by WF may suggest a negative weeding effect at 4 WAP. However, at 8 WAP, weeding twice (WX2) significantly increased plant height (34.43 cm), followed by weeding once (28.86 cm) which did not vary with plant height produced by weed-free (25.79 cm). No weeding resulted in the shortest plants (20.53 cm) at 8 WAP. The analysis of variance of treatments on average leaf number/plant showed that weeding regime and variety x weeding regime interaction significantly ($P < 0.05$) affected leaf number/plant at 4 and 8 WAP (Table 3). Weeding once produced the highest average number of leaves/plant (11.12), while other weeding regimes did not differ in their average leaf number at 4 WAP.

All weeding regimes evaluated equally increased average leaf number/plant over No weeding (NW) which produced a smaller leaf number/plant (19.37) at 8 WAP. The interaction effect of variety and weeding regime showed that weeding Baba 70 (V2) twice produced the highest average number of leaves/plant (13.12) at 4 WAP. However, at 8 WAP, Obasanjo 2 weeded once or twice produced significantly the highest average number of leaves/plant which did not differ from one another (46.88 and 39.16). The least number of leaves was obtained from Baba 70 x NW (11.22). Stem girth/plant (cm) was significantly influenced by variety and variety x weeding regime interaction at 4 WAP (Table 4). Obasanjo 2 and Baba 70 recorded greater secondary growth (2.67 and 2.65 cm respectively) than Game Changer (2.39 cm). Interaction effect showed that keeping the Obasanjo 2 variety weed-free at 4 WAP produced the highest value of stem girth/plant (3.10 cm). No significant treatment effect was obtained on average stem girth/plant at 8 WAP.

CONCLUSION AND RECOMMENDATIONS

The result of this study showed that weeding at 4 WAP should be encouraged as this gave the best result in terms of leaf area, plant height and leaf number where Baba 70 did best and also a Game changer at 8 WAP, practically WX2 should be adopted to improve the growth attributes.

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Table 1: Effect of the weeding regime on the leaf area (cm^2) of three newly improved cassava varieties at Umudike.

	Weeding regime (4 WAP)					Weeding regime (8 WAP)				
Variety	**NW**	**WF**	**WX1**	**WX2**	**Mean**	**NW**	**WF**	**WX1**	**WX2**	**Mean**
Game changer (V1)	85.9	95.9	115.1	76.7	**93.4**	351	451	642	560	**501**
Baba 70 (V2)	85.8	74.3	125	181.8	**116.7**	249	435	449	538	**418**
Obasanjo 2 (V3)	64.1	71.9	73.1	68.5	**69.4**	359	433	413	295	**375**
Mean	**78.6**	**80.7**	**104.4**	**109**		**320**	**440**	**501**	**464**	
LSD (0.05) Variety = 15.7**					LSD (0.05) Variety = NS					
LSD (0.05) Weeding regime = 8.0*					LSD (0.05) Weeding regime = 88.0*					
LSD (0.05) Var x Weeding regime = 17.4					LSD (0.05) Var x Weeding regime = NS					

*, ** = Significant at 5 and 1% probability levels, respectively; NS = Not significant at 5% probability level.

Table 2: Effect of the weeding regime on plant height (cm) of three newly improved cassava varieties at Umudike

	Weeding regime (4 WAP)					Weeding regime (8 WAP)				
Variety	**NW**	**WF**	**WX1**	**WX2**	**Mean**	**NW**	**WF**	**WX1**	**WX2**	**Mean**
Game changer (V1)	10.00	9.00	12.83	11.42	**10.81**	22.08	23.75	30.50	38.38	**28.68**
Baba 70 (V2)	11.34	9.12	13.00	12.19	**11.41**	14.42	25.88	30.08	31.38	**25.44**
Obasanjo 2 (V3)	11.21	8.88	11.94	8.81	**10.21**	25.08	27.75	26.00	33.54	**28.09**
Mean	**10.85**	**9.00**	**12.59**	**10.81**		**20.53**	**25.79**	**28.86**	**34.43**	
LSD (0.05) Variety = NS						LSD (0.05) Variety = NS				
LSD (0.05) Weeding regime = 1.16*						LSD (0.05) Weeding regime = 4.14*				
LSD (0.05) Var x Weeding regime = NS						LSD (0.05) Var x Weeding regime = NS				

= Significant at 5% probability level; NS = Not significant at 5% probability level.

Table 3: Effect of the weeding regime on leaf number/plant of three newly improved cassava varieties at Umudike

	Weeding regime (4 WAP)					Weeding regime (8 WAP)				
Variety	**NW**	**WF**	**WX1**	**WX2**	**Mean**	**NW**	**WF**	**WX1**	**WX2**	**Mean**
Game changer (V1)	8.88	8.50	11.00	8.12	**9.12**	24.62	19.29	28.12	25.84	**24.47**
Baba 70 (V2)	11.75	10.33	11.25	13.12	**11.61**	11.22	29.33	17.21	31.46	**22.31**
Obasanjo 2 (V3)	9.62	9.88	11.12	8.62	**9.81**	22.25	36.50	46.88	39.16	**36.20**
Mean	**10.08**	**9.57**	**11.12**	**9.96**		**19.37**	**28.37**	**30.74**	**32.15**	

LSD (0.05) Variety = 1.68 SD (0.05) Variety = NS
LSD (0.05) Weeding regime = 0.88* LSD (0.05) Weeding regime = 5.72*
LSD (0.05) Var x Weeding regime = 1.88* LSD (0.05) Var x Weeding regime = 9.66**

*, ** = Significant at 5 and 1% probability levels, respectively; NS = Not significant at 5% probability level.

Table 4: Effect of the weeding regime on stem girth/plant (cm) of three newly improved cassava varieties at Umudike

	Weeding regime (4 WAP)					Weeding regime (8 WAP)				
Variety	**NW**	**WF**	**WX1**	**WX2**	**Mean**	**NW**	**WF**	**WX1**	**WX2**	**Mean**
Game changer (V1)	2.42	2.44	2.56	2.18	**2.39**	3.28	3.13	3.50	4.38	**3.57**
Baba 70 (V2)	2.63	2.42	2.74	2.82	**2.65**	2.25	3.63	3.61	3.79	**3.32**
Obasanjo 2 (V3)	2.64	3.10	2.53	2.43	**2.67**	3.40	3.62	3.31	3.09	**3.36**
Mean	**2.57**	**2.65**	**2.61**	**2.47**		**2.98**	**3.46**	**3.48**	**3.75**	

LSD (0.05) Variety = 0.14* LSD (0.05) Variety = NS
LSD (0.05) Weeding regime = NS LSD (0.05) Weeding regime = NS
LSD (0.05) Var x Weeding regime = 0.26* LSD (0.05) Var x Weeding regime = NS

= Significant at 5% probability level; NS = Not significant at 5% probability level

Genotypic Variation of Yellow Root Cassava Genotypes at Preliminary Yield Trial of Breeding Stage in Umudike

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Abstract
*This study was carried out at Umudike, Abia State, Nigeria to evaluate genotypic variation among selected yellow root cassava genotypes at preliminary yield trial of breeding stage. Thirty-two (32) selected yellow cassava root genotypes and two control released cassava varieties were evaluated for root yield, dry matter content, cassava mosaic disease, number of root produced and harvest index. The experiment was planted in a Randomized Complete Block Design (RCBD) with three replications. Plot size was 4m x 5m (20m^2) with a planting spacing of 1m x 1m.The experimental site was at National Root Crops Research Institute (NRCRI), Umudike in humid rainforest Agroecological Zone of Nigeria. The data collected were subjected to Analysis of variance (ANOVA) using General Linear Model GLM) procedure in SAS software, 2002. The analysis of variance shows significant difference among genotypes for Fresh Root Yield (FRY), Dry Matter Content (DMC), Dry Root Yield (DRY), and Harvest Index (HI). Genotype NR190055 (30.00t/ha) and NR190062 (17.36%) shows the highest FRY and DMC respectively. A significant positive correlation exist between HI and FRY (r = 0.54303***), and DRY (r = 0.55054***); FRY is correlated to DRY (r = 0.99855***).*
Keywords: Harvest parameters, biofortification, cassava, phenotypic data, cropping season, design

INTRODUCTION

Cassava is a major staple food for about half of the Nigerian population and nearly 55 million tons of fresh cassava is produced annually in the country (FAOSTAT 2014). Nigeria is the largest player in cassava production round the globe (Nnadokie *et al*., 2015) and the country's total annual production for cassava came to about 59 million tonnes in 2017. Vitamin A deficiency (VAD) is a major public health concern for communities that depend mainly on cassava for their daily carbohydrate requirements. The Worldwide production of cassava amounted to 278 million metric tons in 2018, out of which Africa's share was about 61% (FAOSTAT,2020), Globally, cassava production has increased by 240 million metric tons since 2010 (FAOSTAT,2020). According to FAO projections, by 2025, about 62% of global cassava production will come from sub-Saharan Africa (FAOSTAT, 2020). In view of the above, this paper attempts to evaluate the influence of fresh root yield (FRY), dry matter content (DMC), and cassava mosaic disease (CMD) at Preliminary yield trial of breeding stage in NRCRI, Umudike

MATERIALS AND METHODS

Thirty-two (32) yellow root cassava genotypes were selected from the clonal evaluation stage and were established in the preliminary yield with two cassava varieties as checks (TME419 and TMS070539). Cassava planting stakes were planted on November 2022 laid out in Randomized Complete Block Design (RCBD) with a plot size 4m × 5m. The experiment was replicated three times. A planting distance of 1 m x 1 m was maintained making 20 stands per plot. Pre and post-emergence herbicide was used after planting. Weeding of the farm was done manually. The plants were scored for resistance to major cassava disease and pests 1,3,6,9 and 12 MAP. Determination of dry matter, fresh root yield, and dry root yield of the cassava genotypes were carried out at harvesting using specific gravity method.

Statistical analysis

The data collected were subjected to analysis of variance (ANOVA) using General Linear Model (GLM) procedure in SAS software, 2002 to test for the treatment of effect and significant interaction of the variables considered.

RESULTS AND DISCUSSION

Significant negative correlation was observed between cassava mosaic disease and harvest index, (r = - 0.07145) fresh root yield (r = - 0.12801) and dry root yield (r = - 0.12349), a positive correlation between HI and FRY (r = 0.54303***), negatively correlated to dry matter content (r = - 0.03528) and correlated positively to DRY (r = 0.55054***); FRY is correlated to DRY (r = 0.99855***) (Table 1). The analysis of variance shows significant difference among genotypes for FRY, DMC, DRY and HI (Table 2). Four genotypes had fresh root yield better than the checks varieties. Genotype NR190055 shows the highest FRY of 30.00t/ha while NR180023 revealed the least value of 18.00t/ha. Genotype NR190062 had the highest dry matter content (17.36%) while NR180063 had the least valve (16.96%) (Table3).

Table 1: Correlation among disease, yield related traits of selected yellow root cassava genotypes evaluated in NRCRI, Umudike

SOURCE	CMD	HI	FRY (t/ha)	DMC (%)	DRY (t/ha)
CMD	1	-0.07145	-0.12801	0.05611NS	-0.12349
HI		1	0.54303***	-0.03528	0.55054***
FRY			1	0.29961NS	0.99855***
DMC				1	0.31160NS
DRY					1

*(P<0.05), ** (P<.001), *** (P<.0001), ns - not significant, CMD: cassava mosaic disease, FRY: fresh root yield, DMC: dry matter content, DRY: dry root yield, HI: harvest index

Table 2: Analysis of variance of yellow root cassava genotypes reaction to disease, and yield Components in NRCRI, Umudike

SOURCE	DF	FRY (t/ha)	DMC (%)	DRY (t/ha)	CMD	HI
REPS	2	50.39NS	0.37NS	1.31NS	0.48NS	0.004NS
GENOTYPES	33	155.40***	26.71***	4.62***	1.52NS	0.05***
ERROR	66	43.22	0.37	1.24	0.67	0.009
R^2		0.64	0.97	0.65	0.53	0.73
CV%		38.06	3.63	37.46	36.84	19.55

*(P<0.05), ** (P<.001), *** (P<.0001), ns- not significant, CMD: cassava mosaic disease, DMC: dry matter content, FRY: fresh root yield, HI: harvest index, CV: coefficient of variation

Table 3: Agronomic mean performance of selected yellow root cassava genotypes to disease, and yield attributes in NRCRI, Umudike

GENOTYPES	ROOT NUMBER	FRY (t/ha)	DMC (%)	HI
NR190054	36.67	29.11	17.23	0.55
NR190063	30.00	24.22	16.96	0.65
NR190023	56.67	18.77	17.30	0.50
NR190055	21.00	30.00	17.03	0.52
NR190062	60.67	23.00	17.36	0.53
TME419	23.33	17.44	17.32	0.61
TMS070539	20.00	15.44	17.06	0.61
LSD (0.05)	25.68	10.71	10.71	0.16
CV %	65.56	38.06	38.06	19.55

FRY: fresh root yield, DMC: dry matter content, HI: harvest index

CONCLUSION AND RECOMMENDATIONS

In terms of fresh root yield and dry matter content, genotype NR190055 and NR190062 perform better.

ACKNOWLEDGMENTS

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Some Qualities of Selected Nigeria White Yam Landraces (*Dioscorea rotundata*) Grown in South East Nigerian

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Abstract
Popular Nigeria white yam landraces were grown in national root crop research institute Umudike experiment farm located between latitude 05⁰ 29' N; and longitude| 07⁰ 33' E. Thirty-three white yam (Discorea rotunda) varieties were collected from national root crop research institute Umudike modern yam bar after harvest at twelve months of maturity. The Yam tubers were ogini, punch, aaka, igbudugamdu, fakesta, etem, yandu, pampas, amula, awada, abi, obiaotuugo, aga, ojuiyawo, meccakusa, asangwu, ogoja, ikotoama, alumaco, ebute, ekpe, ame, agbaiyo, myamiyo, mumuiye, nwopoko, mkuku, hembakwuisi, amola, mamaiyo, nndu, afiemine and nyam-iyo. Yam tubers were sorted and used for the determination of dry matter, starch content, peel loss and flour yield using standard methods. Data obtained were statically analysed and results in all parameter recorded shows significant differences. Starch content ranged from 25.966% in abi to 50.794 % in agbaiyo. Dry matter was from 19.002% in abi to 46.790% in meccakusa. Peel loss had the lowest percentage value in amola (6.518%) and the highest in ekpe (27.700%). Awada had the highest flour yield of 30.916%, while the lowest flour yields of 13. 918% was in pampas. Landraces such as ojuiyawo, meccakusa, asangwu, agbaiyo, ame, nndu, afiemine amola awada and mamaiyo could be used by breeders and processors for their specific higher desirable traits as well as for crop improvement.
Keywords: Yam landraces, starch, peel loss, flour yield and dry matter.

INTRODUCTION

Yam belongs to the family *Dioscoreacea* (Abdoulaye, *et. al.* 2014) in the genus *Dioscorea*, 0ne of the most important staple food in West Africa after cereals (Umesh, 2014). Nigeria is the leading producer of edible yam, producing up to 34 million tonnes, out of 48.7 million tonnes of yam produced in the world as far back in 2018 (Ekwu et. al. 2005,Nwankwo and Ukpabi, 2018), with white yam (*D.* ro*tundata)* and water yam (*D. Alata)* as the two most cultivated yam species in the country (IITA, 2006). It is an important starchy food source crop in at least ten tropical countries from Nigeria to Jamaica and the Solomon islands, accounting for 155 million inhabitants. More than 85% of world yam production takes place in West Africa (FAOSTAT, 2012).

White yam (*D. rotundata)* originated in Africa. It is the most widely grown and preferred yam species (IITA, 2018). Tuber of white yam is roughly cylindrical in shape, the skin is smooth and brown and the flesh is usually white and firm. There are large number of the cultivars that exist with differences in their production and postharvest characteristics. The plant is a perennial vine cultivated for its large, edible and underground tuber which can grow up to 120 pounds in weight and up to 2 meters in length. Dry matter content is one of important yam breeding targets in developing new improved varieties (Asiedu and Sartie, 2010) and also in screening for quality attributes that determine yam cultivar acceptability for multiplication. The quality of yam tubers for potential industrial uses is influenced by its dry matter content (Andres et. al., 2017). Starch is the main component of yam tubers, it is very vital in consumption of yam tubers and for industrial purposes. Starch determines the textural, functional and rheological properties of yam food products (Amani et al., 2004). Peel losses are considerably high in some cases for instance yam peels constitute more than about 14% of the volume of yams consumed and peeling loss invariably result to reduced flour yield. This work investigates some qualities (dry matter peel loss, starch and flour yield) of popular Nigeria white yam landraces grown in Umudike South East of Nigeria.

MATERIALS AND METHODS

Thirty-three white yam *(Discorea rotunda*) varieties were collected from national root crop research institute Umudike modern yam bar after harvest at twelve months of maturity. Yam tubers were sorted and used for the determination of dry matter and starch content. The dry matter content and starch yield of each yam varieties were determined using methods as stipulated by Association of Analytical Chemist (AOAC, 2010) and Oyewole and Afolami (2001) respectively. Peel loss and flour yield by the method as described in Etty, *et. al.,*(2019). These yam tubers were obtained from different location in Nigeria and planted in National Root Crops Research Institute experiment farm located between latitude 05^0 29’ N; and longitude| 07^0 33’ E. *D. Rotundata* varieties used were Ogini, punch, adaka, igbudugamdu,, Fakesta, etem, yandu, pampas, amula, 10, ogoje, obiaturugo, aga, gandegbawge, maccakusa, asangwu, ogoja, ikotoama, alumaco, ebute, ekpe, ame, agbaiyo, myamiyo, mamuyo, nwopoko mkpuku, hembakwasi, nndu, *afiemine*

RESULTS AND DISCUSSION

The results of the percentage starch, dry matter, peel loss and flour yield of popular Nigeria yam landraces are presented in table one. Significant differences (P > 0.05) were observed in all parameters. Starch content ranged from 25.966% in abi to 50.794 % in agbaiyo. Dry matter was from 19.002% in Abi to 46.790% in meccakusa. Peel loss had the lowest pecentage value in amola (6.518%) and the highest in ekpe (27.700%). Awada had the highest flour yield of 30.916%, while the lowest flour yields of 13. 918% was in Pampas that had no significant differences with Nndu at the value of 13.939%. Agbaiyo with highest result in starch (50.794%) did not fall within first highest five in dry matter, flour yield and peel loss. Meccakusa had the highest in dry matter (46.790%), its starch content of 42.277% was within first highest five. meccakusa had higher flour yield (19.66%) than agbaiyo (16.068). However agbaiyo had lesser peel loss (16.857) than Meccakusa (18.566). Awada that had highest flour yield (30.916%) had lesser peel loss (13.255%) than agbaiyo and meccakusa, starch content of 45.046 higher than meccakusa. However its dry matter content (22.265%) were lower than agbaiyo and meccakusa.

CONCLUSION AND RECOMMADATIONS

This study had shown that the landraces had desirable traits that could be used by breeders, processors and for crop improvement. Especially, landraces such as agbaiyo, meccakusa and awada that had more than one higher trait.

Table 1: starch content, dry matter, peel loss and flour yield of popular Nigeria yam landraces (%)

Name of landraces	Starch	Dry matter	Peel loss	Flour yield
Ogini,	37.856^{j}	27.075^{q}	19.729^{g}	14.151^{y}
Punch	42.619^{d}	38.725^{h}	10.486^{p}	20.196^{f}
Aaka	31.421^{o}	39.950^{ef}	19.227^{h}	16.623^{n}
Igbudugamdu	28.653^{r}	32.745^{l}	16.430^{k}	17.126^{l}
Fakesta	42.388^{d}	34.055^{k}	20.136^{f}	14.164^{y}
Etem	45.259^{c}	31.540^{m}	16.885^{j}	17.510^{i}
Yandu	35.215^{k}	42.115^{d}	9.265^{r}	17.524^{i}
Pampas	40.993f^{g}	27.310^{q}	13.569^{m}	13. 918^{z}
Amula	29.975^{q}	30.060^{no}	15.203^{l}	14.238^{x}
Awada	45.046^{c}	22.265st	13.255^{m}	30.916^{a}
Abi	25.966^{t}	19.002^{v}	10.165^{p}	20.432^{e}
Obiaotuugo	38.002^{j}	31.683^{m}	20.728^{d}	17.440^{j}
Aga	34.038^{mn}	30.572^{n}	7.031^{t}	15.397^{u}
Ojuiyawo	34.530^{lmn}	22.505^{s}	8.090^{s}	29.570^{b}
Meccakusa	42.277^{d}	46.790^{a}	18.566^{i}	19.686^{g}
Asangwu	41.469^{ef}	43.650^{c}	26.131^{b}	14.315^{w}
Ogoja	41.645^{de}	37.090^{i}	20.180^{f}	17.439^{j}
Ikotoama	45.643^{c}	23.666^{r}	10.896^{o}	15.901^{q}
Alumaco	34.768^{kl}	40.235^{e}	9.786^{q}	17.373^{k}
Ebute	39.696^{h}	29.695^{o}	8.417^{s}	15.952^{p}
Ekpe	33.995^{mn}	28.610^{p}	27.700^{a}	17.003^{m}
Ame	48.834^{b}	32.730^{l}	7.275^{t}	14.688^{v}
Agbaiyo	50.794^{a}	32.270^{l}	16.857^{j}	16.068^{o}
Myamiyo	42.190^{d}	36.505^{j}	17.125^{j}	14.246^{x}
Mumuiye	30.819^{p}	33.715^{k}	11.555^{n}	17.117^{l}
Nwopoko	34.471^{lmn}	39.430^{fg}	11.463^{n}	15.427^{t}
Mkpuku	28.668^{r}	39.790e^{fg}	10.169^{p}	15.900^{q}
Hembakwuisi	38.655^{i}	44.850^{b}	20.643^{de}	25.902^{c}
Amola	35.542^{k}	39.835^{ef}	6.518^{u}	15.743^{r}
Mamaiyo	48.914^{b}	21.110^{u}	20.299^{ef}	15.666^{s}
Nndu	27.539^{s}	33.485^{k}	9.776^{q}	13.939^{z}
Afiemine	48.790^{b}	39.210g^{h}	23.298^{c}	18.462^{h}
Nyam-Iyo	35.464^{k}	21.810^{t}	18.260^{i}	24.333^{d}

Sample means with the same letter down the columns are not significantly different ($P<0.05$).

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Comparative Analysis of Nutrient Media on *Agrobacterium* Growth Dynamics

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Abstract

The choice of a suitable growth medium is critical for optimizing bacterial growth, assuring the reproducibility of experimental data, and obtaining high biomass production. The main aim of this research is to examine the growth rates of two Agrobacterium strains in Yeast extract peptone (YEP), Luria-Bertani or lysogeny broth (LB), and Yeast extract mannitol (YEM) medium. This study evaluated the different nutrient media for the best fit in increasing bacterial growth and biomass yield, which is critical for applications in plant genetic transformation activities.. Two Agrobacterium strains (LBA4404 and AGL-1) were used for this experiment, results of the optical density (OD) were recorded at three hourly intervals for a period of 24 hours, the results of the mean OD showed that LBA4404 performed best in LB media (0.417±0.30-0.517±0.32), followed by LBA4404 cultured in YEP media (0.342±0.22-0.395±0.25). AGL-1 performed best in YEP media (0.461±0.28-0.502±0.29) followed by LB (0.423±0.31-0.451±0.28), in all, cultures of YEM had the least growth performance, the same trend was observed for the midi culture experiments. Our findings, suggest that the growth rate of Agrobacterium is dependent on the media type and possibly, strain type.

Keywords: Agrobacterium strains, genetic transformation, optical density (OD), nutrient media, bacterial growth

INTRODUCTION

Culture media are essential tools developed to support the growth and reproduction of microorganisms by meeting their nutritional needs. The two most commonly used types are liquid and solid media for cultivating bacteria. The advent of culture media in the 19th century paved the way for significant advancements in microbiology. In 1881, Robert Koch demonstrated that bacterial growth could be optimized by incubating them in a broth composed of meat extract or fresh cow serum (Atmanto *et al*., 2022). Since then, culture media have been widely employed in bacterial research. Studies show that bacterial growth in a closed system typically follows a predictable pattern, known as a growth curve, which comprises four distinct phases: lag, exponential (log), stationary, and decline. Understanding the specific growth conditions of bacteria enables more accurate control of their proliferation under given conditions (Iqbal *et al*., 2021). Different bacterial species require different growth conditions, and optimal growth is necessary for subsequent steps like DNA extraction or genetic transformation. One prominent bacterium, *Agrobacterium tumefaciens*, is a gram-negative, aerobic, motile, rod-shaped soil bacterium that typically measures 1.5-3.0 x 0.6-1.0 µm. This bacterium is known for causing crown gall disease in plants by integrating its *T-DNA* into the host genome

(Petrovicheva *et al*., 2017), a process that has been harnessed for the production of transgenic plants. By using *Agrobacterium*, plant breeding times can be significantly reduced, and new genes can be introduced into crops efficiently. Microbial growth and metabolism are heavily dependent on the composition of the growth medium used. Therefore, selecting the right medium is crucial for maximizing bacterial growth, ensuring the reproducibility of results, and achieving high biomass yields. This study focuses on three common microbiological media: yeast extract peptone (YEP), lysogeny broth (LB), and yeast extract mannitol (YEM). YEP consists mainly of yeast extract and peptone, providing a rich source of vitamins, amino acids, and nutrients. It is commonly used for cultivating various bacteria, including *Agrobacterium* species, due to its ability to promote rapid growth and high cell densities (Sambrook & Russell, 2001). YEM is specifically designed to support the growth of nitrogen-fixing bacteria, such as *Rhizobium* and *Agrobacterium*, and contains yeast extract, mannitol, and essential minerals, creating a balanced environment for both growth and nitrogen fixation. This study evaluates the growth patterns of two different *Agrobacterium* strains, each with potentially distinct physiological and metabolic needs. Gaining insights into how these strains respond to different media can help optimize growth conditions for various applications (Gao *et al*., 2013). The main objective is to compare the growth of the two strains in YEP, LB, and YEM media to identify the best medium for maximizing bacterial growth and biomass production. Such findings are crucial for improving the efficiency of *Agrobacterium*-mediated plant transformations and will benefit researchers in plant genetic engineering (Kong *et al*., 2014).

MATERIALS AND METHODS

Bacterial Strains

Two strains of *Agrobacterium tumefaciens* were used in this study, LBA4404 derived from a less virulent strain Ach5 and AGL-1. These two strains are being used in the genetic transformation of monocots and dicot plant species.

Nutrient Media

Three selective complex media broths were used to test their efficiency in supporting the growth of Agrobacterium under similar conditions with respective antibiotics specific for each strain. Ready to use Yeast Extract Mannitol (YEM), Yeast Extract Peptone (YEP), Luria Bertani Broth (LB), were obtained from Biotech lab of NRCRI, Umudike, 11.80 grams of mixture for YEM, and 25 grams of mixture for YEP media is suspended in 1000 ml of distilled water then the medium was buffered to pH 7.0 and sterilized by autoclaving at 15 psi pressure and 121°C for 15 minutes. Rifampicin (10 mg/ml) and streptomycin (30 mg/ml) specific for *LBA4404*, Rifampicin and carbenicillin (250mg/ml) for AGL-1 were added in the medium after sterilization to allow growth of only desired bacterial strain.

Place and Duration of Study

This study was conducted at cloning Laboratory in Biotechnology unit of National Root Crops Research Institution, Umudike, Abia State, Nigeria between June and August 2024.

Culture Conditions

A single colony from the fresh plate of each Agrobacterium strains: *LBA4404*, and *AGL-1* were inoculated in 5 ml of all nutrient broth containing respective antibiotic (mentioned above) in falcon tubes and allowed to grow under the same condition at 28°C with continuous shaking at 180 RPM over orbital shaker (Incubator with Shaker T100L

Techmel & Techmel USA). Three replicates of each strain over each medium were set up for experimentation.

Growth Curve

Optical Density (O.D) is a measure of the turbidity of the bacterial growth and was measured as absorbance at 600 nm, at every 3hourly interval for each of the nine cultures using a UV/VIS spectrophotometer (yoke instrument) and their three replicates and mean of all three replicate readings ± standard error (SE) were plotted against media type to analyze the growth of bacterial strains over different nutrient broths.

Statistical Analysis

The growth analysis experiments were performed with three replications per treatment. Each experiment was repeated at three times, and the reported data are the means of these experiments. All data presented as mean ± standard error (SE). Data were analyzed with RStudio version 4.4.1. Differences were determined by two-way analysis of variance (ANOVA), and significant ($P < 0.05$) differences among mean values were estimated using the *dplyr* library function in R.

RESULTS AND DISCUSSION

As presented in table 1, results of the mean optical density (OD) showed that LBA4404 performed best in LB media (0.417±0.30-0.517±0.32), followed by LBA4404 cultured in YEP media (0.342±0.22-0.395±0.25). AGL-1 performed best in YEP media (0.461±0.28-0.502±0.29) followed by LB (0.423±0.31-0.451±0.28).

Luria-Bertani (LB) Medium is one of the most frequently used general-purpose media for bacterial growth. It has been widely used for culturing various bacteria, including *Agrobacterium* species, due to its balanced nutrient content. Studies have shown that *Agrobacterium* strains exhibit rapid exponential growth in LB medium, often reaching maximum cell density within 24-48 hours (Rao & Dasgupta, 2020). This corroborates our result as presented in figures 1 and 2, where it can be observed that LB media gave a substantial mean growth performance after YEP media. YEM medium contains yeast extract, mannitol, K_2HPO_4, $MgSO_4$, and NaCl, which provide a rich environment for the growth of *Agrobacterium*. The mannitol in YEM serves as a carbon source that enhances bacterial growth, while the yeast extract supplies vitamins and growth factors essential for cellular activities. Several studies have reported that *Agrobacterium* strains show enhanced growth performance in YEM compared to LB, due to the additional carbohydrate source in YEM (Khan *et al*., 2021).The low performance of YEM cultures from our result was expected since the media is nutrient deficient. YEM is commonly used when preparing *Agrobacterium* cultures for inoculation during plant transformation experiments, as it supports high-density growth while providing a moderately balanced nutrient composition (Chatterjee & Roy, 2021). The role of mannitol in enhancing bacterial growth has been well documented, making YEM a preferred medium for experiments that require extended bacterial proliferation (Smith *et al*., 2020). On the other hand, YEP medium is particularly effective for growing *Agrobacterium* to high cell densities, making it suitable for applications that require large quantities of bacterial cells, such as plant transformation protocols (Mullins *et al*., 2019).Our results showed that the foregoing is true, since, the overall performance of the cultures was higher in YEP. Research has shown that *Agrobacterium* strains grow more efficiently in YEP compared to LB and YEM, particularly when high biomass is required (Kumar & Singh, 2021). The combination of yeast extract and peptone in YEP results in better nutrient availability, promoting faster growth and higher cell yields (John & Smith, 2019).

Therefore, YEP is typically used in conjunction with *vir* gene inducers when preparing *Agrobacterium* for plant transformation. When comparing the three media types, LB, YEM, and YEP, studies indicate that all three media support robust growth of *Agrobacterium* strains. However, YEP is often preferred for achieving high cell densities due to its richer nutrient content. YEM also supports efficient growth, particularly in experiments that require an additional carbon source, while LB is widely used due to its availability and ease of preparation (Mullins *et al*., 2019). The major difference between these media lies in their ability to induce virulence gene expression. LB and YEP support rapid bacterial growth but do not naturally induce the expression of virulence genes. YEM, while not inducing *vir* genes itself, can be combined with inducers to facilitate efficient plant transformation (Kumar & Singh, 2021). Our results therefore, suggest that the content of media as well as concentration of the contents are key factors contributing to the variation in growth dynamics of *Agrobacterium* in general, furthermore, our results showed that different bacteria strains grow differently in different media types it was observed that AGL-1 and *LBA44404* performed best in YEP and LB media respectively this finding is in tandem with the report of Mullins *et al*. (2019).

CONCLUSION AND RECOMMENDATIONS

The choice of nutrient media has a significant impact on the growth performance of *Agrobacterium* strains. While LB, YEM, and YEP all support bacterial proliferation, their effectiveness in plant transformation protocols depends on the specific needs of the experiment, including the requirement for *vir* gene expression. YEP, with its rich nutrient content, is optimal for biomass production as can be seen from our result, while YEM provides an additional carbon source for enhanced growth. LB remains a widely used general-purpose medium but may require supplementation with chemical inducers for virulence gene activation.

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Table 1: Optical density of *Agrobacterium* strains (*LBA4404 and AGL-1*) cultured

MEDIA/REP	LB+R/C/ AGL-1	YEM+R/C/ AGL-1	YEP+R/C/ AGL-1	LB+R/S/ LBA4404	YEM+R/S/ LBA4404	YEP+R/S/ LBA4404
			GROUP ONE			
1	0.423±0.31	0.185±0.08	0.461±0.28	0.459±0.28	0.184±0.08	0.353±0.24
2	0.451±0.28	0.273±0.25	0.502±0.29	0.517±0.32	0.182±0.08	0.395±0.25
3	0.431±0.258	0.186±0.07	0.479±0.28	0.417±0.30	0.159±0.09	0.342±0.22
			GROUP TWO			
1	0.403±0.25	0.172±0.08	0.396±0.24	0.444± 0.25	0.180±0.08	0.389±0.25
2	0.472±0.26	0.161±0.08	0.443±0.24	0.433±0.29	0.188±0.08	0.365±0.23
3	0.441±0.261	0.159±0.08	0.393±0.24	0.473±0.27	0.186±0.07	0.373±0.22
			GROUP THREE			
1	0.423±0.26	0.195±0.08	0.417±0.27	0.434±0.26	0.172±0.08	0.336±0.23
2	0.392±0.23	0.187±0.07	0.479±0.28	0.439±0.26	0.193±0.09	0.466±0.34
3	0.406±0.24	0.177±0.08	0.484±0.28	0.435±0.28	0.169±0.07	0.411±0.30

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Analysis of Sweetpotato Farmers Seed System in Ebonyi State, Nigeria: Implication for Seed System Development

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Abstract
The study provided information on the analysis of sweetpotato farmer's seed system in Ebonyi State, Nigeria with regards to seed system development. A multi-stage sampling design that involves random and purposive procedure was used to select 60 sweetpotato farmers. The study employed descriptive statistics to ascertain the farmer's seed variety, seed security and variety security. Estimation of factors that influence sweetpotato seed varietal choice was done using Multinomial Logit. Challenges farmers faced in seed system were identified using 4 point-scale. The study found 7 varieties available in the study area (namely; Nwaoyiria, Butter milk, Gbarimotor, Ex-Igbariam, TIS0087/087, Mothers Delight and King J) with the mean seed security and varietal index of 0.5171 and 0.2551 respectively. Pest and disease attack was the most strongly agreed constraints militating against functional in the seed system, inadequate planting material at planting (70.00%), unavailability of varietal choice (65%), low quality of vine and oor access of seed multiplication infrastructure (60% each), poor vine business outlets (55%) and seed market related problems (50.00%). The study proffers solutions geared towards ensuring availability and affordability of pest and disease free sweetpotato seeds for farmers at a sustainable system. This can be achieved through a capacity building and informal training of the farmers on seed system conservation, multiplication and production of quality seeds. However, breeders in the system should endeavor to play alongside with the farmers and ensure that their requests are maintained during the breeding process, especially in term of varietal choice.
Key Words: Availability, Choice, Selection and Sustainability

INTRODUCTION

Agricultural production in Nigeria is dominated by farmers with small farm holdings who are known to produce more than 90% of the food consumed in the country (Njoku et al., 2016) and operates with informal seed system. Likewise, in sweetpotato sector, the farmers' access of seed ranging from farmer to farmers exchange, use of own old materials or volunteer sprouts etc. Okoye *et al*., (2021) noted that in Nigeria, sweetpotato seed system is still informal where farmers source seed from neighbor's f arms and out-growth from previous farms. The selection, multiplication, dissemination and storage of this system take place as integral parts of crop production rather than as discrete activities (Sperling et al., 2013).

