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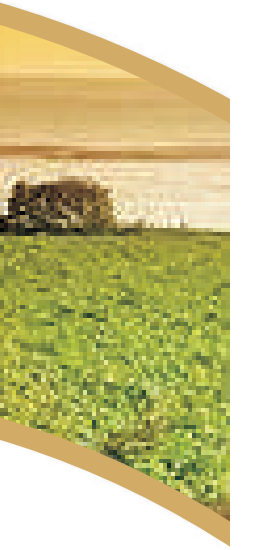

8th CONFERENCE & 67th ANNUAL GENERAL MEETING

Theme:
Climate Change: Agricultural Innovations and Bio-entrepreneurship for Sustainable Development, Food Sufficiency and Economic Transformation

Held at the

FEDERAL UNIVERSITY OF AGRICULTURE, ABEOKUTA

DATE: Sunday 7th - Thursday 11th July, 2024
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8th Annual Conference and 67th AGM-ABEOKUTA of The Association of Deans of Agriculture in Nigeria Universities (ADAN), Held at The FUNAAB Red Senate chamber, Abeokuta, Ogun State, Nigeria, from July 7th to 11th, 2024. Theme: Climate Change: Agricultural Innovations and Bio-entrepreneurship for Sustainable Development, Food Sufficiency and Economic Transformation. **Edited by:** A. E. Obayelu, O.M Olosunde, P. B. Abdulsalam-Saghir, O.S. Sowande, E.O. Fakoya and J.J. Atungwu

ASSOCIATION OF DEANS OF AGRICULTURE IN NIGERIAN UNIVERSITIES (ADAN) - ABEOKUTA 2024 CONFERENCE PROCEEDINGS

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LENGTH-WEIGHT RELATIONSHIP, GROWTH PATTERN AND CONDITION FACTOR OF GREY MULLETS (*Mugil cephalus* Linnaeus, 1758) IN SELECTED ESTUARIES OF ILAJE, ONDO STATE

***Ikuesan, B. B., Olowojuni, O., and Makinwa, C.A**
Department of Fisheries and Aquaculture Technology, Olusegun Agagu University of Science and Technology, Okitipupa, Nigeria.
Corresponding email: bbikuesan@oaustech.edu.ng

ABSTRACT
This study investigated the length-weight relationship and growth pattern of the grey mullet fish population. Fish samples (≤ 100) were collected from Mahin Lagoon and Ugbo Waterway using cast nets between April and July 2023. In Mahin, grey mullet samples collected exhibited a length range of 10.66 to 23.07 cm, with a mean length of 16.68 cm (± 3.20), whereas in Ugbo, the range was 8.10 to 25.67 cm, with a mean length of 16.99 cm (± 0.12). The mean body weight in Mahin and Ugbo were 40.25 g (± 15.06) and 33.33 g (± 10.33), respectively, with a significant difference (P > 0.05) observed between the two locations. Linear positive length-weight relationships were established, revealing negative allometric growth. The condition factor (K) exceeded 1 in both locations, indicating excellent fish condition. However, the specific patterns observed in *M. cephalus* populations in Ilaje coastal waters are suggested to have been influenced by unique local factors such as habitat structure, hydrodynamics, and anthropogenic disturbances, especially at Ugbo waterway, an area that serves as the hub of maritime transport activities in the region. Therefore, an urgent need for distinct management approaches to protect these stocks, to ensure their sustainability, socioeconomic improvement and aquaculture potential development is highly recommended.
Keywords: Coastal estuaries, Condition factor, Grey mullet, Ilaje, Length-weight relationship, Ondo state

INTRODUCTION
The fishery sector plays a crucial role in the Nigerian economy, contributing significantly to employment, food security, foreign exchange earnings, and poverty alleviation. Fish, being a major source of animal protein, plays a crucial role in meeting dietary protein requirements (FAO, 2020) globally. Studies on fish biology, such as those focusing on *Mugil cephalus* along the Atlantic coast of the Niger Delta Region, are essential for effective fisheries management (Ajibare, 2024). Grey mullet, a significant member of the Mugilidae family, is found in tropical and temperate coastal and brackish waters globally. In Nigeria, the Mugilidae family, with eight species, holds importance in coastal areas, supporting local livelihoods and signifying brackish and seawater species. The focus of this study has the potential for aquaculture in brackish water lagoons.

While some studies have reported length-weight relationships of *M. cephalus* in other parts of the country and other developing nations, there appear to be a dearth of data on its biology from Ondo State lagoons. Meristic and morphometric analyses are crucial tools in fisheries research, providing insights into anatomical features and aiding in species identification, stock assessment, and fisheries management. Given the phenotypic differences observed between *M. cephalus* and other species in Ilaje Local Government, a comprehensive study is warranted. Therefore, the primary objective of this study was to investigate the length-weight relationship, growth pattern, and morphological characteristics of grey mullets found in the coastal estuaries of Ondo state.

MATERIALS AND METHODS
The study focused on Mahin Lagoon and Ugbo Waterway, situated in the Ilaje Local Government Area of Ondo State, Southwest Nigeria. These locations were chosen based on observed variations in fish species abundance, salinity levels, commercial activities, and proximity to the Atlantic Ocean. Mahin Lagoon, with latitude 6.11 - 22.20° N and longitude 4.48 - 4.25 ° E, and Ugbo waterway, with latitude 6.9 - 10.77° N and longitude 4.47 - 4.16 ° E, represent two of the nine largest coastal lagoons in Southwestern Nigeria. The salinity of these lagoons exhibits seasonal variation, with high brackish water prevailing

during the dry season (December – May) and freshwater conditions during the rainy season (June – November). Spanning approximately 2.3 km and 1.5 km in diameter, Mahin and Ugbo Lagoons are recognized as significant fishing areas, with Mahin Lagoon serving as a transportation route from Igbokoda to coastal settlements. The lagoons exhibit diverse and dynamic ecologies influenced by their proximity to the ocean, tidal movements, and seasonal variations. Algal blooms are notable during the peak rainy season, impacting the physico-chemical characteristics of the lagoon and potentially leading to changes in the local food chain (Ajibare and Loto, 2023).

A descriptive cross-sectional research approach was employed to study *Mugil cephalus* in both water bodies. The study commenced at the onset of the rainy season, collecting fish samples from April to July 2023 using standardized techniques like cast nets, *Obiriki*, and *Asun* devices. A total of 100 fish samples per water body were collected from commercial catches. The age and growth patterns were analyzed by plotting the percentage frequency against the size range of the standard length. The length-weight relationship (LWR) was determined using the equation W = aL^b, where W = weight in grams, L = length in cm, a = regression constant, and b= regression coefficient. The condition factor (K) was calculated using Fulton's equation, providing insights into the well-being of the fish.

Statistical Analysis

Data were analyzed using Excel and SPSS (vs. 21). Descriptive stats summarized fish traits, while inferential stats, Analysis of Variance, ANOVA, detected differences. Correlation analysis was used to explore relationships, and multivariate techniques (Principal component analysis, PCA, and discriminant analysis) were used to assess patterns in morphology and meristic. The length-weight relationship and condition factor unveiled insights into physiological state and growth performance.

RESULTS AND DISCUSSION

Size Distribution: The analysis of mullet size distribution in Ilaje coastal waters revealed diverse lengths and weights. At Mahin, lengths ranged from 10.66 to 23.07 cm (mean ± SD: 16.68 ± 3.20), while at Ugbo, it spanned 8.10 to 25.67 cm (mean ± SD: 16.99 ± 0.12) (Table 1). The mean body weight significantly differed ($P \geq 0.05$) between Mahin (40.25 ± 15.06g) and Ugbo (33.33 ± 10.33g). This diversity suggests the area's suitability for both juvenile and adult individuals, emphasizing the potential for sustainable management and habitat preservation. The observed size distribution underscores the adaptability of grey mullets to various ecological niches, aligning with global findings on diverse habitats contributing to sustainable fish species management.

Tables 1: Size distribution of *Mugil cephalus* collected from Ilaje coastal waters.

Locations	N	Length (cm)		Weight (g)
		Range	**Mean±SD**	
Mahin	**70**	**10.66 -23.07**	**16.68±3.20 [a]**	**40.25±15.06[b]**
Ugbo	**70**	**8.10 - 25.67**	**16.99±0.12 [a]**	**33.33±10.33 [a]**

*****Mean with the same superscript along the columns is not significantly different at p>0.05

Table 2: LWR, Growth pattern and Condition factors of *Mugil cephalus* collected from Ilaje coastal waters

Parameter	Mahin	Ugbo
B	**0.35**	**0.41**
a	**0.55**	**0.45**
R^2	**0.81**	**0.94**
R	**0.90**	**0.97**
G.P	**NA**	**NA**
K	**1.97±0.49 [a]**	**2.06±0.24[a]**

*LWR= Length-weight relationship, B= regression coefficient, a= regression constant, R^2= coefficient of determination, R= correlation coefficient, NA = Negative allometry, K= condition factor

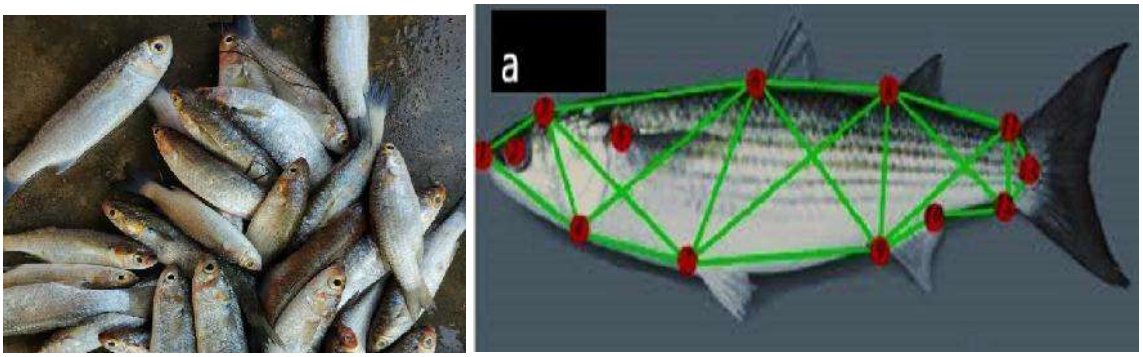
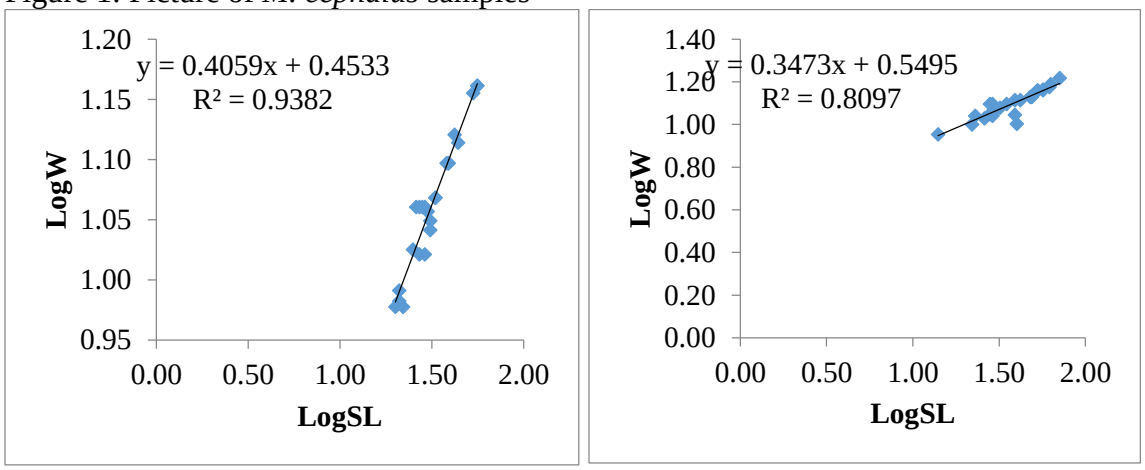


Figure 1: Picture of *M. cephalus* samples



A B

Figure 2: LWR of *Mugil cephalus* at Ugbo River (A) and Mahin Lagoon (B)

Length-Weight Relationship and Growth Pattern: The length-weight relationships displayed linear positive trends in grey mullets from both locations, with Mahin's parameters as follows: R^2= 0.81, b= 0.35, a= 0.55 (Table 2) and Ugbo's as R^2= 0.94, b= 0.41, a= 0.45. The negative allometric growth pattern observed (i.e., faster increase in length than weight) aligns with findings in other fish species and indicates a species-specific growth pattern influenced by environmental conditions (Figure 2). Condition factor (K) values were above 1, indicating good health during the study period, with no significant difference ($P < 0.05$) between the two locations. The negative allometric growth pattern suggests that environmental conditions play a crucial role in shaping the morphological characteristics of this species. Similar patterns observed in other species underline the species-specific nature of growth influenced by habitat variations. The present study resonates with previous findings on negative allometric growth in mullets, reflecting the species' adaptability to different habitats and environmental factors.

Condition factor values above 1 indicate good health, and the slight variation between locations underscores the need for further investigation into factors influencing condition factor differences. Seasonal changes, migration, and resource availability may contribute to these variations. The difference in condition factors could be due to the availability of food organisms at a particular time, state of maturity, age of fish, and in some species, the sex of the fish, as well as differences in gonad development (Muchlisin, *et al*., 2017).

The differences in length-weight relationships (LWR) and condition factors among species in this

study could result from a combination of factors that require further investigation. Variations in the condition factor of several fishes have been reported by Ajibare and Loto (2022) and Olawusi-Peters *et al*., (2014) concerning the feeding rhythm, physico-chemical environmental parameters, and physiological status of crustaceans and *Tilapia* spp, respectively. The study's results align with Soyinka *et al*., 2023, revealing negative allometric growth in *M. cephalus* and *Liza falcipinnis* investigated in Lagos Lagoon with condition factors recorded as 1.81 and 2.16, respectively, indicating good condition during the experiment.

CONCLUSION AND RECOMMENDATION

In conclusion, the study provides crucial insights into the adaptation and response mechanisms of grey mullet to the hydrodynamic environment of the inland waters of Ondo state coastal areas. The diverse size distribution and adaptability of the species emphasize the need for habitat conservation and management. The negative allometric growth pattern, condition factor values, and phenotypic variability reflect the species' ability to cope with dynamic environmental conditions. Future investigations should aim deeper into the underlying causes of phenotypic variability to ensure the sustainable management and potential aquaculture practices of these valuable fish species in the region's unique water bodies.

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EGG QUALITY PARAMETERS OF LAYING PULLETS FED CASSAVA (Manihot esculenta) PLANT MEALS

Asaniyan*, E. K. and Adeyemi, M.A.
Department of Animal Production and Health, Olusegun Agagu University of Science and Technology, P.M.B.353, Okitipupa. Ondo State, Nigeria.
*correspondent Author: E-mail: ek.asaniyan@oaustech.edu.ng Phone: +2348035726703

ABSTRACT
Three cassava plant meal products (CPMs) namely CPM 1: Cassava leaves (27.78%) + Tender stem (5.56%) + unpeeled tuber (66.67%); CPM 2: cassava leaves (23.81%) + Tender stem (4.76%) + unpeeled tuber (71.43%) and CPM 3: Cassava leaves (20.83%) + Tender stem (4.17%) + unpeeled tuber (75%) were developed to replace maize in diets of laying chickens. The CPMs were then used to constitute three experimental diets. The diets were 100% cassava-based in replacement of maize. Six hundred (600) day-old Isa Brown pullets were randomly assigned to three experimental diets in a completely randomised design study that lasted 12 months. It evaluated the egg quality of laying pullets. There were 10 replicates per treatment with each replicate comprising 20 laying pullets. Diet CPM 1 supports the internal quality of eggs especially egg yolk colour while either diets CPM 2 or CPM 3 favour external egg quality in terms of egg weight and shell surface area. For the internal quality of eggs, diet CPM 1 is better especially when the market is targeting egg processors. Diet CPM 2 on the other hand is recommended for external quality when targeting the market for fresh eggs.
***Keywords**:* Alternative energy, maize, Cassava plant meal product, egg weight, yolk colour

INTRODUCTION
The high cost of feed is a major factor affecting poultry production in Nigeria. Efforts should be geared towards achieving sustainable availability of eggs at affordable prices and acceptable quality. The escalating prices of feed ingredients such as maize and soya bean meal contributed immensely to the high cost of producing an egg per day. Consequently, the seasonal fluctuation in the supply of conventional feed ingredients (Anaeto and Adighibe, 2011) and the growing demand for traditional energy and protein feed ingredients as food by the ever-growing human population and other industrial uses (Diarra and Devi, 2015) opened the need for cheaper alternative ingredients, especially for maize; the major energy source in poultry feeds. Cassava is the highest supplier of carbohydrates among staple crops and can potentially replace maize completely as an energy source in poultry diets (Morgan and Choct, 2016). Cassava root meal,
whole cassava meal, cassava leaf meal and cassava peel meal are the main cassava products used in poultry diets (Aderemi *et al*., 2012), and its evaluation in diets of broilers (Akinfala *et al*., 2002) and cockerels (Matanmi *et al*., 2004) as a suitable replacement for maize. Therefore, cassava-based diets can have enhanced nutritional quality through the incorporation of cassava leaves which are richer in protein (Ngiki *et al*., 2014). Consequently, this study tends to evaluate the egg quality parameters of laying pullets fed cassava plant meal-based diets.