According to Lipper et al, (2010), seed system is the economic and social mechanism by which farmers' demand for seed and preference for desirable traits, with demands met by various possible sources of supply. It is also the network of stakeholders involved in producing and planting the seed (including vegetative seed) of a particular crop in a certain area. The seed system is associated with certain agricultural and seed-production technologies, and with the genetic resources needed to produce the seed (Root Tuber and Banana RTB, 2016). Farmers formed an integral part of the seed system having been the end users. In an actual and organized system, they determines the variety, quantity, production, storage and to an extent seed movement/regulations. In order to develop a seed system especially in sweetpotato, analyzing farmers' seed systems will help to assure healthy farmer seed (e.g., resilience, efficiency), detect how key farmers seed-system processes appear (e.g., rates of adoption, seed diffusion, or genetic change) following McGuire (2000). Considering the various processes involved in seed provision, selection, and storage as a system permits a holistic analysis of strengths and weaknesses, and possibly helps us choose more appropriate seed interventions that will geared towards formal seed system.

METHODOLOGY

Ebonyi State is located in the South-East geo-political zone of Nigeria with its capital at Abakaliki. It lies between latitudes 5 0 40′ and 6 0 45′ North and longitudes 7 0 30′ and 80 46′ East of the greenwish meridian (Awoke and Okorji, 2004) with three agricultural Zones and 13 LGAs. A multi-stage sampling design that involves random and purposive procedure was used for the study. Out of 13 LGAs, the study randomly selects 3 LGAs- Ikwo, Ishielu, and Akakiliki LGAs based on their intensity of sweetpotato production. In the second stage, one community (Amagu, Ntezi and Afikpo respectively) from each of these LGAs was purposively selected from giving a sample of 3 communities. In the last stage, 20 sweetpotato farmers were randomly sampled from the list of sweetpotato farmers collected from the State ADP totally 60 farmers for the study.

Descriptive Statistics were used to ascertain the farmer's seed variety, seed security and variety security. Factors that influence sweetpotato seed variety were estimated using Multinomial Logit MNL. Finally, constraints/challenges farmers faced in seed system were analyzed using 4 point scale (Strongly Agree 4, Agree 3, Disagree 2, Strongly Disagree =1).

$$\text{Seed security} = \frac{\text{Number of seed available}}{\text{Number required}}$$

$$\text{Variety security} = \frac{\text{Number of variety available}}{\text{Number of variety required}}$$

Seed and variety security takes a value between 0 and 1, inclusive. Farmers are seed and variety secured when they have value closer to 1.

MLE model is explicitly modeled as:

$$Y1= \beta_0+ \beta_1X_{1+} \beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6 +\beta_7X_7+\beta_8X_8+\beta_9 X_9 +\beta_{10}X_{10}+u_i \quad (1)$$

Where, Y1= seed Variety (White =1, Cream =2, Yellow = 3 and Orange Variety =4).
X_1= gender (dummy variable; male=1, female=0), X_2= educational background (years), X_3= number of times of extension contacts, X_4= membership of cooperatives (dummy variable; yes =1, no=0) , X_5= farming experience (years), X_6= area cultivated with sweetpotato (hectare), X_7= price of seed (N), X_8= farm income (N), X_9= variety type (dummy variable; white variety=1, orange variety = 0), X_{10}= productivity (t/ha)
ui= error term

RESULTS AND DISCUSSION

Average socio-economic characteristics of the respondent

The results in Table 1 presented the average socio-economic characteristics of respondents in Ebonyi State. The study showed mean household of about 5 persons, farming experience of 7 years, total farm size of 0.8010 hectare and average yield of 655 kg. This indicated that the respondents had a large household size, experienced in farming, operates on small farming holdings and had an encouraging yield following Okoye et al, (2021). The study also found that majority of the farmers are female (80.00%), within the ages of 31-50 years (100.00%), married (100.00%), had secondary school education (85.00%), and do not have extension contacts and are not members of cooperative society (100.00% each).

Table 1: Average socio-economic characteristics of respondents

	Mean	Std. Dev.	Min.	Max.
Household size	5.15	1.2048	3.00	7.00
Farming experience	7.0000	2.4906	2.00	10.000
Farm size	0.8010	1.65101	0.10	7.00
Yield	655.00	142.5256	500	1000
Dummy				
Gender (female)	48(80.00)			
Age (31-40, 41-50)	30(50.00)			
Marital status(married)	60(100)			
Educational status (secondary)	51(85.00)			
Membership of cooperative society (no)	60(100.00)			
Extension contact (no)	60(100.00)			
Monthly income				

Source: Field survey, 2024

Farmer's seed variety, seed security and variety security

Farmer's Seed Variety

The results in Table 2 showed the distribution of farmers according to seed variety and choice. The study found 7 varieties in place and available in the study area namely; Nwaoyiria, Butter milk, Gbarimotor, Ex-Igbariam, TIS0087/087, Mothers Delight and King J. However, all (100%) farmers noted availability of Nwaoyiria in their farm while 96.70% planted it in the last planting season.

Table 2: Distribution of farmers according to Seed variety and choice

Variety Name	Freq. Available	Freq. planted	Best variety
Nwaoyirima	60(100)	58(96.70)	42(70.00)
Butter milk	11(18.33)	8(13.30)	2(3.30)
Gbarimotor	42(70.00)	42(70.00)	12(20.00)
ex-igbariam	18(30.00)	11(18.33)	0(0.00)
TIS0087/087	5(8.30)	3(5.00)	0(0.00)
Mothers Delight	8(13.30)	3(5.00)	4(6.70)
King J	2(3.30)	2(3.00)	0(0.00)

Source: Field survey, 2024

Farmer's Seed Security and Variety Security

The results in Table 3 presented the farmer's sweetpotato seed security and variety security in the study area. The study showed a seed security and varietal index of 0.5171 and 0.2551 respectively indicating that the farmers in the study area are sweetpotato seed secured but varietal in secured. This explained that the farmers are actually planting sweetpotato but the variety or cultivar planted may not be their desired and choice, leading them to plant the available.

Table 3: Farmer's Seed Security and Variety Security

Items	Mean	Std .dev.	Min	Max.
Average farm size intended to plant	0.8010	1.7008	0.0100	5.0000
Farm size Actual Planted	0.4142	0.6074	0.0100	1.5000
Number of seed available (Bundle)	137.9286			
Number of seed Required	266.733			
Seed security	**0.5171**			
Number of Desired Variety available	2.0411	0.9565	1.0000	4.0000
Total number of variety required/variable	8	4.514	1.0000	8.0000
Variety security	**0.2551**			

Source: Field survey, 2024

Socio-Economic Factors influencing farmer's sweetpotato seed choice in term of variety selection

The results n Table 4 presented the Multinomial logit regression estimates on the determinants of choice of variety seed among sweetpotato farmers in Ebonyi State, Nigeria. The study found the LR Chi2 highly significant at 1% level indicating a regression of best fit. The R^2 value of 0.5798 showed that 57.98% of the variability in sweetpotato seed variety selection was explained by the independent variables.The study estimated the coefficient for sex to be positive and significant at 10 % level for the choice of cream fleshed variety indicating that any increase in number of male farmers will increase the selection of CFSP other than OFSP. The coefficient for age was significant at 5% level of probability and negatively related with choice of variety selection, implying that any increase in age will reduce the choice of selecting WFSP other than OFSP. This is expected as the aged are more concern of nutritional foods than the younger ones. The coefficients household sizes were positive and significant at 10% and 5% level of probability for white and cream fleshed variety selection. This indicated that increase in household size will lead to an increase in selecting WFSP and CFSP other than the OFSP.

Table 4: Multinominal Logit Regression Estimates on the Determinants of Seed Source among Sweetpotato Farmers in Ebonyi State, Nigeria (Ikwo)

Variables	Parameter	White	Cream	Purple
Sex	X_1	-0.0586(-0.07)	2.4143(2.54)*	-34.2085(0.99)
Age	X_2	-0.0438(2.65)**	-0.0799(-0.89)	0.0480(1.69)
Household size	X_3	0.0685(2.28)*	0.4175(2.94)**	-36.6692(0.02)
Education	X_4	-0.4127(-0.34)	0.5188(0.30)	0.7937(4.25)***
Farming Experience	X_5	0.0073(0.05)	-0.2269(-1.10)	-1.8110(0.98)
Farm size	X_6	0.6067(1.56)*	1.1847(2.53)*	-3.1066(0.72)
Farm income	X_7	6.99e-07(0.22)	-6.53e-06(-0.93)	-0.0003(-0.00)
Yield	X_8	0.0009(2.40)*	0.0007(2.00)*	0.00069(2.69)**
Constant	Bo	-1.7617(-0.33)	632.4544(0.00)	632.4544()
Number of observation	60			
LR Chi2	57.09			
Prob > chi2	0.0000			
Log likelihood	-46.6036			
Pseudo R^2	0.5798			

Source: Field survey, 2024. Figures in parenthesis represent t – values,
***, **and * are Significant at 1%, 5% and 10% respectively

The result also showed that coefficient for educational level was highly significant at 1% and positive at PFSP choice, indicating that farmers with higher educational background will select PFSP other than OFSP. With education farmers will increase prior access to external information, and analyzing the information. Okoye et al, (2021) noted that the level of education of a farmers determine its level of access to information. The study also showed that the coefficients for farm size were positive and significant at 10% each for WFSP and CFSP choice. This simply implied that any increase in farm size will increase choice if WFSP and CFSP other than OFSP possibly as a result of its availability and accessibility. Furthermore, the coefficients for yield of sweetpotato were significant and positively related with the choice of selecting WFSP (10%), CFSP (10%) and PFSP (5%), indicating that increase in yield in these varieties will increase the chance of selecting the other than OFSP. This explained the need and interest of every farmer in the yielding bulking variety for livelihood improvement.

Constraints militating against Farmers in Sweetpotato Seed system

The results in Table 5 depicted the constraints/challenges farmers faced in seed system. The study noted pest and disease attack as the most strongly agreed constraints militating against functional in the system followed by, inadequate planting material at planting (70.00%), unavailability of varietal choice (65%), low quality of vine and oor access of seed multiplication infrastructure (60% each), poor vine business outlets (55%) and seed market related problems (50.00%).

Table 5: Distribution of Constraints/challenges farmers faced in seed system

Constraints	Strongly Agree	Agree
Pest and diseases attack	60(100)	0(0.00)
Low quality of the vine	36(60.00)	24(40.00)
Unavailability of varietal choice	39(65.00)	21(35.00)
Inadequate planting material at planting	42(70.00)	18(30.00)
Inadequate knowledge on vine conservation	45(75.00)	15(25.00)
Seed market-related problem	30(50.00)	30(50.00)
Poor access of seed multiplication infrastructure	36(60.00)	24(40.00)
Poor vine business outlets	33(55.00)	27(45.00)

Source: Field survey, 2024. Figures in parentheses are percentage values

CONCLUSION AND RECOMMENDATIONS

The study found four major varieties of sweetpotato planted by farmers in Ebonyi State namely; Nwaoyrima, Gbarimotor, Butter milk and Ex-igbarim in that order.The sweetpotato farmers in the study area were found also to be seed secured but varietal insure. However, the study also estimated the coefficients for household size, farm size, and yield as common factors influencing choice of selecting WFSP and CFSP other than OFSP while education level and yield were variable influencing the selection for PFSP. The study proffers solutions geared towards ensuring availability and affordability of quality sweetpotato seeds for farmers at a sustainable system. This can be achieved through a capacity building and informal training of the farmers on seed system conservation, multiplication and production. However, breeders in the system should endeavor to play alongside with the farmers and ensure that their requests are maintained during the breeding process, especially in term of yield, color and shape.

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Climate Change and Rice Yield Variability Nexus in Nigeria

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Abstract

A significant portion of Nigeria's economy is based on agriculture, and being vulnerable to bad weather patterns. The empirical research about the impact of climate change on Nigeria's rice output is still somewhat limited. This study specifically looked at how Nigeria's rice yield is affected by climate change. The Nigerian Meteorological Center provided climatic data (temperature and rainfall), while FAOSTAT provided statistics on rice yield (1980-2020). Regression modelling, trend analysis, and descriptive analysis were the analytical techniques used in the data analysis. The results of the research showed that the pattern of rice yield varies. The outcome demonstrates how humidity and yearly rainfall affect Nigeria's rice production. Humidity had a positive coefficient and was significant at 1% while a negative value was recorded for rainfall. Pesticides and potash fertilizer, two non-climatic elements, had significant values of 1% and a positive coefficient, respectively. The study concluded that climate change significantly influences rice yield variability in Nigeria. The study recommended that Irrigation facilities should be provided for rice farmers in the event of rain shortage to help them mitigate the challenge of drought. Fertilizers inform of subsidies should be provided for the farmers which will help them increase their rice yield.

Keywords- Rice yield, Climate change, ARCH family regression, Fertilizer, Nigeria

INTRODUCTION

Agriculture and climate change are interdependent and strongly related. The IPCC (2007) states that while there is growing evidence that developing nations are more vulnerable to climate change than developed ones, policymakers should pay particular attention to how vulnerable Nigeria's agricultural sector is to the phenomenon. The country's agricultural sector employs between 60 and 70 per cent of its labour force and generates between 30 and 40 per cent of its GDP. In addition to providing the nation with foreign exchange gains, the sector is a source of raw materials for several processing businesses. As per Adedeji *et al*. (2017), the detrimental consequences of climate change are anticipated to exert a notable influence on agricultural output and consequently on the assurance of food supply, particularly within Nigeria. This is due to the dominance of inadequately equipped smallholder farmers within the Nigerian agricultural sector, who cannot effectively manage and adjust to these adversities. It has been predicted that Nigerian rice production will be impacted by climate change. In Nigeria, rice is an important cereal in production and land area. In Nigeria, rice, which is cultivated on 1.77 million hectares, is now a staple food in the majority of both urban and rural houses (Ayinde *et al*, 2013).

Since temperature and rainfall are two main factors affecting rice production in Nigeria, it is imperative to examine how the country's climate affects rice production (Ifeanyi-Obi *et al*. 2012). Environmental hazards such as drought, floods, salt stress, and extreme temperatures are expected to cause yield loss in rice production. A spike in temperature and drastic changes in rainfall patterns would create adverse growing conditions. On the other hand, empirical study on the extent to which variations in Nigeria's rice output could be attributed to changes in climate conditions is still in its early stages (Kolapo and Kolapo, 2022). One important factor that can direct the creation of policy is having a thorough grasp of how Nigeria's rice production is impacted by climate change. Importantly, this knowledge is required if government initiatives to produce enough rice to support itself are to succeed. This emanated greater investments made by the Nigerian government to boost rice production relative to other cereals. The study's main goal is to examine the impact of climate change on Nigeria's rice output. The study's specific objectives are to explain the trend of rice production in Nigeria and analyse the impact of climate change on rice production in Nigeria.

MATERIALS AND METHODS

The annual data used for the study were sourced from the Nigerian Meteorological Agency and FAOSTAT database. The series spans four decades (1980 to 2020). The choice of the time lag was due to the availability of data. The variables used in the model specified are rainfall, temperature, phosphate fertilizer, nitrogen fertilizer area of land used for rice cultivation, and Rice Output which is the dependent variable while Rainfall, Temperature, phosphate fertilizer, nitrogen fertilizer and area of land put to rice cultivation are the explanatory variables. Rice output - Annual Rice output (MMT) Rainfall – average annual rainfall was used for the variable (mm); Temperature – average annual temperature (Degree Celsius); Land area – average area of land put to rice cultivation annually (hectare).

The study adopts the Arch family regression model to examine the impact of climate change on rice output in Nigeria between 1980 and 2020. Rainfall, temperature, phosphate fertilizer, nitrogen fertilizer and land area put into rice cultivation in the country represent the study's independent variables (Xi), while Rice output represents the dependent variable (Yt). The data was analyzed using the STATA 15 software package. The statistical analysis was conducted using t-statistics, unit root test, co-integration test and regression model. These tests are essential in testing the reliability of the parameter estimates.

Model Specification

The regression model in implicit form is:
Y = f(X1,X2,X3,X4)

The equation is better put as:

$$LY_t = \beta_O + \beta_1 LX_{1t} + \beta_2 LX_{2t} + \beta_3 LX_{3t} + \beta_4 LX_{4t} + U_t$$

Yt = Rice output (MMT); X1 = Average annual Rainfall (mm); X2 = Average annual Temperature (^{O}C) X3 = phosphate fertilizer, X4= Area of land used for rice cultivation (ha) t = Years,

RESULTS AND DISCUSSION

Trends of Annual rice yield, cropland and production quantity

The rise in rice yield in Nigeria steadily rose from 180 thousand tonnes in 2008 to a high peak of 200 thousand tonnes in 2011 (Figure 1). After this time, a sharp decline occurred during the years 2012 through 2013, after which another sharp rise was seen in 2014 and 2015. The most recent two years (2019-2020) indicate a declined yield.

Descriptive Statistics

Table 4.1 shows descriptive statistics in which mean, minimum, maximum, and standard deviation were analyzed for the data series of rice crops. This crop has an all-time maximum yield of 26709 kg/ha and an all-time minimum yield of 12999kg/ha with a mean of 17921.37 kg/ha. The total cropland area of rice has a max and min of 43472 and 33300 tonnes/ha respectively with a mean of 43472 tonnes/ha. The average rainfall as it affects production taking the value 3.337667mm shows a steady supply of rainfall to the production in Nigeria. The average temperature is 24.8^{0}C indicating a steady and moderate temperature for rice growth.

Table 1: Descriptive Statistics

Variables	Observation	Mean	Standard Deviation	Minimum	Maximum
Yield (Kg/ha)	30	17921.37	3754.242	12999	**26709**
Product. (Tons)	23	430.3956	170.0912	191.7	**851.1**
Total crop Area	30	40813.77	2873.931	33300	**43472**
Potash fert.	30	1.369667	1.023431	.39	**4.24**
Phosphate fert.	30	1.488667	1.152583	.35	**4.6**
Nitrogen fert.	30	4.626667	2.031859	1.55	**8.42**
Rainfall (MM)	30	3.337667	2.582998	0	**5.27**
Temp (^{0}C)	30	24.89667	.9302367	23.55	**26.94**
Humidity	30	12.789	.4896891	11.72	**13.61**
Surface soil	30	.5083333	.0773743	.37	**.64**
Root zones	30	.537	.0592569	.45	**.64**
Pesticides	30	.447	.3842427	.03	**1.32**

Source: Data analysis 2024

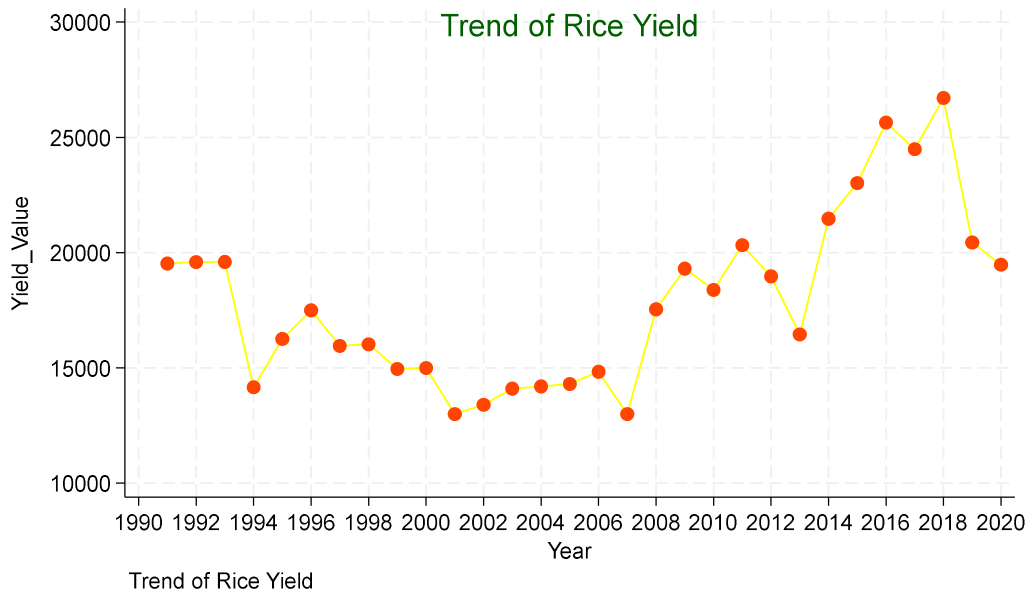

Figure 1: Trends of Annual rice yield

Impact of climate change on rice output

The results of the effect of climate change impact on rice crop yield are presented in Table 4.4. ARCH-family regression was performed and the result is presented in Table 4.4. The Prob>chi^2 = 0.000 were significant. Also, the arch (L1) was significant indicating that the selected explanatory variables adequately predicted the yield of rice crops. From the table, variables such as rainfall, humidity, surface soil wetness, root zone soil wetness, Potash fertilizer, Nitrogen fertilizer and pesticides significantly affect the yield of rice crops in Nigeria. In previous years, rainfall had a significant (p=1) negative impact on rice yield due to its statistically significant (p=1) negative coefficient with climate factors. This could be explained by the inconsistent rainfall patterns observed in previous years. This suggests that a decline in rainfall will cause the rice yield to decline further. Humidity had a positive and statistically significant coefficient. This suggests even further that higher humidity levels result in higher rice yields. Thus, rice yield is increased when moisture is available for rice production. At the 1% probability level, the coefficient of surface soil wetness was statistically significant and negative. According to the evidence, the decrease in rice production was caused by a shortage of surface soil moisture. The absence of moisture in the soil causes the rice yield to be affected when the soil surface is dry. At the 1% probability level, the root zone soil moisture coefficient was positive and statistically significant. This demonstrates how a rice plant's ability to retain moisture in its roots increases rice yield. The positive and statistically significant coefficient of potash fertilizer indicates the significance of fertilizer application in raising rice output. Contrary to popular belief, there is a statistically significant negative correlation between rice yield and nitrogen fertilizer. This indicates that boosting rice yield is not as dependent on nitrogen fertilizer. Therefore, increasing rice output may not always result from applying nitrogen fertilizer. The application of pesticides was found to positively and statistically significantly affect rice yield, as expected. Consequently, the use of pesticides to combat illnesses and pests that affect rice produced more rice. This proves the value of pesticides in managing diseases and crop pests caused by climate change.

Table 2: Parameter estimates of the ARCH family regression

Variables		Coefficient	OPG stand. Err	t-stat
Temperature		117.0573	154.2413	0.76
Rainfall		-109.5377***	41.98507	-2.61
Humidity		2292.76***	373.1995	6.14
Surface soil wetness		-20421.58***	8029.834	-2.54
Root zone soil wetness		20177.87***	7965.505	2.53
Potash fert.		3723.333***	745.3152	5.00
Phosphate fert.		75.55829	471.8629	0.16
Nitrogen fert.		-1544.335***	182.7694	-8.45
Pesticides		7771.667***	432.4655	17.97
Constant		-16460.57***	5745.911	-2.86
	arch			
	L1.	8.131302***	3.269	2.49
		32.42387	18875.1	0.000
Constant				
Loglikelihood		-257.0887		
Waild $chi^2(9)$		29118.19		
Prob>chi^2		0.0000		

Source: Author computation, 2024. *** denotes significance at a 1% level.

CONCLUSION AND RECOMMENDATIONS

The study concluded that climatic and non-climatic factors significantly influence rice yield in Nigeria. Rainfall, humidity, surface soil wetness, and root zone soil wetness were found to have a significant impact on rice production. Additionally, non-climatic factors such as potash fertilizer, nitrogen fertilizer, and pesticides also played a crucial role in determining the yield of rice crops. The study recommends several measures to increase future rice yields in light of these findings. It is important to provide rice farmers with irrigation facilities to help them cope with drought conditions during periods of insufficient rainfall. Secondly, fertilizers should be made available to farmers at subsidized rates to boost their rice production. These recommendations aim to address both climatic and non-climatic challenges, ensuring better rice yields in the future.

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Livestock Production a Source of Food Security: A Review

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Abstract
In Nigeria where agriculture is still an important part of the national economies, especially among the poorest portion of the society, livestock has been in the spotlight for many developments. Up to 60 to 80 percent of the poor in Nigeria depends on livestock at least partly, and the consumption of livestock products is increasing greatly, Governments have seen the sub-sector both as an opportunity to reduce hunger and to boost economic activity. This paper examine the role of livestock in multiple ways by ending hunger and all forms of malnutrition contributing to food security by direct consumption of livestock products. They include: increasing the direct consumption of nutritious animal-source foods; helping to generate income; supporting the creation of employment; foreign exchange; Poverty reduction and creation and providing the world with sufficient and reliable supplies of meat, milk, eggs and dairy products, and of primary commodities used for clothing, bedding and other household items.
Keywords: ***Livestock, Food security, Hunger, Sustainable and Productivity***

INTRODUCTION

A significant proportion of the 377 million people in West Africa depends directly or indirectly on livestock value chains for food, as input to crop production, transport, as a source of cash, investment, and storage of wealth, for social purposes, or as insurance during impending crises. (Smith *et al.*, 2013) In some Sahelian countries, such as Burkina Faso, Mali, and Nigeria, about 60 percent of the population is involved in livestock production. In these countries, livestock production contributes between 37 and 82 percent to the agricultural GDP. The demand for animal products as a source of quality protein and micronutrients is increasing with population growth, urbanization, growing middle class, and due to shifting consumer preferences towards animal products. The protein in meat, milk, and eggs is dense and more bio-available than plant-based protein (FAO, 2019b).

Despite the considerable potential of livestock in Nigeria, it however leaves much to be desired in terms of utilization. Projections show that the consumption of poultry meat, pork, and eggs is rapidly increasing and without a doubt, aiming to reach six to seven folds in Nigeria by 2050 Likewise, milk consumption is likely to triple during the same period. Meeting such a growing demand, requires tremendous efforts such as increasing public and private investment towards the livestock subsector (FAO, 2018b).

Poor husbandry practices, inadequate feed and water, the prevalence of various animal diseases, poor extension services, and inadequate infrastructure and limited market access pose as impediments to the growth of this subsector. This is further exacerbated by climate change and extreme weather conditions, as well as incidences of conflicts and insecurity that are spreading over the years in the northern part of Nigeria.

For Nigeria to eradicate poverty and hunger, livestock sector must be up to date, reliable information on the potentials, opportunities, and proper planning of appropriate interventions and informed decision-making must be put in place (Krätli, 2014).

This paper attempts to contribute in this regard through knowledge-sharing based on different studies commissioned by the Food and Agriculture Organization of the United Nations (FAO) in Nigeria in recent years which depend on livestock as a source of generating substantial revenue and ensuring livelihoods of the populace in other to sustain food security and also as a prime commodity for the generation of foreign currency for national economy and source of employment.

Role of Livestock to the Food Security in Nigeria

Income generation

Most of the meat produced in West African countries is sold by weight in Kilograms. The prices vary from country to country and even from place to place in a specific country. Likewise, meat of different species fetch different prices. Having said that, the price used for computing the estimated total monetary value of meat produced in a region is based on average selling price in each country. The volume of meat produced in West African countries was obtained from records of animals slaughtered in 2011 or 2012. Accordingly, the monetary value of annual meat production in the region is estimated at USD12.3 billion

Diversity of livestock

In most of the countries, livestock plays a predominant role in the livelihood of rural populations, whose daily activities revolve around the exploitation of livestock and whose monetary needs are animal-dependent. The sales of livestock contribute to the acquisition of basic livelihood foodstuff and goods (i.e. cereals, sugar, clothing, etc.) and to support expenses for raising or educating children, to pay for health services and for other social activities. In agro-pastoral systems, farmers invest in livestock excess revenues that can be spared from crop cultivation activities as a means of storing wealth. In addition, livestock plays important cultural and religious roles in the livelihood of the populations in Nigeria (Pica-Ciamarra *et al.*, 2014a)

Food security, nutrition and health

Livestock plays an important role in household food security and the development of crop production, the latter through animal draft power and the supply of manure for soil fertility. It provides high nutritional value protein, in form of meat, milk and eggs, and plays a vital role in food security on its own or exchange with grain. In the case of pastoralists, milk and its products make up a big portion of the basic diet and provide essential micronutrients, and for whom meat provides either resources to purchase grain, or is consumed occasionally as a high-quality food (Hatfield and Davies, 2006 and FAO, 2019b). Crop farmers very often keep poultry or, less commonly in the region, pigs in backyard systems that are also fundamental in providing essential nutrients (Idi and Ganda-Idé, 2009), cheaply fed on leftover and scraps in such systems. Indeed, animal products provide energy, minerals and vitamins but their predominant role is the supply of some essential amino acids and vitamins, which the human body cannot synthesize and must be necessarily provided by food. Foods of animal origin are also important in the recuperation of nutritionally deficient kids and pregnant or lactating women, and many cases of malnutrition in the region may be related to the poor animal product intake (Stabler and Allen, 2004 and Muehlhoff, Bennett and McMahon, 2013). Additionally, the role of draft power and manure provision is particularly important in West Africa, due to the abundance of integrated crop-livestock systems where livestock producers need the crop residues to feed their animals and crop farmers need manure to maintain soil fertility. Draft animals provide a valuable resource to prepare the land for cropping (Hiernaux and Fernández-Rivera, 2000) transport products to markets and inputs from markets to farms.

Economic value
Livestock represents an important component of the West African's agricultural sector, directly contributing to an average of 12 percent to the sector's GDP. It also contributes about 3.2 percent of the overall regional GDP, or 19.1 billion USD. This amount does not include the value of processed products mostly accounted for under industry and secondary products, such as manure, draught power and transport, which are provided mainly to the crop sub-sector but are extremely difficult to quantify (Hatfield and Davies, 2006).

The contribution of the livestock sub-sector to economic growth can be boosted through vertical and horizontal multiplier effects that goes beyond production. Indeed the non-agricultural sectors tend to have a higher response to changes in livestock production than agriculture itself. Nevertheless, in West Africa as for other developing countries, the livestock sub-sector is highly segmented and the levels of labour productivity differ between processing and production and within production, between commercial and subsistence farmers. Thus, a simple multiplication of similar opportunities could result in an expansion of underemployment. Policies should promote livestock system models that lead to higher labour productivity, facilitate value-addition, and are labour-intensive (FAO, 2018b).

Poverty reduction and Job creation
Livestock is intimately associated with wealth. In fact, the word "capital" originates from the Latin word "caput", or head (of cattle), denoting the use of livestock for generating revenues and accumulating wealth more than 2000 years ago. Livestock ownership has therefore a very important role that impacts both the economy of rural households and the use as a financial tool.

Poverty is a more or less generalized phenomenon in West Africa, especially in rural communities. It is manifested as weakness in major areas of the human well-being: analphabetism, malnutrition, low life expectancy, poor health, unhospitable habitat and reduced participation in socio-economic life. It is measured by monetary indicators such as poverty threshold, incidence of poverty, depth and severity of poverty, or by livelihood indicators such as the Human Development Index (HDI), of which the subregion displays the worst score worldwide (AFDB, OECD and UNDP, 2016), with only Cabo Verde and Ghana not being considered least developed countries. According to HDI report of 2019, 40 percent of the 10 countries at the bottom of the list of 189 countries and territories are found in West Africa (UNDP, 2019).

While livestock rearing is an important economic activity in the sub-region, West African households own relatively less number of cattle than households in other regions. However, they hold more small ruminants, especially sheep, which is related to the widespread animal diseases (Seo and Mendelsohn, 2007). Poultry ownership is particularly widespread because of the little labour required to keep them in a backyard system. As village chicken are mainly reared near homestead, they are largely managed by women, as are most livestock associated to the household (Niamir-Fuller, 1994). The smallholder farmers raise small ruminants and poultry mainly for cash and household consumption. The small ruminants and poultry are relatively easy to own by resource-poor farmers, especially women, as these animals have short cycle reducing the risks inherent to agricultural production

Equality and empowerment

The livestock production in Nigeria is usually managed by adult males and females, usually visible in livestock markets and registered as owners of the animals. However, both women and children play significant roles in the livestock-associated livelihoods, and their roles imply also their social importance within their communities. The role they play in livestock production gives important opportunities for their empowerment and for designing entry strategies in achieving it.

CONCLUSION AND RECOMMENDATIONS

It is pertinent to note that the livestock sub-sector is increasingly becoming competitive and attractive for strategic national investment in Nigeria despite the challenges confronting it. The globalization of food systems has triggered a large growth in the food security and far more livestock produce is traded today than 30 years ago, with the result their commodity markets and food security outcomes are connected across space and time.

Livestock contribute directly to food security, through providing food, employment and income and indirectly, for example through provision of manure for crop production. A large proportion of crops is used for livestock feed and traded internationally. In developed nations, up to two-thirds of total cereal production is used as animal feed.

However, it is believed that with the appropriate investments, the sub-sector can support national production against cheap and lower quality imports, and also save foreign exchange spent on import, while at the same time earning some foreign exchange for the country. Producing the quality of products that will enable access to profitable export markets as well as compete with some of the high quality imported products has been challenging for countries in West Africa (Codjia, 2016 and Correia, 2016). That goal, however, has been achieved in other parts of Africa, namely in Botswana, through the implementation of a national coordination body of beef production (the Botswana Meat Commission) that has achieved a more efficient production, well-planned infrastructure, and safe standards for accessing export markets.

Investing in local value addition for economic and environmental sustainability remains consequential for the transformation of the livestock sub-sector (Manzano, 2016). But the Botswana example shows the complexity and inadvertent effects of interventions in the livestock sub-sector that seek to transform the age-long extensive systems of production to intensive systems to meet the standards for competitive markets, and the risk to oversee trade-offs with social and environmental factors (Manzano, 2017b). Senegal is working on several projects to improve productivity and commercialization at the national level of the milk sub-sector (Gueye, 2017).

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Marketing of Selected Cassava Products in Gwagwalada Area Council, Abuja, Nigeria: Prospects and Constraints

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Abstract
Cassava, crucial for millions, has untapped potential due to poor marketing. Effective marketing can improve livelihoods. This study assessed cassava product marketing in Gwagwalada Area Council, Abuja, Nigeria, focusing on prospects and constraints. Objectives included describing marketers' socioeconomic characteristics, marketing channels, costs, returns, and constraints. Data were analyzed using descriptive statistics, net farm income, and the Henry Garrett ranking technique. Results showed most marketers were married, with average ages of 40-43 years and household sizes of 5-9. Net farm incomes were ₦27,448.19 for garri, ₦37,002.03 for fufu, and ₦31,885.16 for cassava flour. High transportation costs, limited market access, and poor facilities were major constraints. The study concluded cassava products were profitable and suggested supporting transportation costs or improving road networks.
Keywords: Farm Budgeting Techniques, Cassava, Marketing, Nigeria.

INTRODUCTION

Nigeria, the top cassava producer in 2020 with 20% of global output (Eze et al., 2023), has vast agricultural potential beyond production, including value-addition, job creation, and waste reduction (Adeyemo & Koruwa, 2018). Effective marketing is essential (Rahman & Awarije, 2016). Despite its lead, challenges like inadequate storage and poor infrastructure persist (FAO, 2020).

METHODOLOGY

The Study Area

The study area, Gwagwalada town, is located between latitude 8.25° and 25° North and longitudes 6°45' and 7°45' East. It is one of the oldest towns in the Federal Capital Territory (FCT), which covers about 8000 km² in Nigeria's middle belt and North-Central geopolitical zone. Bounded by Kaduna, Nasarawa, Kogi, and Niger States, Gwagwalada is a large municipality with 10 wards, including Dobi, Gwako, and Zuba. Farming is the main economic activity, with major crops being cassava, sweet potatoes, yam, rice, guinea corn, millet, and barley (Achukwu *et al*., 2023).

Sampling Procedures and Sample Size

The study employed a multi-stage sampling technique. First, Gwagwalada Area Council was purposefully selected for its high population of cassava product marketers. Second, five wards (Gwagwalada Centre, Kutunku, Dobi, Zuba, and Paiko) were randomly selected from the ten wards in the council. Finally, 140 respondents were randomly chosen from a sample frame of 216 cassava product marketers, using Yamane's (1967) formula for sample size determination with a 5% precision level.

Method of Data Analysis
Three different analytical tools were employed for this research including Descriptive statistics, the farm budgeting technique (net farm income) and the Henry Garrett ranking technique.

Descriptive Statistics
This analytical tool was used to examine the socio-economic characteristics of selected cassava product marketers, including; gender, marital status, household size, age, level of education, cassava marketing experience and membership in a cooperative. Descriptive statistics involve mean, frequency distribution tables, percentages etc. This was used to achieve specific objectives (i) and (ii) the socioeconomic characteristics of cassava product marketers and the marketing channel of cassava products in the study area.