MATERIALS AND METHODS
Description of Study Area
The study was carried out at the Poultry Unit of the Teaching and Research Farm, Olusegun Agagu University of Science and Technology (OAUSTECH) Okitipupa, Nigeria.
Collection and Preparation of Test Ingredients
Cassava variety (TMS 30572) aged 2 years was purchased in a commercial farm around Okitipupa. The TMS 30572 cassava variety is well adapted to the tropic, has excellent tuber and leaf yield, and is highly resistant to cassava bacterial blight (Osakwe *et al.,* 2000). All the cassava components were sundried for an average of 2 to 3 and 4 to 5 days for the unpeeled cassava tuber and leaves/tender stems respectively.

Product Development

Three cassava plant meal products (CPMs) were developed, namely; CPM 1, CPM 2 and CPM 3 (Table 1). The CPM products were mixed at different ratios to achieve a minimum crude protein level of 10 % as maize. The mixing of the CPMs followed the procedure earlier described by Akinfala *et al.* (2002). The CPMs were then used to replace maize in the experimental diets (Table 1). The proximate compositions of the experimental diets are presented in Table 2.

Table 1: Composition of the experimental diets

	Cassava Plant Products Meal (CPM) Based Diets		
Ingredients	**Diet 1 (CPM1)**	**Diet 2 (CPM2)**	**Diet 3(CPM3)**
Cassava Plant Meal product (CPM)	50	50	50
Groundnut Cake	6	6	6
Soya Bean Meal	12	12	12
Wheat offal	10	10	10
Palm kernel cake	11.8	11.8	11.8
Fish Meal	1	1	1
Bone Meal	3	3	3
Oyster shell	5.5	5.5	5.5
Vitamin Premix	0.25	0.25	0.25
Salt	0.25	0.25	0.25
Methionine	0.1	0.1	0.1
Lysine	0.1	0.1	0.1
Total	100	100	100

CPM 1: Cassava leaves (27.78%) + Tender stem (5.56%) + unpeeled tuber (66.67%); CPM 2: cassava leaves (23.81%) + Tender stem (4.76%) + unpeeled tuber (71.43%) and CPM 3: Cassava leaves (20.83%) + Tender stem (4.17%) + unpeeled tuber (75%).

Pullets and Experimental Treatments

Six hundred (600) day-old Isa Brown pullets were purchased from a reputable farm in Ibadan, Oyo State. The experimental pullets were randomly assigned to three experimental diets in a completely randomised design. There were 10 replicates per treatment with each replicate comprising 20 laying pullets. All the experimental pullets were brooded for two weeks during which they were provided adequate heat using an electric bulb during the day and a charcoal fire at night. Three experimental diets fed laying birds were formulated as presented in Table 1. Diets 1, 2 and 3 were 100 % cassava-based in replacement of maize and contain CPM 1, 2 and 3.

Chemical Analysis

The proximate analysis of the experimental diets was carried out as outlined by AOAC (2010). A total of 250 eggs (5 eggs per replicate) were randomly collected for weekly egg quality analysis. A dial pipe gauge (Ozaki MFG. Co., Tokyo, Japan) was employed for measurements of the eggshell thickness. Egg weight, yolk colour, yolk height and Haugh unit were evaluated using an egg multi-tester (Touhoku Rhythm Co. Ltd., Tokyo, Japan).

Statistical Analysis

All experimental data were analysed using a One-way Analysis of Variance while means were separated by the Duncan Multiple Range Test at a 95 % level of significance (SAS Inst. Inc., Cary, NC).

RESULTS AND DISCUSSION

Except for the ether extract, the proximate analysis parameters of the experimental diets were not significantly ($P>0.05$) different among the diets (Table 2). CPM 1 had the highest value of ether extract significantly ($P<0.05$) different from other diets with CPM 3 having the lowest value of ether extract. This showed that the experimental diets virtually had similar levels of proximate parameters. However, the significant difference experienced in the level of ether extract among the diets suggested that the diets had different fats/fatty acids content. The ether extract values decreased with the increased % inclusion of unpeeled cassava tubers to the CPM mixtures in the experimental

diets. Meaning that the unpeeled cassava tuber can influence the caloric value of the diet.

Table 2: Proximate composition of experimental diets fed laying birds

Parameters	DIETS			SEM	p-value
	CPM 1	CPM 2	CPM 3		
Dry Matter	92.31	90.28	90.85	0.97	0.78
Crude Protein	18.88	19.06	19.22	0.90	0.98
Crude Fibre	5.89	5.94	5.98	0.45	1.00
Ether Extract	1.02[a]	0.87[b]	0.76[c]	0.04	0.005
Ash	5.57	5.70	5.84	0.45	0.98
Nitrogen free Extract	68.79	68.43	68.20	0.90	0.99

CPM 1: Cassava leaves (27.78%) + Tender stem (5.56%) + unpeeled tuber (66.67%); CPM 2: cassava leaves (23.81%) + Tender stem (4.76%) + unpeeled tuber (71.43%) and CPM 3: Cassava leaves (20.83%) + Tender stem (4.17%) + unpeeled tuber (75%).

Table 3: External and internal egg quality parameters of laying pullets fed experimental diets

Parameters	DIETS			SEM	P-value
	CPM 1	CPM 2	CPM 3		
Internal egg quality					
Average egg weight (g)	54.75[b]	57.70[a]	59.00[a]	0.68	0.01
Eggshell thickness (mm)	0.44	0.45	0.41	0.01	0.28
Egg shell weight (%)	12.32	12.56	13.16	0.45	0.78
Egg circumference (cm)	4.88	4.72	4.92	0.14	0.50
Egg length (cm)	5.24	5.13	5.37	0.15	0.45
Shell index	0.76	0.76	0.78	0.005	0.38
Shell surface area	69.53[b]	73.34[a]	74.93[a]	0.86	0.01
Internal egg quality					
Haugh Unit Score (%)	86.52	84.60	85.84	1.31	0.24
% Yolk weight	23.90	24.95	24.01	0.42	0.57
Yolk height (cm)	1.33	1.28	1.27	0.03	0.75
Yolk diameter (cm)	3.43	3.48	3.50	0.05	0.86
% Albumen weight	56.17	54.48	56.82	1.70	0.87
Albumen height (cm)	0.87	0.90	0.91	0.03	0.13
Yolk colour	9.54[a]	7.85[b]	7.75[b]	0.21	0.02

CPM 1: Cassava leaves (27.78%) + Tender stem (5.56%) + unpeeled tuber (66.67%); CPM 2: cassava leaves (23.81%) + Tender stem (4.76%) + unpeeled tuber (71.43%) and CPM 3: Cassava leaves (20.83%) + Tender stem (4.17%) + unpeeled tuber (75%).

In Table 3, all the internal quality parameters, except for average egg weight and shell surface area were not significantly ($P>0.05$) different among the diets. This is in agreement with the report that cassava root meal had no deleterious effects on egg quality (Lei *et al.*, 2017). The average egg weight and shell surface area values increased with increasing % content of unpeeled cassava tubers in the CPMs of the experimental diets; with CPM 3 and CPM 1 having the highest and the lowest values for the two parameters respectively. However, diets CPM 3 and CPM 2 were not significantly ($P>0.05$) different for the two parameters. Meaning that the presence of unpeeled cassava tubers in the diets supported increased egg weight. Then, it supports better return on egg production in terms of egg grading in favour of large eggs. Similarly, egg yolk was the only internal egg quality parameter that was significantly ($P<0.05$) affected by the experimental diets; with CPM 1 having the highest yolk colour score and CPM 3 having the lowest but similar to CPM 2. This tends to show that the diets had a similar influence on the majority of the egg internal quality parameters, but the egg yolk colour parameter experienced the unequal influence of the diets. The colour intensity of the yolk decreased with increased % content of unpeeled cassava tubers of the CPMs in the experimental diets. Egg yolk colour mostly depends on the pigments; carotenes and xanthophylls from the diets as laying hens cannot

synthesize the pigments (Sun *et al*., 2013). The tendency is high that these pigments were decreasing as the percentage of the unpeeled cassava tubers in the CPMs of the experimental diets increased. Hence diet with CPM 1 contributed more into the colour intensity of the yolk. Therefore, increased % level of unpeeled cassava tuber diluted the pigment intensity of the yolk colour as found in this study. Meaning that 66.67% level in CPM 1 diet with highest colour intensity would be the optimum inclusion level since 71.43% and 75% inclusion levels in CPM 2 and CPM 3 containing diets respectively were similar in values.

CONCLUSION AND RECOMMENDATION

Consequently, feeding laying pullets with diet CPM 1 (66.67% of unpeeled cassava tubers) supports the internal quality of the egg especially egg yolk colour while feeding the pullets with either diets CPM 2 or CPM 3 favours external egg quality in terms of egg weight and shell covering (shell surface area) of the egg. However, feeding the pullets with CPM 3 containing a 75% inclusion level of unpeeled cassava tubers might not be necessary because of the similar values recorded with CPM 2 (71.43% of unpeeled cassava tubers) diets. Therefore, diets CPM 1 and CPM 2 optimally supported the internal and external qualities of eggs respectively. For internal quality, diet CPM 1 is appropriate especially when the market is targeting egg processors while diet CPM 2 on the other hand is recommended for external quality when targeting the market for fresh eggs.

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ADOPTION OF AGROFORESTRY TECHNOLOGIES AMONG SMALLHOLDER FARMERS: IMPLICATION FOR SUSTAINABLE FOREST PRODUCTS DEVELOPMENT IN ONDO STATE, NIGERIA

Bamigboye E. O.
Department of Agricultural Economics and Extension
Olusegun Agagu University of Technology, Okitipupa, Nigeria

ABSTRACT
The study was conducted to investigate agroforestry technologies usage among smallholder farmers in Okitipupa local government area of Ondo State in 2023. The study employed a multi-stage sampling procedure to sample 120 respondents for the study. Data were collected through the aid of a structured interview schedule and analysis run on it using descriptive and inferential statistics. Results showed that the average age was 47.17±13.55 and male constituted (57.5%) of the sampled respondents. Majority of the farmers had farm sizes of 6-10 acres above 10 years farming experience. Alley cropping, silvopasture, forest farming and home garden had the highest rates of adoption among the respondents. Limited market demand, high initial investment, lack of access to agroforestry extension services, high cost of planting material, lack of technical knowledge, access to credit facilities and climate change reduced the extent of adoption of agroforestry technologies in the study area . Factors influencing the extent of adoption of agroforestry technologies had a significant effect (p=0.000) on the adoption of agroforestry technology. It was recommended that agricultural extension services focusing on agroforestry be established and strengthened and market linkages and value chains for agroforestry products be created.
Keywords: Agroforestry, technologies, smallholder farmers.

Introduction
One of the most obvious land-use practices in the world's agro-ecological zones and landscapes is agroforestry. One of the oldest types of farming that utilizes land is agroforestry. It has been practiced by about 1.2 billion people worldwide for over 1,300 years (Oyinlola and Adekunle, 2019). Agro-forestry is becoming more popular, especially in sub-Saharan Africa, regarding its contributions to climate change adaptation. Basically, agroforestry allows farmers to produce several products in the same unit of land, in an integrated manner to address a broader array of demand. (Adewusi, 2006).

Agroforestry is a silvicultural plan that responds to the challenges of sustainable forest management, especially adjacent to community settlements. Agroforestry is a prospective solution to reduce the rate of deforestation and overcome the food crisis problem (Ezebilo, 2021). This is an integrated approach to a sustainable land-use system (traditional and modern) in which there are interactions between ecological and economic components (timber/forestry plants with seasonal/perennial tree crops, livestock or fisheries inside or outside forest areas). Agroforestry provides ecosystem services, including climate change mitigation and benefits for smallholders, as well as prospects for sustainable food production . It is against this background that the following objectives were formulated. The broad objective of this study is to assess the extent of adoption of agroforestry technologies among small holder farmers in Ondo State , Nigeria while the specific objectives are to , describe the personal characteristics of the respondents, identified agroforestry technologies that have disseminated to the respondents, examine the factors influencing the adoption of the agroforestry technologies among respondents and examine the constraints to the adoption of agroforestry technologies among farmers in the study area

METHODOLOGY
The study employed a multi-stage sampling technique in the selection of farmers who employed agroforestry technologies within Okitipupa local government area of Ondo state. This involved three stages, the first of which was the random selection of twelve local communities within Okitipupa LGA in Ondo state. The second stage involved the selection of ten farmers randomly from each of the selected communities, totaling 120 farmers. Descriptive statistics was employed to analyse the data collected . Chi-square, and Pearson's Product Moment

Correlation coefficient (PPMC) was used to make inferential deductions

RESULTS AND DISCUSSION

In Table 1, majority (36.7%) of the smallholder farmers fell within the age range of 31 and 40 years, with a greater percentage (57.5%) of the population being males. Highly significant portions (84.2%) of the population were married. Majority (50.8%) of the farmers had attained educational levels at the tertiary level with (35%) of the farmers having household sizes within 3-5 members. This implied that families with higher numbers were most likely involved with farming activities. A significant majority (81.6%) of the farmers were of Yoruba ethnicity and a greater percentage (58.3%) of the farmers owned the land on which they cultivated. The average land size was 10.23±5.13 with majority (50%) of the farmers having farming experience above 10 years. Majority (35%) of the farmers accessed credit from other sources more than any other financial institutions.

Table 1: Distribution of respondents based on their selected personal characteristics

Personal Characteristics	Frequency	Percentage (%)	Mean	SD
Age				
Below 30	6	5		
31 – 40	44	36.7		
41 – 50	31	25.8		
51 – 60	13	10.8	47.17	13.55
Above 60	26	21.7		
Sex				
Male	69	57.5		
Female	51	42.5		
Marital status				
Single	15	12.5		
Married	101	84.2		
Widowed	4	3.3		
Religion				
Christianity	89	74.2		
Islam	23	19.2		
Traditional	8	6.7		
Educational Level				
No formal education	5	4.2		
Primary education	25	20.8		
Secondary education	29	24.2		
Tertiary education	61	50.8		
Household size				
Below 3	31	25.8		
3 – 5	42	35.0		
6 – 8	41	34.2		
Above 8	6	5.0		
Farming experience in years				
1 – 5	34	28.3		
6 – 10	26	21.7		
Above 10	60	50		
Farm size in acres				
Below 5	30	25		
6 – 10	54	45		
11 – 15	24	20		
16 – 20	11	9.2	10.23	5.13
Above 20	1	8		
Credit source:				
Commercial banks	31	25.8		
Family/Friends	18	15		
Coporative society	42	35		

Source: Field Survey, 2023

Distribution of respondents according to agroforestry technologies disseminated

Table 2 reveals the agroforestry technologies highlighted in the study and the responses of the respondents to them. The table then delves further into the adoption levels as well as the highlighted technologies.

Improved planting materials were seen to have been adopted by a substantial 61.7% of small holder farmers in the study area indicating a noteworthy adoption rate that showcases the fact that a significant portion of rubber farmers recognizes the advantages of using improved planting materials, such as disease-resistant or high-yielding clones. However, it's important to note that 11.7% of respondents have not adopted these materials, and 3.3% have opted dis-adoption, indicating potential barriers to widespread adoption despite the evident benefits. (Rank: 4th).

Table2: Distribution of agroforestry technologies according to their levels of adoption

Agroforestry Technologies	Not Adopted		Adopted		Dis-continued		Mean $\bar{X}$	Rank
	F	%	F	%	F	%		
Improved planting materials	14	11.7	74	61.7	4	3.3	1.89	4th
Improved gamplasm techniques	17	14.2	72	60	3	2.5	1.85	7th
Pest and disease control	20	16.7	61	50.8	11	9.2	1.90	2nd
Soil fertility management	19	15.8	64	53.3	9	7.6	1.90	2nd
Agroforestry practices	27	22.5	40	30.3	25	20.8	1.98	1st
Training and capacity building	25	20.8	53	44.2	13	10.8	1.89	4th

Constraints Influencing the Level of Adoption of Agroforestry Technologies

In Table 3, Amongst the constraints highlighted, the most prominent reported by respondents in the study area was the high cost of improved planting materials, with a staggering 68.3% of respondents considering it a serious constraint. This emphasizes the significant financial burden faced by farmers in acquiring quality planting materials (Kolade etal 2020) The mean score of 3.63 indicates its highest constraint rank

Table 3: Distribution of the constraints associated with farmers level of adoption of agroforestry technologies

Constraints	Not a constraint F (%)	Minor constraint F (%)	Moderately constraint F (%)	Serious constraint F (%)	Mean $\bar{X}$	Rank
High cost of improved planting materials	3 (2.5)	1 (0.8)	34 (28.3)	82 (68.3)	3.63	1st
Lack of technical know-how	3 (2.5)	17 (14.2)	15 (12.5)	85 (70.8)	3.52	4th
Inadequate extension services	9 (7.5)	2 (1.7)	51 (42.5)	58 (48.3)	3.32	6th
Limited access to credit facilities	3 (2.5)	6 (5)	32 (26.7)	79 (65.8)	3.56	3rd
High cost of labor	5 (4.2)	16 (13.3)	40 (33.3)	59 (49.2)	3.28	7th
Inadequate market information	8 (6.7)	17 (14.2)	38 (31.7)	57 (47.5)	3.20	11th
Poor infrastructure (e.g., roads, electricity)	3 (2.5)	6 (5)	29 (24.2)	82 (68.3)	3.58	2nd
Land tenure issues	4 (3.3)	19 (15.8)	46 (38.3)	51 (42.5)	3.20	11th
Pests and diseases	8 (6.7)	24 (20)	41 (34.2)	47 (39.2)	3.06	13th
Climate change and weather variability	12 (10)	26 (21.7)	42 (35)	40 (33.3)	2.92	16th

Source: Field Survey, 2023

Multiple response

Factors Influencing Dis-Adoption of Improved Rubber Technologies

Factors influencing the adoption of agroforestry technologies

Table 3 unveiled factors that influenced the adoption of agroforestry technologies among the farmers of which lack of access to agroforestry information and training (51.7%), high initial investment costs (91.7%), limited market demand for agroforestry (44.2%), land tenure issues (87.5%), availability of land for agroforestry (80.8%), insufficient government support (90.8%), fear of crop loss or failure (67.5%) and social or cultural beliefs(38.3%).