Farm Budgeting Techniques
The Net Farm Income (NFI) was calculated using complete budgeting to estimate the total costs and returns of cassava product marketing. The formula used was: NFI = TR – TC, where NFI is the Net Farm Income, TR is the Total Revenue, and TC is the Total Cost, which includes Total Fixed Cost (TFC) and Total Variable Cost (TVC). Total Revenue (TR) was calculated as TR = P x Q, where (P) is the price of the cassava products and (Q) is the output in kilograms. This method was used to estimate the costs and returns of the selected cassava products in the study area.

Henry Garrett Ranking Technique
Cassava product marketers ranked constraints according to their priority level using Garrett's ranking technique, as outlined in specific objective four. The ranks were converted into score values using the formula from Dhanavandan (2016):

$$\text{Percentage Score} = \frac{100(R_{ij} - 0.5)}{N_j} \tag{1}$$

Where R_{ij} = Rank is the rank of ith Item jth Individual, and (Nj) is the number of items ranked by the jth individual. The percentage positions were translated into scores using Garrett's Table. The scores for each component were totalled, and the mean values were computed. The elements with the highest mean values were considered the most significant constraints.

RESULTS AND DISCUSSION
Socioeconomic Characteristics of the Selected Cassava Products Marketers in the Study Area
The socio-economic characteristics studied included age, sex, marital status, household size, education level, marketing experience, and cooperative membership. Most marketers were female (Onyemauwa, 2012), aged 31-50 (Ettah & Nweze, 2016), married (Oladeji *et al*., 2023), with household sizes of 8-9 (Oluyole *et al*., 2013), and had secondary or tertiary education (Akubo *et al*., 2023).

Table 1: Socioeconomic Characteristics of the Selected Cassava Products Marketers

Table Summary

Product	Participants	Avg. Age	Household Size	Education Level
Garri (75)	43	8	Secondary	6 years
Fufu (44)	43	9	Primary	15 years
Cassava Flour (21)	40	5	Tertiary	12 years

Source: Computed and modified from field data, 2024

Key Observations: 1. Garri is the most popular product among participants; 2. Participants are generally middle-aged and have medium-sized households; 3. Education levels vary, with most having secondary education; 4. Experience in marketing is highest among Garri producers; 5. Cooperative membership is widespread among Garri and Fufu producers.

Marketing Channels of Cassava Products in the Study Area

The study identified two main marketing channels for cassava products: wholesalers and retailers. About 16.43% of wholesalers marketed garri, 10% marketed fufu, and 2.12% marketed cassava flour. Among retailers, 37.14% marketed garri, 21.43% marketed fufu, and 12.86% marketed cassava flour. These results indicate a strong preference for garri among both wholesalers and retailers in the study area.

Table 2: Marketing Channel of Cassava Products in the Study Area

Variables	Frequency	Percentages (%)
Wholesaler		
Garri	23	16.43
Fufu	14	10.00
Cassava flour	3	2.12
Retailer		
Garri	52	37.14
Fufu	30	21.43
Cassava flour	18	12.86
Total	**140**	**100**

Source: Computed from field data, 2024

Cost and Returns of the Selected Cassava Products Marketed in the Study Area

The study assessed the costs and returns of marketing cassava products. Average processing costs were ₦43,410.00 for garri, ₦51,196.67 for fufu, and ₦29,885.47 for cassava flour. Labour costs were ₦2,830.00 for garri, ₦4,130.83 for fufu, and ₦849.00 for cassava flour. Transportation costs averaged ₦443.60 for garri, ₦825.83 for fufu, and ₦515.30 for cassava flour. Total production costs were ₦55,395.15 for garri, ₦65,391.31 for fufu, and ₦39,935.17 for cassava flour. Net farm incomes were ₦27,448.19 for garri, ₦37,002.03 for fufu, and ₦31,885.16 for cassava flour, indicating profitability.

Table 3: **Average Costs and Returns of the Selected Cassava Products in the Study Area**

Product	Total Cost (₦)	Net Farm Income (₦)
Garri	55,395.15	27,448.19
Fufu	65,391.31	37,002.03
Cassava Flour	39,935.17	31,885.16

Source: Computed and modified from field data, 2024

Key Observations: 1. Garri, fufu, and cassava flour represent the primary processed cassava products studied; 2. Total costs are highest for fufu, followed by garri and cassava flour; 3. Net farm income is highest for fufu, with garri and cassava flour showing comparable profitability; 4. Variable costs, particularly those related to raw materials and labour, constitute the majority of total costs for all products.

The Constraints Faced by Cassava Product Marketers in the Study Area

The study identified key constraints using Henry Garrett's ranking technique: high transportation costs (9754), lack of market access (6984), and poor marketing facilities (6975) were the top issues. Other constraints included poor pricing, low profits, poor storage, high purchasing prices, lack of credit, and product spoilage. These findings align with previous research on rural road conditions affecting cassava marketing.

Table 4: Constraints Faced by the Cassava Product Marketers in the Study Area

	Ranks Given by Cassava Product Marketers	
Constraint	**Mean**	**Ranking**
High cost of transportation to the market	69.67	1st
Lack of access to the market	49.89	2nd
Poor marketing facilities	49.82	3rd
Poor pricing of the products	49.18	4th
Low profit from business	48.01	5th
Poor storage facilities	47.10	6th
High purchasing price	44.27	7th
Lack of credit facilities	44.00	8th
Product spoilage	44.00	9th

Source: Computed and modified from field data, 2024

Figures in parentheses are estimated using *Fx* = Product of frequency of respondents and scale value

CONCLUSION AND RECOMMENDATIONS

The research on cassava product marketing in Gwagwalada Area Council, Abuja, Nigeria, highlighted that most marketers were women, primarily dealing in garri. All cassava products were profitable, enhancing marketers' incomes and living standards. However, marketers faced significant challenges, including high transportation costs, limited market access, and poor marketing facilities. The study recommends improving the transportation sector to reduce costs, possibly through subsidies or better road networks. It also suggests implementing skill enhancement programs focusing on modern marketing techniques, digital marketing, and business management to help marketers adapt to market changes. Additionally, the study encourages innovation in cassava processing and promoting new cassava-based products to enhance market opportunities and profitability, with support from the Agricultural Development Programme (ADP) and other agencies.

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Risk Assessment and Market Linkages among Cassava-based SMEs in Abia State

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Abstract
The study assessed the risk of market linkages among cassava-based SMEs in Abia State, Nigeria. The objectives of the study are; to identify the type of risk involved in the market linkages of cassava-based SMEs, assess the level of risk involved in the market linkages of cassava-based SMEs and estimate the determinants responsible for the risk involved in the market linkages of cassava- based SMEs in the study area. A multi-stage sampling technique was used in selecting 120 respondents for the study. Data collected using a well-structured questionnaire administered to the respondents were analyzed through ordinary least square regression (OLS). The significant determinants of the risk involved in the market linkages of cassava-based SMEs were income, labour, distance to market, and access to information. Income and access to information were negative and significant at 5% and 1% probability levels respectively while labour and distance to the market were positive and significant at 5% and 1% probability levels respectively. In conclusion, this study highlights the importance of understanding market linkage risks faced by cassava-based SMEs in Abia State Nigeria. It provides valuable insights for policymakers, stakeholders and SMEs to develop targeted interventions and risk management strategies. It is therefore recommended that SMEs should always monitor and evaluate market linkages performance as well as continuously assess and mitigate risk to enhance the success, revenue growth and contribution to the Nigerian economy.
Keywords: Risk, Market linkages, Cassava, SME

INTRODUCTION

Cassava-based Small and Medium Enterprise (SME) is a business that operates within the cassava value chain from cultivation, and processing to distribution of cassava-derived products. According to Osuafor *et al*., (2020), cassava is a popular food crop grown in West Africa and it occupies a unique position in the world's food economy. Small and medium scale Enterprise (SME) plays a foundational role in global food supply chains. These small, often family-led entities serve as cornerstones for rural communities and is hailed globally for their enormous contribution to Gross Domestic Product (GDP), economic development and employment creation (Mason 2009; Beck and Cull 2014; Shanthi and Schneider 2018). However, the cassava-based SMEs face numerous challenges, particularly in establishing and maintaining effective market linkages.

Market linkages refer to the relationships and connections that exist among various actors within a market system that enable the flow of goods, services, information, and resources (Quader *et al*., 2023). It encompasses the relationships and interactions between different entities involved in the market. Therefore, market linkages for cassava-based Small and Medium Enterprises (SMEs) involve the connections and relationships that exist within the cassava value chain. These entities include producers, suppliers, distributors, retailers, consumers, and other stakeholders (Umoren, 2019). Market linkages are critical for the survival and growth of cassava-based SMEs. However, market linkages are often plagued by risks.

Risk refers to the likelihood or probability of an event or outcome deviating from what is expected or desired. According to Ambarawati *et al*., (2018), risks are chances of failure or loss that the actual return from holding an asset or investment would change from the expected return over time and maintained that the agricultural value chain was susceptible to failure due to inherent risks associated with biological and natural phenomenon. Apata (2019) further noted that risks are uncertain events or phenomena which could have the probability of causing losses. In a study on unravelling risk structures in Nigerian cassava supply chains by Adeosun and Opata (2016), their findings confirm that agricultural production was exposed to many risks which affected the farmers/operators and stakeholders in the cassava value chain. Risk is believed to play an important role in the investment decisions of small and medium-scale enterprises.

Given the importance of cassava to livelihoods of individuals, it is important to understand the market linkages of cassava based products and its associated risk. This study therefore contributes to these knowledge gaps by assessing the risk of market linkages of cassava based SME's in Abia State, Nigeria.

METHODOLOGY

StudyArea

The study was carried out in Abia State Nigeria. Abia State is a state in South Eastern part of Nigeria with its capital in Umuahia. It was created on 27th August, 1991 and has 17 local Government Areas (LGAs). It is between longitude 7^0 23' and 8^0 02'E and latitudes 5^0 47' and 6^0 12'N. The state has an estimated population of 4,143,100 people, (NPC, 2022) It covers a land area of 776,270 square kilometers.

Abia state is selected for this study because there are many small and medium size agribusiness enterprises in the state that are involved in the processing of these agricultural commodities into different value-added products for local consumption and export in which cassava based SMEs' is involved.

Sampling Technique

The sampling procedure that was used in the study involved multi stage sampling technique. Initially, two agricultural zones namely Aba and Umuahia Agricultural zone were purposefully selected from the three Agricultural zones in the State. These zones were purposely selected because of the intensity of cassava farming and cultivation in the area. In the second stage, two Local Government Areas were randomly chosen from each of the two selected agricultural zones. In the third stage, three communities were randomly chosen from each of the four Local Government Areas resulting in twelve communities. Finally, ten cassava based SMEs were purposively selected from each community and this gave a total of one hundred and twenty (120) respondents.

Data Collection and Analysis

Ordinary least square regression model (OLS) was used to estimate the determinants of risk mitigation factors in the market linkages of cassava- based SME's in the study area.

Model Specification

This model is specified implicitly as:

OLS Multiple Regression Model

$$Y= (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9,\ldots X_{11}) \quad (4)$$

Where;Y =Level of Risk, X_1=experience (years),X_2= income (Naira),X_3= technology (traditional=1, modern= 0), X_4= labour (number of workers), X_5= membership of cooperative society (Yes=1, No= 0), $X_{6=}$access to credit (Naira), X_7 = Distance to market (km), X_8 = access to information (Yes=1, No=0), X_9 =total produce of cassava(kg), X_{10} =selling price(Naira), β_i = the parameter, μ_i = the error term

RESULTS AND DISCUSSION

Determinants of Risk Mitigation in Market Linkages among Cassava- based SMEs

Table 3 shows the regression estimates of determinants of risk mitigation in market linkages among cassava- based SMEs in the study area.

Table 3: Regression Estimates of the Determinants of Risk Mitigation in Market Linkages among Cassava- based SMEs in the Study Area

Variables	Linear	Exponential	+Semi log	Double log
Constant	3.904 (7.269)***	1.427 (7.548)***	6.053 (3.324)***	2.111 (3.267)***
Years of experience	0.0012 (1.305)	0.008 (1.084)	0.109 (1.310)	0.023 (0.772)
Income	-5.659E-007 (-1.762)*	-1.497E-007 (-1.718)*	-0.291 (-2.482)**	-0.077 (-2.395)**
Technology	-0.036 (-0.025)	-0.021 (-0.444)	-0.090 (-0.700)	-0.035 (-0.765)
Labour	0.029 (2.293)**	0.013 (2.350)**	0.082 (2.756)**	0.023 (2.504)**
Membership to cooperative society	0.075 (1.531)	0.026 (1.525)	0.112 (1.822)*	0.038 (1.782)*
Access to credit	-0.168 (-0.899)	-0.049 (-0.749)	-0.189 (-1.041)	-0.054 (-0.835)
Distance to market	0.122 (4.261)***	0.043 (4.247)	0.837 (4.145)***	0.294 (4.118)
Access to information	-0.291 (-3.084)***	-0.105 (-3.149)	-0.299 (-3.210)***	-0.107 (-3.239)***
Quantity of cassava product produced	-0.122 (1.392)	9.997E-005 (0.277)	0.162 (0.751)	0.041 (0.539)
Selling price of produce	0.171 (-0.444)	-4.074E-006 (-0.140)	0.159 (0.772)	0.034 (0.458)
R	0.748	0.744	0.759	0.744
R^2	0.731	0.728	0.743	0.728
F-ratio	8.690***	8.581***	8.954***	8.576***

Source: Computed from field survey data, 2024. Key: ***, ** and * = significant at 1%, 5% and 10% respectively. + = Lead Equation and the values in parenthesis are the t-values.
Semi log function was chosen as the lead equation among the four functional regression forms. This was based on the magnitude of the R^2 value, F-ratio value and the number of significant variables. From table 4.5, the R^2 value of 0.743 shows that 74.3% of the variations in market linkage risk were explained by the independent variables. The F-ratio value of 8.954 which was highly significant at 1% probability level shows that the model has a good fit.

From the Table, the significant determinants of the risk mitigation factors in the market linkages among cassava- based SMEs were income, labour, distance to market, and access to information.

The co-efficient of income (-0.291) was negative and significant at 5% probability level. This implies that the risk involved in the market linkages of cassava- based SMEs decreases as the income increases.This could be due to the fact that with increased income, safety aparatum operations and gadgets that will ensure reduced risk can be easily procured and employed, which will ensure that farm risks are reduce to the barest minimum. This is in line with Minten *et al*., (2018); Uzun *et al*., (2019) who noted that lack of financial services including credit and insurance, limits SME's capacity to invest in their operations and cope with risks.

The co-efficient of labour (0.082) was positive and significant at 5% probability level. This implies that the risk involved in the market linkages of cassava- based SMEs increases as the labour increases. This could be due to the high financial expenses and other irregularities and uncertainties associated with increased labour, which will invariably contribute to risk.

The co-efficient of distance to market (0.837) was positive and significant at 1% probability level. This implies that the risk involved in the market linkages among cassava- based SMEs increases as the distance to market increases. This is in line with the *apriori* expectation. The higher the distance to market, the higher the exposure of the individual to transportation problems given the high volatility associated with the transport system in most parts of the country. One of the ways to improve profitability could be enhancing market access through improved value chain linkages, which would enable small-scale agribusinesses to negotiate better prices for their products (Olukunle, 2013).

The co-efficient of access to information (-0.299) was negative and significant at1% probability level. This implies that the risk involved in the market linkages of cassava-based SMEs decreases as the access to information increases. This could be due to the fact that access to information enables and equips individuals with knowledge and skills required to safeguard them over farm and market risks. Chinonso *et al*.,(2021); Ogundipe *et al*., (2020) noted that the dearth of access to timely market information leaves SME's in the dark about prevailing market issues and consumer preferences and hence leads to increased risk.

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Effect of Oregano Leaf Meal (OLM) on Carcass Characteristics of Weaner Rabbits

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Abstract
The study evaluated the effect of dietary Oregano leaf meal (OLM) (Origanum vulgare) meal on carcass characteristics of weaner rabbits. Twenty-four (24) mixed-sex and breeds weaned rabbits (28d old, weighing 630g) were assigned to four groups (n=6 per group) and subdivided into three replicates of two rabbits each. The basal diet i.e., commercial grower mash constituted treatment 1 while OLM was included at 1, 2 and 3g per 1kg basal diet to constitute treatments 2, 3 and 4, respectively. All rabbits were fed ad libitum throughout the 56 days of the experiment. At day 56, three (3) rabbits were randomly picked per treatment based on approximately equal weight for carcass evaluations. Results indicated significant differences (P<0.05) in thoracic, forelimb, hind limb, slaughter weight, lumbosacral, dressing weight, dressing percentage, kidney, intestine, and cecum between treatments. Liver and heart did not differ (P>0.05) between rabbits fed OLM. However, rabbits fed the control diet had the best results for carcass characteristics. Rabbits fed OLM showed results similar to those fed control diets. This study indicated that OLM is a good feed source for rabbit production as no abnormality was observed in the internal organs. It is, therefore, recommended that OLM should be included in rabbit diets for improved carcass and meat quality. However, further studies are necessary to determine the optimal degree of tolerance for rabbits at different production stages.

Keywords: Oregano leaf, rabbit, carcass characteristics, internal organs

INTRODUCTION

Globally, the high cost of feed ingredients is a continuous threat to food security. They limit production by resource-poor farmers and impact significantly on the will to purchase rabbit, poultry and ruminant meat by consumers. Again, the increase in health challenges consuming animal products has led to an increasing consumers' preference for healthy, nutritious and safe animal products which are easily digestible, and rich in protein but contain low lipid and cholesterol contents (Simonova *et al*., 2010). In Nigeria, micro-livestock production including rabbit, quail and snail farming is gaining popularity as the ideal animal protein source with numerous health benefits and good returns on investment (Ozung *et al*., 2013). According to (Fasuyi *et al*., 2005), rabbit production is one of the cheapest means of providing readily available animal protein for the teeming Nigerian populace. This is due to its relatively lower cost of production, prolificacy, ability to convert forages not competed for by humans into rich animal protein and ease of management (Ozung *et al*., 2013). In recent times, researchers have now focused on exploring natural plant materials including; forages, vegetables, shrubs and tree leaves that are available all year round to serve as feed and alternative antibiotics in many farm animals due to their numerous antimicrobial properties (Simonova *et al*., 2010; FAO 2011). The report of (Elwan *et al*., 2019) encouraged the use of nutritional antioxidants for improved rabbit production. Thus, several plant species are now incorporated into feeding regimes of fattening rabbits as feed supplements for productivity and meat quality (Kone *et al*., 2016; Zepeda-Bastida *et al*., 2019). One such plant is the Oregano leaf for its antimicrobial and photogenic properties (Njoya *et al*., 2018). Oregano (*Origanum vulgare*) has attracted great interest as its essential oil is rich in monoterpenes, thymol and carvacrol, which exhibit good antioxidant and antimicrobial activities *in vitro* and *in vivo*, together with stimulating animal digestion (Elwardany *et al*., 2022). This present study evaluates the effect of a commercial grower mash supplemented with Oregano leaf meal on carcass characteristics and internal organs of weaner rabbits.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Rabbit Unit of the teaching and research farm of Kabba College of Agriculture, Ahmadu Bello University. Kabba is a town in Kogi State, in mid-west Nigeria, in the northern Guinea Savannah Zone, located at latitude 7^0 49′43″ N, longitude 6^0 04′23″ E at an altitude of 436 m above sea level.

Experimental Design and Management of Birds

Twenty-four (24) weaned rabbits of mixed sexes and breeds were obtained from a commercial farm in Kaduna state. The mean weights of rabbits for all the pens were approximately equal. There were four treatment groups each with three replicates. Each replicate had 2 rabbits in a completely randomized design. The rabbits were given Ivermectin injections against both endo and ectoparasite. Anti-stress medications (Vitalyte) were administered as and when due. The cages were well disinfected with Dettol and equipped with drinkers and feeders. Before the experiment, the rabbits were fed a commercial grower mash and given a one-week adjustment period to get used to the cages and diets. Fresh feed and water were provided *ad libitum*. The experiment lasted for eight (8) weeks.

Carcass characteristics

Twelve (12) rabbits were selected from the experimental animals and used for the carcass analysis. The animals reflecting the mean weight of the sample size were selected from the three replicates for carcass yield and organ characteristics evaluation. The final live weights of the rabbits picked randomly were recorded after the animals were fasted overnight before slaughtering. They were tagged individually for proper identification and recording. The rabbits were culled by severing their jugular vein and carotid artery at the atlas vertebra. The rabbits were hung head downward for 10 minutes to allow for proper bleeding. The carcasses were dressed by removing the pelts and were decapitated at the Atlanta-occipital joint. The hind feet were cut along the joint between the tibia calcaneus cut at the carpal region and the tails were removed close to the base. All the parts were weighed individually and expressed as the percentage of live weight. The organs (heart, liver, kidneys, lungs, spleen) were also weighed and expressed as a percentage of live weight as prescribed by (Awosanya *et al*., 1989). The live weights of the rabbits were obtained before slaughter using a weighing scale.

Data analysis

The data generated were subjected to Analysis of Variance (ANOVA) using SAS (2003). The means were separated using the Duncan Multiple Range Test (DMRT) as described by Duncan (2003).

RESULTS AND DISCUSSION

The carcass characteristics of weaner rabbits fed grower mash supplemented with varying levels of Oregano Leaf Meal (OLM) are presented in Table 2. The results show that the dietary treatments had significant (P<0.05) effects on the thoracic, fore limb, hind limb, dressing percentage, slaughter weight, lumber sacral and dressing weight of rabbits across the treatment groups. However, the results showed that rabbits fed without OLM had the best values for the hind limb, dressing percentage, slaughter weight, lumber sacral and dressing weight. Apart from the linear increase observed as the levels of OLM increased for the thoracic and limb, other parameters did not show much linear increase. This result is dissimilar to the findings of (Soultos *et al*., 2009) who reported increased meat yield in rabbit-fed Amaranthus diets. The increased weight for the cut parts observed for rabbits fed a diet without OLM might be probably due to its high nutritional contents leading to higher nutrient availability and digestibility. Although it is well established that rabbits can tolerate some extent of fibrous feedstuffs, the time taken to digest the fibrous materials could result in the lower cut weights observed for rabbits fed diets with OLM. Rabbits fed a diet without OLM had the best dressing percentage and dressing weight. However, amongst the treatment-fed OLM, it was observed that rabbits fed high levels of OLM had a better dressing percentage than the ones fed with lower levels of OLM. This could be attributed to the ability to convert feed to meat efficiently. Findings from this result are consistent with the report of (Zepeda-Bastida *et al*., 2009) which indicated a 60% dressing percentage with no differences in the carcass quality of rabbits fed *Tithonia tubaeformis* weed. Table 3, shows that apart from kidney, intestine and caecum there were no significant (P>0.05) differences in the liver and heart of rabbits. The results showed that while OLM did not impact several parameters in carcass characteristics as compared to rabbit-fed grower mash, they did significantly (P<0.05) affect the carcass characteristics among treatments fed OLM. Regarding internal organs evaluation, (Abou-Kaseem *et al*., 2021) reported that a diet supported by plant extracts and essential oils had no negative effects on meat quality and internal organ characteristics. However, (Dalle-Zotte *et al*., 2021) and (Palazzo *et al*., 2020) demonstrated that, compared to control diets, rabbits fed diets containing medicinal and aromatic plants showed insignificant increases in the internal organs of rabbits. The increased weight for the caecum observed for rabbits fed a 2g/kg grower diet could probably be due to the level of fibre in the diet. The inclusion level and type of fibre are the main factors that affect digestibility by stimulating the feed intake and mean retention in the caecum (Cullere *et al*., 2016).

CONCLUSION AND RECOMMENDATIONS

The empirical findings in this study provide a new understanding of the Oregano plant in rabbits. Cumulatively, OLM can be beneficial for rabbit's health and performance. However, further studies are needed to ascertain the optimum level that rabbits can tolerate at different production phases.

Table: Grower Mash Proximate Analyses

Parameter	Starter feed
Dry matter	94.13
Crude protein	22.87
Crude fibre	7.03
Ether extract	4.93
Ash	5.81
NFE	46.51

NFE=Nitrogen Free Extract

Table 2: Carcass characteristics of rabbits fed varying levels of supplemental Oregano leaf meal

	Oregano leaf meal				
Parameters	0.00	1.00	2.00	3.00	SEM
Thoracic (%LW)	10.22^{b}	7.26^{d}	9.72^{c}	10.45^{a}	0.10
Fore Limb (%LW)	9.86^{c}	15.19^{b}	17.80^{a}	17.97^{a}	0.10
Hind limb (%LW)	17.23^{a}	9.44^{c}	10.67^{b}	9.21^{d}	0.26
Dressing %	86.42^{a}	63.61^{c}	68.76^{b}	68.74^{b}	012
Slaughter wt. (%LW)	1524.00^{a}	1278.00^{b}	1261.67^{c}	1261.33^{c}	5.93
Lumber sacral (%LW)	19.96^{a}	18.67^{b}	18.53^{b}	17.87^{c}	0.12
Dressing wt. (%LW)	1402.67^{a}	889.33^{d}	919.33^{b}	908.00^{c}	1.58

a, b, c = Means with different superscripts on the same row differ significantly (P <0.05)
SEM = Standard Error of Means

Table 3: Internal organs of weaner rabbits fed varying levels of supplemental Oregano leaf meal

	Oregano leaf meal				
Parameters (g)	0.00	1.00	2.00	3.00	SEM
Liver	36.00	36.33	35.67	37.67	1.11
Kidney	9.33^{a}	8.43^{a}	5.33^{b}	8.33^{a}	0.92
Intestine	120.33^{a}	93.33^{cb}	98.33^{b}	89.67^{c}	4.49
Heart	5.33	5.67	7.33	5.67	1.16
Caecum	94.67^{b}	82.00^{c}	164.67^{a}	94.67^{b}	1.73

a, b,c = Means with different superscripts on the same row differ significantly (P <0.05)
SEM = Standard Error of Mean

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Evaluation of Cowpea Spacing and Weed Management Strategies on Growth, Yield and Water Use Efficiency (WUE) Under Rain-Fed Conditions in the Derived Savannah Agro-Ecologies

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Abstract
This study evaluated the effects of cowpea spacing and weed management strategies on growth, yield, and water use efficiency under rain-fed conditions .Eight treatments, comprising four weed management practices (Pendimethalin, Fusilade Forte, manual weeding, and control) and two cowpea spacing regimes (60x60 cm and 60x30 cm), were assessed. Results showed that manual weeding at 60x60 cm spacing significantly improved growth parameters and water relations. The result also revealed that significantly higher yields (2.0t/ha) were obtained on plots treated with pendimethalin over Fusilade Forte indicating improved resource utilization while manual plot at both spacing distance gave the highest yield. Similarly, Consumptive water use (CWU), water use efficiency (WUE) and total soil moisture (TSM) were highest under manual weeding at 60x30 cm, while soil water Storage (SMS) remains constant. WUE was better with Pendimethalin at 60 x 30 cm (2.05 kg/m^3). The study concludes that integrated weed management strategies, involving optimal spacing and manual weeding, can enhance cowpea productivity and water use efficiency under rain-fed conditions. It is recommended that pendimethalin, a pre-emergence herbicide be applied at the rate of 4l/ha in cowpea production as this encourages more foliage in terms of canopy development which translated into higher yields and increased productivity for sustainable cowpea production.

Keywords: Cowpea, Weed Management, Spacing, Water Use Efficiency (WUE), Rain-fed

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is a vital legume crop in the derived savannah agro-ecologies of West Africa, providing protein-rich grains and fodder for livestock. However, its productivity is severely constrained by weed competition and inadequate water management. Optimizing cowpea spacing and weed management strategies is crucial for improving growth, yield, and water use efficiency (WUE) under rain-fed conditions. Cowpea, a drought-tolerant crop, exhibits unique physiological adaptations to conserve water. Its deep root system enables water uptake from deeper soil layers (Kumar *et al*., 2018). However, weed competition can significantly reduce cowpea's water uptake efficiency (Lambers *et al*., 2017). Effective weed management and optimal spacing can enhance cowpea's WUE by reducing soil evaporation and promoting canopy development (Maddonni *et al*., 2016). Weed management is critical for cowpea production, as weeds compete for water, nutrients, and light (Borel *et al*., 2017). Common weed management strategies include chemical control using herbicides like Pendimethalin and Fusilade Forte (Eussen, 2017). Cultural control method includes manual weeding with hoe and cutlass and spacing adjustments (Kumar *et al*., 2018). Integrated weed management involves combining chemical and cultural methods for effective weed control and management (Ghahremanpour *et al*., 2019). Cowpea spacing affects growth, yield and WUE. Closer spacing can enhance light interception and canopy development, Maddonni *et al*., (2016), reduce soil evaporation and weed growth (Borel *et al*., 2017). This study aims to evaluate the effects of cowpea spacing and weed management strategies on Growth, yield and Water use efficiency of cowpea under rain-fed conditions in the derived savannah agro-ecologies.

METHODOLOGY

Experimental site and weather condition

The experiment was conducted at the Teaching and Research Farm of the Department of Agricultural Technology of the Federal Polytechnic, Ado-Ekiti between April and June, 2022. The ambient temperature ranges between 25^{o}C to 31^{o}C while the temperature ranges from 24.5 °C to 30.1°C and from 24.7 °C to 32.4 °C for the minimum and maximum temperatures respectively. The common weed species at the experimental site include: *Euphorbia hirta*, *Imperata cylindrical* (L.), *Chromolaena odorata* (L.,), *Ageratum conyzoides* (L.) *Tridax procumbens* and *Cyperus rotundus*. Land preparation was done manually.

Treatments and experimental design

There were 8 treatments which consisted of two spacing distance and 4 methods of weed control treatments and these were replicated three times to make 24 plots. The experiment was a 2x4 factorial scheme arranged in a Randomized complete Block Design (RCBD). The two spacing distance employed included planting cowpea seed at 60x60cm and at 60x30cm while the weed control treatments included use of the Pendimethalin applied as pre-emergence herbicide at 4l/ha.ii. Fusilade Forte applied as post-emergence herbicide at 1.5l/ha at three weeks after sowing (3WAS), iii. Hoe weeding at 2, 4 and 6 and 8 WAS and a weedy check as control. The size of the experimental plot was 20m x 10m. The Field was thereafter demarcated into plots of 2m x 2m while planting of cowpea seeds were done manually. Three seeds were planted per hole at a depth of 3cm and later thinned to two stands per hole. The cowpea variety planted was Ife brown obtained from the seed processing unit of the Agricultural Development Project (ADP), Ado-Ekiti.

Soil sample analysis and field management practices

Soil samples were randomly taken at 0-30cm depth using soil auger before land preparation (which served as control) and after treatment application in plots treated with pendimethalin and Fusilade Forte were analyzed for physical and chemical properties in the labouratory. Pendimethalin was applied as a pre-emergence herbicide using hand knapsack sprayer while similar spray was used to apply Fusilade forte as post emergence herbicide three weeks after sowing. Cowpea plants were protected against insect pests by regular spraying with DD Force, an organophosphate to destroy all sucking and chewing insects such as aphids, spider mites, thrips. This was applied at two weeks interval before flowering and weekly from flowering to mature fruit stage.

Determination of Soil Moisture Storage (SMS)

The soil water-holding capacity (WHC) was measured through laboratory tests to determine the crop's root depth and soil volume. The total available water (TAW) was estimated by multiplying the WHC by the soil volume to estimate the crop's water uptake pattern and daily water requirements. (Allen *et al*, 2019), while the Total Soil Moisture was determines as TSM (mm) = RF (mm) + CSW (mm) + IR (mm), where: TSM = Total Soil Moisture (mm), RF = Rainfall (mm.) CSW = Consumptive Soil Water (mm). IR = Irrigation (mm) since this experiment is under rain-fed conditions, IR = 0. (Vereecken *et al*, 2020).

Determination of Consumptive Water Use (CWU) and Water Use Efficiency (WUE)

CWU=Total Water Applied-Water Lost through Evaporation and Run off
(Allen *et al*, 2019) while the Water Use Efficiency was estimated as:

$$WUE = \frac{\text{Biomass or Yield produced}}{\text{Water consumed}}$$

Parameters evaluated and data analysis

Five plants each was randomly selected while parameters evaluated included; Plant height (cm), Number of leaves, Number of branches, Leaf area development (cm^2), Weed density, Days to flowering, Shoot biomass (g), Pod length (cm), Pod weight (g), Number of seed per pod, Number of pod per plant, and Seed yield (t/ha).All data collected were subjected to analysis of variance (ANOVA) while treatment means were separated using Duncan's Multiple Range Test (DMRT) .Standard error was also employed to determine the accuracy of the samples used in the study area.

RESULTS AND DISCUSSION

The result in Table 2 shows that the growth characters were significantly affected by weed management and spacing treatments. Manual weeding at 60x60 cm recorded the tallest plants, number of leaves and leaf area (85.5 cm, 76.8), 92.5 cm²) respectively. Days to first flowering, pod length, pod weight, number of pods per plant, and number of seeds per pod were influenced by weed management and spacing. Manual weeding at both spacing had the earliest flowering (35 days), while Fusilade forte at 60x60 cm had the longest pods (14.0 cm). Seed yield was highest under manual weeding at 60x30 cm (2.4 t/ha). WUE, CWU, TSM, SMS, varied significantly among treatments. CWU was highest under manual weeding at 60x30cm (388.59 mm) and lowest under control check at 60x30 cm (291.49 mm). TSM was highest under manual weeding at 60x30 cm (1137.9 mm) and lowest under control check at 60x30 cm (1040.9 mm). SMS remained constant across treatments (974.9 %). WUE was highest under manual weeding at 60x30 cm (2.47kg/m^3) and lowest under control check at 60x30 cm (0.62kg/m^3). This result agree with the findings of Kumar *et al*. (2018), who reported improved growth and yield under integrated weed management. The higher CWU and TSM under manual weeding at 60x30 cm indicate increased water availability, leading to better growth and yield. However, contrasting results were reported by Eussen (2017), who found reduced water use efficiency under manual weeding. This discrepancy may be due to differences in experimental conditions. High CWU values indicate increased water consumption, potentially leading to water scarcity (Maddonni *et al*., 2016). Low WUE values, as observed under control checks, suggest inefficient water use. According to Varaprasad et al. (2017), optimal spacing and weed management can improve WUE. The result of this research supports this, as manual weeding at 60x30 cm exhibited the highest WUE. Increased seed yield under manual weeding at 60x30 cm can be attributed to improved water relations and reduced weed competition (Ghahremanpour et al., 2019). High CWU values may lead to water scarcity, while low WUE values indicate inefficient water use. Optimal spacing and weed management strategies can improve WUE, leading to increased seed yield.

CONCLUSION AND RECOMMENDATIONS

Manual weeding at 60x30 cm proved effective in improving growth, reproductive characters, and water relations. Integrated weed management strategies should consider optimal spacing and water conservation practices. It is recommended that pendimethalin, a pre-emergence herbicide be applied at the rate of 4l/ha be used in cowpea production as this encourages more foliage in terms of canopy development which translated into higher yields and increased productivity for sustainable cowpea production

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Table 1: Soil physical and chemical properties at experimental site.

Chemical Properties	Value
pH (H2O)	6.90
Nitrogen (g/kg)	0.07
Available Phosphorus (mg/kg)	1.73
Exchangeable Na (cmol/kg)	0.02
Exchangeable K (cmol/kg)	0.02
Exchangeable Ca (cmol/kg)	1.47
Exchangeable Mg (cmol/kg)	4.20
Soil Organic matter (%)	4.01

Table 2: Evaluation of cowpea spacing and weed management strategies on growth, yield and WUE under Rain-Fed conditions at harvest

Treatment	**Plant height (cm)**	**Number of leaves**	**Leaf Area (cm^2)**	**Days to first flowering**	**Shoot biomass (g)**	**Pod length (cm)**	**Pod weight (g)**	**Number of pod per plant**	**Number of seed per pod**	**CWU** (mm)	**TSM (mm)**	**SMS (%)**	**WUE** kg/m^3	**Seed yield (t/ha)**
SBS/PPEH	60.1^{d}	**63.9^{c}**	**70.6^{c}**	40.9^{c}	34.5^{b}	13.9^{b}	13.0^{a}	10.0^{c}	9.0^{c}	340.59	1090	974.9	1.85	1.8
SBT/PPEH	50.5^{e}	64.0^{c}	66.1^{d}	45.0^{b}	33.6^{b}	11.5^{d}	12.5^{b}	9.5^{d}	8.7^{d}	359.49	1108.9	974.9	2.05	2
SBS/FFPEH	65.8^{c}	65.3^{b}	88.0^{b}	40.5c	35.7^{b}	14.0^{a}	12.3^{b}	11.0^{b}	9.0^{c}	329.19	1078.6	974.9	1.64	1.6
SBT/FFPEH	60.6^{d}	69.6a	81.9^{a}	40.9^{c}	36.0^{b}	12.6^{c}	12.1^{b}	10.9^{c}	7.7e	348.09	1097.5	974.9	1.85	1.8
SBS/MW	85.5^{a}	76.8^{a}	92.5^{a}	35.0^{d}	43.0^{a}	11.9^{d}	11.7^{c}	12.9^{d}	11.0$_{a}$	369.69	1119.1	974.9	2.26	2.2
SBT/MW	75.0^{b}	71.5^{a}	88.7^{b}	35.9^{d}	41.6^{a}	11.0^{d}	11.4^{c}	11.6^{b}	10.9^{b}	388.59	1137.9	974.9	2.47	2.4
SBS/WC	49.6^{e}	55.7^{d}	60.1^{e}	48.5^{a}	35.0^{b}	10.8^{e}	10.0^{d}	10.0^{c}	9.0^{c}	291.49	1040.9	974.9	0.62	0.6
SBT/WC	40.5^{f}	43.9^{e}	59.9^{f}	50.0^{a}	33.9^{b}	10.7^{e}	10.3^{d}	8.9^{e}	8.7^{d}	308.39	1057.8	974.9	0.82	0.8
Mean	**61.25**	**66.25**	**76.25**	**42.25**	**35.25**	**12.38**	**12.13**	**10.5**	**9.26**	**343.13**	**1094.5**	**975**	**1.83**	**1.9**
SD	**12.19**	**9.19**	**12.41**	**5.53**	**3.59**	**1.19**	**1.25**	**1.22**	**0.89**	**24.45**	**34.59**	**0**	**0/61**	**0.63**
SE±	**4.31**	**3.27**	**4.42**	**1.97**	**1.28**	**0.42**	**0.45**	**0.43**	**0.32**	**8.69**	**12.29**	**0**	**0.22**	**0.22**
LSD (0.05)	**10.94**	**8.25**	**11.23**	**5.01**	**3.26**	**1.07**	**1.15**	**1.1**	**0.82**	**22.14**	**31.33**	**N/A**	**0.56**	**0.56**
CV (%)	**19.88**	**14.07**	**16.25**	**13.08**	**9.89**	**9.59**	**10.29**	**11.62**	**9.62**	**7.13**	**3.16**	**0**	**33.33**	**33.16**

Mean followed by the same superscript significantly different at 0.05% probability on the same row using Duncan's Multiple Test(DMRT)**-** (PPEH)-Pendimethalin Pre-Emergence Herbicide.(FFPEH)-Fusilade Forte Post Emergence Herbicide.(MW)-Manual Weeding(WC) -Weedy Check.SBS-Sixty By Sixty.SBT- Sixty By Thirty. SD-Standard Deviation

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Analysis of Post-harvest Management Training Needs for Maize Growers in Kogi State, Nigeria

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Abstract
The study analysed post-harvest management training needs for maize growers in Kogi State, Nigeria. Multi stage sampling procedure was used to select one hundred and sixty (160) maize growers. A structured questionnaire, complimented by the interview scheduled, was used for data collection. Data collected were described using frequency, percentages and mean. The result showed that 82.5% of the respondents were males with farming experience of 28.9 years. ADP (82.5%) and ministry of agriculture (78.1) were the major sources of post-harvest management training in maize. Training on maize preservation ($\bar{X}$ =2.93), training of sorting on infected maize from healthy ones training ($\bar{X}$ =2.84), and training on maize drying ($\bar{X}$ =2.39) were the most important training needs in the study area. The most common constraints faced by maize growers were transportation challenge (95.0%), inadequate training on post-harvest (88.6%), and high cost of post-harvest materials (83.4%) It is recommended that women be encouraged to venture into maize production. Feeder and accessible roads should be constructed for farmers to ease the transportation challenge. Lastly, training should be prioritized for maize growers to address post-harvest farm losses.
Keywords: Post-harvest Management, Training need, Maize growers

INTRODUCTION

Maize is one of the most important arable crops cultivated in Nigeria. In terms of demand and consumption, maize is second only to rice. Maize is widely grown on any type of soil and can withstand drought and high temperatures. It is also used as food, mostly for infants and the feeding of farm animals. The current economic challenges have shifted the attention of most people from highly exorbitant foods to maize. The maize crop cannot withstand too much stress, and despite being grainy in nature, it is highly susceptible to post-harvest losses due to the activities of weevils and other insects (Oyelami *et al.,* 2018). Post-harvest losses in maize are high. The losses often forced farmers to sell produce at the point of production only to buy it back at highly exorbitant prices a few months after harvesting. Post-harvest management training is vital in order to reduce post-harvest losses in maize. Post-harvest management in maize can be defined as an inter-disciplinary science and methods applied to the maize crop after harvesting for the purpose of preservation, conservation, quality control/enhancement, processing, packaging, storage, distribution, marketing, and utilization to meet the food and nutritional requirements of consumers in relation to their needs (Pelemo *et al.,* 2018). Maize farmers post-harvest management training needs such as sorting, grading, processing, transportation, preservation, and disease control are expected to enhance the longevity of tomatoes and reduce post-harvest losses. A need-based training is expected to bring about a desirable alteration in the skills, knowledge, and attitude of the farmer. The importance of post-harvest management in agricultural production cannot be overemphasized. Post-harvest management promotes agricultural production by reducing post-harvest losses to the bearest minimum, enhancing nutrition, adding value to agricultural products by opening new marketing opportunities, generating new jobs, and enhancing other related economic sectors for viable growth. Maize as a cereal crop requires lots of post-harvest management practices in order to reduce post-harvest farm losses and also meet the growing needs of the world population. Specifically, the objectives of the study were to describe the socioeconomic characteristics of maize growers, identify sources of training needs, and identify the training needs of maize farmers.

METHODOLOGY

The study was conducted in Kogi State. The state is located between latitudes 60 33' and 80 44 N and longitudes 50 22' and 70 49' E. Kogi State has a total population of 3,278,487 (NPC, 2006), and with a growth rate of 3.2%, the state has an estimated population of 4,636,071 in 2017. The state has a land area of about 30,354.74 square kilometers (Kogi State Ministry of Information Working Document, 2016). The state has about 2 million hectares of cultivable land, with only about 0.5 million hectares currently under cultivation (Kogi State Ministry of Information working document, 2016). The major food crops grown in the state are yam, cassava, maize, sorghum, rice, millet, cowpea, pigeon pea, groundnut, bambaranut, cocoyam, sweet potato, beniseed, melon, banana, plantains, and cotton. Fruits and leafy vegetables such as okra, pepper, fluted pumpkin, and spinach are highly cultivated in the area. (Kogi State Ministry of Information Working Document, 2016). A multi-stage sampling technique was employed for this study. The first stage involved the random selection of three (3) agricultural zones in the state. The second stage involved the selection of one (1) local government area from each of the zones, making a total of three (3) LGAs. The third stage involved the random selection of four (4) communities each from the selected LGAs, making a total of twelve (12) villages. The fourth stage involved the use of proportional sampling to select 10% of the farmers from the sampling frame to give a total of one hundred and sixty (160) respondents. Primary data was used for this study. Data were collected by the researcher, assisted by well-trained enumerators, using a structured questionnaire complimented with interview schedules. The study objectives were described in terms of frequency distribution, percentages, and mean.

Analytical Techniques

Post-harvest training needs of tomato farmers was measured using a 3-point likert type scale of Most important 3, Important 2, Not important 1. A mean score of 2.0 was obtained by adding 1+2+3=6 and dividing by 3. The decision rule was any mean ($\overline{X}$) scores > 2.0, indicates important, while scores < 3.0 is termed not important.

RESULTS AND DISCUSSION

Socio-Economic Characteristic of Maize Growers

Results in Table 1 revealed that the majority of maize growers (83.5%) were males. More males might be owing to the serious and difficult tasks involved in post-harvest management, which range from sorting, grading, packing, shelling, cleaning, processing, storage, pest control, and disease control, that are better handled by men. Results in Table 1 indicated that the mean farming experience of the farmers was 28.9 years. The finding implied that maize growers had long-term experience and were well exposed to maize production. This is expected to equip them with knowledge and skills in post-harvest management. The result in Table 1 showed that the mean farm size of maize growers was 3.3 hectares, indicating a small farm size. The result is in line with that of Aliber and Hart (2016), who revealed that the majority of farmers in sub-Saharan African countries are subsistence farmers by nature. Results in Table 1 showed that 61.0% of maize growers had access to extension services. The finding indicated that more than half of the maize growers had access to extensions. To some extent, access to extension is expected to improve the skills, knowledge, and perception of farmers' post-harvest management. This is because access to extension grants farmers the opportunity to access new innovation that will improve their income and livelihood. These findings agreed with Barnabas *et al*. (2019), who reported that the majority of farmers in Kogi State, Nigeria, had access to extension services.

Table 1: Distribution of the maize growers according to socio-economic characteristics (n=160)

Variables	Frequency	Percentage	Mean
Sex			
Male	132	82.5	
Female	28	17.5	
Experience in Farming (year)			
1-10	17	10.6	28.9
11-20	29	18.1	
21-30	40	25.0	
31-40	41	25.6	
>40	33	20.7	
Farm size			
≤1.0	20	12.5	3.30
1.01-2.0	41	25.6	
2.01-3.0	42	26.2	
3.01-4.0	29	18.1	
4.01-5.0	8	5.0	
>5.0	20	12.5	
Access to extension			
Accessed	97	60.6	
Not accessed	63	39.4	

Sources: Field survey, (2018)

Sources of Post-Harvest Management Training for Maize Growers

Table 2 indicated that ADP (82.5%), ministry of agriculture (78.1%), extension officers (57.5%), others farmers (41.9%) were the sources of post-harvest management training for maize growers. This finding is in agreement with that of Tsado *et al.* (2018), who reported that other farmers and friends were the major sources of information on the improved rice varieties in Niger State, Nigeria. The least sources of training available for maize growers were World Bank assisted programme (11.3%) and parents (7.5%).

Table 2 Sources of post-harvest management training for maize growers (n=160)

Sources of training	Frequency	Percentage	Rank
ADP	132	82.5	1st
Ministry of agriculture	125	78.1	2nd
Extension officers	92	57.5	3rd
Others farmers	67	41.9	4th
Non Governmental Organization	54	33.8	5th
Friends	47	29.4	6th
Parents	12	7.5	9th
World Bank Assisted Programme	18	11.3	8th
Farm forum	45	28.1	7th

Sources: Field survey, 2018. *Multiple responses

Post-Harvest Training Needs in Maize of Maize Growers

Table 3 revealed that the most important post-harvest management training needs for maize growers were, training on methods of maize preservation ($\bar{X}$ =2.93), training of sorting on infected maize from healthy ones ($\bar{X}$ =2.84), training on maize drying ($\bar{X}$ =2.39), training on maize packing ($\bar{X}$ =2.36) and training on methods on processing maize to other products ($\bar{X}$ =2.33). This implies that post-harvest management training is important as indicated by maize growers in the study area. However, training of transportation of maize ($\bar{X}$ =1.71) and training on marketing of maize ($\bar{X}$ =1.36) were not important according to growers.

Table 3: Distribution of the farmers according to post-harvest training needs in maize (n=160)

Types of training received	Very important	Important	Not important	Sum	Mean
Training of methods maize preservation	152 (95.0)	5 (3.1)	3 (1.9)	469	2.93
Training of sorting on infected maize from healthy ones	136 (85.0)	22 (13.8)	2 (1.3)	454	2.84
Training on maize drying	87 (54.4)	59 (36.9)	4 (2.5)	383	2.39
Training on maize packaging	70 (43.8)	78 (48.8)	12 (7.5)	378	2.36
Training on methods on processing maize to other products	56 (35.0)	100 (62.5)	4 (2.5)	372	2.33
Training on persona hygienes in maize	60 (37.5)	89 (55.6)	11 (6.9)	369	2.31
Training on pests and diseases control in maize	34 (21.3)	95 (59.4)	31 (19.4)	323	2.01
Training on transportation of maize	47 (29.4)	20 (12.5)	93 (58.1)	274	1.71
Training on maize marketing	22 (13.8)	14 (8.8)	124 (77.5)	218	1.36

Sources: Field survey, 2018. *Multiple responses

Constraints Affecting Post-Harvest Management in Maize

Table 1 showed transportation challenge (95.0%), inadequate training on post-harvest (88.6%), high cost of post-harvest materials (83.4%) and shortage of funds (80.6%) were the major constraints affecting post-harvest management in maize. This finding agrees with that of Pelemo *et al*. (2022) who stated that transportation challenge and inadequate funds were constraints faced by maize farmers in Niger State. Maxwell (2014) on the other hand stated that lack of access to road network which at times contribute to post-harvest farm losses and negatively affect their income and livelihood of farmers.The least constraint affecting post-harvest management in maize were inadequate credit (69.4%) and disease attack (61.3%).

Table 4: Constraints affecting post-harvest management in maize (n=160)

Variables	Frequency	Percentage
Transportation challenge	152	95.0
Inadequate trainings on post-harvest	142	88.6
High cost of post-harvest materials	134	83.4
Shortage of funds	129	80.6
Inadequate market information	124	77.5
Insect attacks	121	75.6
Inadequate credit facilities	111	69.4
Disease attack	98	61.3

Sources: Field survey, 2018

CONCLUSION AND RECOMMENDATIONS

It can be concluded that majority of maize growers were males with large farming experience and access to extension services. ADP, ministry of agriculture, and extension officers were the major sources of training to maize growers. Training on methods of maize preservation, training of sorting on infected maize from healthy one, and training on maize drying were the most important training needs for maize growers. It is recommended that women should be encouraged to venture in maize production. Feeder and accessible road should be constructed for farmers to ease transportation challenge. Lastly, training should be prioritized for maize growers to address post-harvest farm losses.

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Yam Agripreneurial Activities among Youths in Taraba State, Nigeria

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Abstract

Agripreneurship is often touted as one of the innovative approaches to addressing poverty and food insecurity in Nigeria and emerging economies. It is also considered a means out of unemployment for many Nigerian economies' rapidly increasing youth population. Yam farming is one of the practices for livelihood among youths in Taraba State, therefore this study assessed yam agripreneurial activities among youths in Taraba State, Nigeria. The finding revealed that youths are mostly engaged in yam production (mean=3.50), marketing (mean=3.12), Loading/offloading (mean=2.90), and transportation ((mean=2.52) activities. The result of youth attitude towards yam agripreneurial activities was positive. The result revealed yam cultivation (79.4%) as the major income activities with moderate income from marketing (71.3%) and loading/offloading (65.4%) activities in the study area. Also, lack of capital (94.1%), communal/family conflict on farmland (90.4%), Pest and diseases infestation (89.0%), postharvest pest damage (87.5%), Crime and theft (86.8%), high cost of hired labour (81%), poor road network (71.3%) and destruction of yam farm by cattle (68.4%) were the major constraints facing Yam agripreneurial activities among youths in the study area. The study recommended that youths in the study area join the existing or form viable cooperative societies to enable them to access credits and improved inputs such as improved seed and agrochemicals at subsidised costs.

INTRODUCTION

Agriculture married entrepreneurship some years ago which birthed a child called Agripreneurship. Agripreneurship is the profitable marriage between entrepreneurship and agriculture among farmers (Bairwa *et al.,* 2014). The commercialization of agriculture didn't bring along the long-presumed rural development because most young people find agriculture unattractive and as a result, remain unemployed in society (Babbie, 2016). According to the National Bureau of Statistics (2023), over 20 million young people actively seeking jobs but to no avail. Consequently, agriculture remains a prime candidate as a sector that youths can look up to for job opportunities; all that is required is a switch from considering agriculture simply as a subsistence-level production activity to one that could make use of the improved technologies thereby accommodate our swelling youth population in several ways both on and off the farm. Moving from a subsistence level of Agriculture and making it attractive for the youth requires some Agricultural entrepreneurial knowledge on modern Agricultural value chain.

Youth Agripreneurship is a crucial point that has come into the development agenda only recently but is still underexplored to its peak. The appealing narrative of youth entrepreneurship in agriculture seems to take a foothold as it is increasingly championed by politicians, development organizations, and scientists (Uneze, 2013). NGOs have equally joined and started development projects involving business skills trainings and micro-credit initiatives. It is believed that youth engagement in agribusiness will not only help to reduce unemployment but, has great implications on poverty reduction, food security and economic development (Yami *et al.,* 2019). Unfortunately, there are no studies on the yam agripreneurial activities for the sustainable livelihood of youths in Taraba state. This constitutes the basis upon which agricultural extension programmes and policies can be drawn for sustainable livelihood and hence reduced poverty among youths in Taraba State. The specific objectives are to: examine yam agripreneurial activities among youths in Taraba State; determine the level of Yam income activities among the youths and investigate constraints to yam agripreneurial activities among youths in the study area.

METHODOLOGY

This study was conducted in Taraba State, Nigeria. The State lies between Longitudes $9^0$30'E and $11^0$45'E and Latitudes $6^0$25'N and $9^0$30'N with a land area of 54, 473km^2 (Taraba State Diary, 2015). It shares borders with Plateau, Nasarawa and Benue States to the West, Adamawa and Gombe States to the North and the East with the Republic of Cameroon. The 3.2% projected annual growth of the population of Taraba State as of 2022 is estimated at 3,798,569 people (National Population Commission, 2006). The land is naturally good for agriculture. It is, therefore, no surprise that the state is nicknamed, "Nature's Gift to the Nation" (Riki *et al.,* 2021). Agriculture is the major occupation of the people of the State employing over 70% of the total population engaging in both crops and animal production on a fairly large scale.

A multistage sampling procedure was used for the selection of 136 respondents for the study. Primary data were collected through the administration of structured questionnaires to respondents. Data collected were analyzed using descriptive statistics and the Herfindahl–Hirschman Index (HHI). The Herfindahl–Hirschman Index (HHI) is defined as the inverse of the level of yam income diversification activities (D), which was adopted in (Roy and Basu, 2020; Tesfahun *et al.,* 2022). Thus:

$$D = \frac{1}{\sum Si^2} \qquad (1)$$

where D is the level of yam income diversification activities and

$$\sum Si^2 = \text{HHI} \qquad (2)$$

where HHI = $S1^2 + S2^2 + S3^2 + S4^2 + S5^2$ and Si = share of income source i in youth total income.

$$Si = \frac{Yi}{Y} \qquad (3)$$

$$Y = \sum Yi$$

where Yi = total income from source i. Y = total income from all sources.

Following Ayantoye (2017), the value of the HHI that lies between 0.01 and 0.14 shows low yam income activities, 0.15 and 0.25 show moderate concentration, while the HHI above 0.25 indicates high concentration.

RESULTS AND DISCUSSION

Yam Agripreneurial Activities engaged by youths

The result of youth participation in yam value chain agripreneurial activities is presented in Table 1. The result indicated Yam agripreneurial activities by youth in the study area. The mean value of 2.0 and above implies that the youth were actively engaged in the activities while less than 2.0, the activity was not engaged. This scale was obtained from a three-point Likert scale. The finding shows that youths are mostly involved in yam production (mean=3.50) ranked first, followed by marketing (mean=3.12), Loading/offloading (mean=2.90), transportation activities (mean=2.52) while few youths engaged in processing activities (mean=1.73) of yam produce. This shows that most of youth are involved in yam value chain activities in the study area. This finding also supports FAO's (2012) report that farmer-entrepreneurs need to be efficient in transporting and marketing produce.

Table 1: Yam Agripreneurial Activities engaged by Youths

Yam Activities	Mean	Std. Deviation	Ranking
Production	3.50	1.24	1
Processing	1.73	0.684	5
Marketing	3.12	0.94	2
Loading/offloading	2.90	0.88	3
Transportation	2.52	0.48	4

Source: Field survey (2023)

Level of Yam income activities among the youths

Table 2 shows the level of Yam income activities among youths was determined using the Herfindahl–Hirschman Index (HHI). The results revealed a high score in yam cultivation (79.4%) as their major income activity with moderate income from marketing (71.3%) and loading/offloading (65.4%) activities in the study area. The least Yam income activities among youths were processing (89.0%) and transportation of Yam. This study implies that youths acquired their income from diverse Yam value chains ranging from production to transportation.

Table 2: Level of Yam income activities among the youths

HHI	Cultivation	Processing	Marketing	Loading/ offloading	Transportation
0.01-0.14	0(0)	121(89.0%)	10(7.4%)	41(30.1%)	111(81.6%)
0.15-0.25	28(20.6%)	14(10.3%)	97(71.3%)	89(65.4%)	21(15.4%)
>0.25	108(79.4%)	1(0.7%)	29(21.3%)	6(4.4%)	4(2.9%)
Mean	0.42	0.10	0.23	0.19	0.11

Field survey, 2023

Challenges to Yam Agripreneurial activities among youths in Taraba State

The result in Table 3 presents youths' perceived constraints affecting the sustainability of yam agripreneurial activities development in the study area. Challenges were ranked according to their severity. As shown in the Table, lack of capital (94.1%), communal/family conflict on farmland (90.4%), Pest and disease infestation (89.0%), postharvest pest damage (87.5%), Crime and theft (86.8%), high cost of hired labour (81%), poor road network (71.3%) and destruction of yam farm by cattle (68.4%) were the major constraints facing Yam entrepreneurial activities among youths in the study area. Lack of capital (94.1%) to promote commercial yam farming among youth was one of the limiting factors to the sustainable development of yam agripreneurial activities in the study area. Gwary *et al.* (2011) also noted that lack of capital was the major constraint to entrepreneurial agricultural activities in the Michika Local Government Area of Adamawa State. Ajijola *et al*. (2014) further found that inadequate finance was the major problem affecting yam production in Oke-Ogun, Oyo state. Communal/family conflict on farm land (90.4%) such as Tiv-Jukun and farmer-herder crisis hindering yam entrepreneurial activities because of fear of attack on farms. Furthermore, the destruction of yam farms by cattle and herdsmen (68.4%) which always led to conflict was considered a constraining factor to the sustainable development of yam entrepreneurial activities. The consequence is seen in the loss of farm produce and lives. The study conducted by Adelakun *et al.* (2015) reported that the majority of farmers in southwest Nigeria suffer economic losses from farmer-pastoralist conflicts. Pest and disease infestation (89.0%) and postharvest pest damage (87.5%), were also considered as a constraining factor to sustainable yam agripreneurial activities among youth in the study area. This study is similar to Zaknayiba and Tanko's (2013) study in Kogi state which found the incidence of pests and diseases as a leading problem for yam farmers.

Table 3: Challenges to Yam Agripreneurial activities among youths

Challenges	Frequency	Percentage	Ranking
Postharvest pest damage	119	87.5	4th
Insufficient capital	128	94.1	1st
Unfavourable weather variability	56	41	10th
Crime and theft	118	86.8	5th
Pest and disease infestation	121	89.0	3rd
Communal/family conflict on farmland	123	90.4	2nd
Destruction of yam farm by cattle	93	68.4	8th
change of government and agricultural policies	27	19.9	13th
Lack of access to subsidized input	77	56.6	9th
Poor road network	97	71.3	7th
Unstable price and poor pricing of yam Produce	32	23.5	12th
High cost of hired labour	111	81	6th
Long distance to market	41	30.1	11th

Source: Field survey (2023)

CONCLUSION AND RECOMMENDATIONS

This study concluded that Yam agripreneurial activities identified among youth in Taraba state were yam cultivation, marketing, Loading/offloading and transporting. The sustainability of yam agripreneurial activities of youth in the State is constrained by insufficient capital, communal/family conflict on farmland, Pest and disease infestation, postharvest pest damage, Crime and theft, high cost of hired labour, poor road network and destruction of yam farm by cattle.

This study endorses policy formulation and implementation of agricultural extension programmes through government and non-governmental agencies that will stimulate more youths to go into yam-based enterprises as well as improve methods of pest and disease infestation control to reduce postharvest loss. With this, more youths will be engaged in yam agripreneurial activities and there will be an upsurge production of yam produce, provide direct employment and income, and reduce poverty and food insecurity in the State. Also, youths in the study area need to join the existing or form viable cooperative societies to enable them to access credits and improved inputs.

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Analysis of Factors Affecting Adoption of Improved Soyabean Production Technologies among Rural Farmers in Niger State, Nigeria

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Abstract
The study analyzed factors affecting the adoption of improved soybean production technologies among rural farmers in Niger State, Nigeria. All the soybean farmers in Niger State, Nigeria formed the population of the study. Multi-stage sampling techniques were used to select 163 respondents for the study. Primary data were obtained using a structured questionnaire administered to the respondents. The data were analysed using descriptive statistics. The results show that the majority (95.1%) of the respondents have high-level adoption of NCRI recommended planting season of June–July as soybean production technology, many (77.3 %) of them adopted Sam soy2, about 79.8 % of them adopted fertilizer (N.P.K) 3bags and SSP4bags/ha. The findings indicate that respondents encountered three types of constraints: socioeconomic, infrastructural, and institutional. In conclusion, the farmers adopted the improved soybean production and post-harvest technologies but were constrained by certain factors. Based on the results, it is recommended that farm input supply should be timely and at an affordable price, there should be creation of awareness and farmers training on technology usage, there should be provision of credit and loans to farmers, more markets and good roads should be made available mostly in the rural areas.
***Keywords:* Adoption, Improved Soyabean, Production, Technologies, Farmers**

INTRODUCTION

Soyabean is produced in large quantities in the Middle-belt and Northern States of Nigeria and is readily available in most markets in the Southern and Western States due to the virile activities of merchants. Soybean products and their uses have been promoted in Nigeria (Odebode, 2005), particularly in the Eastern States of Nigeria through the extension unit of the Agricultural Development Programme (Njoku, 2005).

The adoption of new technology has been recognized as one of the essential tools to increase agricultural productivity which can result in food security and job creation in Nigeria. Idrisa (2009) reported that, with the development of improved varieties, commercial production of soybean has expanded beyond its “traditional home” (Benue, Kaduna, Niger and Plateau) states. It is now produced in other states, such as Bauchi, Borno, Jigawa, Kano, Kebbi, Kwara, Lagos, Nasarawa, Oyo, Sokoto, Taraba, Zamfara and Federal Capital Territory. The broad objective of the study was to analyse factors affecting the adoption of improved soybean production technologies among rural farmers in Niger State, Nigeria. The study aimed to: i) identify improved soybean production technologies adopted by rural farmers, and ii) identify factors affecting the adoption of improved soybean production technologies by rural farmers.

METHODOLOGY

The study area: The study was conducted in Niger State, Nigeria. The State is located in the middle belt zone of the country. It lies between latitudes 8° and 11°20'N and longitudes 4°30' and 7°40'E.

Population and Sampling Procedure

The population for the study includes all soyabean farmers in the study area. To account for the large population size, a sample of one hundred and sixty-three (163) respondents was chosen using stratified random sampling techniques. This method was used to ensure that each member of the population had an equal opportunity to be included in the sample. A multi-stage sampling procedure was used to select respondents from the list obtained from the Niger State Agricultural Mechanization and Development Authority (NSAMDA). Stage 1 involved a selection of two Local Government Areas from each of the three zones in the State using a simple random sampling technique. This means, 6 LGAs were selected (i.e., 6 LGAs from the three zones). Stage 2, a sample frame of farmers was developed and one per cent (1 %) of the farmers were selected using proportional allocations across the six (6) LGAs.

Data analysis techniques: Data for this study were subjected to descriptive statistics. Frequency, percentage and mean were used to analyze objective one, objective two was analysed using factor analysis.

RESULTS AND DISCUSSION

Farmers' adoption level of improved soybean production technologies

Table 1 shows the results of the adoption level of soyabean production technologies by farmers in Niger state, and it revealed that the majority (95.1 %) of the respondents had high-level adoption of NCRI recommended planting season of June– July and many (79.8 %) of the respondents had high-level adoption of fertilizer (N.P.K3bags and SSP 4bags /ha) indicating the possibility of an increase in crop yield as the application of improved agricultural practices has a positive impact on crop yield. Many (77.3 %) of the respondents highly adopted Sam Soy 2, this could be as a result of its high-yielding potential over other varieties. The results of the study revealed that 61.3 % of the respondents have a high level of adoption of single cropping, also (59.1 %) of the respondents adopted Butachlor: 2-3Lt/ha at a high level. Some (55.2 %)) of the respondents adopted TGX 1448-2E at a high level 55.2 % of them adopted fusillade: 2 Lt/ha at a high level, and 46.6 % of them adopted Pendimethalin: 3-4Lt/ha at a high level. About (43.6%) of them adopted Nuvacron: 5ml/10L of water and 42.9 % of them adopted Decis at 40ml/10L at a high level. The results in Table 2 further revealed that 40.5 % of the respondents adopted Karate:20ml/10L of water at a high level, while 29.4 % of them adopted Weeding frequency (first: two weeks after planting and second weeding six weeks after planting) at a high level. Most farmers in the study area adopted soybean production technologies at very low levels.

Table 1: Soybean Production Technologies Adopted by Farmers in the Study Area

Type of technology	Adoption Level					
	H	M	L	N	S	
Improved varieties	**%**	**%**	**%**	**%**	**%**	**T**
Sam soy2	77.3	4.9	1.8	11.0	4.9	100
(b)TGX 1448-2E	55.2	3.1	1.2	38.0	2.5	100
(c)TGX 1904-6F	54.6	1.8	2.5	38.7	2.5	100.
Fertilizer (N.P.K) 3ba & (SSP) 4ba.	79.8	2.5	12.9	3.7	1.2	100
Pest and Disease Control						
(a) Decis at 40ml/10l of water	42.9	0.0	3.1	44.2	9.8	100.
(b) (b) Nuvacron:5ml/10L of water	43.6	2.5	6.1	39.3	8.6	100
(c) (c) karate:20ml/10L of water	40.5	1.2	3.7	48.5	6.1	100
(Use of herbicides)						
(d) (i)Pre-Emg						
(a) Butachlor:2-3Lt/ha	49.1	4.9	3.7	37.4	4.9	100
(b) Pendimethalin:3-4Lt/ha	46.6	1.8	3.1	38.7	9.8	100
(ii)Post-em. Fusillade: 2Lt/ha	55.2	2.5	3.7	34.4	4.3	100
Single cropping	61.3	1.2	1.8	28.2	7.4	100
Weeding frequency.	29.4	19.0	11.7	38.7	1.2	100
Seed rate (40-50 kg/ha)	15.3	3.7	11.7	65.0	4.3	100
Planting time (June– July)	95.1	3.1	1.8	0.0	0.0	100

Note; H= high level of adoption, M = moderate level of adoption, L = low level of adoption, N = Not adopted, S = stopped using and T= total, Source: Field Survey, 2019: Multiple responses recorded

Constraints to Adoption of Improved Soyabean Production Technologies by Farmers

Table 2 shows the results of factor analysis in Niger State, and these factors include; socio-economic factors with high loadings on low demand for the processed products (0.598), Time-consuming and tedious nature of technologies (0.694), inadequate processing skills (.408), lack of labour for operation (0.724), lack of access to land (0.727), high cost of agricultural input (0.336), and rural infrastructural factors with high loadings on lack of access to processing facilities (0.540), non-availability of improved storage facilities (0.540), and poor road network (0.618). The institutional factors with high loadings include non-provision of information on agriculture (0.560) ineffective extension services and coverage (0.351) and lack of access to the market (0.720). Low demand for processed products also militates against technology adoption as locally processed agricultural products have low national and international demand due to low quality and poor processing techniques employed by rural farmers. The time-consuming and tedious nature of technologies affects the adoption level as many local farmers find it difficult to understand and operate innovations in their farming activities. Lack of access to land also affects adoption as most rural farmers practice small-scale farming due unavailability of land which results in a low level of technology adoption. Lack of labour for operation equally militates against adoption because most rural farmers hardly take the risk of employing labour, since most of them cultivate small areas of land whereby resulting to low level of technology adoption, since most of them cultivating small area of land whereby resulting in a low level of technology adoption. This result was in line with Fakayode *et.al.* (2008) who reported that labour employment affects productivity. The high cost of agricultural input also affects the adoption level as most farmers in rural areas are small-scale farmers, so they find it difficult to purchase and apply farm inputs like improved seeds and inorganic fertilizers in their farming activities. Inadequate rural infrastructure as represented by factor 2 is a constraint to agricultural technology adoption due to lack of access to processing facilities as most rural small-scale farmers cannot afford to purchase soyabean processing machines because of the high cost. Non-availability of improved storage facilities makes most soyabean produce go spoiled as a result of poor storage facilities used by rural farmers in storing their farm produce, this in turn leads to a low adoption level of improved technologies. Poor road infrastructure hinders the marketing of processed agricultural products in rural areas.

Also, institutional factors such as non-provision of information on agriculture is a constraint because most rural farmers do not television and radio to listen to information passing across through these mediums alongside ineffective extension services and coverage that limit the spread of information on agricultural technologies, again most rural farmers dwell in remote villages that are a distance from agricultural research institutes where technologies are developed, such farmers hardly become aware and adopt new technologies, accompany with lack of rural markets.

Table 2 Factor Analysis of Constraints to Adoption of Improved Soyabean Production Technologies

	Niger State		
Constraints	**Fact. 1**	**Fact. 2**	**Fact. 3**
Lack of access to processing facilities	0.048	0.540*	-0.202
Low demand for processed products	0.598*	0-.018	-0.160
The time-consuming and tedious nature of technologies	0.694*	0-.083	-0.294
Non-provision of information on Agricultural technologies	0.094	0.056	0.560*
Ineffective extension services and coverage	-0.201	-0.249	0.351*
Inadequate processing skills	0.408*	-0.165	0.250
Non-availability of improved storage facilities	-0.238	0.540*	0.159
Lack of access to the market	-0.007	0.043	0.720*
Poor road network	0.50	0.618*	0.140
Lack of labour for operation	0.724*	0.266	0.077
Lack of access to land	0.727*	0.155	0.105
High cost of agricultural inputs	0.336*	0.155	0.247

Source: Field Survey, 2019. Method: Varimax with Kaiser's Normalization
F1= Socio--economic factors, F2= Infrastructural factors and F3= Institutional factors.

CONCLUSION AND RECOMMENDATIONS

Farmers in the study area adopted improved soyabean production technologies such as Sam soy2, single cropping, correct planting time of June- July, and fertilizer application at a high level. Farmers adopted improved soybean production technologies but faced three categories of constraints: socioeconomic, infrastructural, and institutional constraints. Based on the findings of the study, the following recommendations were made: farm input such as TGX1448-2E, TGX1904-6F, Sam soy 2, fertilizer, insecticides and herbicides should be made available to farmers at the right time and place, Government should subsidize price of farm input to enable farmers to purchase them at affordable price Also, agencies responsible for distribution of agricultural technologies should create awareness and training services to farmers on the use of agricultural technologies especially in the Local Government Areas where the technologies have not been introduced.

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Influence of Slope Aspects on Soil Physicochemical Properties and its Implication for Horticultural Crops Production in Itakpe, Kogi State, Nigeria

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Abstract
Topography and slope aspects influence soil erosion and consequently have impact on the properties of soils. This study assessed the effect of soil aspects on some soil properties of basement complex rocks derived in Itakpe, Southern Guinea savanna of Nigeria. Two major slope aspects (North and Northwest) were studied. Soil samples collected from 29 points with 30 m distance apart at 0 – 30 cm were analyzed. The aim was to test if there are any differences in soil properties due to the slope aspects and to determine the land's suitability for horticultural crops production. The study determined that there are no significant differences in the contents of soil particle fractions, pH, and organic matter content, available phosphorus, total nitrogen, exchangeable bases and effective cation exchange capacity (ECEC) along the slope aspects (P < 0.05). Results have shown that the mean Total nitrogen (N), Exchangeable bases; Calcium (Ca), magnesium (Mg, potassium (K)) and sodium (Na) and Effective cation exchange capacity (ECEC) was 8.88 cmolkg-1 were low. Irrespective of slope aspects, base saturation was rated high with values > 85.13 %. Despite low variation in some properties as influenced by soil aspects, the studied soils have potential for horticultural crops production and to sustain this land use type. The recommended quality soil management practices include adoption of rotational fallows and application of crop residues, manures and organo-mineral fertilizers before farming on the land for optimum yield.