Table 2: Distribution of the respondents according to factors influencing the adoption of agroforestry technologies

Factors influencing adoption	Not a factor		Strongly a factor	
	F	%	F	%
Lack of access to agroforestry information and training	58	48.3	62	51.7
High initial investment costs	10	8.3	110	91.7
Land tenure issues	15	12.5	105	87.5
Lack of available land for agroforestry	23	19.2	97	80.8
Insufficient government support	11	9.2	109	90.8
Fear of crop loss or failure	39	32.5	81	67.5
Limited market demand for agroforestry products	67	55.8	53	44.2
Social or cultural barriers	74	61.7	46	38.3

Source: Field Survey, 2023

Hypotheses Testing

Table 3 showed that the three of the personal characteristics of the respondents had positive relationship with the extent of adoption of agroforestry technologies. These are age r=0.513, p=0.001, Educational level r=0.614, p=0.000.

These are the explanatory variables influencing the adoption of agroforestry technologies. By extension the more the educational level of a farmer the more he understand the importance of adoption of improved technologies .

Table 3 : Relationship between personal characteristics of the farmers and extent of the adoption of Agro- forestry technologies

Variable	Coefficient	P-value	remarks
Age	0.513	0.001	Significant
Educational level	0.614	0.000	Significant
Years of Farming experience	0.635	0.003	Significant

Source: Data Analysis, 2023

**** Correlation is significant at 0.05 level 2tailed**

CONCLUSION AND RECOMMENDATION

In conclusion, the research yielded data that revealed a high level of adoption of agroforestry technologies among the small holder farmers in Okitipupa despite the factors and constraints that they find associated with the adoption and utilization of these technologies. Therefore to bolster the adoption level even more, it is recommended that agricultural extension services that focus on agroforestry be established and strengthened, set up agroforestry demonstration farms in regions where farmers can witness the practical application and benefits of agroforestry practices, develop customized training programs that cater to the specific needs and levels of experience of farmers, and create market linkages and value chains for agroforestry products.

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TRICHODERMA CONCENTRATION AND APPLICATION STRATEGIES: INSIGHTS FOR EFFECTIVE WHITE MOLD MANAGEMENT IN TOMATO CULTIVATION"

[*1]Ariyo, A.C., [2]Ajayi, A.M., [1]Adeyemi, D. P.

[1]Department of Crop, Soil and Pest Management, Olusegun Agagu University of Science and Technology, Okitipupa, Ondo State,

[2]Department Crop, Soil and Pest Management, Federal University of Technology, Akure. Ondo State Nigeria

*Corresponding author email: ac.ariyo@oaustech.edu.ng; Phone number: 08030419050

ABSTRACT

A greenhouse study was conducted to evaluate the ability of different concentrations of an isolate of *Trichoderma asperellum* to enhance the growth and control of a white mold pathogen caused by *Sclerotium rolfsii* in tomato seedlings. As a prophylactic measure, two weeks old healthy tomato seedlings were treated with *T. asperellum* conidia in various concentrations via foliar application. Dual culture techniques revealed 60% inhibition in the mycelia growth of *S. rolfsii* when inoculated 24hrs before the introduction of the pathogenic fungi, which was significantly higher as compared to *T. asperellum* introduced 24hrs after the pathogenic fungi. On two-weeks-old healthy tomato seedlings, a suspension of *S. rolfsii* was first applied, and they were covered with clear polythene for 24 hours before being exposed to various conidial concentrations of *T. asperellum*. Data collected were subjected to an analysis of variance and means separated using Tukey's test. The study revealed that Trichoderma-treated plants differ significantly from fungicide-treated plants in terms of disease incidence and severity rate, as well as other growth parameters. This is especially true when comparing plants treated with 10^5 and 10^3 conidia/ml of *T. asperellum*. The effectiveness of various *T. asperellum* concentrations depends significantly on the application technique, with 10^5 conidia/ml providing the best performance with noticeably lower incidence and severity values than Mancozeb-treated plants.

Keywords: *Trichoderma asperellum*, conidia concentration, seed priming, Prophylatic, Curative.

INTRODUCTION

Worldwide, tomato (*Solanum lycopersicum* L.) is one of the most important and widely cultivated vegetable crops consumed in diverse ways. It is a cash crop for smallholders and medium-scale commercial farmers and a source of vitamins. Tomatoes were originally named after the food family to which they belong, the solanaceae, as *Solanum lycopersicum* (Linnaeus), and were also referred to as members of the solanoid or nightshade family. The tomato plant can grow from 0.7 to 2 m in height as an annual crop in temperate climates in greenhouses and soilless media (Caoxl *et al*., 2010). Tomatoes, aside from being delicious, are high in vitamin A (Anita *et al*., 2012) and a significant amount of vitamin C, which provides structures to bones, cartilages, muscles and blood vessels, maintains capillaries, bones, and teeth, and aids in iron absorption.the presence of micronutrient such as vitamin K, potassium, magnesium, fiber, and high acid content which makes tomatoes ideal for canning (Caoxl *et al*., 2010).

However, Tomato growers face the risk of annual yield loss of 40 - 50% (Akrami and Yousefi, 2015) due to disease. The major diseases of tomatoes are damping off, wilt blight, leaf spots, and white mold caused by *Pythium aphanidermatum*, *Fusarium* f. sp. *lycopersici*, *Rhizoctonia solani*, and *Sclerotium rolfsii*, respectively. While, *Sclerotium rolfsii* is the most economically important soil-borne fungal pathogen of tomatoes, accounting for over 30% causing root rot; stem rot, wilt and fruit rot diseases of tomatoes, more than 500 species of cultivated plants (Cilliers *et al*.,2000).

Plant disease management has accounted for various uses of a broad spectrum of fungicides, documented to have led to the accumulation of toxic compounds in the soil and be carcinogenic to both humans and animals (María F. *et al*., 2015). Hence, there is a need to investigate additional disease-control strategies, possibly biological means which have been reported to be environment friendly (Monte, 2001). Therefore, the efficacy of *T. asperellum* isolated from soil at the teaching and research farm of the Olusegun Agagu University in

Okitipupa Local government was investigated in this study and tested under different concentrations of 10^5 and 10^3 conidia/ml for the control of white mold of *S. rolfsii* of tomato by seed priming and nursery soil treatment under glasshouse conditions.

MATERIALS AND METHODS

The study was carried out at the Olusegun Agagu University of Science and Technology, Okitipupa, Ondo State. The pathogen *S. rolfsii* was isolated from diseased tomato fruits collected at the Okitipupa local market, and *Trichoderma asperellum*, an antagonistic fungus, was isolated from soil samples at the teaching and research farm of the University's according to the method of Jameel *et al.* (2014).

For the in-vitro antagonistic test, conidia of *T. asperellum* were prepared and adjusted to different concentrations using a hemocytometer slide and conidia concentration at 10^7, 10^5 and 10^3 conidia/ml was used for this study.

The study assessed the activity of *T. asperellum* against *S. rolfsii* using Petri dishes and four inoculation methods which include simultaneous, delayed for prevention, and delayed for cure, along with a control where inhibition zones between isolates were also observed.

The greenhouse (in vivo) test involved treating healthy tomato seeds with the different conidia concentrations for Seed priming, while conidia concentrations were sprayed on two-week-old tomato seedlings for foliar application/prevention before the application of the pathogenic fungus and curative methods involved the application of conidial concentration 24 hours after application of the pathogenic fungus. Control treatments included healthy tomato plants with no *S. rolfsii* infection, and chemical fungicides (Mancozeb) were used as a standard control.

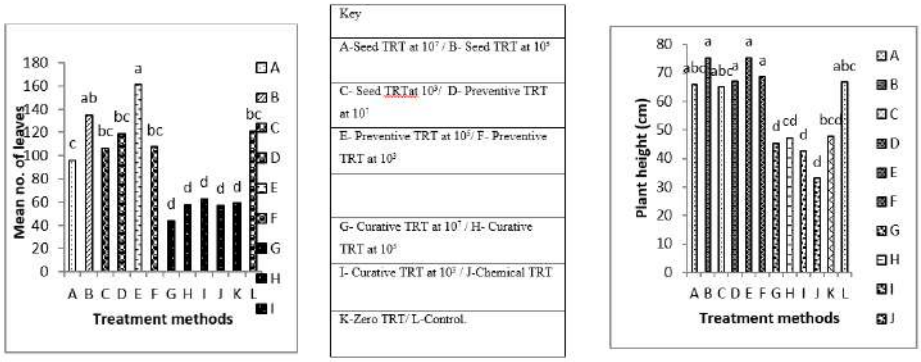
Statistical analysis was conducted using ANOVA, analyzed using Minitab17 VS and means were separated using Tukey's test.

RESULTS AND DISCUSSION

Effects of treatment combinations on growth parameters of tomato

The results obtained for growth parameters on a number of leaves and plant height for various treatment combinations and disease severity and incidence of white mold are shown in Figures 1 and 2 respectively.

For the growth parameter, no significant difference was recorded in the mean value for number of leaves and plant height under the curative approach for all concentrations of *T. asperellum* when compared to standard chemical used, while, the highest mean value with a significant difference was recorded under preventive treatment at 10^5conidia/ml (E).



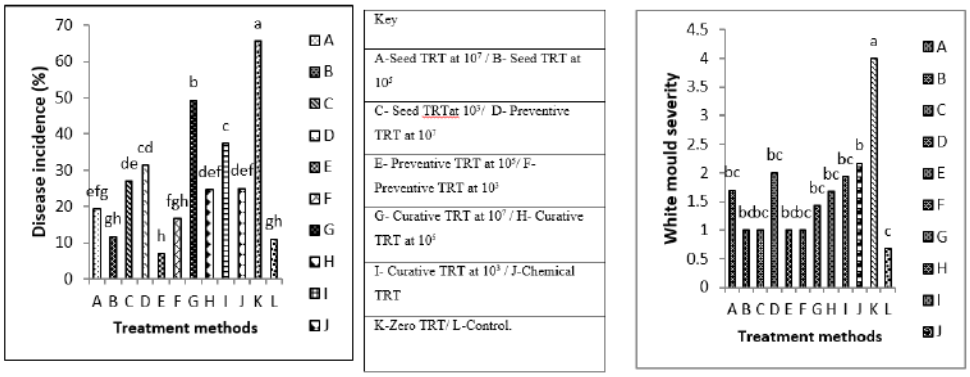
Means with the same letter(s) are not significantly different from each other according to Tukey's test. (P≤0.05)

Figure 1: Effects of different treatment combinations on number of leaves and plant height of tomato.

Effects of treatment combinations on disease severity and incidence of the white mold of tomato.

Visual observations of diseased tomato plants showed the initial symptoms of white mold disease caused by *S. rolfsii*, manifested in form of an

elliptical blister (uredia) on the leaves. Partial and irreversible wilting of the plant, visible outgrowth of sclerotia on the stem or soil line and eventually death of the whole plant were also observed. The highest value with a significant difference at 65% disease incidence and severity was recorded in K (zero treatment), followed by G & I (curative treatment at 10^7 and 10^3 conidia /ml) having an incidence of 50% and 38%, respectively as shown in Figure 2 below, while the best performance was recorded for the prophylactic method at conidia concentration of 10^5/ml



Means with the same letter(s) are not significantly different from each other according to Tukey's test. (P≤0.05)

Figure 2: Effects of different treatment combinations on incidence and severity of white mold.

In this study, 10^5 conidia/ml concentration appeared to give the best performance across all parameters under seed treatment and preventive methods. However, research has shown that the efficacy of *T. asperellum* depends on the method of application. While certain concentrations under certain application methods may give a significant improvement on certain parameters, the same concentrations applied differently may have no significant effects. Hermosa *et al*. (2012) reported using *T. asperellum*–cucumber interaction, that the induction of plant responses is a time- and concentration-dependent phenomenon while Harsukh *et al*. (2013), suggested that optimal application of bio-control agents such as *Trichoderma* is possible only when the operating mechanisms are fully understood.

It can therefore be recommended that *Trichoderma asperellum* be used at a concentration 10^5 conidia/ml prophylactically by seed treatment as a biocontrol agent in the management of white mold disease of tomato.

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COMPARISON OF INNOVATIVE METHODS OF PROCESSING ORANGE FLESHED SWEET POTATOES FOR IMPROVED NUTRIENT COMPOSITION AND STORABILITY.

Olufelo J. O.
Department of Crop production, University of Agriculture and Environmental Sciences, Umuagwo, Owerri, Imo State, Nigeria.
Corresponding Author: *jolufelo@yahoo.com

ABSTRACT
The nutritional composition of orange-fleshed sweet potato (*Ipomoea batatas*) flour extracted from various innovative processing techniques was evaluated. Orange fleshed sweet potatoes used for the study was sourced from the National Root Crops Research Institute, Umudike, Nigeria. The
three different processing techniques used were peeled; scratched peeled, and puree samples. Each of the sample were replicated thrice in the laboratory. The mean score from each tested sample (Mineral determination) was subjected to Statistical Analysis System (SAS™, 2017) procedures for Analysis of Variance (ANOVA) and least significant difference (LSD) test which was defined at ($p<0.05$). Result of the proximate composition of the flours and the puree showed significant differences among the samples evaluated. However, the crude protein content for both puree and scratched OFSP was insignificantly different at ($p< 0.05$). The puree sample recorded the highest protein content (5.48±0.24) and moisture content (85.95±3.89), respectively, and was closely followed by scratched OFSP with (5.02±0.01) while the least was recorded in the peeled sample (4.03±0.04). The study concluded that scratched OFSP through cabinet drier processing was considered the best alternative to the puree method of storage of orange-fleshed sweet potatoes and the best method of processing in areas where electricity is erratic or not available.
Keywords: Deterioration, Nutrient composition, Orange-fleshed Sweet Potato, Proximate, Puree.

INTRODUCTION
The development of orange-fleshed sweet potato (OFSP) during the past years is a case study of a disruptive innovation to address a pressing need as its affects the production, processing, preservation and utilization of the crop (Alam *et al*., 2016). The crop is an extremely rich plant-based source of pro-vitamin A (beta-carotene). Sweet potato (Ipomoea batatas) belongs to the morning-glory family. Despite its name, it is not related to the potato, unlike the potato- which is a tuber, or thickened stem, the sweet potato is a storage root (Etong *et al.* 2014). The plant is an important economic crop in many countries. It is ranked the fifth most important food crop in developing countries and the sixth in world food production after wheat, rice, maize, potatoes, maize, and cassava. All the plant parts, roots, vines, and young leaves of sweet potatoes are used as foods, animal feeds, and traditional medicine around the world (Dibi *et al*., 2017)). According to recent research, the high levels of vitamin A deficiency among children less than five years of age in sub-Saharan Africa are worrisome, and need urgent attention. When the innovation was introduced consumers strongly preferred white or yellow-fleshed sweet potato, so it was necessary to create a demand to respond to that need. However, the urge to increase production was hindered by an inadequate storage system for OFSP. The orange-fleshed sweet potato is a seasonal crop, perishable, and cannot be stored for a long period unless preserved in some way (Dibi *et al*., 2017). These, consequently, pose challenges to most agricultural products in storage houses, especially in rural areas (Islam *et al*., 2016). According to Malavi *et al*., (2022), the major challenge faced by this crop is that its storage roots cannot be stored for more than a few weeks after harvest, however, the suggested that traditionally the crop could be boiled, fried, roasted, baked, or included in a wide range of tasty and famous recipes, nutritive first courses, delicious soups, main dishes, and desserts. The crop can further be processed into purée, juice, canned, frozen, dried, and snack products. Information on other methods of preservation from wet (fresh) OFSP tubers to dry flour formulations on these improved sweet potato varieties appeared scanty. It is, therefore, quite clear that there is a need to explore other processing techniques of OFSP from wet (fresh) OFSP tubers to flour form, with caution of not compromising the nutritional constituent of the resulting products.

Therefore, the objective of this study was to determine the nutritional evaluation of orange fleshed sweet potato flour extracted from modern innovation processing techniques.

MATERIALS AND METHODS

The sum of 30kg orange-fleshed sweet potato (OFSP) variety used for the study was sourced from the National Root Crops Research Institute, Umudike, Nigeria. All experiments were carried out in the Department of Crop Production Laboratory, University of Agriculture and Environmental Science, Umuagwo, Imo State in a Completely Randomized Design with three replicates.

Methods of puree preparation

Ten kilogramme (10kg) of OFSP tubers were washed thoroughly with clean water to remove dirt and other foreign materials. The OFSP were peeled, washed with distilled water, sliced to 1.5 mm thick, and boiled at 100^{o}C in clean water for about 15min until tender, drained, and cooled at room temperature. Mashed and stored inside a refrigerator at (+4^{o}C) until usage.

Laboratory preparation of sweet potato flour

Peeled OFSP samples, 10kg each of were washed thoroughly with clean water to remove dirt and other foreign materials. The orange-fleshed sweet potatoes were peeled, washed with distilled water, and sliced to 1.5mm thickness using a slicer machine. The sliced OFSP were then parboiled for about 20 minutes, sieved, and then arranged neatly in a cabinet drier at 80^{O}C for 60 minutes. They were then removed and immediately turned into flour using a hammer milling machine and stored until usage.

Laboratory preparation of scratched sweet potato peels

Ten kilogramme (10kg) of OFSP tubers were washed thoroughly with clean water to remove dirt and other foreign materials. The Orange-fleshed sweet potatoes were scratched with a knife, washed with distilled water, and sliced to 1.5mm thickness using a slicer machine. The sliced OFSP were then parboiled for about 20 minutes, sieved, then arranged neatly in a cabinet drier at 80^{O}C for 60 minutes. The OFSP was then removed and immediately turned into flour using a hammer milling machine and stored.

Proximate Analysis

The moisture, ash, fat, protein, crude fiber and carbohydrate content were determined according to a procedure described.

Data Analysis.

The mean score from each tested sample (Mineral determination) was subjected to Statistical Analysis System (SAS™, 2017) procedures for Analysis of Variance (ANOVA) and least significant difference (LSD) test which was defined at ($p<0.05$).

RESULTS AND DISCUSSION

Table 1: Proximate analysis of orange-fleshed sweet potato processed with diverse techniques.

Method%	Moisture%	Ash%	Fat %	Crude protein	fibre	CHO %
Puree	84.95±3.89b	0.63±0.17b	1.99±0.33c	5.38±0.24b	0.70±0.11cd	71.75±3.05cd
Peeled	13.71±0.57a	2.32±0.12c	1.40±0.01d	4.03±0.04c	0.63±0.02de	70.98±0.65e
Scratched	13.05±0.21c	2.85±0.04ab	1.87±0.00c	5.02±0.01b	0.70±0.02e	73.17±0.14b
LSD	4.72	0.23	0.34	0.81	0.81	3.84

CHO- Carbohydrate

Table 1 shows the proximate Composition of OFSP processed with different techniques. Samples recorded from all the techniques showed that moisture content ranged from (13.05% in scratched to 84.95% in puree) % with puree recording the highest value while the lowest value was recorded in the scratched OFSP sample. The result of the proximate composition of the flours and the puree showed that the scratch-peeled OFSP had the highest ash content ranging from (2.85±0.04), crude fiber (5.38±0.24) and carbohydrate content (73.17±0.14) with a decrease in the moisture content from 13.05±0.21. The puree had the highest moisture content and crude protein (5.48±0.24), thou not significantly different from scratched unpeeled (5.02±0.01) while the peeled had the lowest crude protein (4.03±0.04). Table 1 revealed that there was a significant ($p< 0.05$)

difference in moisture content with the puree recording the highest while scratch peeled had the lowest. This is expected as the boiling process provided for the starch granules in the potato to imbibe and retain more water. This high moisture content reduced their shelf life and storability; that was why they were stored at a temperature of ±4^{o}C to maintain the quality, quantity, and taste of the puree. The peeled and scratched sample placed in a cabinet drier showed reduced moisture content of food materials than other processing methods, owing to the dry technique where the food samples are heat treated without immersing in water liquid. (Alam *et al.*, 2016) reported that dry heat dehydrates foods causing water loss while the increase in moisture of the steamed sample was due to the moist heat employed in the process. Also, the three methods of processing retained the minimum required nutrients needed, either as peeled or scratched flour when compare to puree. This finding produced 2.0kg of flour from every 10kg of wet OFSP scratch peeling method adopted hence, may be a promising alternative to puree production especially in rural areas where electricity is erratic or not available.

CONCLUSIONS

This study has shown that processing OFSP through scratched methods via cabinet drier not only maintained the nutritional and mineral constituency of Orange-fleshed sweet potatoes but also increased the quantity of flour production. The study, therefore, recommends that scratching OFSP tubers and processing them through dry cabinet methods can be used as an alternative replacement for puree production, especially where electricity and cold room availability might be beyond reach.

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SOCIO-ECONOMIC FACTORS INFLUENCING BOA LOAN ACCESSIBILITY AMONG FARMERS IN OGUN STATE NIGERIA

Ayodele, J. O.[1*] Adeokun, O. E.[2] Omeni-Pius, R. O.[3] Nwaogu I. P.[4]

[1]Department of Cooperative and Rural Development, University of Agriculture and Environmental Sciences, Umuagwo, Imo State, Nigeria. johnayodele365@gmail.com +2348064691846
[2]Department of Business Admnistration, Oduduwa University Ipetumodu, Osun State, Nigeria adeokunolusegun@gmail.com +2348037968565
[3]Department of Peace Studies and Conflict Resolutions, University of Agriculture and Environmental Sciences, Umuagwo, Imo State, Nigeria ominipiusraymond@gmail.com +2348065616115
[4]Department of Cooperative Economics and Management, Nnamdi Azikiwe University, Awka, Anambra State
ijeomanwaogu@gmail.com+2347031031557 ***Corresponding author**

ABSTRACT
The study examined socio-economic factors influencing BOA loan accessibility among farmers in Ogun State Nigeria. The three zones of the operation were sampled using multistage sampling techniques. Primary data utilized for the study was obtained with the use of a well-structured questionnaire from one hundred and nine 109 respondents only for data analysis. The result reveals that the majority (58.7%), of them were male 75.2% aged less than 50 years) with an average age of 42.5 years, 75.2% were married with had mean household size of 5 persons' majority 98.2% possessing one form of formal education or other, (71.6%), engaged in farming as main occupation had an average of 5 years of farming experience and (64.2%) practiced Christianity as religion. It was recommended that farmer's awareness and sensitization campaign should be embarked on by relevant government agencies and the BOA brings in more educated farmers and farmers with large farm holdings.
Keywords: BOA, Loan Acquisition, Access to Loan

INTRODUCTION
Bank of Agriculture (BOA) is the nation's foremost agricultural and rural development finance institution. It was incorporated in 1972 as Nigerian Agricultural Cooperative Bank Limited (NACB) to reflect the inclusion of cooperative financing into its broader mandate. In October, 2001, following the Federal Government effort to streamline the operations of its agencies, that were believed to be performing overlapping functions, three institutions, Nigerian Agricultural Cooperative Bank (NACB) Peoples Banks of Nigeria(PBN) and the risk assets of the Family Economic Advancement Programme (FEAP) were merged to form Nigerian Agricultural, Cooperative and Rural development Bank (NACRDB) in October 2010, following the rebranding of the bank to reflect its institutional transformation Programme, the Bank adopted the new name Bank of Agriculture (BOA) in the year 2013.

Statement of the Problem
Agricultural credit is an important tool for getting the inputs in time increasing thereby the productivity of the farms particularly those small ones. It is obvious that small farmers face a lot of problems in getting and returning the loans, hence it improves the quality and quantity of Agricultural Production. Olagunju, F., and Ayinde, O. (2017) Certainly, the use of credit facilities in the farm could translate to higher resource employment and capacity utilization, increased output and income, and reduce poverty in the rural economy, especially among the farmers, and be helpful to increase food production which would lead to an improvement in the welfare of the farmers and consequently a reduction in their poverty and food insecurity level Olagunju, F., and Ayinde, O. (2017)

Objectives of the study: The broad objective of the study is to determine socio-economic factors influencing BOA loan accessibility among farmers in Ogun State Nigeria.

1. Examine the socio-economic characteristics of the farmers which influence access to loan obtained by the farmers from BOA
2. Identify the constraints to farmers' access to agricultural loans acquisition from BOA

RESEARCH METHODOLOGY

Study design: This study is a descriptive survey which was intended to determine the socio-economic factors influencing BOA loan accessibility among farmers in Ogun State Nigeria.

Area of Study: The study was carried out in Ogun State, Nigeria. The State has a landmass of about 1.7 million hectares. It is currently made up 20 Local Government Areas (LGAs) spread across four main divisions – Egba, Ijebu, Remo and Yewa/Awori (NPC, 2006).

Sources of data: Primary data were mainly used for this study. They were obtained through well-structured questionnaire which was administered by trained enumerators and the researcher.

Methods of Data Analysis: Descriptive statistics such as frequency distribution tables, percentages and measures of central tendency were used to describe socioeconomic characteristics of the farmers

RESULTS AND DISCUSSION

The socio-economic characteristics of the farmers include: An assessment of the socio-economic characteristics of the respondents becomes important because of its tendency to influence their borrowing and repayment behaviors. As stated below, Sex of borrowers could have implications on loan repayment and by implication, default. It is important to understand how the respondents' sex would likely influence loan repayment. This could facilitate credible loan administration. The results revealed that majority (58.7%) of the respondents were male. It is evident that majority (75.2%) of the respondents were younger than 50 years with mean age and standard deviation of 42.51 and +11.03 years respectively. Result on marital status reveals that majority (75.2%) of the respondents were married. This is an indication that married people were the predominant BOA agricultural cooperators loan Scheme. The table also revealed that the vast majority (83.5%) of the respondents had at most 6 individuals in their households with an average of 5 individuals per household. This household size is considerably moderate and may not have substantial effect on the use of borrowed fund for unintended household consumption expenditure. In other words, the level of the household size may not have significant effect of repayment. The results on education of respondents analyze that only minority (1.8%) of the respondents had no any form of formal education. This implies that the vast majority (98.2%) had one form of formal education or the other. Besides, substantial number (39.4%) of the respondents had HND/BSC certificates. Obtained results revealed that vast majority (71.6%) of the respondents were farmers. With the high level of education among the beneficiaries, there is the tendency that if they invest the loan in farming, reasonable profit could be generated that will enable repayment of the loan. Also, an evaluation of the farming experience of the beneficiaries revealed that the majority had between 1-5 years of experience with an average of 5 years per beneficiary. Management therefore needs to put in place, practical measures to mitigate the risk in the BOA loan scheme so as to improve the quality of the overall loan portfolio of the bank. These factors, pose major tasks for the loan administrator namely, how to: Ensure continuous patronage from farmers, guide against mis-use of loan, and ensure prompt and full repayment of loan.

CONCLUSION AND RECOMMENDATIONS

This study set out to determine socio-economic factors influencing BOA loan accessibility among farmers in Ogun State Nigeria. The study found that age, education level, farm size, loan experience, household size, amount repaid, and net income, collectively had significant influence on access to BOA loan. Furthermore, it was also found that high interest rate, difficulties and protocols involved in obtaining loan, cost of obtaining loan is too much, inability to provide guarantor, loan is inadequate, untimely disbursement of loan, harsh loan recovery procedure were indicated by the farmers to have on one way or the other hindered seamless access to BOA loans. It was recommended that **1.** BOA should consider setting up a committee to address issues relating to constraints as identified by the farmers, especially the high interest rate, requirement for guarantor, and difficulties and protocols involved in obtaining loan. When this is done and various issues

resolved, it will be easier for the cooperators to have access to BOA loans. **2.** Farmers awareness and sensitization campaign should be embarked on by relevant government agencies and the BOA brings in more educated farmers and farmers with large farm holdings. Indeed, the study has revealed that BOA loan administrators favour these categories of farmers in in agricultural loan disbursements.

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BOOSTING SUSTAINABLE ECONOMIC GROWTH: THE POTENTIALS OF AGRICULTURAL MARKETING IN SOUTH-EAST, NIGERIA

CHUKWUEMEKA O. ONYEAGWARA

Department of Marketing, Entrepreneurship and Co-operative Development, University of Agriculture and Environmental Sciences, Umuagwo, Imo State.
E-mail: Onyeagwara23@gmail.com Phone Number: 08039234031

ABSTRACT
This study explored agricultural product marketing's role in driving sustainable economic development in Nigeria's South-East States. It aimed to assess the current state of agricultural marketing in the region, identify key factors influencing sustainable economic growth, and analyze how agricultural marketing can contribute to this growth. The research design used mixed methods, with qualitative interviews of stakeholders and quantitative surveys among 200 participants selected through purposive sampling. Thematic analysis was applied to qualitative data, revealing recurring themes, while SPSS was used to analyze quantitative data ($p<0.05$ significance level). The findings indicated a significant relationship between agricultural marketing and sustainable economic growth, with positive correlations between key growth factors and the potential of agricultural marketing strategies. Effective implementation of these strategies was shown to enhance sustainable economic growth in South-East Nigeria. Recommendations included prioritizing agricultural marketing investment, developing tailored marketing strategies, and establishing monitoring and evaluation mechanisms. Policymakers and stakeholders were urged to focus on these actions to improve economic growth and market competitiveness in the region.
Keywords: Agriculture, marketing, sustainability, economic growth, Southeast Nigeria

INTRODUCTION
Agricultural marketing plays a vital role in connecting farmers with consumers, benefiting both parties by increasing farmers' income and ensuring a stable food supply. To succeed in agricultural marketing, understanding consumers' needs and preferences is crucial, along with effective branding, promotion, distribution channels, pricing strategies, and after-sales services (Inegbedion, Inegbedion, Asaleye, Obadiaru & Asamu, 2021). In the South East region of Nigeria, agricultural marketing is essential for the movement of agricultural products, ensuring fair prices for farmers and contributing to sustainable economic growth. Sustainable economic growth requires inclusive development opportunities and environmental sustainability. The region has great potential in agricultural marketing due to its abundant arable land, favorable climate, and natural resources. However, challenges such as inadequate infrastructure and limited market access hinder the sector's ability to contribute to economic stability and job creation (Asogwa & Onyegbulam, 2021). This study aims to assess the current state of agricultural marketing in Southeast Nigeria, identify key factors influencing sustainable economic growth, and explore how agricultural marketing can contribute to this growth. Sustainable economic growth considers social, economic, and environmental aspects and requires a comprehensive approach that accounts for various factors. Other studies support this notion by emphasizing the role of sustainable agricultural practices and the potential for economic growth through agricultural activities.

Sustainable economic growth refers to the long-term development that considers the social, economic, and environmental aspects of a region. This concept is supported by various studies and articles. Kulik (2024) defined sustainable development as a balance between meeting the needs of the present without compromising future generations. Nuswantara et al. (2023) examined the role of political connections in moderating board size and financial distress, highlighting the need to consider multiple factors in achieving sustainability. Hariram et al. (2023) proposed an integrated socio-economic-environmental model called sustainalism to address sustainable

development. They argued that this model can effectively balance economic growth with social and environmental considerations. These findings support the notion that sustainable economic growth requires a comprehensive approach that accounts for various factors. In the context of agriculture, Asogwa and Onyegbulam (2021) examined the contributions of agricultural value-added output to employment creation and regional trade integration in Sub-Saharan Africa, emphasizing the potential for sustainable economic growth through agricultural activities.

MATERIALS AND METHODS

This study utilized a quantitative approach, employing surveys and data analysis to measure specific variables of interest. The target population included farmers, agricultural extension officers, policymakers, agribusinesses, and consumers within Nigeria's South-East region. A sample size of 200 participants was purposefully selected based on their industry experience and expertise. The collected quantitative data underwent analysis using statistical techniques, including descriptive statistics, correlation analysis, and regression analysis within SPSS software. Statistical significance was determined using a significance level of $p < 0.05$.

RESULTS AND DISCUSSIONS

Table 4.1: Responses to the questions on sustainable economic growth in Nigeria

Statement	SA	A	U	D	SD	Total
Diversification of the Economy	120	66	3	6	5	200
Investment in Infrastructure Development	109	69	6	8	8	200
Human Capital Development (Education and Healthcare)	133	59	1	5	2	200
Promotion of Small and Medium Enterprises (SMEs)	124	59	6	7	4	200
Renewable Energy Development	144	47	4	4	1	200
Total	630	300	20	30	20	1000
Average	126	60	4	6	4	200
Percentage	63	30	2	3	2	100

Source: Field survey, 2024

As shown in the table above, on average, 126 (63%) respondents, 60 (30%) respondents, 4 (2%) respondents, 6 (3%) respondents, and 4 (2%) respondents strongly agreed, agreed, were indifferent, disagreed and strongly disagreed, respectively on the evidence of sustainable economic growth in Nigeria.