Keywords: Slope aspects, soil properties, horticultural crops, management practices, Itakpe

INTRODUCTION
Soil physical and chemical properties determine its productivity and sustainability. Soil as a product of process and certain factors (soil forming factors) is very heterogeneous. Topography play a major role in soil formation as it affects climate and pattern of soil distribution in the landscape or the spatial differences of the soil properties (Weil and Brady, 2017).

Itakpe physical features are mainly made of gently undulating high plains developed on basement complex rocks. The vertical flow of water is also affected by the impervious subsurface horizons due to the presence of plinthites through a phenomenon called plinthization process (Ivan *et al.* 2022). The distribution of soil properties may be influenced by this phenomenon as Itakpe is predominantly a rocky landscape. It is also important to know the source of variability of soil properties along and across slopes (Ivan *et al.* 2022; Ogban, 2021). Itakpe is erosion prone most especially at upper slope positions where the removal of topsoil is as a result of the combined effect of tillage and water (Zhao *et al.* 2016). Assessing the soil for its quality is a step towards restoration or reclamation when degradation of soils occurs (Adenle *et al.* 2020). There is dearth of information on the influence of slope aspects on the terrain of Itakpe and its environs. This therefore necessitated the study to assess the effect of slope aspects on soil properties and its implication of farming horticultural crops in Itakpe; proposed research and demonstration farm of the Kogi State Polytechnic.

MATERIALS AND METHODS

Study Area

The experiment was carried out in the School of Agricultural Technology, Kogi State Polytechnic, Itakpe campus located at approximately 7° 39' 20" N and 6° 21' 40" E. The state falls within the southern Guinea savanna (SGS) agro-ecological zone.

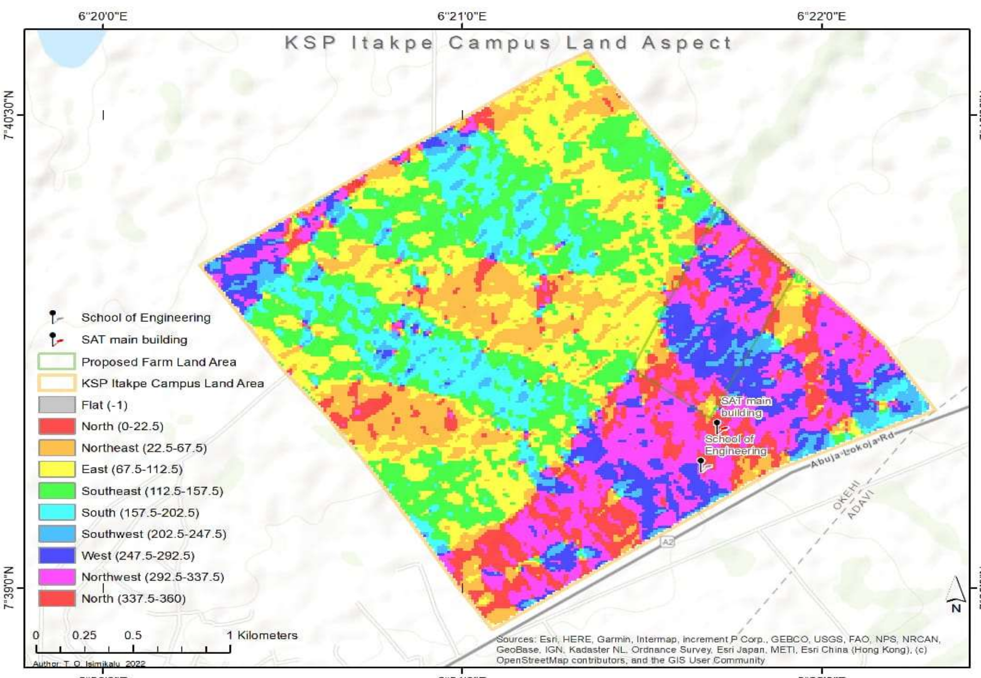

Figure 1: Map showing the land aspect of study area

Field study and soil sampling

The research covered an area of 2 hectares of the research and demonstration farm. Soil sampling was carried out with the use of soil auger. Soil was sampled in transect of 29 points of 30 m interval at 0 – 30 cm depth and bulked into 18 samples. Global Positioning System (GPS) was used to locate the points and recorded it. Soil morphological features/properties were identified for each sample at every sampling point (*in situ*). Each soil sample was bagged in individual, clean polyethene bags and labeled appropriately before they were transported to the laboratory for processing and analysis.

Soil sample preparation and analysis

The soil samples were air-dried for two weeks in the laboratory, larger soil aggregates were gently crushed in a mortar using a porcelain pestle and passed through a 2 mm sieve before soil testing. The soil samples (<2 mm) were subjected to routine soil analyses.

Land Suitability Evaluation and Approach

The land suitability evaluation of the soils was done using the unconventional procedures. Mean values of soil parameters were used as a unit and suitability classes were assigned to each land quality/characteristic measured, overall suitability rating of the soils was by arithmetic method. Suitability of land for the production of horticultural crops was done by simply matching the land use requirement/crop requirement with the land qualities/mean soil properties measured (FAO, 1995).

RESULTS AND DISCUSSION

Effect of Slope Aspects on Soil Chemical Properties

The result of the effects of slope aspect on soil chemical properties is presented in Table. The predominant slope aspects of Itakpe were the North and Northwest slope aspects. Results showed that there was no significant difference in the means of the soil properties measured due to slope aspect at $p \leq 0.05$. This indicates that slope aspects (North and Northwest) dominant in the study area do not influence the distribution of the various soil properties in the study area. It could be due to the current management of the land which is under fallow. Cultivation may be a predisposing factor to the effect of slope aspect on the soil properties, hence, soils shall be re-evaluated for slope aspect effect when the land is put to use for horticultural crops farming. The soils did not differ significantly in their chemical compositions due to slope aspects which could also be attributed to the similarity or sameness of the parent material they originated from.

The heterogeneity of soil properties for the two major slope aspects (North and Northwest) was found to be insignificant and that soils of the study area have the same origin which accrued the similar trend for the distribution of the soil properties. However, the land was observed or found to be suitable for horticultural crops farming. The result did not affirm that slope aspect had effect on the soil particle size distribution of the soils in Itakpe.

Organic C and total N are low and therefore require build-up of these nutrients in the soils. Measures to improve their replenishment may include prevention of burning of litters and encourage practices of incorporating organic residues. Exchangeable bases (Ca, Mg, K and Na) in the studied soils are presently adequate to sustain the intended land use which is production of horticultural crops. Soil pH was generally moderately to slightly acid. Since pH affects crop yields, crop suitability, plant nutrient availability and soil microbial activity and affect vital soil processes, there is need to manage the soil pH by measures of liming and cropping practices that improve soil organic matter like growing of cover crops alongside cucumber for the overall health of the soil, for instance, returning plant residues back into the soil. The results of this research showed that the land is suitable for horticultural crops production and test cropping is highly recommended. The low ECEC and nutrient reserves of the study area have been attributed to the fact that soils of Itakpe Nigeria are strongly weathered, have little or no content of weather able rock in their sand and silt fractions and have predominantly kaolinite in their clay fraction (Adenle *et al.*, 2020). The soil is inherently low in fertility and would therefore depend on soil amendments for sustainable agricultural productivity.

Land Suitability Evaluation and Rating for Horticultural Crops

Results of soil analysis as presented in Table 1 shows suitability of soils for horticultural crops production in Itakpe. Results revealed that the land is suitable or well-suited for horticultural crops farming. The land was rated highly suitable (S1) using the arithmetic method. This class of suitability could be achieved due to the growing nature of horticultural crops as they do well in a wide range of soils and climatic conditions, although the fertility status of the soils of the study area is relatively low.

CONCLUSION AND RECOMMENDATIONS

The study evaluated the effect of slope aspects on soil properties and its suitability for farming horticultural crops at the proposed site of the research and demonstration farm of the Kogi State Polytechnic, Itakpe. The indicators of soil quality namely; organic carbon and pH are similar for the two major slope aspects identified. The organic matter is low implying that the soil is low quality. Adoption of rotational fallows, application of manures, incorporation of crop residues and addition of organo-mineral fertilizers are recommended to enable the production of horticultural crops in the study area. Ploughing across the slope to incorporate organic materials would help improve the soil organic matter which will impact positively on soil aggregation translating into improved infiltration, water retention capacity and controlling erosion on the farm.

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Table 1: Effect of Slope Aspect on Soil Chemical Properties

SID	Slope Aspect	pH in H20	pH in KCl	OC (%)	OM (%)	TN (%)	EC (mS/cm)	Av. P (mg/kg)	Na	K	Mg	Ca	TEB	Ex Acidity	ECEC
											cmol/kg				
N1	N	5.7	5.2	1.32	2.28	0.066	0.52	4.81	0.38	1.93	2.1	3.95	8.36	1.19	9.55
N2	N	5.9	5.2	1.4	2.41	0.07	0.49	3.43	0.4	2.17	2.33	4.28	9.18	1.02	10.2
N3	N	5.7	5.1	1.28	2.21	0.064	0.51	4.39	0.39	1.89	2.01	3.88	8.17	1.23	9.4
N4	N	6.1	5.5	1.02	1.76	0.051	0.45	5	0.44	1.52	1.63	3.52	7.11	1.34	8.45
N5	N	6.1	5.5	1.12	1.93	0.056	0.46	3.96	0.45	1.83	1.93	3.76	7.97	1.28	9.25
N5	N	5.8	5.2	1.04	1.75	0.051	0.54	2.5	0.49	1.61	1.74	3.59	7.43	1.31	8.74
N6	N	6.5	5.8	0.4	0.69	0.02	0.23	3.78	0.57	1.02	1.17	2.72	5.48	1.67	7.15
	Mean	5.971	5.357	1.083	1.861	0.054	0.457	3.981	0.446	1.71	1.844	3.671	7.671	1.291	8.963
	SD	0.287	0.251	0.334	0.577	0.017	0.105	0.859	0.067	0.372	0.376	0.489	1.174	0.197	0.979
	CV	0.048	0.047	0.308	0.31	0.31	0.23	0.216	0.15	0.217	0.204	0.133	0.153	0.153	0.109
NW1	NW	5.7	5.1	0.96	1.66	0.048	0.51	3.73	0.51	1.33	1.47	3.36	6.67	1.43	8.1
NW2	NW	6.2	5.5	1.36	2.34	0.068	0.44	4.39	0.37	2.05	2.19	4.08	8.69	1.15	9.84
NW3	NW	5.9	5.2	1.44	2.48	0.072	0.5	3.43	0.43	2.2	2.41	4.32	9.36	0.93	10.29
NW4	NW	6	5.4	0.97	1.67	0.049	0.46	3.58	0.49	1.38	1.56	3.45	6.88	1.47	8.35
NW5	NW	6	5.3	0.98	1.69	0.049	0.47	2.89	0.44	1.42	1.6	3.5	6.96	1.45	8.41
NW6	NW	5.8	5.2	0.74	1.28	0.037	0.55	3.73	0.43	1.17	1.32	3.21	6.13	1.6	7.73
NW7	NW	6	5.3	0.92	1.59	0.046	0.46	3.27	0.53	1.24	1.44	3.4	6.61	1.56	8.17
	Mean	5.943	5.286	1.053	1.816	0.053	0.484	3.574	0.457	1.541	1.713	3.617	7.329	1.37	8.699
	SD	0.162	0.135	0.252	0.431	0.013	0.038	0.465	0.056	0.41	0.416	0.414	1.204	0.242	0.967
	CV	0.027	0.025	0.239	0.237	0.238	0.078	0.13	0.122	0.266	0.243	0.114	0.164	0.177	0.111

N – North, NW – Northwest, SCL – Sandy clay loam, S – Sand

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Effects of Point of Sale (POS) Services on Rice Farming Activities in Rural Communities of Niger State, Nigeria

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Abstract
The study was conducted to examine the effects of Point of Sale (POS) Services on rice farming activities in rural communities of Niger State, Nigeria. Specifically, the study examined level of rice farmers utilization of POS services in rural communities and nature of POS financial services benefited by rice farmers in the rural communities. Multi-stage sampling techniques were employed to select 225 respondents on which primary data were elicited from the respondent with the aid of a structured questionnaire complemented with interview schedule using kobo tool box. Data collected were analyzed using descriptive statistics (such as mean, frequency distribution count and percentages). The study revealed that majority 90.4% of respondent had high utilization of POS services in their rice production. Also, checking of account balance (84.7%), fund transfers (82.4%), mobile recharge card (80.9%), cash deposit (78.2%) and agricultural goods transportation fare payment (73.8%) were the major financial services benefited rice farmers. The recommended that efforts should be made to further enhance the accessibility and reliability of POS services in rural communities.
Keywords: POS; Services; Rice; and Farming

INTRODUCTION

Efficient payment systems play a pivotal role in the economic development of nations, serving as a cornerstone for seamless and secure financial transactions (Asante, 2018). The careful oversight and promotion of such systems by monetary authorities have been integral to fostering robust economies worldwide. However, the Nigerian payment system, deeply entrenched in cash transactions, has faced challenges in delivering the necessary levels of efficiency and effectiveness vital for sustainable economic growth. The implications of this cash-centric approach extend beyond mere convenience, encompassing security concerns, counterfeiting risks, fraud vulnerabilities, and logistical inconveniences (Central Bank of Nigeria (CBN), 2016).

In response to the imperative of reducing the volume of physical cash in circulation and mitigating the associated risks, the CBN took a proactive stance by introducing electronic payment systems (Ahiakpor *et al.,* 2020). These innovative systems, including payment cards such as smart cards and various paper-based instruments, heralded a new era of financial transactions within the country. This strategic move aimed to enhance the safety and convenience of transactions while fostering the broader

adoption of digital payment methods, ultimately contributing to a more secure and efficient financial ecosystem.
The introduction of electronic payment systems initiated a wave of transformative e-payment initiatives in Nigeria. Central to these efforts were the establishment of switching companies, pivotal in enabling seamless interconnectivity across various financial institutions. Additionally, innovative payment instruments like Point of Sale (POS) terminals and Automated Teller Machines (ATMs) emerged, providing consumers with convenient and secure alternatives to cash transactions. As a result, the adoption of electronic payment systems gained momentum, with noteworthy growth witnessed in the utilization of these advanced financial technologies (Salimon, 2016). Rice farming, as a critical agricultural activity in Nigeria and many other nations, plays a pivotal role in ensuring food security and supporting rural livelihoods. The integration of POS services into the Nigeria Banking sector presents a unique and underexplored opportunity to transform traditional farming practices. The existing research has predominantly concentrated on urban retail settings, emphasizing how POS services facilitate electronic transactions, enhance inventory management, and improve overall business efficiency (Afolabi, 2016; Adepoju, 2019). These studies highlight the positive impact of POS adoption on revenue generation, customer satisfaction, and SME development, shedding light on its benefits in the commercial sector. However, despite the increased adoption of POS services in various sectors, there remains a critical gap in knowledge regarding their potential effects within rural rice farming communities. The potential challenges and barriers that may arise in the implementation of POS services within the rice farming context remain uncharted territory. Hence, the research problem at hand revolves around the absence of empirical research that delves into the effects of POS services on rice farming activities in rural communities. The lack of comprehensive studies on this subject poses a significant gap in understanding the potential benefits, challenges, and implications of integrating POS systems into traditional agricultural practices. Based on the foregoing the study aimed to examine level of rice farmers awareness and utilization of POS services in rural communities and describe the nature of POS financial services benefited by rice farmers in the rural communities.

METHODOLOGY

The study was conducted in Niger State. The State is located in the Guinea Savannah Ecological Zone of Nigeria. In terms of landmass, it is the largest state in Nigeria. It covers a total land area of 74.244sq.km, which is about 9.3% of Nigeria's total land area (Kolapo and Adeyera, 2021). It is located within Longitude 3^{o}30' and 7^{o}20' East and Latitude 8^{o} 20' and 11^{o}30' North, with a population of about 3,950,249 (NPC, 2006) and with a growth rate of 3.2%, the State has an estimated population of 6,306,546 in 2022 (NSGIS, 2015).

Multi-stage sampling techniques were employed to select 225 respondents on which primary data were elicited from the respondent with the aid of a structured questionnaire complemented with interview schedule using kobo tool box. Data collected were analyzed using descriptive statistics (such as mean, frequency distribution count and percentages).

RESULTS AND DISCUSSION

Level of utilization of POS services in rural communities

The result presented in Table 1 indicates that most (68.4%) of the respondents in the study area utilised POS services, while 31.6% showed low level of utilization. The high percentage of POS service usage can be attributed to the increasing availability and accessibility of POS terminals in rural areas, driven by financial institutions and mobile money operators, likely encourage farmers to utilise this technology for their transactions. As rural areas undergo modernity, the need for more efficient, cashless payment methods has grown, making POS systems a suitable option for farmers to buy inputs, sell produce and manage their finances with ease. More so, the rise in POS usage can also be linked to financial inclusion programmes spearheaded by the State Government and financial institutions in Niger State aimed at extending financial services to underserved rural populations. These initiatives involved the deployment of POS terminals to remote areas, coupled with educational campaigns to inform rural dwellers about the benefits and use of POS services. Additionally, the utilisation of POS services may also be influenced by farmers' awareness of the convenience and security that these systems offer compared to cash transactions. This disagree with the study of Muhammad and Abubakar (2019) who assessed the use of digital financial services among smallholder farmers in Northern Nigeria. The study revealed that the adoption of digital financial services was generally low among rural farmers with only 35.0% of respondents adopting the digital financial services.

Table 1: Level of utilization of POS services in rural communities

Level of utilization	Index	Frequency	Percentage
Low	<2.5	71	31.6
High	≥2.5	154	68.4

Source: Field survey, 2024

Nature of POS financial services accessed by the respondents

Table 2 presents the result of various POS financial services utilized by the respondents in the study area. Checking account balances (96.4%), cash withdrawals for agricultural production (95. 6%), cash payment (95.6%), mobile recharge (94.7%) and fund transfer for agricultural production (93.8%) were the most frequently used POS service by respondents in the study area. The high percentage (96.4%) of respondents using POS terminal to check account balances indicates that this service is crucial for farmers managing their finances. Respondents often need to stay updated on their financial status to make informed decisions about purchasing inputs, paying for labour, or investing in farm improvements. Regularly checking account balances through POS services provide farmers with real-time access to their funds, helping them ensure that they have enough capital to support their farming activities. The convenience and accessibility of POS terminals make it easier for farmers to monitor their finances without visiting commercial bank, especially in rural areas where banking infrastructure may be limited. This is similar to the study of Singh and Rana (2021) on the usage of digital financial services in rural areas and found that checking account balances via POS systems was a widely used service, especially in agricultural communities.

Cash withdrawals for agricultural production were utilised by (95.6%) of the respondents, suggesting that this is a vital service for respondents. Farming operations such as buying seeds, fertilisers, and hiring of labour often require readily cash. POS services provide a fast and efficient way for farmers to withdraw cash without the need to travel long distances to banks, saving them time and effort. This access to cash is especially important during planting and harvesting seasons when financial needs are higher, and delays in acquiring cash could negatively impact production. This corroborates the study of Adegbite and Ojo (2020) who reported that 92% of rural respondents used POS services to check their account balances regularly. The study added that, it was particularly beneficial for those who had limited access to physical banking facilities.

Mobile recharge through POS services were also used by 94.7% of the respondents, indicating the importance of staying connected in rural farming communities. Mobile phones are essential tools for farmers, not only for communication but also for accessing market information, receiving updates from extension agents, and managing farm-related activities. Recharging phones via POS services ensures that farmers remain connected without needing to travel to urban areas for mobile recharge, making this service highly convenient. This is similar to the study of Omole and Ikuomola (2021) who opined that mobile recharge through POS terminals was a commonly used service in rural Nigeria.

Fund transfers for agricultural production, utilised by 93.8% of respondents, highlights the growing importance of digital financial transactions in rural farming practices. Farmers often need to transfer funds to suppliers, labourers, or cooperative societies, and POS services make this process possible and faster than traditional methods. Fund transfers also reduce the risks associated with carrying large amounts of cash, offering farmers a safer and more efficient way to manage payments related to their farming operations. Okafor and Olusegun (2021) stressed that fund transfers for agricultural production were among the most commonly used POS services. The study added that farmers used this service to transfer funds for purchasing seeds, fertilizer, and hiring labor, especially in peak farming seasons.

Table 4.4: Natures of POS financial services accessed by the respondents

Variable	Frequency*	Percentage
Checking account balance	217	96.4
Cash withdrawals for agricultural production	215	95.6
Cash deposit	215	95.6
Mobile recharge	213	94.7
Fund transfer for agricultural production	211	93.8
Smart card recharge	210	93.3
Cash deposit for agricultural production	209	92.9
Bill payment for agricultural production	208	92.4
Saving account management	207	92.0
Payment of purchased input	207	92.0
Mini-statement of account	206	91.6
Agricultural goods transportation fare payment	203	90.2
Cardless withdrawals	199	88.4
Agricultural loan repayment	198	88.0
Online shopping	187	83.1

Source: Field survey, 2024. *Multiple responses were recorded

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Effects of Drying Methods on Reducing Sugar and Ascorbic Acid Contents of some Varieties of Mango (*Mangifera indica* L.) Fruit Chips in Yola, Adamawa State

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Abstract
An experiment at Modibbo Adama University, Yola, assessed the effects of drying methods on the nutritional content of mango fruit chips from Tommy Atkins, Keitt, and bush mango varieties. The mangoes were dried using oven, sun, and solar methods. Nutrient analysis before and after storage focused on reducing sugar and ascorbic acid contents. The study used a split-plot design with three replications, and data were analyzed using ANOVA and LSD at a 5% probability level. Significant differences (P<0.05) were found in reducing sugar and ascorbic acid among other varieties. The Keitt variety had the highest reducing sugar (2.24%) and ascorbic acid (6.61 mg/100 g). Drying methods did not affect reducing sugar but significantly influenced ascorbic acid content, with sun drying yielding the highest ascorbic acid (7.20 mg/100 g) after storage. Solar drying was effective, maintaining nutrient levels comparable to oven and sun drying. Solar drying boosts nutrients like reducing sugar and ascorbic acid, making it a viable method for preserving mangoes.
***Keywords**: ascorbic acid, drying, mango, reducing sugar, variety*

INTRODUCTION

Mango (*Mangifera indica*) is a significant tropical fruit, native to South Asia, and widely cultivated globally (Márcio et al., 2004). Ranked fifth in global fruit production by FAO in 2009, mangoes have an annual production of 33.5 million metric tonnes (FAO, 2011). Known for their health benefits, mangoes are rich in sugars, vitamin C, and provitamin A, which help reduce cardiovascular diseases and certain cancers (Halvorsen et al., 2006; Gross, 2010). Due to their high water content, mangoes are highly perishable, making drying a suitable preservation method. In Nigeria, mangoes are abundant but have a short harvest period, leading to significant postharvest losses (Tounkara, 2011; Kameni et al., 2002; Louis, 2008). Drying mangoes is a practical alternative to reduce these losses, especially in rural areas with favourable drying conditions (Boulemtafes, 2014). Dried mangoes can help address vitamin A deficiencies (Boulemtafes, 2011). Various drying methods, including sun, solar, and atmospheric drying, can be used (Lydia & Zinash, 2017). This study compared oven, solar, and sun drying methods for Tommy Atkins, Keitt, and local mango varieties to determine the best method for preserving nutritional content in rural areas. The goal was to recommend drying methods that maintain the nutrient content of mangoes during the drying process.

MATERIALS AND METHODS

The experiment was conducted at Modibbo Adama University, Yola, Nigeria, with nutritional analysis in the Biochemistry Department. Yola's annual mean temperatures range from 15.2°C to 39°C (Adebayo and Zemba, 2020). The study used a split-plot design with three drying methods (oven, sun, and solar) and three mango varieties (Tommy Atkins, Keitt, and local). A locally fabricated solar cabinet dryer was used, consisting of a collector and drying unit covered with UV-stabilized Visqueen sheets and food-grade black paint. Mango fruits were washed, blanched, and sliced uniformly. Samples were dried in the solar dryer at 30-55°C for about 8 days, in the oven at 60°C for 76 hours, and under the sun at 27.7-33.3°C for 13 days. Dried products were packed in polyethene bags for storage. Nutritional analysis focused on reducing sugar and ascorbic acid contents before and after drying and storage. Data were collected and analyzed using ANOVA. The study aimed to determine the best drying method for preserving nutritional content in mango varieties, with results showing significant differences in nutrient retention based on drying methods and mango varieties.

RESULTS AND DISCUSSION

The study examined the effects of variety and drying methods on reducing the sugar and ascorbic acid content of mango chips. Significant differences ($P \leq 0.05$) were found among mango varieties for reducing sugar content. The Keitt variety had the highest reducing sugar before and after storage (1.69% and 2.24%), while the local variety had the lowest (1.27%). Sun drying resulted in the highest reducing sugar content (1.69%), followed by solar and oven drying (1.48% and 1.25%, respectively). The increase in reducing sugar during storage is attributed to the conversion of non-reducing sugars to reducing sugars (Ranote and Bains, 1982; Ayub *et al*., 2010; Nayak *et al*., 2012; Vijay *et al*., 2005). Significant differences ($P \leq 0.05$) were observed among the varieties of ascorbic acid content. The Keitt variety had the highest ascorbic acid content before and after storage (3.380 mg/100g and 6.607 mg/100g). Sun drying recorded the highest ascorbic acid content before storage (7.20 mg/100g), followed by solar and oven drying (6.67 mg/100g and 6.44 mg/100g). After 60 days of storage, sun drying still had the highest ascorbic acid content (6.564 mg/100g). In conclusion, the solar drying method effectively preserves the nutritional content of mangoes, including reducing sugar and ascorbic acid, making it a viable option compared to oven and sun drying methods.

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Table 1: Effects of Varieties and Drying Methods on Reducing Sugar Content (%) of Dried Mango Chips Before and After 60 Days of Storage

Treatments	Before storage	After Storage
Variety		
Tommy Atkins	1.46	1.99
Keitt	1.69	2.24
Local	1.27	1.58
P<F	0.003	0.016
LSD	0.140	0.350
Drying Methods		
Oven drying	1.25	2.02
Solar drying	1.48	1.92
Sun drying	1.69	1.87
P<F	0.006	0.273
LSD (0.05)	0.237	0.186
Interaction		
Variety x Drying methods	NS	NS

NS = Not significant, * = Significant

Table 2: Effects of Varieties and Drying Methods on Ascorbic Acid Contents (Mg/100g) of Dried Mango Chips Before and After 60 Days of Storage

Treatments	Before Storage	After Storage
Variety		
Tommy Atkins	2.719	4.924
Keitt	3.380	6.607
Local	2.648	6.019
P<F	0.012	<0.001
LSD	0.0989	0.3754
Drying Methods		
Oven drying	6.44	5.133
Solar drying	6.67	5.852
Sun drying	7.20	6.564
P<F	0.041	<0.001
LSD (0.05)	0.587	0.5141
Interaction		
Variety x Drying methods	NS	NS

NS = Not significant

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Detection of Fungi Species Involves Locus Beans (*Parkia biglobosa* Jacq.) Spoilage in Dutsin-ma Local Government Area, Katsina State, Nigeria

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Abstract
This study investigated the fungi responsible for locust bean spoilage, utilizing chemical testing, fungal isolation, and microscopic examination to carry out a complete analysis of the impact of fungus on locust bean spoilage. The background explains why it's important to understand the composition and microbes to develop better preservation methods for these culturally and nutritionally valuable beans. The technique used included testing the chemical properties like pH, moisture content, and acidity levels. Fungal isolation techniques were used with selective agar and sterile procedures to identify and characterize fungi. Microscope examination involved preparing slides and staining to get detailed morphological information. The results showed a pH range of 6.0 to 6.8, indicating slightly acidic to neutral conditions. Moisture content was 9.7% to 11.2%, while acidity ranged froac1.5% to 2.3%. Fungal isolation identified Aspergillus as the main species, with unique colony features. The microscope revealed structural characteristics like branched strands, spore shapes, and specialized reproductive structures. In conclusion, combining chemical analysis and fungal characterization gives a profound understanding of what causes locust bean spoilage. Finding a lot of Aspergillus highlights the microbial factors and the need for targeted preservation methods. This study lays the foundation for future research to improve the shelf-life and safety of locust beans, helping preserve this culturally meaningful and nutrient-dense food.
Keywords: Fungi, Locust Beans, Agar, Culture

INTRODUCTION

For centuries, using native plant resources for food and medicine has been an integral aspect of human culture. Among these resources, *Parkia biglobosa,* commonly known as Locus Beans, holds a significant place, particularly in West and Central Africa. This plant species, valued for its nutritious seeds and diverse applications in traditional cuisine, is a crucial component of local diets and economies. However, despite its cultural and economic importance, there exists a gap in our understanding of the factors influencing the quality and spoilage of Locus Beans, particularly regarding the involvement of fungi species within Dutsin-ma LGA. This research aims to contribute to the knowledge base surrounding Locus Beans by investigating the fungi species responsible for its spoilage. Understanding the specific fungi involved and the conditions favouring their growth is essential for devising effective preservation and storage strategies. Furthermore, this research aims to investigate the physicochemical parameters of Locus Beans, such as pH, moisture content, and acidity, analyzing the various factors that impact its quality. The African locust bean tree, *Parkia biglobosa* are perennial tree legumes which belong to the sub-family Mimosoideae and family

Leguminosae (now family Fabaceae). They grow in the Savannah region of West Africa up to the southern edge of the Sahel zone 13°N (Campbell-Platte, 2018). A matured locust bean tree (20-30 years) can bear about a ton of above-harvested fruits. From experience, the tree can start to bear fruits from 5-7 years after planting (Musa, 2011). *Parkia biglobosa* tree plays a vital ecological role in recycling nutrients from deep soil, by holding soil particles to prevent soil erosion with the help of its roots. It also provides shade where it is found (Campbell-Platte, 2018). The most important use of the African locust bean is found in it, although it has other food and non-food uses, especially the seeds which serve as a source of useful ingredients for consumption (Campbell-Platte, 2018). It has been reported that the locust bean is rich in protein, carbohydrates, soluble sugars and ascorbic acid. The cotyledon is very nutritious and has less fibre and ash content. The oil content is suitable for consumption since it contains acid and iodine. The oil has very high saponification and would be useful in the soap industry (Alabi *et al*., 2015). It has also been reported that the husks and pods are good for livestock (Douglass, 2016; Obiazoba, 2018). The locust bean tree is also important in medicinal practices for ailments such as bronchitis, pneumonia, malaria, diarrhoea, and as poison for sore eyes (Farombi, 2013).

Objectives of the Study

To guide the study, the following objectives were formulated;

1. To isolate and identify fungi associated with locust bean spoilage *Parkia biglobosa*).
2. To determine the pH, moisture content and acidity.
3. To propose strategies for preventing and managing fungal spoilage in locust beans.

Research questions

The study seeks to answer the following questions:

1. Which fungal species are commonly associated with the spoilage of locust beans?
2. What are the pH, moisture content and acidity?
3. What measures can be implemented to prevent and control fungal spoilage in locust beans?

Research hypothesis

Ho1: There is no significant relationship between fungal species and locust beans
Ho2: The pH levels, moisture content, and acidity of locust beans (*Parkia biglobosa)* do not significantly vary within the sample population,
Ho3: There is no significant relationship between the strategies of preventing and managing fungal species and locust bean spoilage.

METHODOLOGY

The study was conducted in Dutsin-ma Town, and an experimental design was adopted to systematically investigate and characterize fungi species associated with Locus Beans spoilage. This design allows for a detailed analysis of the factors contributing to spoilage while providing a framework for the collection and interpretation of data. The population under consideration includes Locus Beans from diverse sources within the chosen research area. The population is not limited to specific varieties or stages of maturity to ensure a representative sample that reflects the broader fungal diversity associated with Locus Beans. A systematic random sampling technique was employed to ensure the representativeness of the collected samples.

Experimental Procedure
Physicochemical Parameters Analysis
pH determination
According to Cheesbrough (2006) to assess the pH of Locus Beans, the methodology involves grinding a representative sample. Subsequently, a slurry was prepared by combining the ground sample with distilled water. The pH of the resulting slurry was measured using a calibrated pH meter. This procedure is carried out to determine the acidity level in Locus Beans, contributing to a comprehensive understanding of their physicochemical characteristics.

Moisture content determination
The procedure for determining moisture content begins by weighing a sample of Locus Beans. Subsequently, the sample was dried in an oven at a specified temperature until a constant weight was achieved. The moisture content was then calculated using the formula: Moisture Content (%) = [(Initial weight - Final weight) / Initial weight] 100. This method ensures a precise assessment of the moisture content in the Locus Beans, providing essential data for the overall characterization of their composition.

Fungal Isolation, Colony Identification, Fungal Characterization and Identification
Aseptic techniques were employed for the isolation of fungi from surface-sterilized beans. The isolated fungi are cultured on selective agar media (Potato Dextrose Agar), and incubated at an optimal temperature for fungal growth (25-30°C), (Cheesbrough 2006). Fungal colonies were monitored for growth, and characteristics such as colour, texture, and morphology were documented. Sub-culturing of individual colonies was performed for further characterization. Microscopic examination involves preparing slides of fungal hyphae, spores, and reproductive structures. Staining techniques like lacto phenol cotton blue were employed for detailed morphological characterization.

Data analysis and results
The results of the findings are presented in tables below, offering a clear and organized representation of the outcomes, followed by a comprehensive discussion that interprets the findings within the broader scope of locust bean spoilage.

RESULTS AND DISCUSSION
Table 1 presents results for the physicochemical characteristics of Locust Beans. The pH values range from 6.0 to 6.8, indicating a slightly acidic to neutral environment. Moisture content varies between 9.7% and 11.2%, providing insights into the water content of the samples. Acidity levels range from 1.5% to 2.3%, reflecting the acidic nature of Locust Beans.

Table 1: pH, Moisture Content, and Acidity Levels in Locust Beans

Sample	pH Value	Moisture Content (%)	Acidity (%)
1	6.2	10.5	1.8
2	6.8	9.7	2.3
3	6.0	11.2	1.5

Table 2: Fungal Isolation and Identification Results

Sample	Fungal Species Isolated	Colony Characteristics
1	*Aspergillus niger*	Colour: Green, Texture: Velvety, Morphology: Sporulating
2	*Aspergillus flavus*	Colour: Yellow, Texture: Powdery, Morphology: Conidiophores
3	*Aspergillus fumigatus*	Color: White, Texture: Cottony, Morphology: Spherical

The isolation of fungal and identification processes reveals the presence of different Aspergillus species, each exhibiting unique colony characteristics. *Aspergillus niger* appears as green, velvety, and sporulating. *Aspergillus flavus* is yellow, powdery, and exhibits conidiophores. *Aspergillus fumigatus* is white, cottony, and displays spherical morphology.

Table 3: Microscopic Examination Results for *Aspergillus spp.*

Sample	Hyphae Characteristics	Spore Characteristics	Reproductive Structures
1	Septate, Branched, Hyaline	Conidia, Single-celled, Pigmented	Conidiophores, Conidia chains
2	Non-septate, Unbranched, Hyaline	Conidia, Multicellular, Hyaline	Conidiophores, Sporangia
3	Septate, Branched, Pigmented	Conidia, Single-celled, Brown	Conidiophores, Cleistothecia

The microscopic examination results show varied hyphae, spores, and reproductive structures for different *Aspergillus* spp. In Sample 1, hyphae are septate, branched, and hyaline, having conidia, single-celled, and pigmented. Sample 2 exhibits non-septate, unbranched, hyaline hyphae, and multicellular, hyaline conidia. Sample 3 displays septate, branched, pigmented hyphae, with single-celled, brown conidia. The structures observed contribute to the morphological characterization of Aspergillus spp. colonies.

The acidity levels of the locust beans were pretty neutral overall, between 6.0 to 6.8 pH. This is decent and means the beans should be good to eat quality-wise. The moisture content was moderate too, from 9.7% to 11.2%. This gives a sense of how much water is in there, which is key for how long the beans will last. The acidity itself was low, ranging from 1.5% to 2.3%, which makes sense for locust beans. So, the different chemical tests helped describe the beans fully. The fungal isolation identified Aspergillus as the main fungus in all the bean samples. The colonies had unique features like green color, cotton-like texture, and separated strands for sample one, yellow color, powdery texture, and stalks releasing spores for sample two, and white color, fuzzy texture, and sacs of spores for sample three. This shows Aspergillus fungus is common in the locust beans, matching past research linking it to spoiling of the beans.

Putting together the chemical tests and fungal characterization gives a complete picture of what's causing the beans to spoil. The neutral to slightly acidic pH range, along with the moderate moisture content, offers conditions that let Aspergillus grow. The low acidity levels found suggest it might not affect bean quality much but needs monitoring to control fungus spread. Identifying Aspergillus through both isolation and microscope examination highlights the need for good preservation methods. The unique colony traits and structural features seen under the microscope provide insights into the specific Aspergillus strains ruining the locust beans.

CONCLUSION AND RECOMMENDATIONS

The findings from this research underscore the intricate interplay between physicochemical characteristics and fungal presence in the spoilage of locust beans. The prevalence of *Aspergillus* spp. highlights the need for targeted preservation strategies to mitigate the impact on the quality and safety of locust beans. The microscopic details obtained through fungal characterization contribute to a nuanced understanding of the spoilage mechanisms and provide a foundation for further studies in food microbiology.

Based on the findings of this research, the following recommendations were made;

1. Given the prevalence of Aspergillus spp., further research into innovative preservation methods, such as modified atmosphere packaging or natural antimicrobial agents, could enhance the shelf life of locust beans.
2. Establishing regular monitoring protocols for pH, moisture content, and acidity levels in locust beans can aid in the early detection of deviations and prompt intervention to prevent fungal proliferation.
3. Conducting genetic analysis of isolated Aspergillus spp. strains can provide insights into their specific attributes, including potential mycotoxin production, allowing for more targeted mitigation strategies.
4. Educating farmers, processors, and consumers about correct storage practices and the dangers linked to fungal contamination can enhance food safety.

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Analysis of Consumers' Willingness to Purchase Street Food in Aba South Local Government Area of Abia State, Nigeria

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Abstract
The study analyzed consumers' willingness to purchase street food in Aba South LGA of Abia State. Multi-stage sampling technique was used to select 150 consumers of street food. Primary data was collected using semi structured questionnaire and were subjected to descriptive and inferential statistics. Socio-economic characteristics results showed that consumers of street food were more of male and of middle age group. Fairly good proportion of the consumers were single. The street food consumers had one form of formal education or the other with sizeable household and monthly income of ₦41,000 – ₦50,000. The perceived factors that influence consumers decision to purchase street food has hygienic ($\bar{X}$=5.00) topping the list. The result on consumers' willingness to purchase street food showed ready –to – eat meals ($\bar{X}$ = 4.67) in the lead. The logit estimates of factors influencing consumers' willingness to purchase street food showed that gender, age, price of street food, street food quality and physical environment of the vendor were significant at varying levels. Problems encountered by street food consumers are price of the food (100.00%), poor hygiene (100%) and inadequate storage facilities (67.33%). The study therefore recommended that Street food vendors should be issued a formalized vending license and their operations frequently monitored to build consumers' trust. This will also ensure a clean and healthy environment for the vendor, the customer and the society.

Keywords: Street food, Willingness to Purchase, Consumer decision, Vending licence

INTRODUCTION

Street foods are defined as "any ready foods and beverages prepared and vended at outdoor public locations for immediate consumption (FAO, 2016a). Street foods are on the increase in recent times due to their affordability, convenience and availability for consumers (Bellia *et al*., 2016). It is estimated that about 2.5 billion people depend on street foods daily across the world because they are economical and affordable (FAO, 2016b). They ensure that food security needs of many people in urban areas are met (FAO, 2016a). Street foods are "ready-to–eat" foods and beverages prepared and sold by vendors and hawkers especially in the street and other similar public places (FAO, 1997). Tinker (1997) defined street foods as any minimally processed food sold on the street for immediate consumption. They are foods obtainable from a makeshift or portable stall.

Street foods are extremely heterogeneous in nature and encompass meals, drinks, and snacks. They also show great variation in terms of ingredients, methods of retail, processing and consumption and are sold on the street from "pushcarts or baskets or balance poles, or from stalls or shops having fewer than four permanent walls" (FAO, 2007). According to FAO (1997), 2.5billion people eat street food everyday around the world. In many developing countries, street foods are common and important features of urban centers; and are important because they provide a source of employment and income for men and women**.**

Despite the potential to improve both nutrition and food security among urban population, street foods can sometimes cause concern because of their potential to cause serious food poisoning outbreaks due to microbiological contamination, improper use of additives and the presence of other adulterants and environmental contaminants (FAO, 1995). Predisposing factors for food poisoning and serious health problems are also associated with unlicenced and untrained vendors (Johnson and Yawson, 2000). This study therefore, will be beneficial to both the sellers and buyers of street foods because the findings will tend to justify the level of willingness of buyers to consume road side foods and carefully analyzed the possible strategies of increasing customers willingness to purchase and enable vendors achieve profit maximization. The study specifically: i described the socioeconomic characteristics of street food consumers, ii identified perceived reasons for consumers decision to purchase street food in the study area, iiidetermined the level of consumers' willingness to purchase street food, iv analyzed the determinants of consumers' willingness to purchase street food, v identified major problems that militate against street food consumption in the study area.

METHODOLOGY

Multi-stage sampling technique was used to obtain the samples for this study. In the first stage. three communities were selected randomly.Second stage, five (5) villages were randomly selected from the selected communities to give a total of fifteen villages. Finally, in each of the villages, 10 consumers of street food were randomly selected making a total of 150 consumers of street food. The primary data used were collected with the help of a structured questionnaire to reflect the specific objectives.

Both descriptive and inferential statistics were employed in the data analysis. Objectives i, ii and v were realized using descriptive statistics such as frequency counts and percentages. Objective (iii) was realized using mean score with the help of a five (5) point likert scale. While objective (iv) was realized using logit regression model. Mean was calculated by multiplying the frequency (f) of the responses under each response category by assigning value and dividing the sum (∑) of the product by the number of the respondents (N) to obtain the mean.

$$X = (\sum fx)/N$$

Where $\bar{X}$= mean rating, ∑=Summation, f =frequency, x =assigned score to response category N = number of respondents

Logistic regression analysis studies the association between a categorical dependent variable and a set of independent (explanatory) variables. The name logistic regression is used when the dependent variable has only two values, such as 0 and 1 or Yes and No.

$$Li = ln\left(\frac{pi(y=1)}{1-pi\ (y=1)}\right) = \beta_{0,k} + \beta_{1,k}X_{1,i} + \beta_{2,k}X_{2,i} \ldots\ldots\ldots\ldots\ldots\ldots \beta_{M,k}X_{M,i} + ei$$

L = Logit of choice of street food
P*i* (y=1) = probability of choice of street food
Y = Consumer choice of street food (1 = Yes: 0 = No)
X_1 = Age in years
X_2 = House hold Size (Number)
X_3 = Gender (Dummy: Male=1, female = 0)
X_4 = Income (₦)
X_5 = Educational level (Years)
X_6 = Marital status dummy (married = 1, single = 0)
X_7 = Occupation
X_8 = Place of Purchase of Street food
X_9 = Price of street food (Dummy: High = 1; Low = 0)
X_{10} = Street food Quality (Dummy: High = 1; Low = 0)
ei = Error term

RESULTS AND DISCUSSION

The result of the socioeconomic characteristics shows that males engaged more in the purchase of street foods than the females. Middle Ages group participated more than older one while more singles purchase street food because it is convenient and time-saving for them. Majority had one form of formal education or the other that influenced decision regarding nutritive values attached to street food. Income was a major determinant of purchase of street food and budget share allocation to these foods among households.

The distribution of consumers according to perceived reasons for their decision to purchase street food is presented in Table 1. All items except lifestyle and location were perceived as significant in influencing consumer's decision to purchase street food. Hygiene, quality/taste good, and vendor character topped the list. According to Yeun and Chen (2010), consumer patronage behavior can be influenced by location, atmosphere, meal familiarity, price, and food quality. These results corroborate the findings of Bellia *et al.* (2016) that 64.8 per cent of the interviewees considered cleanliness as a criterion in the acquisition of street food.

Table 1: Distribution of Consumers According to Perceived Reasons that Influence their Decision to purchase Street Food

Street food	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	∑fn	Mean	Decision
Price	100 (500)	50(200)	-	-	-	700	4.67	**
Good aroma	50(250)	75(300)	-	20(40)	5(5)	595	3.96	**
Hygiene	150(750)	-	-	-	-	750	5.00	***
Varieties	75(375)	75(300)	-	-	-	675	4.50	**
Taste good/quality	150(750)	-	-	-	-	750	5.00	**
Convenience	100 (500)	50(200)	-	-	-	700	4.67	**
Location	30(150)	20(80)	10(30)	60(120)	30(30)	410	2.73	Ns
Vendor character	130(650)	20(80)	-	-	-	730	4.87	***
Appealing look	79(395)	71(284)	-	-	-	679	4.53	**

Source: Field Survey, 2021. Mean ≥ 3.0 = ** = Moderately Significant; *** = Highly Significant; Not Significant (Ns). Figures in parentheses are Likert scores

The distribution of consumers according to willingness to purchase street food is presented in Table 2. Ready – to – eat meals and drinks topped the list. Bhowmik (2005) noted that the fact that prices of ready to eat meals are low, enable the urban poor to benefit from them.

Table 2: Distribution of Consumers According to their Willingness to Purchase Street Food

Street food	Always	Often	Occasionally	Seldom	Never	∑fn	Mean	Decision
Ready-to-eat meals	100 (500)	50(200)	-	-	-	700	4.67	***
Snacks	30(150)	20(80)	10(30)	60(120)	30(30)	410	2.73	Ns
Fruits	25(125)	47(188)	-	73(146)	5(5)	464	3.09	**
Drinks	59(295)	63(252)	7(21)	13(26)	8(8)	602	4.01	***
Grand mean							3.63	

Source: Field Survey, 2021. Mean ≥3.0 = ** =Moderately Significant; *** = Highly Significant; Not Significant (Ns). Figures in parentheses are Likert scores

Factors Influencing Purchase of Street Food

The probit model estimates shown in Table 3, posted a goodness of fit chi-square value of 19.04 which is statistically significant at 1.0% level. The coefficient of gender (0.0950) was positive and statistically significant at 5.0% alpha level implying that males were more engaged in the purchase of street food. The findings agreed with that of Ahmed and Krisha (2007). The coefficient (-0.0290) of age was negative and statistically significant at 1.0% alpha level. Young men and women are disposed to purchase street food than the old ones (Diez *et al*., 2006). This result is in line with *a priori* expectation.

The coefficient (-0.0018) of price of street food was negative and statistically significant at 1.0% alpha level. Mill (2017) observed price to be one of the factors restaurant patrons take into account when selecting a restaurant and purchasing food. The coefficient (0.0344) of street food quality was positive and statistically significant at 1.0% alpha level. According to Namkung and Jang, (2007) and Sulek and Hensley (2004), food quality is a primary factor influencing customer patronage of food vendor and purchase of street food. The coefficient (0.1553) of physical environment was positive and statistically significant at 1.0% alpha level. Physical environment has been found to influence consumer's perceived quality and purchase of street food (Boo, 2017; Githiri, 2016; Omar *et al*., 2014).

Table 3: Logit Regression Estimates of Factors influencing Consumers of purchase street food

Variables	Estimated coefficients	Standard errors	Z-ratios	P> IzI
Constant	-1.8219*	1.6517	-1.66	0.096
Age	-0.0290**	0.0143	-2.53	0.011
Marital Status	-0.0072	0.0145	-0.06	0.950
Gender	0.0950**	0.2949	2.15	0.032
Level of Education	-0.0200	0.1858	-0.50	0.618
Monthly Income	0.0557	0.0432	1.13	0.235
Occupation	0.0399**	0.0532	2.35	0.019
Place of purchase of street food	-0.1553	0.1843	-0.12	0.908
Household Size	-0.0119	0.0172	1.33	0.211
Price of street food	-0.0018***	0.0294	-2.71	0.007
Street food quality	0.0344***	0.2054	2.65	0.008
Log likelihood	-60.0918			
LR Chi^2	19.04			
Pseudo R^2	0.6731			

Source: Field Survey, 2021. ***, **, * Significant at 1.0%, 5.0% and 10.0% levels respectively.

Problems Militating Against Consumers' Willingness Purchase of Street Food.
The hygienic aspects of street food vending are a major concern for food control officers. Vending stands are often crude structures. Running water, washing facilities and toilettes may not be available. Another is price of food

Table 4: Distribution of Consumers according to Problems Militating Against their Willingness Purchase of Street Food

Problems	Frequency	Percentage
High transportation cost	77	51.33
Inaccessible the area	32	21.33
poor road network	15	10.00
inadequate storage facilities	101	67.33
Price of the food	150	100.00
Poor hygiene	150	100.00

Source: Field survey, 2021. * Multiple Responses Recorded

CONCLUSION

The study concluded that gender, age, price of street food, street food quality, physical environment of the vendor and marital status influenced consumers' willingness to purchase street food. Food consumers were constrained by price of the food, inadequate storage facilities and poor hygienic nature of street food vending.

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Spatio-Temporal Variations of Heavy Metals Concentration in Surface Water and Sediments of Yewa Lagoon Lagos, Southwest Nigeria

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Abstract
The study examined the levels of arsenic, lead, copper, zinc, and cadmium in the surface water and sediments of Yewa Lagoon over two years (April 2017 to March 2019). Located on the western side of Lagos State, seven stations were selected based on their proximity to communities and human activities. Monthly water and sediment samples were collected using a motorized boat. Water samples were preserved with nitric acid, while sediments were air-dried and disaggregated. Heavy metals were measured using a UNICAM 929 London Atomic Absorption Spectrophotometer. The mean concentrations of arsenic, lead, copper, zinc, and cadmium in surface water were 0.25 ± 0.02, 2.48 ± 0.31, 0.22 ± 0.03, 0.47 ± 0.04, and 0.15 ± 0.02 ppm, respectively. In sediments, the mean concentrations were 3.04 ± 0.19, 6.89 ± 2.67, 7.06 ± 2.06, 8.81 ± 2.67, and 0.07 ± 0.02 ppm, respectively. The concentrations were significantly higher in sediments than in surface water, with levels of lead and cadmium exceeding acceptable limits for aquatic life. Urgent measures are needed to address pollution and ensure a healthy water supply and food security.

Keywords: Heavy metals, Anthropogenic Activities, Surface Water, Sediments, Yewa Lagoon.

INTRODUCTION

Heavy metals, defined as metals with a density greater than 5 g/cm³ (Khayatzadeh and Abbasi, 2010), are high-priority pollutants given their toxic nature and long-lasting harmful effects on the water body and the environment (Don-Pedro et al., 2004). Monitoring these metals is crucial for effective environmental management. They enter water bodies through industrial runoff, sewage, automotive emissions, and other sources (Chukwu, 1991; Edward & Ugwumba, 2010; Khayatzadeh & Abbasi, 2010). Airborne inorganic elements also contribute significantly to metal presence in rivers (Aiyesanmi, 2006). Naturally occurring metals from soil and rock mineralogy, such as iron, manganese, zinc, copper, cadmium, and lead, enter aquatic ecosystems through leaching and weathering (Laws, 1981; Ezigbo, 1989). Sediment metal concentrations are often 10 to 100 times higher than in water (Ahmed et al., 2017; Don-Pedro et al., 2004). The EPA lists arsenic, cadmium, chromium, copper, mercury, nickel, lead, and zinc as common pollutant heavy metals (Athar & Vohora, 2001). While some metals are essential at trace levels, others like lead, cadmium, and mercury are hazardous (Khayatzadeh & Abbasi, 2010). Fish, particularly embryos and larvae, are indicators of metal contamination (Lin & Hwang, 1998). Arsenic, used in various agricultural products, is a carcinogen and causes severe health issues (Pandey & Madhuri, 2014). Yewa

Lagoon, vital for local communities, faces significant heavy metal pollution, necessitating urgent monitoring and remediation (Lawson & Oloko, 2013).

MATERIALS AND METHODS

Study area: Yewa Lagoon is between the Republic of Benin and Nigeria which lies approximately within latitudes $6^0 22'$ to $6^0 36'$ North and longitudes 2^0 50′ to 2^0 54′ East of the Greenwich Meridian. The map of Yewa Lagoon showing the sampled stations is shown in Figure 1. Seven sample stations were selected using GPS based on their nearness to the surrounding villages as follows: Iyafin, Afowo, Ibawe, Itohun, Iragbo, Ere and Yewa River Entrance Coded A, B, C, D, E, F and G respectively.

Field and Laboratory sampling

Water and sediment samples for heavy metal determination were collected monthly from all sampled stations between 0900 and 1200 using a motorized boat. Plastic containers for water samples were thoroughly washed, rinsed with distilled water, and acidified with 2-3 ml of nitric acid (HNO_3) at the sampling point to keep ions in solution (Popoola et al., 2015). Samples were labelled and transported to the laboratory for further analysis. Sediment samples were collected using a Van Veen grab, air-dried at room temperature, and pulverized. For digestion, 0.5 g of sediment was weighed into a pre-cleaned borosilicate beaker, and 20 ml of nitric acid was added. The mixture was digested on a hot plate in a fume cupboard, cooled, and filtered into a 250 ml volumetric container with de-ionized water. Preserved water samples were refrigerated before analysis (APHA, 1998). Water samples were similarly digested and filtered. All digested samples were analyzed using an atomic absorption spectrophotometer (AAS). Standards of copper, arsenic, zinc, cadmium, and lead solutions were prepared from 1000 mg/l stock solutions. The detection limit was 0.0001 mg/l using the UNICAM 929 London AAS at Multi-Laboratories, Igbe-Ikorodu, Lagos. Data were analyzed using descriptive statistics, paired t-tests, and ANOVA with Microsoft Excel and IBM SPSS 20.0 Software for Windows.

RESULTS AND DISCUSSION

The study measured heavy metals in Yewa Lagoon's surface water and sediments from April 2017 to March 2019. Arsenic (As) in surface water averaged 0.25 ± 0.02 ppm, peaking at 0.42 ppm in March 2019 and dipping to 0.19 ppm in June 2017. Sediment arsenic ranged from 1.71 ppm at Ibawe to 4.08 ppm at Yewa River Entrance, averaging 3.04 ± 0.91 ppm. Dry season arsenic levels were higher caused by evapotranspiration (WHO, 1998). Lead (Pb) in water averaged 2.48 ± 0.31 ppm, with a high of 4.63 ppm in March 2019 and a low of 1.99 ppm in September 2018. Sediment lead ranged from 4.03 ppm at Iyafin to 10.06 ppm at Yewa River Entrance, averaging 6.89 ± 2.67 ppm. Lead levels exceeded the acceptable limit for aquatic life (WHO, 1998; NESREA, 2011), posing health risks (Pandey & Madhuri, 2014). Cadmium (Cd) in water averaged 0.15 ± 0.02 ppm, peaking at 0.27 ppm in March 2019. Sediment cadmium ranged from 0.05 ppm at Iyafin to 0.10 ppm at Yewa River Entrance, averaging 0.07 ± 0.02 ppm. Cadmium levels exceeded drinking water limits (WHO, 1998), with potential health impacts (Pandey & Madhuri, 2014). Copper (Cu) in water ranged from 0.19 ppm at Afowo to 0.27 ppm at Yewa River Entrance, averaging 0.22 ± 0.03 ppm. Sediment copper ranged from 4.08 ppm at Iyafin to 9.30 ppm at Yewa River Entrance, averaging 7.06 ± 2.06 ppm. Copper levels were higher in the dry season (WHO, 1998). Zinc (Zn) in water averaged 0.47 ± 0.04 ppm, ranging from 0.42 ppm at Afowo to 0.54 ppm at Yewa River Entrance. Sediment zinc ranged from 5.47 ppm at Iyafin to 11.75 ppm at Yewa River Entrance, averaging 8.81 ± 2.67 ppm. Zinc levels were higher in the dry season but within acceptable limits (WHO, 1998). The heavy metal levels were elevated during the dry season and in sediment, possibly due to industrial discharge and other anthropogenic influences (Don-Pedro et al., 2004; Ahmed et al., 2017).

CONCLUSION AND RECOMMENDATIONS

This study was conducted to assess the spatial and temporal variations of heavy metals (As, Pb, Cu, Zn, and Cd) in the surface water and sediments of Yewa Lagoon, South-west Nigeria. Seven stations (Afowo, Iyafin, Ibawe, Itohun, Iragbo, Ere and Yewa River) along the Yewa Lagoon with identified anthropogenic activities such as dredging, domestic and industrial waste discharges were selected. The heavy metal concentrations, when compared with the acceptable limit for aquatic life and domestic usage (WHO, 1998; NESREA, 2011) showed exceedingly high values for Pb and Cd, while Cu, Zn and as concentrations were within the permissible limits. The trend of heavy metal accumulations in the water samples was in the order of Zn > Pb > Cu > As > Cd. The concentration of heavy metals in the sediment was in the order of Pb> Zn > As > Cu > Cd. The results suggested the influence of raw sewage, industrial and agricultural discharge, liquid fossil fuel spills from fishing and transport boats and metal-laden industrial and domestic effluents as the major sources of higher Pb and Cd above the permissible limit. Finally, the selected heavy metals were all significantly higher in the dry season in the surface water as well as sediments which suggest the influence of season (e.g. rainfall, Run-off and precipitation) on the analysed metals. Based on this study, the framework for mandatory action should be initiated for continual assessment of Yewa Lagoon to ensure the conservation of its aquatic resources. The result of this work requires urgent attention to be paid to the lagoon in terms of regulating and monitoring the effluents that are being washed into the water from different sources and upgrading the available environmental guidelines for aquatic life and domestic uses of water resources. Enlightenment programs for the general public on the risks of Yewa Lagoon pollution are very necessary.

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Table 1: Spatial variations of heavy metals in the surface water of Yewa Lagoon

Parameters	Afowo	Iyafin	Ibawe	Itohun	Iragbo	Ere	YRE	Mean ±std	WHO	NESREA
Arsenic (ppm)	0.21^{a}	0.22^{ab}	0.23^{abc}	0.25^{bcd}	0.26^{bcd}	0.26^{cd}	0.28^{d}	0.25±0.02	10	
Lead (ppm)	2.08^{a}	0.22^{ab}	2.31^{abc}	2.68^{cd}	2.58^{abcd}	2.62^{bcd}	2.93^{d}	2.48±0.31	0.01	0.01
Copper (ppm)	0.19^{a}	0.22^{a}	0.2^{a}	0.23^{ab}	0.23^{ab}	0.23^{ab}	0.27^{b}	0.22±0.03	≤5	0.001
Zinc (ppm)	0.42^{a}	0.22^{a}	0.46^{ab}	0.49^{b}	$0.5b^{c}$	0.49^{b}	0.54^{c}	0.47±0.04	≤5	0.01
Cadmium (ppm)	0.13^{a}	0.22^{a}	0.14^{ab}	0.15^{abc}	0.15^{abc}	$0.17b^{c}$	0.17^{c}	0.15±0.02	0.03	

*Means with different letters are significantly different (p>0.05). Key: YRE = Yewa River Entrance, std = Standard Deviation

Table 2: Seasonal variations of heavy metals in surface water during the study period

Parameter	Wet Season			Dry Season		
	MIN	MAX	Mean ± Std	Min	Max	Mean ± Std
Arsenic (ppm)	0.2	0.26	0.23 ± 0.02	0.23	0.33	0.28 ± 0.03*
Lead (ppm)	1.81	2.58	2.14 ± 0.27	2.46	3.41	2.94 ± 0.35*
Copper (ppm)	0.17	0.24	0.20 ± 0.02	0.22	0.32	0.26 ± 0.04*
Zinc (ppm)	0.39	0.51	0.44 ± 0.04	0.45	0.59	0.52 ± 0.05*
Cadmium (ppm)	0.12	0.17	0.14 ± 0.02	0.15	0.2	0.17 ± 0.02*

*(p<0.05) significant

Table 3: Spatial variations of heavy metals in sediment of Yewa Lagoon.

Parameters	Afowo	Iyafin	Ibawe	Itohun	Iragbo	Ere	YRE	Means ± Std
Arsenic	1.71	2.15	2.47	3.63	3.63	3.63	4.08	3.04 ± 0.91
Lead	4.05	4.03	4.22	8.73	8.79	8.37	10.06	6.89 ± 2.67
Cadmium	0.05	0.05	0.06	0.08	0.09	0.08	0.10	0.07 ± 0.02
Copper	4.11	4.08	5.01	8.06	8.42	7.47	9.30	7.06 ± 2.06
Zinc	5.77	5.47	6.89	10.63	10.82	10.36	11.75	8.81 ± 2.67

Table 4: Seasonal variations of heavy metals in the sediment of Yewa Lagoon

Parameters	Wet season			Dry season		
	Min.	Max.	Mean ± std	Min.	Max.	Mean ± std
Arsenic (ppm)	2.75	3.36	2.93 ± 0.22	2.61	4.69	3.31 ± 0.68
Lead (ppm)	5.9	7.41	6.63 ± 0.46	6.01	9.35	7.56 ± 0.91*
Copper (ppm)	5.21	7.96	6.04 ± 1.01	5.74	10.7	7.32 ± 1.72*
Cadmium (ppm)	0.05	0.09	0.06 ± 0.01	0.06	0.12	0.08 ± 0.02*
Zinc (ppm)	7.6	9.76	8.36 ± 0.78	7.93	13.15	9.64 ± 1.68*

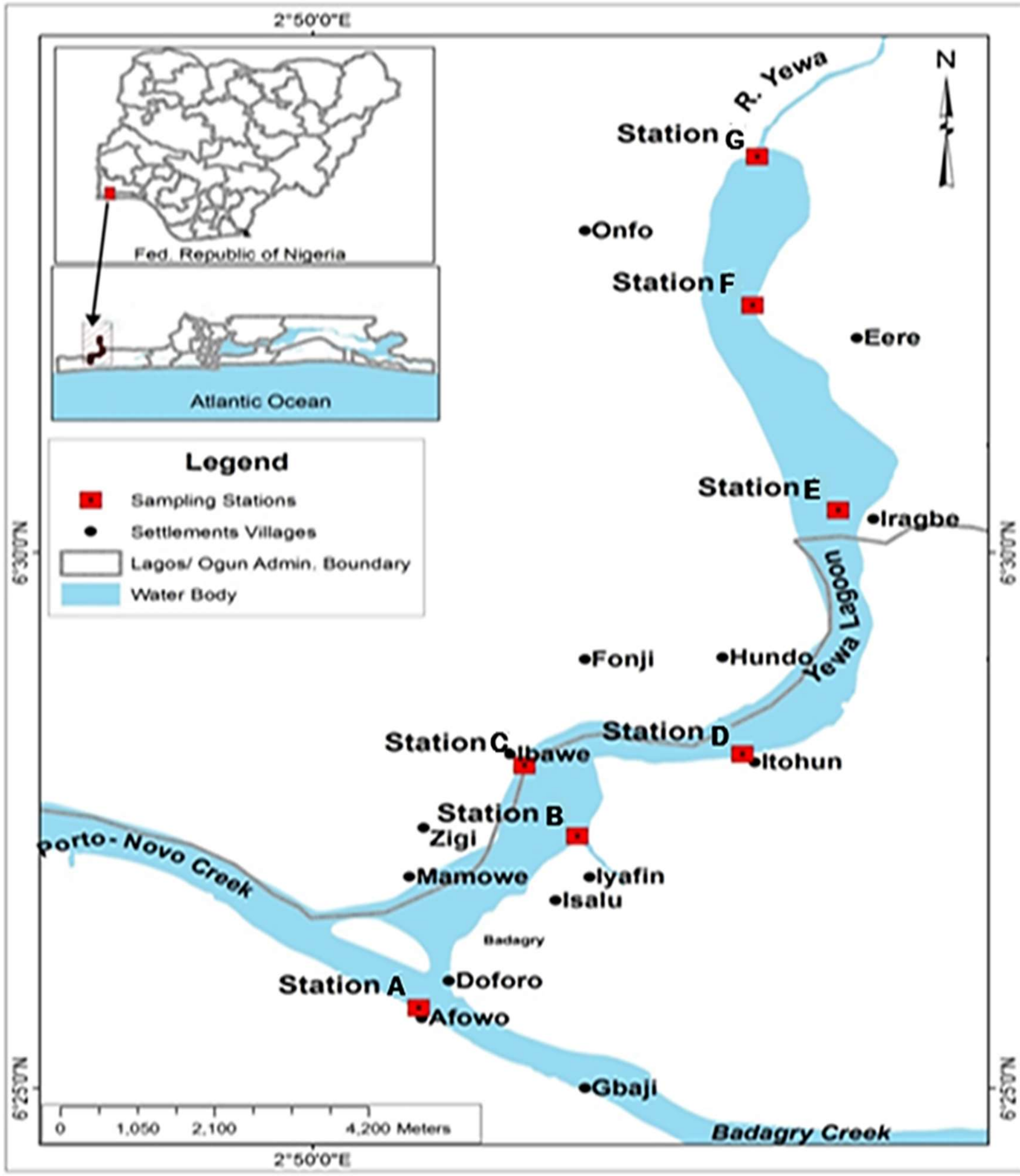

Figure 1: Map of Yewa Lagoon showing the sampled stations

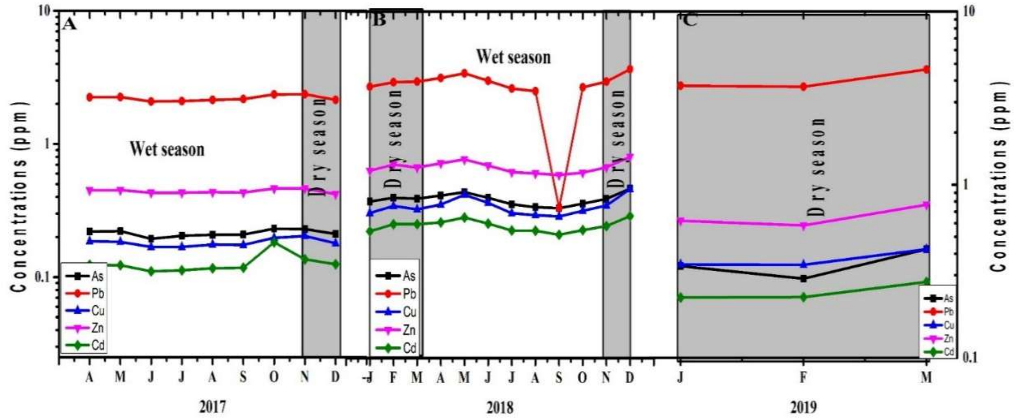

Figure 2: Temporal variations of heavy metals in Yewa Lagoon (Starting from A, April, 2017 to M, March, 2019 respectively)

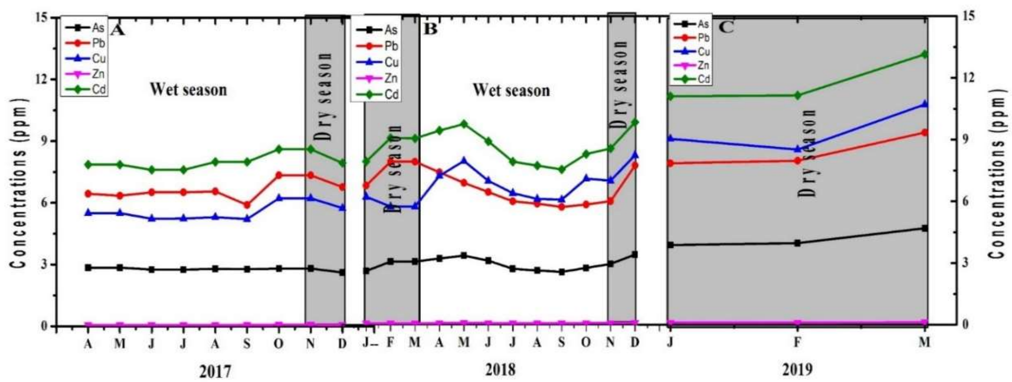

Figure 3: Temporal variation of heavy metals in sediment of Yewa Lagos

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Determination of the Potency of Oil Palm Bunch for the Management of *Spodoptera frugiperda* (J. E. Smith)

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Abstract

Experiment was carried out to determine the efficacy of oil palm bunch ash (0, 3 %, 6%) and DDVP (0.55 %, 1.10 %) as standard check on maize type (Ikom white (Land race), Oba Super 6 variety) for the management of Spodoptera frugiperda (J. E. Smith) in Calabar, Nigeria. The experiment was a 2×5 factorial layouts in Randomized Complete Block Design. Data obtained from the experiment included; army worm incidence and grain yield. The Data were analyzed using Genstat 8.0 statistical package and means compared using Duncan New Multiple Range Test (DNMRT). Similarly, there were significant differences among various insecticides applied on maize (0, 3%, 6% oil palm bunch ash, 0.55, 1.10% DDVP) in relation to army worm incidence and grain yield of maize. The interactions of various insecticides with maize varieties did not have any significant difference in army worm incidence and grain yield. Oba super 6 had significantly greater yield than Ikom white. The application of oil palm wood ash was efficacious in the control of Spodoptera frugiperda, and therefore could be recommended to farmers for the management of the insect pest due to the advantage of being a more ecofriendly insecticide.

Keywords: Spodoptera frugiperda, army worm incidence, yield, oil palm bunch ash, DDVP

INTRODUCTION

Fall armyworm, *Spodoptera frugiperda* (J. E. Smith) is a polyphytophagous pest with *Zea mays* as its primary host. Armyworm is native to the America, where it is recognized as one of the most damaging crop pests (Koffi *et al.*, 2020). The outbreak of armyworm is one that is of huge problem to farmers across most African countries and beyond (Nboyine *et al.*, 2020). The debilitating effects of this pest on cereal crops particularly maize (Bateman *et al.*, 2018), has attracted attentions from all concerned bodies as efforts are made to control the wide spread of armyworm, so as to enhance adequate and stable productivity. Amidst the myriad of control measures that various pest control bodies and individual researchers have carried to control this pest, it has been found to be hugely unsuccessful in many cases and where it was successful, they have also issues of environmental concern to man being raised. In the light of above, this experiment was carried out to evaluate the efficacy of oil palm bunch ash in the control of *Spodoptera frugiperda* on maize to serve as alternative option.

MATERIALS AND METHODS

Experimental Site and land preparation

The experiment was sited at University of Calabar; Department of Crop Science Research and Teaching Farm, Cross River State, Nigeria. The experimental plot was manually cleared, stumped and tilled.

Treatments, experimental design and agronomic practices

The experimental design was a 2x5 factorial laid out in a Randomized Complete Block Design (RCBD) with three (3) replications. The two factor are the maize type (that is; Ikom white (land race) and Oba super 6 (yellow maize) and pesticide applications (two-week interval) at various concentration 0, 3%, 6% concentration of palm bunch ash and 0.625% and 1.25% of DDVP (2, 2 dichlorovinyl dimethyl phosphate). All agronomic practices were carried out appropriately.

Ash: 30g -------- 1000ml of water 3%, 60g ------- 1000ml of water 6%, 0.625ml of DDVP to 1000m1 of water ------- 0.625%, 1.25m1 of DDVP to 1000m1 of water ----- 1.25%

Data collection

Army worm incidence (%): this was calculated as:

$$\frac{\text{Number of infested plots}}{\text{Number of plants sampled}} \times 100$$

Grain yield (t/ha)**:** This was determined after threshing; the number of undamaged seed were weighed after threshing.

Statistical Analysis

This data collected were subjected to statistical analysis using Genstat 8.0. Analysis of variance and significant means were separated using Duncan New Multiple Range Test (DNMRT) at 5 % Probability level. The data obtained for army worm incidence were transformed using arc sine transformation method before being subjected to statistical analysis.