Table 4.2: Responses to the questions on agricultural marketing in Nigeria

Statement	SA	A	U	D	SD	Total
Market Research and Analysis	112	71	4	7	6	200
Product Development and Innovation	122	55	7	9	7	200
Distribution and Logistics	128	61	3	5	3	200
Pricing and Value Chain Management	124	54	3	8	11	200
Promotion and Advertising	134	49	3	11	3	200
Total	620	290	20	40	30	1000
Average	124	54	4	8	6	200
Percentage	62	29	2	4	3	100

Source: Field survey, 2024

Information in Table 4.2 above shows that an average of 124 (62%) respondents, 54 (29%) respondents, 4 (2%) respondents, 8 (4%) respondents, and 6 (3%) respondents strongly agreed, agreed, were indifferent, disagreed and strongly disagreed, respectively on the elements of agricultural marketing in Nigeria.

Test of Hypothesis

H_0: There is no significant relationship between the state of agricultural marketing and sustainable economic growth

H_1: There is significant relationship between the state of agricultural marketing and sustainable economic growth

Descriptive Statistics

	Mean	Std. Deviation	N
Sustainable Economic Development	4.4900	.84467	200
Agricultural Market Research and Analysis	4.3800	.92187	200
Agricultural Product Development and Innovation	4.3800	1.00030	200
Agricultural Product Distribution and Logistics	4.5300	.78241	200
Agricultural Product Pricing and Value Chain Management	4.3600	1.07992	200
Agricultural Product Promotion and Advertising	4.5000	.89105	200

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.985[a]	.971	.970	.14628	1.397

a. Predictors: (Constant), Agricultural Product Promotion and Advertising, Agricultural Product Distribution and Logistics, Agricultural Market Research and Analysis, Agricultural Product Pricing and Value Chain Management, Agricultural Product Development and Innovation

b. Dependent Variable: Sustainable Economic Development

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	137.829	5	27.566	1288.311	.000[b]
	Residual	4.151	194	.021		
	Total	141.980	199			

a. Dependent Variable: Sustainable Economic Development

b. Predictors: (Constant), Agricultural Product Promotion and Advertising, Agricultural Product Distribution and Logistics, Agricultural Market Research and Analysis, Agricultural Product Pricing and Value Chain Management, Agricultural Product Development and Innovation

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.049	.069		-.707	.480
	Agricultural Market Research and Analysis	.146	.038	.159	3.795	.000
	Agricultural Product Development and Innovation	.020	.061	.023	.323	.747
	Agricultural Product Distribution and Logistics	.628	.038	.582	16.709	.000
	Agricultural Product Pricing and Value Chain Management	.076	.050	.097	1.523	.129
	Agricultural Product Promotion and Advertising	.141	.042	.149	3.322	.001

a. Dependent Variable: Sustainable Economic Development

The test of hypothesis conducted in this study aimed to determine whether there is a significant relationship between the state of agricultural marketing and sustainable economic growth. The results of the analysis showed that there is indeed a significant relationship between these two factors. Descriptive statistics were used to provide an overview of the data. The mean values for sustainable economic development and various aspects of agricultural marketing were calculated. The results showed that the mean values for all variables were above 4, indicating a positive perception of these factors among the respondents. The model summary provided information about the predictive power of the model. The R-squared value of 0.971 indicates that 97.1% of the variance in sustainable economic development can be explained by the variables included in the model. The ANOVA table presented the results of the regression analysis. The F-value of 1288.311 with a significance level of 0.000 indicates that the regression model is highly significant. The coefficients table displayed the standardized coefficients for each predictor variable. The results showed that agricultural market research and analysis, agricultural product distribution and logistics, and agricultural product promotion and advertising have a positive and statistically significant impact on sustainable economic development.

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

The study's findings indicate that targeted efforts in agricultural marketing—particularly in areas such as research, distribution, and promotion—can play a crucial role in driving sustainable economic development. The identified relationships underscore the importance of strategic investments and interventions in agricultural sectors to foster broader economic growth, potentially through improved market insights, efficient product distribution, and effective promotional activities.

Based on the study's findings, it can be concluded that focusing on targeted efforts within agricultural marketing can significantly contribute to sustainable economic development. By investing strategically in research, distribution, and promotion within agricultural sectors, there is potential to drive broader economic growth. This conclusion emphasizes the importance of gaining better market insights, enhancing product distribution efficiency, and implementing effective promotional strategies. Therefore, policy makers

and stakeholders should consider these aspects when planning interventions to promote economic development through agriculture.

Based on the findings, it is recommended that emphasis should be laid on the importance of strategic investments and interventions in agricultural marketing to drive sustainable economic development. By focusing on research, distribution efficiency, and promotional activities, policymakers and stakeholders can unlock the full potential of agriculture as a catalyst for broader economic growth and development.

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ROLE OF SOLAR RADIATION IN MAIZE (*Zea mays* L.) YIELD OPTIMIZATION IN NIGERIA'S RAINFOREST

[a,b]**Fayose, C. A*.,** [b]**Fakorede, M. A. B., &** [c]**Jegede, O. O.**

[a] Department of Agricultural Technology, Ekiti State Polytechnic, Isan Ekiti, Ekiti State, Nigeria
[b] Department of Crop Production and Protection, Obafemi Awolowo University, Ile-Ife, Nigeria
[c] Department of Physics and Engineering Physics, Obafemi Awolowo University, Ile-Ife, Nigeria
*Corresponding author: adegoke_chris@yahoo.com; +2348060365729

ABSTRACT

As a result of climate change causing increased weather variability leading to crop production uncertainties, understanding the impact of solar radiation on crop productivity is crucial for sustainable and resilient agricultural practices. Correlation and regression analyses were used to investigate the interrelationship of incident solar radiation and grain yield of maize, *Zea mays* L., when data on daily solar radiation, grain yield and yield components of five maize varieties planted weekly in Randomized complete block design (RCBD) experiments from the onset to the retreat of rainfall for two years at the Obafemi Awolowo University Teaching and Research Farm were analyzed. Solar radiation had a significant ($P \leq 0.01$) positive influence ($r = 0.335$ to 0.419) on growth as well as grain yield from about 30 days after planting (DAP) rather than the earlier stages of maize growth. Grain yield had linear relationships ($R^2 = 0.4$) with average and total solar radiation beyond 31 DAP, especially at the grain-filling stage. It was concluded that grain yield and yield components of maize were positively influenced by solar radiation post-flowering, especially during grain-filling. Maize should be planted when the grain-filling stage coincides with a period of less cloud cover and maximum solar radiation.

Keywords: Climatology, climate change, crop phenology and physiology, solar radiation.

INTRODUCTION

Maize, *Zea mays* L. remains an important ingredient in the diet of animal and human populations of sub-Saharan Africa (SSA), in addition to its numerous uses in the agro-allied industries (Wei, Bian, Du, *et al.*, 2023). In recent decades, the effects of climatic factors on many aspects of crop growth and development such as germination, chlorophyll formation, initiation of floral parts, among others, have become prominent due to climate change which has manifested with varying impacts on different crops, depending on location and time. Fakorede and Akinyemiju (2003) reported a progressive reduction in the effective growing season at the Obafemi Awolowo University Teaching and Research Farm (OAU T&RF) attributable to climate change, and the trend has intensified over time. Regrettably, the relationship between climate and different aspects of growth and development of tropical crops, particularly, maize is poorly understood, especially in SSA, a direct result of the inadequate research attention it has received hitherto. Many maize climatic studies in SSA have often generalized the requirements throughout its growth cycle, neglecting the specific requirements of the crop at different growth and developmental stages. Optimum growth at each stage contributes, directly or indirectly to the final maize yield. Jong, Brewbaker and Chong (1982) and Fayose (2018) found solar radiation as the single most important climatic variable promoting maize grain yield in the tropics of Hawaii, United States of America and Ile-Ife, Nigeria, the location of the present study. To facilitate the adaptation of the crop to climate change and variability to maximize productivity per unit of land area, it is imperative to identify the specific relationship of global solar radiation with maize yield and determine the critical growth stage(s) where performance is significantly affected. In summary, the main goal of this research was to explore and understand the connection between maize grain yield and the amount of solar radiation it receives at different growth and developmental stages in the tropical rainforest of Nigeria. The specific objectives were to i) identify the response pattern of grain yield of maize cultivars to the availability of solar radiation, ii) determine the critical growth stage(s) where

maize grain yield and solar radiation interaction is most significant, and iii) isolate the specific solar radiation variable with the most influence on grain yield.

MATERIALS AND METHODS

The study was conducted at the OAU T&R Farm, Ile-Ife, a marginal rainforest location in Southwestern Nigeria at about 7° 28' N, 4° 33' E and 244 m above sea level, in 2016 and 2017. In each experiment, five maize varieties (four open pollinated varieties, OPV's and one single-cross hybrid), well adapted to the tropical rainforest environments, were planted in 3-replicate randomized complete block designs. The OPVs included White DT STR SYN1 – TZL Comp. 1–W, TZL Comp. 4 DT F_2, TZL Comp. 1 C6/DTSYN1W all of which are drought tolerant (DT) and of intermediate/late maturity, ACR 94 TZE Comp 5 C_3 (early maturing), and Oba Super 1, an intermediate-late single-cross hybrid obtained from Premier Seeds, Zaria. The four OPVs were obtained from the International Institute of Tropical Agriculture – Maize Improvement Program (IITA-MIP), and all five varieties are white-grained, high-yielding and have been released for commercial production in Nigeria and several other West and Central African (WCA) countries. The experiments were planted weekly from 16th and 15th March for 2016 and 2017 to November each year. Each planting date (DOP) represented the individual environment. 42 DOPs (20 in 2016 and 22 in 2017) were analyzed for yield and its components. Each plot contained six or four rows which were 5 m long and 0.75 m apart; within row spacing was 0.5 m. The experimental land was ploughed and harrowed before planting, and the seeds were treated with Apron* which contains thiamethoxam, mefenoxam (metalaxyl-M) and difenoconazole, to control damage by soil-borne diseases and insect pests. Three seeds were planted per hill and thinning was done at 9 DAP to two plants per stand giving an estimated plant population density of 53,333 plants ha^{-1}. Fertilization and other necessary post-planting agronomic practices were carried out.

Data were collected on grain yield and its components such as ear weight, length, diameter and kernel row number. The grain yield data were adjusted to 15 % moisture content. Data on solar radiation was monitored from the automatic weather station (AWS), OAU MET Station located on the OAU T&R Farm. Solar radiation was later summarized per environment for the different growth stages. The summary includes average (AVG) and total solar radiation from planting to emergence at 9 DAP, vegetative (10 – 30 DAP), pre-silk and silk emergence (31 DAP – mid-silk), grain filling (mid-silk – 100 DAP), early vegetative (emergence – 30 DAP), late vegetative (emergence – mid-silk), and emergence to 100 DAP (full cycle). The average of all daily averages over the days in the different categories was tagged average radiation, while the sum of the daily totals was tagged total radiation. Variance analysis for a mixed model was done on all data using PROC GLM of Statistical Analysis System (SAS, 2000). Further analyses were done using regression and correlation analyses to ascertain the relationship of maize grain yield with solar radiation.

RESULTS AND DISCUSSION

Results showed that the environment had highly significant ($P \leq 0.01$) effect on grain yield and its components. One important factor of the environment, critical for crop production is climate, largely driven by solar radiation. Correlation and regression analyses implicated daily average solar radiation as the more important solar radiation variable at the critical stages of flowering and grain filling. For instance, grain yield appeared to be much less affected by the solar radiation variables at the seedling and early vegetative stages (9 to 30 DAP, Table 1). Grain yield was significantly ($P \leq 0.01$) correlated with average radiation at 31DAP to mid-silk ($r = 0.398$), grain-filling stage (mid-silk to 100 DAP, $r = 0.418$) and full growth cycle ($r = 0.419$). Grain yield showed a significant ($P \leq 0.05$) correlation with total radiation at the grain-filling stage only ($r = 0.372$). The ear aspect rating, showed significant negative correlation with both solar radiation variables at all stages (r-value between -0.353 and -0.462) except pre-silk (31- mid-silk), late vegetative and full growth cycle for average radiation; and early vegetative and full growth cycle for total radiation. Ear diameter, ear length

and kernel row number also responded more to average solar radiation at different growth stages, even though all three yield components showed highly significant correlation with total radiation at the grain-filling stage (Table 1). Figures 1 and 2 revealed a somewhat similar trend when grain yield and total solar radiation were each plotted against the different environments/DOPs. However, that trend was only present at the period before and during flowering, late vegetative, and grain-filling stages. The similarity in trend was less apparent when grain yield was plotted against average radiation. The yield components, especially ear length and kernel row number also showed similar, albeit, subtler trends to average solar radiation at the grain-filling stage.

Stepwise multiple regression of grain yield on solar radiation at all stages also identified significant interaction of grain yield with average radiation at grain filling (mid-silk to 100 DAP), average radiation at the late vegetative phase, total radiation at 31DAP to mid-silk, and total radiation at grain-filling stage, in decreasing order of significance. The prediction equation of the linear regression of yield on average solar radiation at grain filling, which was most tangible, was Y = -0.088 + 0.010X; with an R^2 of 17%, which was quite low. Regressing yield on the daily solar radiation variables at the other stages where there was significance in stepwise multiple regression produced much lower R^2 values [11.3%, 1.1% and 13.9% for average radiation at the late vegetative phase, total radiation at 31DAP to mid-silk, and total radiation at grain-filling stage, respectively]. Plotting a polynomial curve for the regression of grain yield on average radiation did not increase the R^2 value significantly, while the regression of yield on total radiation at the grain-filling stage produced a higher R^2 value of about 40 %, significantly higher than average radiation despite their relatively weak correlation, and results from the stepwise multiple regression analysis. The R^2 value only increased appreciably to about 61 % when a sixth-order polynomial curve was plotted for total solar radiation. The result of the regression of yield on daily total radiation is presented in Figure 3.

Table 1: Correlation coefficients of solar radiation accumulated at different growth stages with grain yield and yield components of five maize varieties evaluated in 42 environments at the OAU T&R Farm in 2016 and 2017.

	Yield (t/ha)	Ear weight (kg)	Ear aspect	Moisture content (%)	Ears/plot	Ear length (cm)	Ear diameter (cm)	Kernel row number
ǂ Solar radiation (w/m^2)								
AVG 9DAP	-0.001	0.018	0.378*	0.381*	-0.151	-0.215	0.142	0.067
AVG 10 - 30DAP	0.117	0.135	0.368*	0.345*	0.001	-0.092	0.29	0.214
AVG 31 – mid-silk	0.398**	0.393*	-0.02	-0.155	0.447**	0.337*	0.414**	0.527**
AVG mid-silk - 100DAP	0.418**	0.391*	-0.462**	-0.573**	0.461**	0.553**	0.215	0.343*
AVG early vegetative	0.117	0.136	0.353*	0.352*	-0.019	-0.087	0.273	0.207
AVG late vegetative	0.335*	0.340*	0.139	0.042	0.315*	0.199	0.417**	0.462**
AVG full cycle	0.419**	0.412**	-0.038	-0.181	0.433**	0.383*	0.417**	0.511**
Total 9DAP	-0.004	0.017	0.389*	0.408**	-0.155	-0.225	0.15	0.055
Total 10 - 30 DAP	0.098	0.116	0.380*	0.343*	-0.011	-0.101	0.292	0.207
Total 31DAP – mid-silk	-0.106	-0.097	0.388*	0.15	0.024	-0.044	0.042	0.027
Total mid-silk - 100DAP	0.372*	0.342*	-0.434**	-0.516**	0.390*	0.445**	0.328*	0.454**
Total early vegetative	0.095	0.113	0.298	0.350*	-0.091	-0.073	0.203	0.169
Total late vegetative	-0.036	-0.022	0.439**	0.251	0.013	-0.074	0.152	0.106
Total full cycle	0.121	0.123	0.094	-0.023	0.079	0.149	0.285	0.047

*, ** - Significant at 5% and 1% level of probability, respectively. ǂ DAP = Days after planting

Maize is one of the most adaptable crops which grows and thrives in diverse agro-ecologies and varying climatic conditions. Optimum performance at every stage of maize growth contributes different measures to the final yield of the crop (Badu-Apraku and Fakorede, 2017). The

need arises therefore, to identify the climatic factors favouring optimum expression of important maize traits to boost production in spite of the changing climate and other production challenges. Results herein show significant effect of solar radiation on maize grain yield with correlation and regression analysis showing that maize yield is influenced by solar radiation at the flowering and grain-filling stages rather than the seedling and vegetative stages. Similar trends were observed when yield and total solar radiation were each plotted against the environments. Surprisingly, correlation and stepwise multiple regression analyses implicated average radiation as the more impactful solar radiation variable on grain yield despite regression plots suggesting total radiation. The reason(s) for this is not immediately clear as net radiation showed no significant interaction with grain yield and its components. Further probe into the specific relationship of grain yield with solar radiation at the grain-filling stage suggests a somewhat positive linear response indicating that yield increased with increased total solar radiation. The result is less clear-cut with average solar radiation, though, as observed from the low R^2 value. This seems strange given the level of influence observed in correlation and stepwise regression. Nevertheless, yield is a complex polygenic trait influenced by several factors, genetic and environmental. Most of those environmental factors are also influenced to varying extents by solar radiation. Therefore, a complex interaction is expected among all the factors including grain yield, which might be responsible for the quite strange results. These results also support the findings of Jong *et al*. (1982) which identified solar radiation at the grain filling stage as the singular factor promoting maize grain yield at the tropics of Waimanalo Research Station, Hawaii, USA. The present study cautiously points to average radiation as the more important variable influencing yield. Jong *et al*. (1982) found a strong linear relationship of grain yield with total solar radiation ($R^2 = 0.8$), while we report a weaker linear relationship ($R^2 = 0.4$) with the same variable. The slight variation is attributable to the difference in the coordinates of the two locations, as Waimanalo in Hawaii is located at 20 masl and 21ºN latitude while OAU T&RF is at about 7ºN and 244 masl. The eras of research are also different, with the present study conducted about three decades after the previous study when climate change has really intensified.

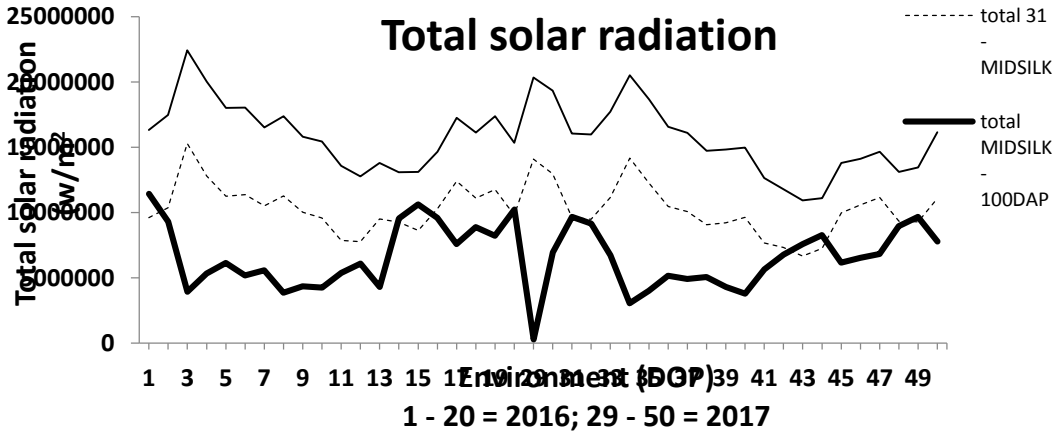

Figure 1: Response of solar radiation to environment (DOP) at different maize growth stages at the OAU T&R Farm in 2016 and 2017.

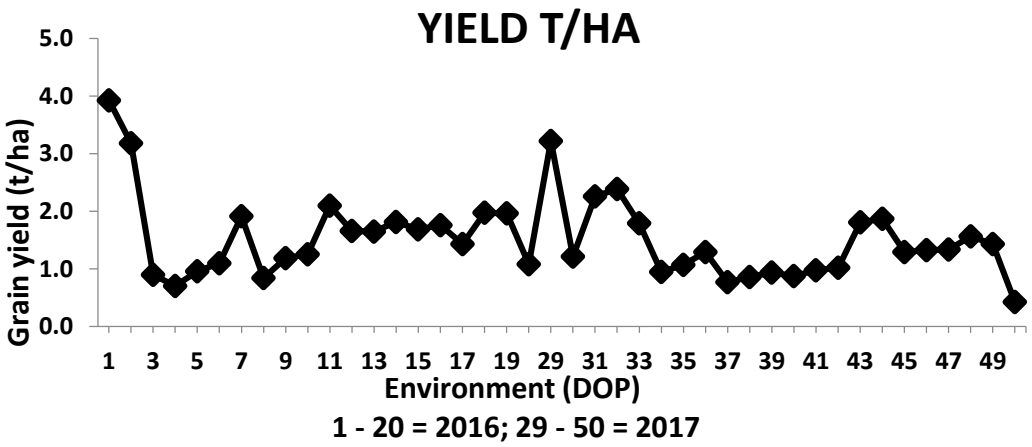

Figure 2: Grain yield of five maize varieties evaluated in 42 environments (DOP) at the OAU T&R Farm in 2016 and 2017.

CONCLUSIONS AND RECOMMENDATION

The grain yield of maize was significantly influenced by solar radiation. Average and total solar radiation both significantly increased grain yield, but average radiation played a greater role. A positive linear response of grain yield to total solar radiation occurred at the grain-filling stage attributable to the role of solar radiation as the main energy source for starch production which is the main ingredient for grain filling. Stepwise multiple regression isolated average solar radiation as the variable promoting yield at the pre-silk, and grain-filling up to maturity stages. We recommend planting maize at a date where flowering and grain-filling stages coincide with periods of less cloud cover, thereby allowing maize crops to receive maximum solar radiation at these stages.

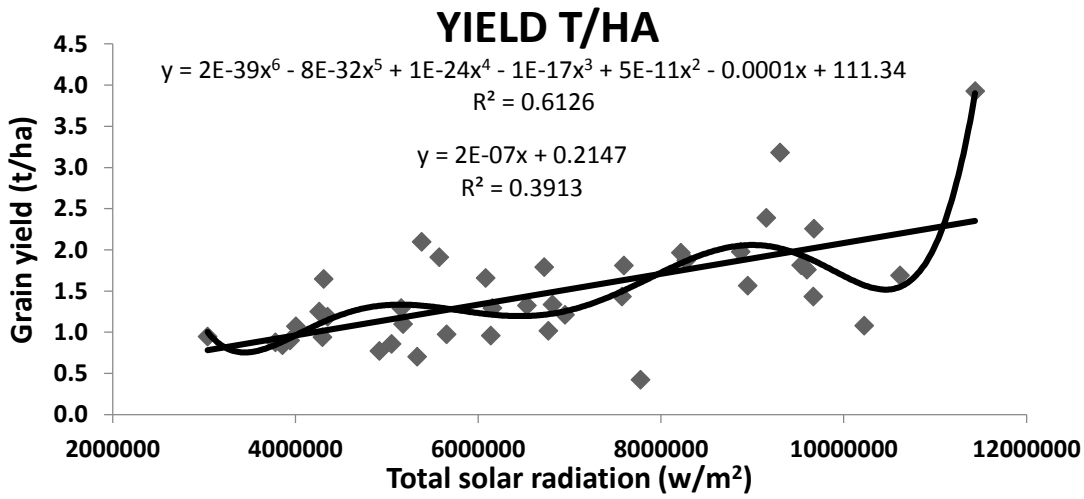

Figure 3: Response of grain yield of five maize varieties to total solar radiation monitored in 42 environments at the OAU T&R Farm in 2016 and 2017.

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EFFECTS OF RABBIT COMPOST TEA AND NPK FERTILIZER ON MAIZE (*Zea mays* L.) GROWTH PARAMETERS

[1]Awopegba T. M.* and [1]Adebiyi C. O.
[1]Department of Agricultural Technology, Ekiti State Polytechnic, Isan-Ekiti, Nigeria
*Corresponding Author: +2348066563742; tmawopegba@ekspoly.edu.ng

ABSTRACT
This study evaluates the effects of rabbit compost tea and NPK (15-15-15) fertilizer on maize (*Zea mays* L.) growth parameters at the Teaching and Research Farm of Ekiti State Polytechnic, Isan-Ekiti, Nigeria. The experimental site is at an elevation of roughly 542 meters, situated between latitude 15° 39' and longitude 70° 12'. This research work was carried out in the wet season of 2023. Four treatments consisting of rabbit compost tea at 400 l ha^{-1}, a combination of NPK at 100 kg ha^{-1} and rabbit compost tea at 200 l ha^{-1}, and the application of NPK (15-15-15) fertilizer at the rate of 200 kg ha^{-1} were laid out in a randomized complete block design (RCBD) with three replicates. Data were collected on maize growth parameters. Data collected on the growth parameters were analysed using the Statistical Tool for Agricultural Research (STAR) and Tukey's HSD test was used to compare significant treatment means. The results demonstrated that all treatments significantly ($p < 0.05$) enhanced growth parameters compared to the control. Specifically, the combination of NPK and rabbit compost tea yielded the highest increases in plant height, stem girth, number of leaves, and leaf area. Rabbit compost tea alone also showed substantial improvements over the control, suggesting its potential as a sustainable organic amendment for smallholder farmers. According to this study, rabbit compost tea is an effective and sustainable organic amendment that smallholder maize farmers should consider using to improve growth.
Keywords: Rabbit compost tea, NPK fertilizer, growth parameters, effect, and maize.

INTRODUCTION
Worldwide, maize (*Zea mays* L.), sometimes known as corn, is a crop that is cultivated in large quantities. According to Badu-Apraku & Fakorede (2017), maize is a member of the grass family. Around the world, maize is a major grain crop that is planted in both temperate and tropical regions with a range of soil types and climates. But to have the best yields, maize needs careful fertility management because it uses a lot of nutrients.

One excellent, nutrient-packed fertilizer that has numerous nutrients for crop growth is rabbit manure (Adi *et al.,* 2020) which is also known as rabbit poop or pellets. Adi et al. (2020) found out that rabbit manure contains high levels of nitrogen, and that applying rabbit manure straight to plants is safe and will not cause any injury to them (Ame, 2021). In terms of nutrients, rabbit manure is twice as rich as chicken manure and four times richer than cow or horse manure (Ame, 2021). Rabbit manure is considered "cold" manure; that is, it can be added directly to plants immediately after collecting from the rabbit hutch without burning the plants.

Rabbit compost tea is a natural, organic fertilizer made from rabbit manure. It is a rich source of nutrients, such as nitrogen, phosphorus, and potassium. Other minerals contained in rabbit manure, including calcium, sulphur, magnesium, and other micronutrients, are also in abundance. Compost tea is a nutrient-rich solution obtained by fermenting compost in water to extract soluble organic matter, beneficial microorganisms, and nutrients (Ramírez-Gottfried *et al.,* 2023). Little or no attention has been drawn to the use of rabbit compost tea for the growth of crops. However, this study will help to evaluate the effects of rabbit compost tea and compare the combined use of rabbit compost tea and NPK fertilizer on the growth parameters of maize.

MATERIAL AND METHODS

Description of Experimental Site and Land Preparation
The research work was conducted at the Teaching and Research Farm of Ekiti State Polytechnic, Isan-Ekiti, Nigeria. At an elevation of roughly 542 meters, this study region is situated between

latitude 15° 39' and longitude 70° 12'. It is located in the southwest of Nigeria, in a rainforest.

Source of Material

An improved maize hybrid (Ife Hybrid-5) was obtained from the International Institute of Tropical Agriculture.

Preparation of Rabbit Compost Tea

The rabbit compost tea was prepared by adding 5 kg of rabbit pellet to 20 liters of water in a container. The content in the container was exposed to sunlight for four days with an enclosed lid. The mixture was stirred twice a day. Finally, the liquid strained from the mixture was known as compost tea

Land Preparation and Experimental Design

The experimental field was harrowed and cleared mechanically, and there after followed by field layout. There were 12 plots measuring 2 m × 3 m (6 m^2) and 1 m of alleyways separating the plots and replicates giving a total land area of 88 m^2 (11 m by 8 m). The treatments and treatment combinations are listed below:

Planting and Cultural Practices

Maize seeds were sown at two seeds per hill at a spacing of 75 cm x 45 cm (29,630 plants/ha). Weeding was done using hand-pulling and hand hoeing at 2, 5 and 8 weeks intervals after planting.

Treatment Application

NPK 15:15:15 fertilizer at 200 kg ha^{-1} was applied by side placement, while rabbit compost tea application was achieved by foliar spray. The treatments were split into two levels of applications as indicated in the treatments table below:

Table 1: List of treatment combinations

Acronym	Treatment description
T_1	0 RCT + 0 NPK
T_2	100 kg ha-^{1} of NPK applied at 2 WAP + 100 kg ha-^{1} of NPK applied at 4 WAP
T_3	200 l ha^{-1} of RCT applied at 2 WAP + 200 l ha^{-1} of RCT applied at 4 WAP
T_4	200 l ha^{-1} of RCT applied at 2 WAP + 100 kg ha-^{1} of NPK applied at 4 WAP

RCT = Rabbit Compost Tea, WAP = Weeks after Planting

T_1 = Control, T_2 = NPK (15-15-15) fertilizer at 200 kg ha^{-1}, T_3 = Rabbit compost tea at 400 l ha^{-1} T_4 = NPK (15-15-15) fertilizer at 100 kg ha^{-1} plus rabbit compost tea at 200 l ha^{-1}.

Agronomic Data Collection

Ten plants were tagged per plot to collect data on the growth parameters. Plant height was measured with the use of the meter rule (cm), and the number of leaves was determined by counting the leaves. At ten weeks after planting, stem girth was measured via vernier caliper (cm), and leaf area (cm^2) was calculated. The data were collected from 3 weeks after planting to 10 weeks after planting on weekly basis.

Leaf Area = Leaf length x maximum leaf width x 0.75 ----------eqn. 1 (Elings, 2000)

Data Analysis

Data collected on the growth parameters were analysed using the Statistical Tool for Agricultural Research (STAR) and Tukey's HSD test was used to compare significant treatment means.

RESULTS AND DISCUSSION

Rabbit compost tea has a high N content of 4.2%. However, NPK fertilizer had a N content of 14.92%, P content of 14.80 and K content of 14.88%, which was far greater than rabbit compost tea (Figure 1). The highest P level was found in NPK fertilizer, with 14.80%. Rabbit compost tea had a 1.75% P content. Calcium and magnesium were the other elements that were analyzed. Rabbit compost tea contained the highest Ca and Mg content of 1.60 and 1.40 mg/kg, respectively.

Throughout maize growth period, all treatments produced significantly taller plants than the control ((Table 2). Plots with NPK fertilizer had the tallest plants (26.33 cm) at 4 weeks after planting (WAP), followed by rabbit compost tea (25.50 cm). The combination of rabbit compost tea at 200 l/ha and NPK fertilizer at 100 kg/ha could reasonably compete with NPK fertilizer on maize height at 5 WAP. However, from 8 to 10 WAP when the experiment was terminated, the combination of NPK fertilizer at 100 kg/ha and rabbit compost tea at 200 l/ha produced the tallest plants.

Maize number of leaves was significantly ($p < 0.05$) enhanced by both the NPK fertilizer and the combination of NPK and RCT fertilizer used as treatments (Table 3). Throughout the period of observation, the rabbit compost tea treatment produced more leaves than the control. The NPK and NPK plus RCT fertilizer treatments did not differ significantly ($p > 0.05$).

All the treatments significantly ($p < 0.05$) increased the maize leaf area when compared with the control at 10 WAP (Table 4). There were no significant differences ($p > 0.05$) among the rest of the treatments; however, there were variations in leaf area in their response to treatments at 10 WAP, with values of 406.00, 396.75, and 409.00, respectively, for the NPK fertilizer, RCT, and NPK plus RCT. At 10 WAP, there were significant ($p < 0.05$) differences in maize stem girth among the treatments. The combined application of NPK and RCT had the highest stem girth (Table 4). The application of NPK and RCT to maize resulted in a significant increase in stem girth, indicating that RCT is a great source of mineral nutrients required for plant growth.

This study has been able to show that compost tea obtained from rabbit pellets or manure contains a considerable amount of macro- and micronutrients. The use of rabbit compost tea as a fertilizer makes nutrients and beneficial microorganisms available for maize plant growth. The results of this study showed that rabbit compost tea, which is prepared without aeration, contains soluble nutrients that promote the growth of maize plant.