RESULTS AND DISCUSSION

Effect of maize varieties and insecticide on armyworm incidence is presented in Table. The result indicated that the application of insecticides had significant effect on the armyworm incidence. At 6 WAP, the application of 0.625% concentration of DDVP (B_3), 6% concentration of palm bunch ash (B_2) and the application of 3% concentration of palm bunch ash (B_1) statistically ($P>0.05$) produced the same level of armyworm incidence. Similarly, 6% palm bunch ash, 0.625% and 1.25% of DDVP had the same level of armyworm incidence ($P<0.05$) which was significantly lower ($P<0.05$) than that of the control. The application of 0.625% concentration of DDVP did not significantly ($P>0.05$) showed different level of armyworm incidence from that of 6% concentration of palm bunch ash. At 10 WAP, the application of 1.25% concentration of DDVP had significantly ($P<0.05$) the lowest level of armyworm incidence. The maize plants without insecticides application had the highest armyworm incidence which was statistically ($P>0.05$) the same with that of 3% concentration of palm bunch ash. However, the application of insecticides (oil palm bunch and DDVP, respectively) had significant ($P<0.05$) effect on the grain yield of maize plants. The lowest yield obtained was from that of plants without insecticide application.

Also there was significant reduction in armyworm incidence occasioned by the application of the insecticides (oil palm bunch ash and DDVP, respectively). This is in conformity with the result from Shinde *et al.* (2020) and Babendreier *et al.* (2020) that the application of ash on maize reduced the infestation of armyworm. This observable reduction in the armyworm incidence may be due to the mortality of larva of armyworm caused by the spread of palm bunch ash solution on maize (Shinde *et al.,* 2020). Furthermore, the application of oil palm bunch ash caused higher grain yield when compared with the untreated control but not DDVP. This could be supported with the findings of Tambo *et al.* (2020) and Shinde *et al.* (2020) that accounted for increase in grain yield of maize due to the application of ash on the plant. This result could further be supported with the assertion that the potency of botanicals on insects increase with increased concentration of the insecticides (Jide-Ojo *et al.,* 2013: Ukatu *et al.,* 2021).

CONCLUSION AND RECOMMENDATIONS

Present study has shown that the application of oil palm bunch ash was effective; as it significantly reduced armyworm infestation couple with the increased yield of the grain harvested when compared with the untreated control plot. This could form the basis for the recommendation of this plant based insecticide to farmers since it is effective in the control of armyworm in addition to its environmentally friendly phenomenon as well as it easy availability to many farmers as cheap source of plant protection.

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Table 1: Effects of maize varieties and insecticides on armyworm incidence

Treatment	2WAP	4WAP	6WAP	8WAP	10WAP	Yield Grain yield (t/h)
Varieties						
Oba super 6 (V_1)	11.30/16.80[a])	14.00(20.30[a])	24.70(28.40[a])	46.70(41.90[a])	56.7(49.50[a])	2.78[a]
Ikom white (V_2)	10.70(15.50[a])	12.70(19.20[a])	24.00(28.10[a])	36.00(35.30[a])	54.0(47.50[a])	2.74[a]
Insecticides						
Untreated control (B_0)	15.00(20.80[a])	18.30(25.20[a])	33.30(38.00[c])	71.70(58.50[d])	90.00(73.30[d])	1.58[a]
3% palm bunch ash (B_1)	13.30(17.70[a])	16.70(23.90[a])	33.30(34.60[bc])	58.30(50.00[cd])	86.70(70.60[d])	1.84[a]
6% palm bunch ash (B_2)	10.00(15.00[a])	13.30(21.10[a])	21.70(27.30[ab])	36.70(37.10[bc])	58.30(49.80[c])	2.32[b]
0.625% DDVP (B_3)	10.00(15.00[a])	10.00(15.00[a])	16.70(23.90[ab])	33.30(35.10[b])	30.00(33.0[b])	3.29[c]
1.25% DDVP (B_4)	6.70(12.30[a])	8.30(13.60[a])	13.30(17.70[a])	6.70(12.30[a])	11.70(16.00[a])	4.77[d]
Interactions						
V_1 X B_0	16.70(23.90[a])	20.00(26.00[a])	40.00(39.10[a])	80.00(63.90[a])	90.00(75.00[a])	1.60[a]
V_1 X B_1	13.30(17.70[a])	16.70(23.90[a])	33.30(34.90[a])	66.70(55.10[a])	6.70(68.90[a])	1.94[a]
V_1 X B_2	10.00(15.00[a])	13.30(21.10[a])	20.00(26.60[a])	43.30(41.20[a])	63.30(52.80[a])	2.38[a]
V_1 X B_3	10.00(15.00[a])	10.00(15.00[a])	16.70(23.90[cd])	36.70(37.20[a])	30.00(33.00[a])	3.31[a]
V_1 X B_4	6.70(12.30[a])	10.00(15.00[a])	13.30(17.70[a])	6.70(12.30[a])	13.30(17.70[a])	4.68[a]
V_1 X B_0	13.30(17.70[a])	16.70(23.90[a])	36.30(36.80[a])	63.30(53.10[a])	90.00(71.60[a])	1.57[a]
V_2 X B_1	10.00(15.00[a])	16.70(23.90[a])	33.30(43.20[a])	50.00(45.00[a])	86.70(72.30[a])	1.74[a]
V_2 X B_2	10.00(15.00[a])	13.30(21.10[a])	23.30(28.10[a])	30.00(33.00[a])	53.3(46.90[a])	2.26[a]
V_2 X B_3	6.70(12.30[a])	10.00(15.00[a])	16.70(23.90[a])	30.00(33.00[a])	30.00(33.00[a])	3.27[a]
V_2 X B_4	6.70(12.30[a])	6.70(12.30[a])	13.30(17.70[a])	6.70(12.30[a])	10.00(15.00[a])	4.85[a]

Means within a column followed by the same letter are not significantly different from one another based on Duncan's New Multiple Range Test (DNMRT) as 5% probability level. * Values in parenthesis have been transformed using sine transformation method.

Assessment of the Causes and Effects of Post-Harvest Losses of Fruits among Rural Farmers in North-Central, Nigeria

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Abstract
The study assessed post-harvest losses of selected fruits among rural farmers in North-Central, Nigeria. Purposive and simple random sampling techniques were employed to select 182 fruit farmers from 4865 registered from Benue, Nasarawa and Kogi States ADP. Primary data were collected using a well-structured questionnaire and analysed with descriptive and inferential statistics. Results show that the major causes of post-harvest losses of fruits were; lack of proper storage facilities ($\bar{x}$ =3.69), lack of agro-based industries (3.63%), poor transportation facilities ($\bar{x}$ =3.59), high temperature ($\bar{x}$ =3.59) and microbial attack ($\bar{x}$ =3.58). Findings also indicate that reduced income of farmers ($\bar{x}$ =3.69), environmental pollution/degradation ($\bar{x}$ =3.60), and increased food insecurity (3.59) were the major effects of post-harvest losses of fruits in the area. The study concluded that many strong factors caused post-harvest fruit losses in the study area, negatively impacting resource-poor farmers. It was recommended that the Government and private sector work together to establish agro-processing industries in rural areas for fruits to reduce post-harvest losses, increase profit and improve their living standard.

INTRODUCTION

The major fruits produced in Nigeria include mango, pineapple, plantain/banana, citrus, guava, and pawpaw (Ibeawuchi, *et al.* 2015). Fruits and vegetables form a substantial percentage of the major food crops cultivated in the tropics and are a source of livelihood for a considerable section of the population. They come as edible plant parts like stems, stalks, roots, tubers, bulbs, leaves, flowers and fruits and are generally consumed raw or cooked, with a main dish which adds variety to enjoyment, and a sense of satisfaction to the diet because of their appealing colours, flavour and texture (Ahmed, 2013). Enormous quantities of fruits and vegetables are produced in Nigeria. For instance, 3.8 million tonnes of onions, 6 million tonnes of tomatoes, 10 million tonnes of plantain and 35 million tonnes of citrus are reportedly produced annually (Pandey, et al. 2013). Despite the high production figures, the populace still suffers acute shortages of food and vegetables due to losses along the value chain. Olayemi *et al*., (2012) estimated that as much as 25% and 40% of fruits and vegetables respectively, are lost after harvest in River State, Nigeria due to poor post-harvest handling measures. If food loss is not reduced, food production in developing countries must be increased by an estimated 70 per cent requiring an investment of USD83 billion annually (Rockefeller Foundation, 2015). Therefore, there is a need to ensure food security by increasing food production, while reducing losses along the supply chain. The production of fresh fruits and vegetables has its challenges. Their perishability and hugeness make them difficult to manage easily during the post-harvest period. According to Age (2017), fruit and vegetable produce are less hardy, perishable and vulnerable to natural and artificial phenomena and failure to take adequate and timely measure care in harvesting, handling, processing, storage and transporting them to the final consumers, they deteriorate or decay fast and become unwholesome for human consumption. Post-harvest loss is one of the general problems facing production in Nigeria, which concerns everyone from the research scientist to the extension/marketers in the field, to the farmers on the farm, and the government policy formulators (Chukwunta, 2014). Post-harvest losses are the measurable qualitative and quantitative damages or spoilage in the after-harvest value chain caused by natural and artificial phenomena (Age, 2017). These losses affect both the quality and quantity of crop produce, thus reducing their economic value and the total income of the producers. Considering the criticality of post-harvest losses and reduction in food security, it is important to understand the structure and scale of post-harvest losses of agricultural produce in Nigeria and identify their causes and possible solutions (Barbara, 2019). Hence, this article addressed the causes and effects of post-harvest losses of fruits in the area.

MATERIALS AND METHOD

Study Area

The study was conducted in the North-Central geo-political region of Nigeria, otherwise referred to as the middle belt. The region comprised six (6) States and the Federal Capital Territory. The States are Benue, Kogi, Nasarawa, Plateau, Kwara and Niger, with a total land mass of 296,898 km^2 lying roughly between latitude 6 1/2^{0}N and 8 1/2^0 N longitude 7 1/2^0 and 10^0 E (Federal Ministry of Agriculture (FMARD), 2015a). The region has a projected population of 31,735728 people at a 3 % growth rate (NPC, 2006). The regions have a favourable agroecological climate for arable crops, tree crops and livestock production.

Sample Size

The sample size of the population consists of 4865 (ADP, 2018) mango and orange farmers in Benue, Nasarawa, and Kogi States of North-Central Nigeria. A sample size of 182 respondents was selected using a multi-stage sampling procedure. First by selecting the geopolitical zone followed by the states within the zone then the local government areas and then the communities within the LGAS where fruit production is dominant. The last stage of selection was to select 182 respondents using a simple random sampling technique, which corresponds to 3.8% of the sample frame obtained from various State Agricultural Development Projects (ADPs) to ensure proportionality. The last selection was to select 182 respondents using a simple random sampling technique, which corresponds to 3.8% of the sample frame obtained from various State Agricultural Development Projects (ADPs) to ensure proportionality.

Method of Data Collection and Analysis

Primary data were collected by using a structured questionnaire. Data collected for this study were analyzed by using both descriptive and inferential statistics. Descriptive statistics employed included frequencies, means percentages and standard deviation.

RESULTS AND DISCUSSION

Perceived causes of post-harvest losses of fruits

The result of the mean scores on the causes of post-harvest losses of fruits in the study area is presented in Table 1. The result showed that the overall causes of post-harvest losses of fruits recorded a grand mean ($\bar{x}$=3.40) higher than the mean cut-off ($\bar{x}$=2.55). The highest mean scores were observed on lack of proper storage facilities ($\bar{x}$=3.69), lack of agro-based industries ($\bar{x}$=3.63), poor transportation facilities ($\bar{x}$=3.59), high temperature ($\bar{x}$=3.59) and microbial attack ($\bar{x}$=3.58). The standard deviations on the causes of post-harvest losses of fruits were all less than 1. This testifies to the uniformity of the answers from the respondents that all the identified factors were the cause of post-harvest fruit losses in the given area. This finding agrees with those of Yahaya and Mardiyya (2019), Age (2017) and Desta (2018), who identified causes of post-harvest losses of fruits and vegetables to include; careless handling during harvesting, processing, transportation, storage etc., microbial attack, inadequate methods in harvesting, high ambient temperature and lower atmospheric humidity. Others are exhausted water and food reserves in the produce, respiration and fermentation, poor ventilation of produce warehouse, dehydration, pest and disease infestation and premature harvesting, as well as lack of knowledge on proper post-harvest handling practices, contaminants/ filthy environment, transportation and breakdown of vehicles, poor marketing facilities, lack of storage and marketing facilities, lack of agro-based industries, risk and uncertainty and among others.

Perceived effect of post-harvest loss of fruits

The result of the perceived effects of post-harvest losses of fruits in North-Central, Nigeria is presented in Table 2. The result shows that the overall perceived effect of post-harvest losses of fruits in the area, on a 4-point rating scale was serious, with a grand mean ($\bar{x}$=3.50) higher than the decision mean cut-off ($\bar{x}$=2.55). The result shows serious effects on all the variables listed. The highest mean scores were observed on reduced income of farmers ($\bar{x}$=3.69), environmental pollution/degradation $\bar{x}$ (=3.60), increased food insecurity ($\bar{x}$=3.59) and reduced quality of produce ($\bar{x}$=3.58). The standard deviation on the effect of post-harvest losses of fruits was all less than 1. This indicates uniformity in respondents that post-harvest losses of fruits have serious effects in the area. The findings confirm those of Mbah, *et al*., (2017) who identified the major effects of post-harvest losses as a reduction in income generation, reduction in quality of produce, unstable supply of produce, high cost of vegetable crops, decrease in the nutritional content of the produce, loss of investment made by the farmer and reduction on availability of vegetables for household consumption. This is further supported by Kughur, *et al.,* (2015) who reported that food losses have several adverse impacts on the farmer's income, consumer prices, nutritional quality of the produce, as well as loss of the actual crop, loss in the environment resources, labour needed to produce the crop and livelihood of the individuals involved in the production process.

Table 1: Perceived Causes of Post-harvest Losses of Fruits North-Central, Nigeria

Causes	Very strong = 4	Strong = 3	Mild = 2	Weak = 1	$\bar{X}$	Std. Dev.
Lack of proper storage facilities	141 (564)	30 (90)	7 (14)	4 (4)	3.69	0.52
Poor transportation facilities	115 (460)	63 (189)	1 (2)	3 (3)	3.59	0.50
Premature harvesting/over-ripening	69 (216)	107 (321)	5 (10)	1(1)	2.17	0.56
Poor processing facilities	113 (452)	63 (189)	4 (8)	2(2)	3.58	0.49
Poor packaging facilities	103 (412)	73 (219)	2 (4)	4 (4)	3.51	0.52
Poor handling of produce causing injuries	92 (368)	82 (246)	2 (4)	6 (6)	3.43	0.52
Poor marketing system	82 (328)	94 (282)	2 (4)	4 (4)	3.40	0.52
Pest and disease infestation	80(320)	91 (273)	7 (14)	4 (4)	3.36	0.57
Contaminants/filthy environment	81 (324)	91 (273)	3 (6)	7 (7)	3.35	0.53
Lack of agro-based industries	125 (500)	50 (150)	4 (8)	3 (3)	3.63	0.52
Microbial attack	118 (472)	57 (171)	2 (4)	5 (5)	3.58	0.51
High temperature	115 (460)	61 (183)	4 (8)	2 (2)	3.59	0.60
Poor ventilation/high humidity	87 (348)	78(234)	8 (16)	9 (9)	3.34	0.58
Reaction of food constituents	66 (264)	97 (291)	9 (18)	10 (10)	3.20	0.58
Inappropriate policies	80 (320)	94 (282)	7 (14)	1 (1)	3.39	0.58
Lack of human, economic and technical resources	114 (456)	53 (159)	8 (16)	7 (7)	3.51	0.58
Poor education or knowledge	82 (328)	91 (273)	6 (12)	3 (3)	3.37	0.56
Inefficient communication	81 324)	93 (279)	6 (12)	2 (2)	3.39	0.57
Unfavourable cultural practices	92 (368)	82 (246)	5 (10)	3 (3)	3.45	0.58
Grand mean ($\bar{X}$)					**3.40**	

Source: Field Survey, 2023

Table 2: Perceived effects of post-harvest losses of fruits in the study area

Perceived Effect	Very serious (4)	Serious (3)	Mild (2)	Less serious (1)	$\bar{X}$	Std. Dev.	Rank
Reduce the income of farmers	135 (540)	40 (120)	5 (10)	2 (2)	3.69	0.47	1st
Reduce the availability of produce	106 (424)	71 (213)	4 (8)	1 (1)	3.57	0.54	5th
Low per capita income of the nation	75 (300)	104 (312)	2 (4)	1 (1)	3.01	0.54	10th
High level of spoilage	97 (388)	80 (240)	2 (4)	3 (3)	3.49	0.52	7th
Low storage or shelf life	109 (436)	69 (207)	2 (4)	2 (2)	3.57	0.51	5th
Increase food insecurity	121 (484)	53 (159)	2 (4)	6 (6)	3.59	0.50	3rd
Waste of time and labour	82 328)	94 (282)	3(6)	3 (3)	3.40	0.56	9th
High level of economic losses	91 (364)	88 (264)	2 (4)	1 (1)	3.48	0.52	8th
Reduce the quality of produce	120 (480)	55 (165)	4 (8)	3 (3)	3.58	0.53	4th
Environmental pollution/degradation	117 (468)	60 (180)	2 (4)	3 (3)	3.60	0.51	2nd
Grand Mean					**3.50**		

Source: Field Survey, 2023

CONCLUSION AND RECOMMENDATIONS

The study assessed the post-harvest losses and management strategies of selected fruits and vegetables among rural farmers in North-Central, Nigeria. The study concluded that many strong factors caused post-harvest fruit losses in the study area, negatively impacting resource-poor farmers. It was recommended that the Government and private sector work together to establish agro-processing industries in rural areas for fruits to reduce post-harvest losses, increase profit and improve their living standard.

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PROCEEDINGS

Microbial Load Evaluation of Chickens Fed Dietary Supplement of Ginger (*Zingibe officinale*) Meal and Synthetic Premix

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Abstract
*This study was conducted to evaluate the effect of dietary inclusion of ginger meal (Zingiber officinale) on the microbial load of broiler compared with the synthetic premix. One hundred and twenty arbor acre day old broiler chicks were used. They were divided randomly into 5 treatment groups designated as T_1, T_2, T_3, T_4 and T_5 comprising twenty-four birds each in three replication. Each group was fed one of 5 formulated diets containing ginger meal at levels of 0.0, 0.05, 0.10, 0.15 and 0.2g/100kg, for eight weeks in a completely randomized design. At the termination of the experiment, three birds per treatment were used for the evaluation of microbial load. Results showed significant ($P < 0.05$) effects of dietary ginger meal inclusion on microbial load in favour of T_3 than in T_2, T_4 and T_5, whereas higher inclusion (T_5) was deleterious to all the evaluated indices. The result of this study showed that the total coliform count (TCC**)** and the total viable count (TVC) were significantly ($p<0.05$) higher in T_1 than in T_2, T_3, T_4, and T_5. This suggest that ginger at increasing inclusion level behaved as probiotics by reducing the total coliform count in the caecum, while no significant ($p>0.05$) difference occurred in the TVC across the ginger groups (T_2 and T_3) compared with the non-ginger group (T_1) in the gizzard. There was reduction in the TCC and TVC of the microbial load in the duodenum across the treatment group, although not significant compared with the control which showed an increase in the TCC and TVC although not significantly ($p>0.05$) different from the ginger group. It can be concluded that ginger could be an alternative growth promoter for antibiotics, and can also be used to improve feed utilization when included at moderate dose of 0.1g/100kg. It is therefore recommended for use in formulating poultry diet for optimal production benefit.*
Keywords: Ginger, Vitamin/Mineral Premix, Microbial load and broiler chicken

INTRODUCTION

The major importance of poultry production is for the production of egg, meat etc. and for the provision of protein to the human. Feeding constitutes up to 75%-80% of the total cost in monogastric production and is a major factor limiting production of livestock. Minerals and vitamins supplements may contribute up to 2-3% of total cost of feed. The essence of animal protein will be compromised if livestock production is limited to synthetic mineral/vitamin which is basically for vitality, acid-base balance, proper metabolism, and muscle contraction and relaxation etc. Synthetic vitamin and mineral supplements in the diet contains synthetic antibiotic which possess negative effect on the farm animal and beneficial microorganism, and its residues in the carcass of animal could be detrimental to the human system, as well as contributes to cost of production in animal husbandry. (Bamidele and Adejumo, 2012; Attia *et al*., 2014; Sa'aci *et al*., 2018). Therefore, on this note, the interest of nutritionist, Veterinarian, farmers, and other key players in recent years are directed towards the search for cheaper, locally and organic mineral/vitamins additive that will be nutritionally viable, non-toxic to beneficial microbes as well contribute to health benefits to the animal for optimum production. (Al-Kassie and Witwit, 2010). Ginger (*Zingiber officinale*) is an important spice. It is a monocotyledonous herbaceous perennial plant that lives longer than two years, belonging to the family of *Zingiberaceae*, its flavouring type is classified as *Zingiber officinale* which is the most popular hot spice in the world (Dhingra and Kumar, 2005). The main important compounds of ginger (*Zingiber officinale*) are Gingerol, gingerdiol, borneol, conphel, citfral, penllandiene and resin. These compounds have the ability to stimulate digestive enzymes, affect the microbial activity (Dieumou *et al*., 2009). Also it acts as an antioxidant, antimicrobial and has various pharmacological effects (Ali *et al.,* 2008). It enhances animal nutrient digestion and absorption because of the positive effects on the gastric secretion of enterokinesia, and digestive enzyme activities (Platel *et al*., 2000). Furthermore, ginger compound have shown various pharmacological effects including Immuno-modulatory, Anti-lipidemic, Anti-inflammatory, Anti-hyperglycemic and antiemetic effects (Ali *et al*., 2008). However information is lacking on effect of ginger in comparison to synthetic vitamin/minerals premix on the microbial load. This study is designed to investigate the response of broiler fed dietary supplement of ginger in comparison to synthetic vitamin/mineral premix, and its assessment in terms of microbial load count and the growth performance.

MATERIALS AND METHODS

Location of the study

This study was done at the Poultry section of the Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike, which is located at Latitude 5^0 28' N and Longitude 7^0 32' E lines at an altitude of 122 meters above sea level. The environment of study is situated within the rainforest zone of Nigeria and is characterized by annual rainfall of about 2167. 8mm in 148 to 155 days, average relative humidity during the rainy season is over 72%. It's has environmental temperature average 22^0C to 30^0C (National Root Crops Research Institute-NRCRI, 2004).

Experimental birds, design and management

A total of 120 day-old broiler chicks were purchased locally within Nigeria for this experiment. Prior to the arrival, the experimental pens and equipment were washed and disinfected. On arrival, the broiler chicks were vaccinated then allocated to experimental pens for brooding for 4 weeks, then, they were allocated to five (5) dietary treatment T_1, T_2 T_3, $T_4$and T_5. The birds were fed diets with ginger meal at 0.00, 0.05, 0.10, 0.15 and 0.20 g/100kg which was supplemented with the synthetic vitamin-mineral premix at 0.25, 0.20, 0.15, 0.10 and 0.05 kg/100 kg, respectively.

During the brooding stage, heat was supplied with the use of brooding devices such as kerosene stove and lanterns. The temperature was regulated by the rule- of- the- thumb (watching the broilers behavior whether to increase or decrease the heat source), routine vaccinations and medications were given across the groups. The experimental design was a completely randomized design. During the brooding stage, the broiler chicks were fed *ad-libitum* with the formulated mash in rubber feeding stray for 4 weeks to enable the chicks have access on the feed. After brooding the feeders were changed to metallic container and raised using ropes to a certain height such that they do not have the chance to spill the feed on the litter. Water was given *ad-libitum* throughout the period of brooding in plastic drinkers. The broiler birds were randomly distributed to five (5) treatments. Each treatment diets was replicated 3 times.

Processing of ginger meal

The ginger was purchased fresh from National Root Crops Research Institution, (NRCRI) Umudike, their rings and husks was peeled off using knife. The peeled ginger was washed and dried (air and sun dried). The essence of air drying was basically to preserve the aromatic compounds, vitamin/mineral nutrients and later ground and sieved the meal that was incorporated into the diets.

Microbial load determination

The method of serial dilution as described by Aneja, (2005) and modified by Booth, (2006) was used for microbial load determination. On day 42, three chickens were randomly selected from each treatment, stunned and slaughtered. The effluence from the gizzard, duodenum, and caecum were gently stripped into sterile sample tubes and immediately transferred on ice to the laboratory for microbial load and culture study. Procedure: 2.5g each of the gizzard, duodenum and caecum samples from each chicken were collected immediately after slaughter, cut into small sizes with a flame sterilized knife under aseptic conditions and transferred into sterile screw-capped bottles and appropriately labeled. 22.5ml of sterile physiological saline solution was added to each sample bottle. The bottles were shaken vigorously to homogenize its contents before being diluted in the serial dilution technique. Test tubes of 9ml sterile physiological saline were set up and labeled from10^{-1} to$10^{-4.}$ Ten-fold serial dilutions were performed by pipetting 1ml from the original bottle containing the respective samples into the tube labeled 10^{-1}. From this tube, 1ml was transferred to the next tube labeled 10^{-2} and mixed properly. This was repeated until the 4th tube for all the samples. After the dilutions, standard microbiological technique was used to spread the inoculums from each sample into freshly prepared nutrient agar plates. A sterile bent glass rod was used to spread out each inoculum. The plates were labeled accordingly and incubated at 37^{0}c for 72 hours. The colony count was performed after 48 hours of incubation. The total aerobic count was expressed as Colony Forming Unit per gram (CFU/g).

RESULTS AND DISCUSSION

Table 1: Microbial load count of broiler chickens fed diets replacement with ginger

	Caecum				
Colony Count	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**
TCC (cfu/mL $\times 10^6$)	6.37 ± 4.19^a	2.83 ± 0.48^b	0.00 ± 0.00^c	0.00 ± 0.00^c	0.00 ± 0.00^c
TVC (cfu/mL $\times 10^6$)	8.37 ± 0.69^a	2.43 ± 0.81^b	0.00 ± 0.00^c	0.00 ± 0.00^c	0.00 ± 0.00^c
Sig. df	0.035			0.339	

Note: Values are presented as Mean ± SEM. Means with different superscripts across rows are significantly different at p<0.05.TCC: Total Coliform Count; TVC: Total Viable Count.

The result of the microbial load of the cecum harvested from the experimental birds fed with the treated diet is presented in Table 1. There were significant ($p< 0.05$) differences in the total coliform count (TCC) and total viable count (TVC) across the ginger groups compared with the non-ginger group (T_1). The TCC and TVC were significantly ($p<0.05$) higher in T_1 than in T_2, $T_{3,}$ T_4, and T_5. This suggest that ginger at increasing inclusion behave as probiotics, reduced the total coliform count in the caecum significantly from 6.37 ± 4.19

cfu/mls in T_1 to 2.83 ± 0.48cfu/mls (55.57% reduction in bacterial load) in T_2, and 0.00 ± 0.00cfu/mls (100% elimination) in T_3, T_4 and T_5, which means complete destruction of the coliform bacteria in the ginger group (as the inclusion level was increased). Similarly, the viable bacteria count was significantly ($p<0.05$) reduced by 70.97% in T_2 and 100% in T_3, T_4, and T_5. This effect could be attributed to the fact that the susceptibility of coliform bacteria to the antibacterial components of ginger are higher than that of the physiological desirable intestinal bacteria. This bactericidal effect at increased inclusions, strongly agreed with Reeds *et al.,* (1993); Amanduruonye *et al.* (2018), who reported simultaneous decrease in *Escherichia coli* populations, and Faghani *et al.,* (2014) who reported significant decrease in *Lactobacillus* spp. counts. Also, the inclusion of ginger in diet produced a remarkable inhibition of duodenal coliform bacteria, yeast and mold in the caecum and all viable microbes in the ileum (Samarasinghe *et al.,* 2003), and this in agreement with our finding. Windisch *et al.* (2007) reported a significant decrease in caeca microbial loads for birds fed 1.5% and 3.0% ginger supplemented diets compared to the control. This strongly confirms the antimicrobial property of ginger. These antimicrobial property of ginger might be attributed to the presence of Alkaloids, Camphene, Glycosides, Saponins, Terpenoids, Methoxymethyl, Propionate, Phenllandrene, gingerol, borneol, gingerdiol and many more compounds found in ginger-- phenolic compounds that have antiseptic, bactericidal and disinfectant properties as reported by Gong *et al.*(2004); Zhan *et al*. (2008). The antimicrobial mode of action is considered to arise mainly from the potential of the hydrophobic essential oils in these plants to intrude into the bacterial cell membrane, disintegrate membrane structures and cause ion leakage (Lee *et al.,* 2004; Windisch *et al.,* 2007) thus suggesting that ginger can effectively be used in animal production to reduce the population of pathogenic micro-organisms thereby reducing the prevalence of disease occurrence. Auta *et al.* (2011) and Ibrahim *et al*. (2011) also reaffirmed the efficacy of ginger as an effective antimicrobial agent against the growth of both gram-positive and gram-negative bacteria, such as *Salmonella, E. coli, Salmonella typhinurium, Shigella spp, Proteus vulgaris, Haemophilus influenzae, Pseudomonas aeruginosa and Streptococcus* species. In contrast, Amaduruonye *et al.* (2018) reported that ginger did not have any detrimental effect on the intestinal micro flora resident at the caecum, but supported the activities of the micro-organisms that aid digestion in the gastro-intestinal tract, hence, not in line with our findings.

Table 2: Microbial load count of broiler chickens fed diets replacement with ginger

	Gizzard				
Colony count	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**
TCC (cfu/mL X 10^6)	$3.20±0.60^a$	$3.53±0.29^a$	$3.23±0.29^a$	$2.57±0.74^a$	$5.17±1.79^a$
TVC (cfu/mL X 10^6)	$6.93±0.38^b$	$4.57±0.81^b$	$3.63±0.58^b$	$1.07±0.61^b$	$3.53±0.60^b$
Sig. df	0.293	0.129	0.388	0.527	0.276

Note: Values are presented as Mean ± SEM. Means with the same superscripts across rows are not significantly (p>0.05) different. TCC: Total Coliform Count; TVC: Total Viable Count

There was no significant ($p>0.05$) difference in the total viable count (TVC) across the ginger groups (T_2 and T_3) compared with the non-ginger group (T_1). The result of the colony count in the gizzard harvested from the experimental birds showed that although there were reduction in the TCC and TVC across the treatment groups compared with the control, the reduction observed were not significant ($p>0.05$) compared with the control. This suggest that coliform resident at the gizzard did not respond (bacteria resistance) to the ginger included diet significantly. This is in agreement with Yarru *et al.* (2009); Ahmadi (2010); Zhang *et al.* (2009) and Amaduruonye *et al.* (2018) who in different study locations reported that ginger at 5, 10, 15 and 20% had no detrimental effect on the coliform bacteria resident on the gizzard and duodenum, but supported the activities of the micro-organisms that aid digestion in the gastro-intestinal tract. This observations supported our findings.

Table 3: Microbial load count of broiler chickens fed diets supplemented with ginger

	Duodenum				
Colony count	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**
TCC (cfu/mL X 10^6)	7.70 ± 0.38^a	4.97 ± 1.27^a	3.13 ± 0.42^a	3.93 ± 1.49^a	3.53 ± 1.10^a
TVC (cfu/mL X 10^6)	7.17 ± 1.24^b	2.53 ± 0.73^b	1.63 ± 0.17^b	2.70 ± 1.15^b	1.47 ± 0.09^b
Sig. df	0.221	0.295	0.094	0.721	0.033

Note: Values are presented as Mean ± SEM. Means with the same superscripts across rows are not significantly (p>0.05) different. TCC: Total Coliform Count; TVC: Total Viable Count

The result presented in Table 3 showed that there was reduction in the TCC and TVC of the duodenum across the treatment group, although not significant compared with the control. In the control group, the microbial load in the duodenum showed an increase in the TCC and TCV although not significantly (p>0.05) different from the ginger group. This implies that there is no observable antimicrobial activity of the included treatment in the duodenum. This bacterial resistance effect could be also attributed to the fact that the susceptibility of coliform bacteria to the antibacterial components of ginger were lower than that of the physiological desirable duodenal bacteria, hence supported by Cullen *et al.,* (2005) and Chen *et al.* (2010).

CONCLUSION AND RECOMMENDATIONS

The result of this study revealed that replacing some vitamins with ginger at moderate (T_3: 0.1g/100kg) inclusion significantly improved the growth parameters and carcass characteristics evaluated in this study better than the low (T_2) and higher (T_4, T_5) inclusions, which also generated higher revenue and gross margin profit as a result of the significantly higher weight gain per kilogram. This could be attributed to increased feed efficiency and utilization in T_3due to increased activity of digestive enzymes such as trypsin, chymotrypsin, and amylase which increased the digestibility of the nutrients contained in the formulated feed. The implication is that considering the very high demand for better carcass quality of broiler chicken, formulating poultry diet with ginger at 0.10/100kg could reduce the cost of production and enhance the growth performance as little quantity of the diet consumed will improve the carcass quality (more meat) of the broiler chicken. It can be concluded that ginger could be an alternative growth promoter for antibiotics, and can be used to increase growth, survival rate, improve feed utilization, with better meat quality and higher income generation at low production cost, hence, highly recommended for use in broiler production.

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Determinants of Livelihoods Diversification among Farming Households in Borgu Local Government Area, Niger State, Nigeria

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Abstract
The study assessed the livelihoods diversification among farming households in Borgu Local Government Area, Niger State, Nigeria. Data was collected from 80 randomly selected respondents using a structured interview schedule. Frequency, means and standard deviation were used to describe the data while binomial logistic regression was used to determine the factors that affected household's diversification. The findings revealed that the mean age of the respondents was 43 years. A greater portion (62.5%) of the respondents was married while 41.3% were educated. The mean family size was 7 persons and the majority (55.0%) of the respondents depended on their savings to establish their livelihoods. The mean monthly income from their major livelihood activities was ₦53846.13 while the income from other sources of livelihood was ₦111618.20. Majority (67.5%) of the respondents had moderately diversified their livelihoods while the major reasons adduced for diversifying livelihoods were limited income from major livelihood activity (81.5%), poor market (48.1%) and increased competition (48.1%). Top-ranked constraints to livelihood diversification respondents included inadequate capital (score $\bar{x}$= 2.7), high market competition (score $\bar{x}$= 2.7), lack of materials (score $\bar{x}$= 2.5), and poor access to loans (score $\bar{x}$ = 2.7). A binomial logistic regression revealed that household size ($p = 0.028$; $p < 0.05$) significantly affected the livelihood diversification of the households. Households should receive education from relevant agencies about managing family size through effective family planning methods.

INTRODUCTION

The agricultural sector is crucial in the country's economy, particularly in developing countries. It contributes significantly to Gross Domestic Product and employs a large proportion of the labour force. In Nigeria, farming as a source of income has failed to bring enough income for farm households (Babatunde, 2013). This is due to the subsistence nature of agriculture, declining farm size, and low produce turnout which characterizes the agricultural sector in developing countries (Oku, 2011; Asiga, 2013). This situation has resulted in change or diversification of livelihood activities by the majority of the rural dwellers into activities other than farming to increase their income and ultimately their standard of living. Diversification refers to the pattern of an individual's voluntary exchange of assets and their allocation of assets across various activities (on and off-farm) to achieve an optimal balance between expected returns and risk exposure conditional on the constraints they face (Dilruba and Roy, 2012). Diversification has two aspects, a shift away from agricultural activities and an increasing mix of income activities. These activities are mostly influenced by livelihood options available in the rural community. In Africa, various studies have shown that while most rural households are involved in agricultural activities such as livestock, crop or fish production as their main source of livelihood, they also engage in other income-generating activities to augment their main source of income (Vihi et al., 2021). The larger percentage of rural producers have historically diversified their productive activities to encompass a range of other productive areas. In other words, very few of them collect all their income from only one source, hold all their wealth in the form of any single asset, or use their resources in just one activity (Barrett *et al*., 2001). Moreover, a previous empirical study by Haggblade *et al.,* (2010) reports that rural residents across the developing world earn 35.50% of their income from non-farm sources.