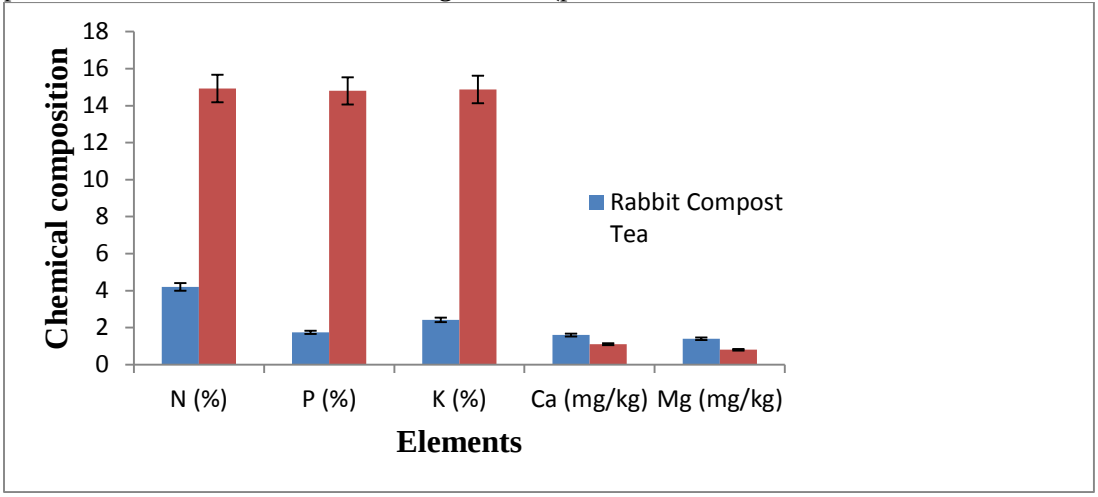

Figure 1: Chemical composition of rabbit compost tea and NPK (15-15-15) fertilizer

Table 2: Effect of rabbit compost tea and NPK fertilizer on plant height at different stages of maize growth

Treatments	Plant height (cm)							
	Weeks after planting							
	3	4	5	6	7	8	9	10
Control	14.67^{a}	18.83^{c}	23.27^{c}	34.67^{c}	47.80^{c}	58.63^{c}	60.03^{c}	60.33^{c}
NPK (15-15-15)	14.83^{a}	26.33^{a}	37.87^{a}	54.53^{a}	69.27^{a}	74.00^{b}	79.20^{ab}	79.66^{ab}
Rabbit compost tea (RCT)	13.13^{a}	25.50^{ab}	32.50^{b}	48.57^{b}	61.77^{b}	71.37^{b}	75.67^{b}	76.17^{b}
NPK + RCT	13.03^{a}	20.93^{bc}	35.26^{ab}	54.07^{a}	71.33^{a}	81.63^{a}	83.07^{a}	83.30^{a}
S.D	1.668	4.238	7.432	9.295	11.877	9.692	10.308	10.331
SEM	0.482	1.224	2.145	2.683	3.428	2.798	2.976	2.982

Means with the same letter in the same column are not significantly ($p > 0.05$) different, as indicated by Tukey's HSD test. S.D = Standard Deviation, SEM= Standard Error of the Mean

Table 3: Effect of rabbit compost tea and NPK fertilizer on the number of leaves at different stages of maize growth

Treatments	Number of leaves (10 plants/plot)							
	Weeks after planting							
	3	4	5	6	7	8	9	10
Control	6.67^{bc}	9.00^{b}	9.00^{b}	11.00^{b}	11.67^{c}	12.33^{c}	13.00^{c}	12.67^{c}
NPK (15-15-15)	7.67^{a}	10.33^{a}	11.67^{a}	13.00^{a}	14.00^{ab}	15.33^{a}	15.67^{a}	15.67^{a}
Rabbit compost tea (RCT)	6.00^{c}	9.67^{ab}	11.00^{a}	12.67^{a}	13.3^{b}	14.00^{b}	14.33^{b}	14.33^{b}
NPK + RCT	7.00^{ab}	9.33^{b}	11.33^{a}	12.33^{a}	14.33^{a}	15.67^{a}	16.00^{a}	15.67^{a}
S.D	0.835	0.792	1.215	0.866	1.231	1.435	1.288	1.379
SEM	0.241	0.229	0.351	0.251	0.355	0.414	0.372	0.398

Means with the same letter in the same column are not significantly (p> 0.05) different, as indicated by Tukey's HSD test.

Table 4: Effect of rabbit compost tea and NPK fertilizer on leaf area and stem girth of maize

Treatments	Leaf area (cm^2)	Stem girth (cm)
	10 Weeks after planting	
Control		
Mean ± SEM	305.00 ± 28.645^{b}	1.63 ± 0.057^{d}
Mean ± S.D	305.00 ± 49.615^{b}	1.63 ± 0.098^{d}
NPK (15-15-15)		
Mean ± SEM	406.25 ± 30.973^{a}	2.05 ± 0.038^{b}
Mean ± S.D	406.25 ± 53.646^{a}	2.05 ± 0.066^{b}
Rabbit compost tea (RCT)		
Mean ± SEM	396.75 ± 17.250^{a}	1.86 ± 0.059^{c}
Mean ± S.D	396.75 ± 29.878^{a}	1.86 ± 0.102^{c}
NPK + RCT		
Mean ± SEM	409.00 ± 22.426^{a}	2.12 ± 0.045^{a}
Mean ± S.D	409.00 ± 38.843^{a}	2.12 ± 0.078^{a}

Means with the same letter in the same column are not significantly (p> 0.05) different, as indicated by Tukey's HSD test.

CONCLUSION AND RECOMMENDATION

This study demonstrated the benefits of using rabbit compost tea as a fertilizer for cultivating maize. The pattern of maize growth in this study infers that rabbit compost tea could compete positively with inorganic fertilizers. Preferably, the combination of rabbit compost tea at 200 l/ha and 100 kg/ha of NPK performed better when compared with the use of 200 kg/ha of NPK. Rabbit compost tea is an effective and sustainable organic amendment that smallholder farmers should consider using to improve the growth of maize.

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COMBINING ABILITY VARIANCE COMPONENTS FOR MORPHOLOGICAL RESPONSES OF MAIZE (*Zea mays* L.) INBRED LINES TO COMBINED DROUGHT AND HEAT STRESSES

Dawaki K. D [1]., Magashi A.I [1]., Daraja Y.B [1]., Yawale M.A.[1]., Garko M.S [3]., Fulani M.S [1]., Sa'ad A.M[1] and Safiyanu S.A.[2]

[1]Department of Crop Science, Kano University of Science and Technology, Wudil P.M.B 3244, Kano-Nigeria
[2]Department of Agricultural Economics and Extension Kano University of Science and Technology, Wudil, P.M.B 3244, Kano-Nigeria
[3]Faculty of Agricultue and Natural Resource Management Sule Lamido University Kafin Hausa P.M.B 048,
Jigawa-Nigeria
Corresponding author: **kabirudawaki@gmail.com**

ABSTRACT
Drought and heat are major abiotic constraints causing limitations to plant growth worldwide and limited focus has been given to combination of the two stresses. The experiment was conducted to study combining ability of maize populations under drought and heat stress conditions. A half diallel cross comprising of nine parental inbred lines were developed and studied in order to estimate combining ability variance components of some morphological traits and to determine the type of gene action of maize traits under drought and heat stress conditions. The parental materials consisted of nine genotypes of maize inbred lines which were crossed in a partial diallel pattern, which generated 45F1's crosses. The crosses were evaluated in alpha lattice design replicated 3 times at Aliko Dangote University of Science and Technology, Wudil, Kano State, Nigeria during 2022 dry season. Analyses of variance showed that both additive and non-additive gene effects were most elaborate in the control of traits. The proportion of GCA mean squares was higher than that of SCA for most of the traits. This showed the higher contribution of additive gene effects to genetic inconsistency of the traits than the non-additive genetic variance in the crosses for most of traits. The magnitude of GCA/ SCA variance components ratio were greater than unity for all the traits measured) implying that the inheritance of these traits were due to GCA and mostly controlled by additive gene action. Additive and non-additive gene actions are imperative in governing grain yield and yield contributor for heat and drought traits which is approved by the existence of vastly significant GCA and SCA mean squares.
Keywords: Combining Ability; Drought; Heat, Inbred lines and Maize

INTRODUCTION
Maize (*Zea mays* L.) is among the most important cereals for both human and animal
Consumption, where used as food, feed, and fodder. In addition, many products such as oil, starch, gluten, alcohol, glucose, and ethanol are obtained as a maize product (El-Shamarka *et al*., 2015). In Nigeria, maize has become one of the 5 major cereals crops (including wheat, barley and sorghum) in terms of production volume, area coverage and household consumption (Abate *et al*., 2015). It occupies about 2 million ha, the 2nd largest production area next to rice. Approximately 9 million smallholders account for 95% of the national maize production (Taffesse *et al*., 2012). However, yet, the actual maize yield is still lag on-farm and on station trial yields (Kassie *et al.,* 2014). This is attributed due to shortage of high yielding varieties, biotic and abiotic stresses (Mosisa *et al*., 2012) are the foremost contributors for low yield.
In contrast, population growth and changing consumption patterns have increased global food demand and are threatening food security in the developing world (Dzanku *et al*. 2015).It is very sensitive to abiotic stresses, including high temperature, which leads to considerable yield loss in crop production. Of the various abiotic stresses such a slight intensity, salinity, drought, temperature (freezing/heat) is the most prevalent that considerably retard not only plant production

but also the quality of crops (Ashraf *et al.*, 2011, Ahmad *et al.*,2012*;* Ashraf 2012). Heat stress is defined as the rise in temperature beyond a threshold level for a period sufficient to cause permanent damage to plant growth and development (Lipiec *et al.,* 2013). The disturbance in cellular homeostasis is due to high temperature stress which can cause drastic reduction in growth, development and even death of plants (Hasanuzzaman‥ 2013) The growth and development optimum temperature is specific to each genotype. The temperature stress occurs when the environmental temperature increases beyond the critical limit. Heat stress is responsible for1.0-1.7% maize yield loss per day,for every degree rise in temperature above 30 EC (Lobell *et al.*2011; Rahman *et al.,*2015) found that heat stress provided at the time of anthesis and subsequent developmental stages of grain formation was more devastating when temperature fluctuated between 40-45EC and sometimes up to 48EC in Nigeria. Drought is defined as a conditionwhereby there is inadequate moisture in the soil at a particular time to meet the needs of the plant (FAO, 2013). Maize yield losses due to drought stress range between 17-60% in southern Africa (Fischer *et al.,* 1989; Rosen and Scott,1992. Meeks *et al*. 2013) evaluated maize inbred lines and their hybrid testcross progeny at seedling stage for germination, survival and recovery after a series of drought cycles and concluded that seedling stress response is more useful as secondary screening parameter for maize genotypes.

Maize plants usually develop different mechanisms to counter act the environmental stresses. They need to adapt quickly to overcome these stresses during their short life cycle.

From simulation models, an average increase in temperature of up to 2.5-5.4EC can be expected by year 2100 coupled with a decrease in precipitation of about 15% (Tadross *et al* .,2007; Ciscar.,2012).Warming is projected to occur during the 21st century, with plausible increases of 4-6EC over the sub-tropics and 3-5EC over the tropics by the end of the century under low mitigation Scenario (Engel *et al.*, 2015). Stress as it is understood today is a factor that alters normal functioning of a number of mechanisms in an organism (Ahmad, 2016). The majority of research on abiotic stresses has focused on individual stresses while in farmers' field, plants are regularly subjected to a combination of stresses (Voesenek and Pierik, 2008; Cairns *et al*,2013). With the general warming of the world, developing cultivars of maize that can perform well under heat stress, drought stress and combined heat and drought stress should be taken into consideration. The tolerance of plants to a combination of different stress conditions, especially those that mimic the field environment should be the focus of future research (Mittler., 2006).The aim of the study was to determine the mode of gene action controlling the inheritance of tolerance to heat, drought and combined heat and drought stress in maize inbred lines. Moreover, the study sought to identify some secondary traits associated with these stresses, which could be utilized for maize selection.

MATERIALS AND METHODS

The parental materials consisted of nine maize inbred lines which were crossed in a partial diallel pattern, which generated 45F1's crosses. The crosses were evaluated in alpha lattice design replicated 3 times at Aliko Dangote University of Science and Technology, Wudil, Kano State, Nigeria during 2022 dry season. One row plot of 5m long spaced 0.75m x 0.25m inter and intra row spacing was used. Sowing was manually done at two seeds per hole. It was thinned to one stand per hole at two weeks after planting. Irrigation water was applied to field capacity once every week to all the conditions during the first 5 weeks (35 days) after sowing. The well- watered and stress conditions were separated from each other by 2.5m alley to prevent spill-over at the water stress sites during the period of imposed water and drought stress and at the beginning and end of each replication; non experimental lines were raised to minimize the edge border effects. Fertilizer was applied at the recommended rate of compound fertilizer (NPK 20:10:10) as basal dressing and urea (46 % N) as top dressing, giving a total plant nutrient of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O per hectare. Three hoe weeding were done; the first one at two weeks after sowing the second at four weeks after sowing and third weeding was at six weeks after sowing. Data were collected on: Days to 50%

Flowering, Days to 50% Silking , Anthesis Silking Interval, Days to Maturity, Tassel Blast, Barren Plant, Leaf Death Score, Plant Height, Ear Height, Plant Aspect, Ear Apect , Grain Weight , Grain Yield

Statistical Analysis was computed using Statistical Analysis System (SAS, 2004) and means were separated by Student Newmans Keul (SNK) at 5% level of significance.

RESULTS AND DISCUSSION

Mean squares due to genotypes for the studied attributes were estimated to describe the observed variation. All traits due to crossing Days to 50% Flowering (0.0005**), Days to 50% Silking (0.55**), Anthesis Silking Interval (0.95**), Days to Maturity (1.64**), Tassel Blast (0.05*), Barren Plant (0.08*) , Leaf Death Score (1.56**), Plant Height (0.21**), Ear Height (1.23**), Plant Aspect (0.05**), Ear Aspect (0.27*), Grain Weight (6.12), Grain Yield (0.62**) , showed significant difference for both General Combining Ability (GCA) and Specific Combining Ability (SCA) at ($P<0.05$) level of significance. This result showed the existence of adequate genetic variability in the experimental genotypes under study and used to curtain the importance of both additive and non-additive components of genetic discrepancy in inheritance of these characters. Mean square of the genotypes due to GCA showed significant difference ($p<0.05$) for the all studied traits (Table 1).The mean square of SCA also showed significant difference ($p<0.05$) for all traits except Tassel Blast (0.05), Barren Plant (0.01) , Plant Aspect (0.01) (0.01) respectively. The results of analysis of combining abilities obtained from this study indicated the importance of both additive gene actions in controlling these agronomically important traits. In line with this study, many maize researchers have reported significant differences in GCA for grain yield and yield-related traits in different maize genotypes studied (Legesse *et al*. (2017), Tolera *et al.* (2017), Bitew *et al*. (2017)]. Generally, the contribution of GCA variance was much greater than that of SCA variance for all the traits indicating the predominance of additive gene action for the inheritance of the affected traits (Table 1). Similar findings were reported by Berhanu (2009) who stated that the contribution of GCA for the total variation was higher than SCA. Anderson *et al*. (2012) observed that the main percentage of genetic variation in maize is because of additive genetic effects. Fan *et al,* (2016) suggested that general combining ability effects of specific lines are controlled by genes with additive effects and these effects can be transferred to the next generation. The magnitude of GCA/ SCA variance components ratio were greater than unity for all the traits measured: Days to 50% Flowering (3.80), Days to 50% Silking (12.33), Anthesis Silking Interval (14.44), Days to Maturity (11.42), Tassel Blast (3.00), Barren Plant (8.00) , Leaf Death Score (11.39), Plant Height (14.00), Ear Height (12.85), Plant Aspect (3.00), Ear Aspect (5.40), Grain Weight (12.03), Grain Yield (11.57) implying that the inheritance of these traits were due to GCA and mostly controlled by additive gene action (Griffing, 1956).

CONCLUSION AND RECOMMENDATION

Analysis of variance showed that both additive and non-additive gene effects were most elaborate in the control of traits. Though, the proportion of GCA mean squares was higher than that of SCA for most of the traits. This showed the higher contribution of additive gene action to genetic inconsistency of the traits than the non-additive genetic variance in the crosses for most of traits. Additive and non-additive gene actions are imperative in governing grain yield and yield contributor for heat and drought traits which is approved by the existence of vastly significant GCA and SCA mean squares. Further evaluation of these inbred lines under drought and heat environments is recommended over multiple locations in order to ascertain the findings of this study

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Table 1: Mean squares for combining ability of 13 heat and drought tolerance traits of maize evaluated at Aliko Dangote University of Science and Technology,WudilResearch Farm during 2022 dry season

Traits	DF	DFF	DFS	ASI	DM	TB	BP	LSD	PH	EH	PA	EA	GR WEIGHT	G YIELDkg
Rep	2	0.002	0.023	0.08	0.02	0.25**	0.39	0.5	0.19	0.37	0.25	0.15	0.13	0.14
Crosses	44	0.005**	0.55**	0.95**	1.64**	0.05*	0.08*	1.56**	0.21**	1.23**	0.05*	0.27**	6.12**	0.62**
GCA	8	0.0038**	0.74**	1.30**	2.17**	0.03*	0.08**	2.05**	0.28**	1.67**	0.03*	0.27**	8.18**	0.81**
SCA	36	0.001**	0.06**	0.09**	0.19**	0.01	0.01	0.18**	0.02*	0.13**	0.01	0.05**	0.68**	0.07**
Error	88	0.0004	0.002	0.007	0.002	0.01	0.01	0.02	0.004	0.005	0.01	0.01	0.01	0.02
GCA/SCA		3.80	12.33	14.44	11.42	3.00	8.00	11.39	14.00	12.85	3.00	5.40	12.03	11.57

KEY: DFF-Days to 50% Flowering, DFS= Days to 50% Silking , ASI= Anthesis Silking Interval, DM=Days to Maturity, TB=Tassel Blast, BP-Barren Plant, LSD=Leaf Death Score, PH-Plant Height, EH=Ear Height, PA=Plant Aspect, EA=Ear Apect , GR WEIGHT=Grain Weight , G YIELD=Grain Yield

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PROXIMATE AND MINERAL ANALYSIS OF ALOE VERA (*Aloe barbadensis miller*) LEAF MEAL

[1]Olayinka, O.I. and [2]Ibiwoye, K.O.
[1]Kabba College of Agriculture, Livestock Section, P.M. B 205, Kabba, Kogi State, Division of Agricultural Colleges, Ahmadu Bello University, Kaduna State. Nigeria.
[2]Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, P.M.B.810107, Zaria, Nigeria.
Corresponding Author: babawaleoluseyi@gmail.com, Phone Number: 07069387726

ABSTRACT
Aloe vera has a long history as medicinal plant with diverse therapeutic applications. An experiment was conducted to analyze quantitatively, the proximate and mineral analysis of aloe vera leaf meal. Result obtained from the proximate analysis of Aloe vera leaf meal was found to be rich in carbohydrate (50.40%), protein and lipid content were found to be relatively high (19.27 and 6.50 % respectively) while ash and crude fat were 10.83 and 1.50% respectively. The results obtained from the mineral analysis were; sodium and potassium content (12.00 and 60.20 mg/kg respectively) of the leaf meal. Aloe barbadensis leaf meal is also found to be rich in calcium and phosphorus (4.20 and 60.18 mg/kg), which is essential for bone formation. Potassium and magnesium (5.0 mg/kg). The overall data suggest that A. barbadensis leaf meal has some nutritional and medicinal properties.
Keywords: Aloe vera, leaf meal, proximate and mineral analysis.