In Borgu Local Government Area, Niger State like most other rural areas, farming households diversify or engage in other income-generating activities as a way of avoiding risk from agricultural disasters or failure, some households diversify into other sectors/farming strategies while others diversify into non-farm activities like tailoring, crafts and skills like knitting, plaiting of hair/barbing, others engage in civil service jobs. Given that the majority of the farmers are smallholders who produce on a subsistence level, and often do not get optimum economic returns on their produce due to reasons ranging from bad road networks, poor storage facilities, lack of good processing techniques, inadequate government policies, to natural disasters like drought, flood, global warming, etc., some farm households diversify into non-farm activities. Information on the extent of diversification and factors influencing the decision of the household to diversify their means of livelihood in the study area is still misery. This study aims to fill this gap. It is against this backdrop that this study was designed to assess the determinants of livelihood diversification among farming households in Borgu Local Government Area, Niger State, Nigeria. The specific objectives of the study were to identify the livelihood activities of the households, determine the livelihood diversification among the households, find out the reasons for diversification among the households, and ascertain the determinants of livelihood diversification.

METHODOLOGY

The study area is Borgu Local Government Area, Niger State Nigeria. The area is one of 25 Local Government Areas (LGAs) in the state, with the headquarters in New Bussa. The area has an area of land of about 16,200sqkm and a population of 172,835 as of the 2006 census and shares boundaries with Benin Republic to the west, and Agwara local government to the south. Borgu Local government lies between latitude $9^{0}53'$N and longitude $4^{0}31'$E. A multi-stage sampling procedure was used to select the sample for the study. Stage 1 involved 40% of the 10 wards in the local government area giving 4 wards. Stage 2 was the random selection of twenty respondents from each ward to eighty (80) respondents as the study sample size. Data were collected from the respondents with a structured interview schedule and analysed using descriptive and inferential statistics. The descriptive statistics included frequency, means and standard deviation while a multinomial logistics regression was used to determine the factors that affect the extent of livelihood diversification among the respondents.

RESULTS AND DISCUSSION

Major livelihood activities of the respondents

Table 1 shows that almost all the respondents were involved in multiple livelihood activities. Some major livelihood activities were crop farming (28.8%) and livestock farming (21.3%). Similarly, the most common minor/other activities they were involved in were crop farming (33.8%), livestock farming (27.5%) and fish farming (23.8%). This suggests that a larger percentage of households were involved in crop production, and supplemented their income through other activities. Literature has shown that a diverse income portfolio creates an avenue for higher and evenly distributed income. Thus, it is easier to combine livelihood strategies than full-time (Ellis, 2000).

Table 1: Livelihood activities of respondents

	Major livelihood		**Minor/other livelihood**	
Livelihood activities	**Frequency (n=80)**	**Percentage (%)**	**Frequency (n=80)**	**Percentage (%)**
Crop Farming	23	28.8	27	33.8
Livestock farming	17	21.3	22	27.5
Fish farming	12	15.0	19	23.8
Fish processing	5	6.3	8	10.0
Civil service	14	17.5	5	6.3
Trading	12	15.0	5	6.3
Clergy	6	7.5	5	6.3
Hunting	2	2.5	4	5.0
Tailoring/Fashion Designing	6	7.5	10	12.5
Volcanizing	4	5.0	4	5.0
Catering	5	6.3	3	3.8
Hairdressing	3	3.8	2	2.5
Mechanic (Vehicle/Motorcycles)	2	2.5	1	1.3
Artisans (carpentering, plumber etc.)	5	6.3	-	-
Barbing	6	7.5	6	7.5
Food vendor	4	5.0	3	3.8
Rice processing	1	1.3	5	6.3
Farm produce storage	9	11.3	1	1.3
Patent medicine store	5	6.3	2	2.5
Shea butter processing	4	5.0	2	2.5
Electrician	4	5.0	2	2.5
Generator repairs	1	1.3	2	2.5
Phone repairs	1	1.3	2	2.5

Source: Field Survey, 2022

The extent of livelihood diversification among the respondents

In Table 2, it is evident that the majority (67.5%) of the respondents had a moderate level of livelihood diversification. The result is in line with the study conducted by Idowu *et al.,* (2014) where the larger farming households moderately diversified their sources of livelihood.

Table 2: Extent of livelihood diversification among the respondents

The extent of livelihood diversification	**Frequency**	**Percentage (%)**
1-2 (Moderately diversified)	54	76.5
3-4 (Highly diversified)	26	32.5

Source: Field Survey, 2022

Reason for diversifying livelihoods among the respondents

Table 3 shows that the common reasons for diversifying livelihoods among the respondents were limited income from major livelihood activity (81.5%), poor market (48.1%) and increased competition (48.1%). This finding is in line with that of Oruche and Faisal (2021) who found that income was the reason for diversifying among rural households in Nigeria.

Table 3: Reasons for diversifying livelihoods

Reasons for diversifying livelihoods	Frequency	Percentage (%)
Limited income from major livelihood activity	65	81.5
Poor market/patronage	39	48.1
Lack of access to appropriate technology	23	28.4
Lack of needed financial assistance to expand	35	43.2
Increased competition	39	48.1
Lack of family encouragement	20	24.7

Source: Field Survey, 2022

Constraints to Diversifying Livelihoods among the Respondents

Table 4 shows that the top four ranked constraints to diversifying livelihoods among the respondents were inadequate capital ($\bar{x}$ = 2.7), much competition in the market ($\bar{x}$ = 2.7), lack of materials ($\bar{x}$ = 2.5) and inadequate loan ($\bar{x}$ = 2.4). Inadequate capital was the most constraint since most of the materials or equipment needed for livelihood activities were purchased. This implies that the respondents need urgent intervention from the government and stakeholders on these major constraints. This finding is consistent with Vihi *et al.* (2021), who discovered that the primary obstacle to diversifying livelihoods among rural households was a lack of capital.

Table 4: Constraints to the diversification of livelihood among the respondents

Constraints	Severe constraint	Mild constraint	Not a constraint	Mean	Std.	Rank
Inadequate of capital	52 (78.8)	12 (18.2)	2 (3.0)	2.7	0.4	1st
Poor access to loan	40 (61.5)	16 (24.6)	9 (13.8)	2.4	0.7	3rd
Inadequate labour	35 (54.7)	18 (28.1)	11 (7.2)	2.3	0.7	4th
Marketing customer loyalty	34 (51.5)	24 (36.4)	8 (12.1)	2.3	0.6	4th
Uncertainty	27 (44.3)	27 (44.3)	7 (11.5)	2.3	0.6	4th
Primary activities leaving	33 (50.0)	26 (39.4)	7 (10.6)	2.3	0.6	4th
Limited education skill	24 (39.3)	28 (45.9)	9 (14.8)	2.2	0.6	5th
Shyness in doing socially	28 (48.3)	19 (32.8)	11 (19.0)	2.2	0.7	5th
Lack of materials	36 (61.0)	18 (30.5)	5 (8.5)	2.5	0.6	2nd
Much competition in the market	49 (76.6)	10 (21.9)	1 (1.6)	2.7	0.4	1st

Source: Field Survey, 2022

Factors Affecting Livelihood Diversification

Table 5 indicates that household size (p = 0.028; p<0.05) is the sole variable influencing multiple livelihoods among the respondents. It implies that the higher the household size the higher the household livelihood diversification since more income will be needed to cater for the needs of the increasing family size. Nagelkerke Square of 0.32 shows that the factors responsible are accountable for 32% variation expressed in the dependent variable (extent of livelihood diversification).

Table 5: Logistic regression of factors affecting livelihood diversification

Variable	B	SE	Wald	Df	Sig
Age	0.022	0.032	0.458	1	0.499
Educational level	0.188	0.032	0.285	1	1.207
Marital status	1.060	0.659	2.586	1	0.346
Household size*	**0.156**	**0.071**	**4.856**	**1**	**0.028**
Monthly income	0.000	0.000	1.670	1	0.280
Experience	0.056	0.006	1.107	1	0.293
Source of capital	0.000	0.000	0.013	1	0.908
Constant	2.652	2.219	1.428	1	0.070

Source: Field Survey, 2022.

CONCLUSION AND RECOMMENDATIONS

The study has shown that the majority (67.5%) of the respondents had moderate livelihood diversification indicating that they depend on more than one livelihood activity. The major constraints facing the respondents were inadequate capital ($\bar{x}$ = 2.7), much competition in the market ($\bar{x}$ =2.7), lack of materials ($\bar{x}$ = 2.5) and poor access to loans ($\bar{x}$ = 2.4). The factor affecting livelihood diversification was household size. Relevant agencies should educate households on the importance of controlling household size through family planning.

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Coping Strategies for Food Insecurity among Adopters of Improved Rice Varieties in Kwara State, Nigeria

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Abstract
The study analysed coping strategies for food insecurity among adopters of improved rice varieties in Kwara State, Nigeria. A three-stage sampling procedure selected one hundred and nine (109) farmers in the study area. A structured questionnaire, complimented by the interview schedule, was used for data collection. Data collected were analysed using frequency, percentages, mean and Kendal Coefficient of Concordance. The result showed that other farmers (58.7%) and friends and relatives (56.6%) were the most reliable sources of information on improved rice varieties. The most common coping strategies for food insecurity among rice farmers were to reduce the number of meals eaten in a day ($\bar{X}$=2.89) and restrict consumption by adults for small children to eat ($\bar{X}$=2.83). Poor output ($\bar{X}$=5.92), inadequate improved varieties ($\bar{X}$=6.03) and poor road networks were the most significant constraints to the adoption of improved rice varieties. It is recommended that extension agents should ensure farmers are equipped with training, skills and knowledge to increase their output. Inadequate improved varieties were one of the major constraints to the adoption of rice varieties. Also, research institutes should ensure farmers' access to improved rice varieties at affordable prices to increase output of rice production, and improve livelihood and food security status.
Keywords: Coping Strategies; Food Insecurity; Adopters; Improved rice varieties

INTRODUCTION

Rice (*Oryza sativa*) is one of the most cultivated crops in the world. It is the third most important cereal grown and consumed globally after wheat and maize (Agro Nigeria, 2018). Many improved rice varieties exist that can be grown in Nigeria, National Cereal Research Institute (NCRI) Baddegi has released many improved rice varieties for cultivation suitable to different agro-climatic conditions, they were classified into four main groups; Early maturity varieties, these includes FARO 27 and FARO 44, Medium maturity varieties, these includes, FARO 29, FARO 35, FARO 37, FARO 50, FARO 51, FARO 52 and FARO 57. The late maturity varieties include FARO 7. FARO 8, FARO 12, FARO 14 and FARO 15 and deep water (floating) arears, FARO 7, FARO 14 and FARO 15 respectively (NCRI, 2009). FARO 44 is one of the many developed rice varieties that is widely distributed and highly adopted compared to other varieties (Adesina, 2012). Food insecurity is the inability of a household not having enough food to eat (Pelemo *et al.,* 2022). Food insecurity has been unprecedented over the years due to the effect of climate change. Baruwa *et al.* (2015) defined coping strategy as "all the strategically selected acts that individuals and households in a poor socio–economic position use to restrict their expense or earn some extra income to enable them to pay for the basic necessities (food, clothing, shelter) and not fall too far below their society's level of welfare". According to Abimbola *et al.* (2013), coping strategies are mechanisms through which households or community members meet their relief and recovery needs, and adjust to future disaster related risks by themselves without outside support. The menace of food insecurity in Nigeria demand urgent approaches and mechanisms that will reduce the negative effects on the populace. The objectives of the study are to identity the sources of information on improved rice varieties; examine coping strategies used by rice farmers and determine constraint to adoption of improved rice varieties.

METHODOLOGY

This research took place in Kwara State. The State is located in the North Central Nigeria. The State lies between latitudes 8°-10°N and longitude 2°45'-6°4'E of the Greenwich meridian. It covers an estimated land area of about 36,825 square kilometers or 8% of the total area of Nigeria. According to National Population Census (NPC) (2006), the state has a population of 2,591,555 peoples, spread across the sixteen Local Government Areas, which was projected to be 3,005,409 as at 2017 using an annual population growth rate of 2.5% (World Bank, 2013). The major Food crops produced in the state are mostly cereal crops namely rice, maize, sorghum, millet, cow pea, melon and they constitute the main staple food aside root and tuber crops (Ajadi *et al.,* 2011). Multistage sampling technique was employed in this study to select the sample size. This involved four stages of selection. The first stage involved random selection of two local Government Areas (LGAs) in the State. In the second stage, three (3) villages involved randomly selected from each LGA in selected State making a total of six (6) villages. In the fourth stage involved the use of proportional sampling to select 10% of the respondents from the sampling frame to give a total sample size of one hundred and nine (109) farmers. Primary data was used for this study. Data was collected by the researcher assisted by trained enumerators using structure questionnaire complimented with interview schedules. Descriptive statistics such as mean frequency distribution table and percentages was be used to analyse (objective i and ii). Objective iii was achieved using Kendall Coefficient of Concordance. The Kendall's W is modeled to output a coefficient which ranges from 0-1, whereas, 0 means no absolute agreement, a random response among raters, 1 means absolute agreement (unanimity) among raters and intermediates between the two (0 and1) indicate the degree of greater or lesser agreement (unanimity) among the responses. The Kendall's *W* was computed as shown below:

$$W = \frac{12}{p^2\,(n^3 - n) - pT}; \qquad 0 \leq w \leq 1 \tag{1}$$

Where,
S - is the sum of squared deviations for each constraints and is given as:

$$s = \sum_{i=1}^{n} (R_i - \bar{R})^2 \tag{2}$$

Ri = total rank for the i the constraints
P = number of respondent (raters),
n = number of constraints to be ranked
T = correction factor for ties.

RESULTS AND DISCUSSION

Sources of information on improved rice varieties

Table 1 indicated that other farmers (58.7%) ranked 1st as the major sources of information, this was followed by friends and relation (56.9%) which ranked 2rd and news print (41.3%) ranked 3rd. The findings showed that other farmers was the major source of information on improved rice varieties in the study area. This might be attributed to sharing of ideas on improved rice varieties among farmers in the study area. This findings agreed with Tsado *et al.* (2018), who found that other farmers (67.7%) was the major source of information on the improved rice varieties in Niger State, Nigeria.

Table 1: Distribution of respondents according to sources of information on improved rice varieties (n=109)

Variables	Freq (%)	Ranking
Other farmers	64 (58.7)	1st
Radio	39 (35.8)	4th
Friend and relatives	62 (56.9)	2nd
Extension agents	29 (26.6)	6th
GO	15 (13.8)	8th
News print	45 (41.3)	3rd
Television	31 (28.4)	5th
NGO	10 (9.2)	9th
Internet	29 (26.6)	6th

Sources: Field survey, 2019. Multiple responses

Coping Strategies used by Rice Farmers

Table 2 showed that the following coping strategies were adopted in the study area. The strategies are reduce number of meals eaten in a day ($\bar{X}$=2.89), restrict consumption of adults in order for small children to eat ($\bar{X}$ =2.83), consume seed stock held for next season ($\bar{X}$=2.79), ration the money you have and buy prepared food ($\bar{X}$=2.71), purchase food on credit ($\bar{X}$=2.44), rely on less preferred and less expensive food ($\bar{X}$=2.37).

Table 2: Distribution of rice farmers according to coping strategies behavior (n=109)

Coping strategies	Weighted sum	Mean ($\bar{x}$)	Ranking
Reduce number of meals eaten in a day	315	2.89	1st
Restrict consumption of adults in order for small children to eat	308	2.83	2nd
Ration the money you had and buy prepared food	296	2.71	4th
Purchasefoodoncredit	266	2.44	5th
Consumeseed stockheldfor nextseason	304	2.79	3rd
Limit portion size at meal times	255	2.34	7th
Rely onless preferred and less expensive food	258	2.37	6th
Borrow food or rely on help fromfriends or relatives	236	2.16	8th
Send household members to eat elsewhere	227	2.08	9th
Send household members to beg	212	1.94	10th

Sources: Field survey, 2019

Constraints Associated with the Adoption of Improved Rice Varieties

Table 3 revealed 38.0% level of probability significant at 1% level of probability, implying that 38.0% of rice farmers agreed on the outcome of the ranking. The result showed weak agreement in accordance to Kendall value. Table 3 showed that poor output ($\bar{X}$

=5.92) and inadequate improved varieties ($\bar{X}$ =6.03) were the most raked constraints in the study area. The exorbitant price of improved is a major setback to the adoption of improved rice. This agreed with Mohammed *et al*. (2019), who reported that inadequate output and inadequate improved varieties were one of the challenges to adoption of Faro (39) by Farmers' in Agricultural Zone 1 of Niger State. Other constraints include poor road network ($\bar{X}$ =6.38), inadequate input ($\bar{X}$ =6.64), inconsistent government policy ($\bar{X}$ =6.67), lack of fertilizer and agrochemical ($\bar{X}$ =7.13). Poor road network is one of the most serious problems encountered by farmers in the study area. The nature of most road at times contribute to loss and reduction in value addition of agricultural produce mostly perishable goods. This agrees with Maxwell (2014), who reported that poor road network is one of the major problem encountered by farmers in Sub-Saharan Africa.

Table 3: Constraints to the adoption of improved rice varieties (n=109)

Variables	Mean ($\bar{x}$)	Ranking
Poor road network	6.38	3rd
Inadequate improved varieties	6.03	2nd
Poor output	5.92	1st
Inadequate input	6.64	4th
Poor extension services	7.33	8th
Problem of fertilizer and agrochemical	7.13	6th
Inconsistent government policy	6.67	5th
Inadequate processing facilities	7.43	9th
Seasonal attack of pest and diseases	7.28	7th
Poor marketing channels	7.47	10th
Kendall's W	0.38	
Chi-Squared	49.285	
Degree	12	
Asymptotic significant	0.000***	

Sources: Field survey, 2019

CONCLUSION AND RECOMMENDATIONS

It can be concluded that others farmers was the most sources of information on improved rice varieties. Reduce number of meals eaten in a day is the most farmers. Poor output is the most constraints to adoption of improved rice varieties. It is recommended that extension agents should ensure farmers are equipped with training, skills and knowledge in order to increase their output.Inadequate improved varieties was one of the major constraints to adoption of rice varieties. Also, research institutes should ensure farmers' access improved rice varieties at affordable prices in order increase output of rice production, improved livelihood and food security status.

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Evaluation of some Selected Insecticides Against Insect Pest of Oil Palm in Benin City, Edo State

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Abstract
Insect pests pose a significant threat to oil palm cultivation in Nigeria, causing substantial economic losses. The trial is to evaluate the synthetic and non-synthetic chemicals in the management of insect pests of oil palm. The experiment was conducted at the main station of Nigeria Institute for Oil Palm Research, Benin City, Edo State. It is a randomized complete block design with seven treatments replicated four (4) times. The field was routinely observed for possible advice side effects of the insecticides on the oil palm. The treated palms were observed weekly for 3 weeks for the presence of insect pests and insect pests were recorded, and the recorded data was subjected to statistical analysis using analysis of variance (ANOVA) with GenStat eighth edition. From observations and results obtained from the field, a major insect pest of palm was not common. This could be as a result of the chemicals applied. The analyzed results show that zonocerous variegatus nymphs and adults were more in than other insect pest irrespective of the chemicals applied. This could be a result of other vegetative crops growing around the plantation. The use of zeropest could be recommended for the management of oil palm pests as it is known to pose no danger to the crop or environment and can equally control insect pests of oil palm.
Keywords: Environment, Nymph, Insect pest, Oil palm, Zeropest, Zonocerous variegatus,

INTRODUCTION

Oil palm, being a perennial crop, is attractive to many pests, leaf-eating caterpillars are among the most important insect pests. They include bagworms, nettle, and hairy caterpillars which feed mainly on the palm fronds. High population levels can lead to the complete skeletonization and death of the fronds. Damage such as 10-13% can also cause a similar loss Kamarudin and Arshad (2006).

There has been a growing problem of pesticide misuse and at the same time, pests have developed some resistance to some pesticides. The solution to this problem is integrated pest management (IPM). The IPM approach requires a good knowledge of the pest's biology and its environment, including the host plant's effect on pest development (Appiah *et al*., 2007, Aneni *et al.,* 2020). The use of biopesticides is gaining popularity as a sustainable and environmentally friendly approach to insect pest management. The objective of this study is, therefore, to evaluate the effect of two chemicals at different concentrate on the insect pest of oil palm

METHODOLOGY

The experimental site was Field 18 the main Station of the Nigerian Institute for Oil Palm Research (NIFOR), Edo State.

Experimental Design Layout

G1	E1	A1	C3	B3	F3	D4
B1	E3	G2	A3	C4	D3	F4
E2	D1	C2	F1	A4	B4	G4
B2	C1	A2	D2	F2	G3	E4

The experimental design for the trials was done in a Randomized Complete Block Design (RCBD). Each treatment was replicated three (3) times.

Treatment Schedule

A = 3.5ml/L of Zero Pest; B = 2.5ml/L of Zero Pest; C = 1.5ml/L of Zero Pest; D = 0.8ml/25L of Laraforce; E = 0.6L/25L of Laraforce; F = 0.4L/25L of Laraforce; G = Control (Water)
The treatment schedule was done based on their active constituent ingredients by using the Manufacturer's specifications as a guide.

Phytotoxicity test

The treated plots were routinely observed for possible adverse side effects of the insecticide on the Palms as well as outbreaks of any unusual insect pests and diseases in the treated plots.

Sampling for Insect Pest Infestation

Observations were made weekly between 7.30 am - 10.00 a.m., to observe, count and record insect pests present on tagged and treated oil palms.

Data Management and Analysis

All the data generated from these trials were converted and analyzed using Analysis of variance (ANOVA) with GenStat eighth edition and treatment means separated by Duncan Multiple Range Test (DMRT) at a 5% level significance.

RESULTS AND DISCUSSION

The results of the statistical analysis are shown in Tables 1, 2, and 3. Results obtained from the experiment share similarities with results obtained from the same experiment carried out on coconut. This could be attributed to climatic conditions, and location as both experiments were almost at the same location. Besides variations shown in the number of insect pests present at different times, some non-important insect pest of oil palm was found on the treated oil palms while the major pests were not much. This probably could be a result of the actions of the chemicals on target pests. However, *Zonocerou variegatus* were more in number in all the palms sampled at all times. The results of the statistical analysis of the insect pests found in oil palm plantations show that there was no significant difference in rain to interference within the different treatment groups when compared. This could be attributed to several reasons but emphasis will be made on seasonality as the experiment was carried out in the wet season thereby giving room for the process. Biopesticide did not show a less reaction when compared to the other non-biopesticides in controlling the insect pest of oil palm More so the zeropest which is a plant in the experiment. The biopesticides could be further examined because it is more sustainable since they lack phytotoxicity, leave no residues, and are eco-friendly (Bhattacharyya *et al* 2016).

CONCLUSION AND RECOMMENDATIONS

The idea of keeping these pests below the economic damage threshold by employing an integrated pest management system or safe pesticide use will not only be profitable to the farmers but will bring balance to the ecosystem. This is one way to encourage and achieve good climatic conditions in our oil palm estates or plantations. Equally, more research needs to be done to know the dosage that will be more effective in the control or management of oil palm insect pests using these chemicals especially the biopesticides and in different locations and seasons

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Table 1: Number of insects present on 1st week after the application of treatments

	Treatment	ZVN	ZVA	WASP	BA	RA	DL	HS	HF	CSI	BF
1	A	4.56	0.71	0.87	1.47	0.71	0.71	0.71	0.71	0.84	0.71
2	B	3.78	0.71	0.96	1.22	0.71	0.71	0.71	0.71	0.71	0.71
3	C	4.50	2.00	0.71	2.12	0.96	0.71	0.71	0.93	0.71	0.71
4	D	3.65	1.17	0.93	1.00	0.71	0.97	0.84	0.99	0.71	1.69
5	E	1.30	0.71	0.84	1.12	0.71	0.71	0.71	0.71	0.71	0.84
6	F	2.71	0.71	0.71	1.22	0.71	0.71	0.71	0.71	0.84	0.71
7	G	3.73	0.84	0.84	1.22	0.96	0.72	0.71	0.71	0.71	0.71
	LSD	**2.96**	**1.55**	**0.19**	**1.49**	**0.22**	**0.17**	**0.07**	**0.37**	**0.21**	**1.12**
	SED	**1.41**	**0.74**	**0.39**	**0.55**	**0.11**	**0.08**	**0.15**	**0.18**	**0.10**	**0.53**

ZVN – *Zonocerous variegatus* nymph, ZVA- *Zonocerous variegatus* adult, BA- Black ant, RA- Red ant, DL- *Diostrombus luteus*, M- Moth, CSI- Ceroplastes scale insect, HF-Housefly, Himacerus spider,

Table 2: Number of insects present on 2nd week after the application of treatments

S/N	Treatment	ZVN	BA	RA	DL	M	CSI	AS
1	A	26.2	0.84	0.71	0.71	0.84	0.71	0.71
2	B	21.80	0.71	0.71	0.71	0.84	0.71	0.97
3	C	18.20	0.71	0.84	0.71	0.71	0.71	0.71
4	D	4.50	1.12	0.71	0.71	0.71	0.84	0.84
5	E	3.00	1.12	0.71	0.71	0.71	0.71	0.97
6	F	12.00	0.84	0.71	0.71	0.71	0.71	0.71
7	G	14.50	0.71	0.71	0.84	0.71	0.71	0.97
	LSD	**20.50**	**0.72**	**0.15**	**0.15**	**0.21**	**0.15**	**0.33**
	SED	**9.76**	**0.34**	**0.07**	**0.07**	**0.10**	**0.07**	**0.16**

ZVN – *Zonocerous variegatus* nymph, BA- Black ant, RA- Red ant, DL- *Diostrombus luteus*, M- Moth, CSI- Ceroplastes scale insect, AS- Alogista spider

Table 3: Number of insects present at the 3rd week after application of treatment

S/N	Treatment	ZVN	ZVA	BA	CSI	AS	M
1	A	4.44	0.93	0.71	0.84	0.84	0.71
2	B	4.70	0.97	0.71	0.84	0.71	0.71
3	C	3.67	0.71	0.93	0.71	0.84	0.71
4	D	5.10	0.84	0.71	0.71	0.71	0.71
5	E	3.13	1.34	0.71	0.71	0.84	0.84
6	F	4.22	0.84	0.71	0.71	0.84	0.71
7	G	3.44	0.84	0.93	0.71	0.71	0.71
	LSD	3.23	0.63	0.36	0.21	0.29	0.15
	SED	2.54	0.30	0.17	0.10	0.14	0.07

ZVN – *Zonocerous variegatus* nymph, ZVA- *Zonocerous variegatus* adult, BA- Black ant, DL- *Diostrombus luteus*, M- Moth, CSI- Ceroplastes scale insect,

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Analysis of Factors Affecting Adoption of Improved Soyabean Production Technologies among Rural Farmers in Benue State, Nigeria

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Abstract

The study analyzed factors affecting improved soyabean production and post-harvest technologies among rural farmers in Benue State, Nigeria. All the soyabean farmers in Benue State, Nigeria formed the population of the study. Multi-stage sampling techniques were used to select 157 respondents for the study. Primary data were obtained using a structured questionnaire administered to the respondents. The data were analysed using descriptive statistics. The results show that the majority (81.5%) of the respondents have high-level adoption of NCRI recommended planting season of June–July as soyabean production technology, many (81.5 %) of them adopted Sam soy2, about 45.9 % of them adopted fertilizer (N.P.K) 3bags and SSP4bags/ha. The findings revealed that respondents were faced with three categories of constraints: socioeconomic, infrastructural, and institutional constraint. In conclusion, the farmers adopted the improved soyabean production technologies but were constrained by certain factors. Based on the results, it is recommended that farm input supply should be timely and at an affordable price, there should be creation of awareness and farmers training on technology usage, there should be provision of credit and loans to farmers, more markets and good roads should be made available mostly in the rural areas.

Keywords:* *Adoption, Improved Soyabean, Production, Technologies, Farmers

INTRODUCTION

Soyabean is a farm crop that belongs to the family of legumes It is scientifically called *Glycine max (L) Merrill.* Soyabean is produced in large quantities in the Middle-belt and Northern States of Nigeria and is readily available in most markets in the Southern and Western States due to the virile activities of merchants. Soyabean products and their uses have been promoted in Nigeria (Odebode, 2005), particularly in the Eastern States of Nigeria through the extension unit of the Agricultural Development Programme (Njoku, 2005). The acceptance of new technologies has been recognized as one of the essential tools to increase agricultural productivity, resulting in food security and job creation in Nigeria. The broad objective of the study was to analyse factors affecting the adoption of improved soyabean production technologies among rural farmers in Benue State, Nigeria. The focus of the study was to: i identify improved soyabean production technologies adopted by rural farmers, and ii. identify factors affecting the adoption of soyabean production technologies by rural farmers.

METHODOLOGY

The study area

The study was conducted in Benue State, Nigeria. Benue state lies within the lower river Benue through in the middle belt region of Nigeria. It lies between Latitude 6º30 N and8º10 N and Longitude 6º35 E and 10º E.

Population and Sampling Procedure

The population for the study includes all soyabean farmers in the study area. Due to the large study population, a sample size of one hundred and fifty-seven (157) respondents was selected using stratified random sampling techniques to ensure that every member of the population had an equal chance of being selected. A multi-stage sampling procedure was used to select respondents from the list obtained from the Benue State Agricultural and Rural Development Authority. Stage 1 involved a selection of two Local Government Areas from each of the three zones in the State using a simple random sampling technique. This means 6 LGAs were selected (i.e., 6 LGAs from the three zones). Stage 2, a sample frame of farmers was developed and one per cent (1 %) of the farmers were selected using proportional allocations across the six (6) LGAs

Data analysis techniques

Data for this study were subjected to descriptive statistics. Frequency, percentage and mean were used to analyze objective one, objective two was analyzed using factor analysis

RESULTS AND DISCUSSION

Farmers' adoption level of improved soybean production technologies

Table 1 shows the adoption level of improved soyabean production technologies. The result revealed that the majority (81.5 %) of the respondents have a high-level adoption of NCRI-recommended planting season of June– July, also many (81.5 %) of the respondents highly adopted Sam Soy 2, this could be a result of its high-yielding potential over other varieties. Some (47.8 %) of the respondents had high-level adoption of single cropping, while 45.9 % of the respondents had high-level adoption of fertilizer (N.P.K 3bags and SSP 4bags /ha.) indicating the possibility of an increase in crop yield as the application of improved agricultural practices has a positive impact on crop yield. Some (35.0 %)) of the respondents adopted TGX 1448-2E at a high level 33.8% of them adopted fusillade: 2 Lt/ha at a high level, and 27.4 % of them adopted Pendimethalin: 3-4Lt/ha at a high level. The low level of adoption of improved agricultural technologies could be due to low expected benefits from the practice or to other factors such as farmers' attitudes or institutional factors which may not encourage the adoption of technologies by farmers (Ajibefun, 2006).

Constraints to Adoption of Improved Soyabean Production Technologies by Farmers

Table 2 shows the results of factor analysis in Benue State, and these factors include; socio-economic factors with high loadings on low demand for the processed products (0.703), Time-consuming and tedious nature of technologies (0.714), inadequate processing skills (0.854), lack of labour for operation (0.353), lack of access to land (0.325), high cost of agricultural input (0.636) and rural infrastructural factors with high loadings on lack of access to processing facilities (0.672), non-availability of improved storage facilities (0.798) and poor road network (0.525)While the institutional factors with high loadings include non-provision of information on agriculture (0.585), ineffective extension services and coverage (0.752), and lack of market access (0.710). These factors affect the use of improved agricultural technologies in the study area causing low crop productivity. Low demand for processed products also militates against technology adoption as locally processed products have low national and international request due to low quality and poor processing techniques employed by rural farmers. The time-consuming and tedious nature of technologies affects the adoption level as many local farmers find it difficult to understand and operate innovations in their farming activities. Lack of access to land also affects adoption as most rural farmers practice small-scale farming due to unavailability of land which results in a low level of technology adoption. Lack of labour for operation equally militates against adoption because most rural farmers hardly take the risk of employing labour, since most of them cultivate small areas of land resulting to low level of technology adoption, since most of them cultivating small area of land whereby resulting in a low level of technology adoption. The high cost of agricultural inputs also affects the adoption rate of farmers in rural areas smallholders, making it difficult for them to purchase and use inputs such as improved seeds and inorganic fertilizers in their farming activities. Inadequate rural infrastructure as represented by factor 2 is a constraint to agricultural technology adoption due to lack of access to processing facilities as most small-scale farmers cannot afford to purchase soyabean processing machines because of the high cost. Non-availability of improved storage facilities makes most soyabean produce go spoiled as a result of poor storage facilities used by rural farmers in storing their farm produce, this in turn leads to a low adoption level of improved technologies. Poor road network makes marketing of processed agricultural products in the rural areas difficult. Also, institutional factors such as non-provision of information on agriculture are a constraint because most rural farmers do not television and radio to listen to information passing across through this medium alongside ineffective extension services and coverage that limit the spread of information on agricultural technologies, again most rural farmers dwell in remote villages that are distance from agricultural research institutes where technologies are developed, such farmers hardly become aware and adopt new technologies. Lack of rural markets also limits adoption level since most rural communities do not have adequate markets where farmers can sell their produce, as a result of this, many farmers settled on small-scale farming just to feed their immediate families.

CONCLUSION AND RECOMMENDATIONS

Farmers in the study area adopted improved soyabean production technologies such as Sam soy2, single cropping, correct planting time of June- July, and fertilizer application at a high level. The farmers adopted the improved soyabean technologies but faced three constraints: Socioeconomic, Infrastructural, and Institutional constraints. Based on the results of this study, the following recommendations were made: recommended farm inputs such as TGX1448-2E, TGX1904-6F and Sam soybean, 2. Fertilizers, insecticides and herbicides should be made available to farmers at the right time and place. The government should subsidize the price of farm inputs to enable farmers to purchase them at affordable prices Also, agencies responsible for the distribution of agricultural technologies should create awareness and training services for farmers on the use of technologies especially in the Local Government Areas where the technologies have not been introduced.

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Table 1: Soybean Production Technologies Adopted by Farmers in the Study Area

Type of technology	**Adoption Level**					
	H	M	L	N	S	
Improved varieties	**%**	**%**	**%**	**%**	**%**	**T**
(a) Sam soy2	81.5	5.7	6.4	5.7	0.6	100
(b)TGX 1448-2E	35.0	18.5	6.4	33.8	6.4	100
(c)TGX 1904-6F	17.8	9.6	1.9	58.6	12.1	100
Fertilizer (N.P.K) 3ba & (SSP) 4ba.	45.9	14.6	19.1	17.8	2.5	100
Pest and Diseases Control						
(a) Decis at 40ml/10l of water	23.6	2.5	5.1	49.7	19.1	100
(b) (b) Nuvacron:5ml/10L of water	21.7	3.2	5.1	52.2	17.8	100
(c) (c) karate:20ml/10L of water	19.7	5.1	5.7	55.4	14.0	100
(Use of herbicides)						
(d) (i)Pre – Emergence						
(a) Butachlor:2-3Lt/ha	24.2	7.0	5.7	44.6	18.5	100
(b) Pendimethalin:3-4Lt/ha	27.4	7.6	11.5	43.9	9.6	100
(ii)Post - emergence Fusillade: 2Lt/ha	33.8	4.5	7.6	40.8	13.4	100
Single cropping	47.8	4.5	1.9	37.6	8.3	100
Weeding frequency.	28.0	17.8	11.5	39.5	3.2	100
Seed rate (40-50 kg/ha)	6.4	3.2	6.4	78.3	5.7	100
Planting time (June– July)	81.5	14.0	1.9	1.3	1.3	100

Source: Field Survey, 2019. Note; H= high level of adoption, M = moderate level of adoption, L = low level of adoption, N = Not adopted, S = stopped using and T= total, Multiple responses recorded

Table 2: Factor Analysis of Constraints to Adoption of Improved Soyabean Production and Post-harvest Technologies

	Benue State		
Constraints	Fact. 1	Fact. 2	Fact. 3
Lack of access to processing facilities	-.117	.672*	-.190
Low demand for processed products	.703*	.110	-.081
The time-consuming and tedious nature of technologies	.714*	-.109	-.028
Non-provision of information on Agricultural technologies	. 230	.235	.585*
Ineffective extension services and coverage	.298	.187	.752*
Inadequate processing skills	.854*	.070	-.042
Non-availability of improved storage facilities	.080	.798*	.032
Lack of access to the market	.079	-044	.710*
Poor road network	.221	-525*	.231.
Lack of labour for operation	.353*	-.065	.115
Lack of access to land	.325*	-.042	.274
High cost of agricultural inputs	.636*	.023	-.222

Source: Field Survey, 2019. Method: Varimax with Kaiser's Normalization

F1= Socio--economic factors, F2= Infrastructural factors and F3= Institutional factors.