INTRODUCTION
Aloe vera (*Aloe barbadensis miller*), belong to the family of the Liliaceae, it is a cactus-like plant and one of the oldest medicinal plant which is a perennial plant with turgid green leaves joined at the stem in a rosette pattern. The Aloe vera leaves are formed by a thick epidermis (skin) covered with cuticles surrounding the mesophyll, which can be differentiated into chlorenchyma cells and thinner walled cells forming the parenchyma, a short stemmed plant growing from 30-100 cm tall spreading by offsets. The parenchyma makes up the majority of the leaf by volume containing the aloe vera gel, synonymous with the inner leaf, inner leaf fillet, or aloe fillet (Guo and Mei, 2016). The plant is rich in many natural health promoting substances and raw pulp of aloe vera contains approximately 98.5% water, while the mucilage or gel consists of about 99.5% water, the remaining 0.5–1% solid material consists of a range of compounds including water soluble and fat-soluble vitamins, minerals, enzymes, mono and polysaccharides, sugar, lignin, phenolic compounds and organic acids. The medicinal qualities of aloe vera are much diversified and adoptogenic, and these include healing effect, reduces blood sugar in diabetes, sooths burn, eases intestinal problem, reduces arthritic swelling, ulcer curative object, stimulates immune response against cancer and it also provides antimicrobial, hypoglycemic effect, antioxidative, stimulates uterine contraction and anti-pruritic activities (Das, 2011). Therefore, the aim of this study is to investigate the proximate and mineral composition of aloe vera leaf meal.

MATERIALS AND METHODS
Collection and preparation of Samples.
Fresh leaves of aloe vera (*Aloe barbadensis miller*) was collected from the Horticultural section of Kabba College of Agriculture, Kabba, Kogi state. The samples were brought to the Biochemical Laboratory of Ahmadu Bello University, Zaria, Kaduna State. Kabba is located in the Southern Guinea Savannah Ecological Zone of Nigeria on the Latitude $7^0$53'N, Longitude $6^0$02'E with an average rainfall of about 1500 mm per annum and average temperature ranges from 18-32^{0}C. It is 427 m above sea level (Kabba College of Agriculture Meterological Station, 2024). The aloe vera was visually inspected. Defective tubers were removed and discarded. Hence, only matured healthy aloe vera leaves were selected. The fresh leaves were chopped and labelled.

Proximate Analysis

Samples were evaluated to determine moisture, crude protein, crude lipid, ash, crude fibre,

carbohydrate and mineral contents employing methods described by Association of Official Analytical Chemist (AOAC, 2005). The proximate values were reported in percentages. Determination of ash content was done by ashing at 550ºC for 3 hours. The Kjeldah method (AOAC, 2005) was used to determine the crude protein contents by multiplication of the nitrogen value with a conversion factor (6.25). The crude fibre content of the sample was determined by digestion method and the lipid content was determined by Soxhlet extraction method (AOAC, 2005). Total soluble carbohydrate was determined by the difference of the sum of all the proximate composition from 100%

Mineral Analysis

The mineral elements determined in this study were sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P), nitrogen (N), chromium (Cr), copper (Cu), selenium (Se) and zinc (Zn) are subjected to employing ethylene diamine tetra-acetic acid (EDTA) method (Harbone, 1973).

RESULTS AND DISCUSSION

The results of the proximate composition are shown in Table 1. Results obtained showed that carbohydrate content was high (50.40%) relative to others proximate values, followed by moisture (11.50%), ash (10.83%) crude protein (19.27%), crude fiber (6.50%) and lipid (1.50%) in descending order. These results indicate that aloe vera leaf meal contains some considerable levels of nutrients other than their phytogenic values. Higher carbohydrate content (50.40%) shows that aloe vera is a good source of energy for the body, this result is in agreement with the report of Adeyeye and Ayejuyo (2000). Carbohydrates provide readily accessible fuel for physical performance and regulate nerve tissue. The carbohydrate of Aloe vera juice have been reported to be glucose and a polyuronide composed of (a) a polyose (molecular weight up to about 2.75 x 105) containing glucose and mannose and (b) hexuronic acids such as glucuronic, mannuronic and galaturonic acids. A polysaccharide acemannan found in aloe vera acts as an immune stimulant against psoriasis vulgaris.The occurrence of carbohydrate as the highest parameter in this study is similar to that of Haque *et al.* (2011) and Mustapha (2006) who reported (56.27 and 56.64% respectively) carbohydrate content in Aloe vera leaf. Average moisture content (11.50 %) was the second highest parameter noted. It has been proven that too much moisture in any sample cause caking especially in flour and can also determine the Storage/Shelve life and the viability of microorganisms' growth (Adeyeye and Ayejuyo, 2000).

Ash content is very important in nutritional evaluation and is a reflection of the mineral preserved in the sample. It represents the total mineral content, which are essential for the proper functioning of tissues and act as second messengers in some biological cascade mechanisms. The value obtained in this result (10.83%) showed that aloe vera has high proportion of minerals which is in accordance with the report of Haque *et al.* (2011). Protein, was the fourth highest (19.27 %) parameter noted. Crude fibre content was the fifth highest (6.50 %). It could help in bowel movement. The lowest parameter noted was crude fat content (1.50 %).

The results of the minerals composition are shown in Table 2. Ten minerals were detected with K and P having the highest content (60.20 and 60.18 mg/kg respectively), followed by Se (20.13 mg/kg), Na (12.01 mg/kg), Cu (6.21 mg/kg), Mg (5.00 mg/kg), Ca (4.20 mg/kg), Cr (1.41 mg/kg), Zn (1.07 mg/kg) and the least is N (0.05 mg/kg). The mineral matter P was found to be (60.18 mg/g) of aloe vera powder. The main function of Ca and P is in the formation of bones and teeth, regulation of nerve and muscle function. It plays an important role in how the body uses carbohydrates and fats. Phosphorus also helps the body make ATP, a molecule the body uses to store energy. The concentration of micro minerals N, Cr, Cu, Se and Zn was found to be 0.05, 1.41, 6.21, 20.13 and 1.07 mg/kg respectively.

Table 1: Proximate composition of aloe vera leaf meal

Parameter	Composition (%)
Moisture content	11.50
Crude protein	19.27
Crude fibre	6.50
Ash	10.83
Crude fat	1.50
Carbohydrate	50.40

Table 2: Mineral composition of aloe vera leaf meal

Parameter	Composition (mg/kg)
Macro elements:	
Potassium (K)	60.20
Phosphorus (P)	60.18
Sodium (Na)	12.01
Magnesium (Mg)	5.00
Calcium (Ca)	4.20
Micro elements:	
Nitrogen (N)	0.05
Chromium (Cr)	1.41
Copper (Cu)	6.21
Selenium (Se)	20.13
Zinc (Zn)	1.07

CONCLUSION

Aloe vera leaves has been proved from the results obtained in this study to be a good source of protein, carbohydrate, fat and minerals. It could therefore, be concluded that Aloe vera is an important dietary source of nutrients in a feed based approach for combating micronutrient deficiency.

RECOMMENDATION

It can be recommended that aloe vera leaf contain both macro and micro minerals which are very essential in the livestock nutrition. Aloe vera leaf are good sources of crude proteins, crude fat, carbohydrate, ash, moisture and crude fibre which have the potentials of being combined in livestock nutrition as feed supplements/ additives or as alternative to antibiotic growth promoter.

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EFFECTS OF AKILIMO ADVISORY SERVICES ON PRODUCTION EFFICIENCY OF CASSAVA-BASED FARMERS IN OGUN STATE, NIGERIA

Ogunseye, E. O. & Adekunle, C. P.
Department of Agricultural Economics and Farm Management, Federal University of Agriculture, Abeokuta, Ogun State
Corresponding Author: anuoluwapoboyle@gmail.com; Telephone: +2348057075092

ABSTRACT
This study examined the effects of Akilimo advisory services **(**an agronomic advisory service that provides tailored recommendations to farmers on aspects of cassava cultivation to optimize productivity and profits) on the production efficiency of cassava-based farmers in Ogun State. A multistage sampling procedure was used to select 192 respondents for the study. Primary data were obtained and analysed using descriptive statistics, Tobit regression, and Stochastic Frontier Analysis. Half (51.7%) of the respondents were aware of Akilimo while 39.0% used one or more Akilimo services provided. Most (87.1%) of the respondents were visited by extension agents. The respondents considered ease of understanding, relevance of information, trust in information, and ease of access in adopting Akilimo. The mean technical efficiency of adopters and non-adopters were 0.79 and 0.61. The mean economic efficiency for adopters and non-adopters was 0.63 and 0.49. Tobit analysis revealed that age (α= -0.012, $p<0.05$), and household size (α= -0.781 $p<0.01$) negatively affected the adoption while awareness (α= 1.106 $p<0.01$) positively affected the likelihood of adopting Akilimo advisory services. SFA reveals that the technical efficiency of adopters was significantly affected by extension visits while years of farming experience affected the technical efficiency of non-adopters. The study concluded that adopters were more technically and economically efficient than non-adopters. Extension agents should be empowered to create awareness and disseminate information on Akilimo to increase farmers' technical and economic efficiencies.

INTRODUCTION
The African Cassava Agronomy Initiative (ACAI) launched Akilimo, an agronomic advisory service specifically designed for smallholder farmers and it is available in application (android), web(online) and mobile-based (text or voice chat) versions. The name Akilimo is formed from the Swahili words 'Akili' (Smart/Intelligent) and 'Kilimo' (Agriculture) which can be translated loosely to smart agriculture (Bentley et al, 2020, 2021).

The Akilimo advisory service provides real-life updated information on current market prices and weather forecasts, supplying information to farmers so they can decide on farming operations and techniques with more knowledge, taking into account their specific location, soil type, and other relevant factors (CGIAR, 2021, LEGG 2021). The service provides farmers with customized recommendations on the following: 1) Fertilizer recommendation, 2) Scheduled planting and harvest date, 3) best planting and agronomic practices such as crop management, and 4) cassava maize intercrop (IITA,2021).

Smallholder farmers in Nigeria employ traditional farming methods and suffer a variety of difficulties like restricted market accessibility, insufficient infrastructure, and difficulties obtaining funding. Agriculture is ever-changing in how it operates. Young people are joining the sector, women's involvement or responsibility increases, natural resources are depleting, and the climate is changing. The traditional way of farming is not enough and sustainable and farmers need extension advice delivery on a faster and easier scale. Nigeria's cassava production contributes almost 20% of the estimated 59 million metric tons per annum worldwide production which made Nigeria the largest cassava producer globally. (F.A.O. 2021; FAOSTAT, 2020,2021). The majority of cassava production is done by subsistence farmers, who cultivate on little land plots, using traditional farming methods, such as hand planting and harvesting, and with limited access to modern technologies and inputs (Ogunsina & Akinleye, 2019; Okechukwu *et al.*, 2020, Osondu, 2017).

Since cassava cultivation is a well-established business in southwest Nigeria, its importance for the nation's GDP and food security cannot be overemphasised. In recent times, there has been a change or development towards more participatory and decentralized extension systems that encourage farmers' involvement in the process of decision-making and provide tailored solutions to needs such as farmer field schools, participatory extension, and digital extension services (Adesope & Adewale 2019, IFPRI, 2019).

This study investigated the effects of Akilimo advisory services on the Production efficiency of Cassava-based farmers in Ogun State. Its specific goals are to a) assess the level of awareness and adoption of Akilimo advisory services in the study area b) assess the perceptions of cassava-based farmers on the adoption of Akilimo advisory services c) determine the socioeconomic factors influencing the adoption of Akilimo advisory services in the area d) assess the effect of Akilimo advisory services on the production efficiency of cassava-based farmers in the area.

METHODOLOGY

The study was carried out in Ogun state, a tropical rainforest zone spanning 16,406,226 km2 in southwest Nigeria and situated between latitudes 70 01′ and 70 18′ and longitudes 20 45′ and 30 55′, served as the study's location. Ogun State shares boundaries with the Republic of Benin to the west, Oyo and Osun States to the north, Ondo State to the east, and Lagos State to the south. The annual precipitation varies from 1,000 to 2,599 millimetres. The National Population Commission (NPC, 2016) states that 3,728,098 people were residing in Ogun State. Ogun State as the top producer of cassava in Nigeria, has benefited from several initiatives related to cassava production, such as the Federal Government of Nigeria's Presidential Initiative on Cassava, the IFAD-assisted Cassava Multiplication Programme (ICMP), the Cassava: Adding Value for Africa (C: AVA) and IFAD-Assisted Value Chain Development Program (VCDP).

Following Cochran (1963), a representative sample from a large population is obtained using:

$$n = \frac{Z^2 p(1-p)}{e^2}$$

The variables are as defined below: n= representative sample, Z = 95% confidence level (1.96). P = proportion of cassava farmers that were trained on use of Akilimo advisory services in the total number of cassava farmers in the study area (13%) e^2= absolute error or precision at 5% type 1 error. Using the values above the least expected sample size was 174 which can be scaled up.

Primary data were utilized in this study. Data on agricultural practices, input accessibility, socioeconomic factors, technical efficiency, acceptability of the Akilimo service, and access to amenities were all collected through the survey. Using a multi-stage sampling, A random selection of 12 farmers (representing adopters and non-adopters) from 16 villages was made to choose a total of 192 respondents. Stage one involved the random selection of two (2) zones from the Agricultural Development Programme (ADP) zones. Stage two involved a purposive selection of two (2) blocks from each zone to make 4 blocks. In stage three, Two (2) circles were selected at random from the blocks, resulting in a total of eight circles. Stage four involved selection of two (2) sub-circles/villages at random from each of the eight circles giving a total of 16 villages. Only 178 respondents responded to the survey very well thereby reducing the number of respondents evaluated.

Objective 1: descriptive statistics were employed.

Objective 2: The perception of cassava-based farmers about the implementation of the Akilimo advisory service was evaluated through the application of descriptive statistics (Likert scale).

Objective 3: Tobit regression analysis was used to examine a set of predictor variable values. The model is presented as follows below.

$$Y_i{}^* = X_i\beta + \varepsilon$$

$$\boldsymbol{Y*} = \begin{cases} \boldsymbol{Y*}, & \boldsymbol{Y* > 0} \\ \boldsymbol{0}, & \boldsymbol{Y* \leq 0} \end{cases}$$

where $\varepsilon \sim N(0, \sigma^2)$ is the disturbance term assumed to be independently and normally

distributed with zero mean and constant variance σ^2

X_i is the vector of independent variables.

β is the parameter of the independent variable

I is the number of independent variables.

The model used for the study is expressed as

Y_i * = $X_1\beta_1 + X_2\beta_2 + X_3\beta_3 + X_4\beta_4 +$ …….. + $X_{11}\beta_{11} + \varepsilon$

Y_i * = Level of Adoption (0= non- adopters, 0.25= adopt one service, 0.5= adopt two services, 0.75= adopt three services, 1= adopt all the four services)

The independent variables are specified as determinants of adoption.

X_1 = Age of the farmer (years).

X_2 = Sex (otherwise = 0; 1 = male).

X_3 = Marital Status (otherwise = 0; 1 = married).

X_4 = Education attained (years).

X_5= Farming experience (years)

X_6= Household size (number)

X_7 = Size of farmland (hectares).

X_8 = Membership of cooperative (otherwise = 0; 1 = member;).

X_9 = Number of extension agents visits (Number).

X_{10} = Intercrop (otherwise = 0; 1 = yes).

X_{11} = Awareness (otherwise = 0; 1 = yes;).

B_i are the parameters to be determined from the analysis.

Objective 4: The Stochastic Frontier Analysis (SFA) was utilized. We looked at technical efficiency using the Stochastic Production Frontier model.

$(Y) = \beta o + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + \varepsilon i$

(2)

Where:

Y = cassava output (kg/ha),

X_1 is farm size (hectares)

X_2 labour (man-days)

X_3 is fertilizer (kilogram/Ha)

X_4 is cassava seeds (kilogram/Ha)

X_5 is Agrochemical (Liters/Ha)

β_0, β_1, β_2, β_3, β_4, β_5 = coefficients of inputs (X_1 ------X_5) with respect to output level.

Since $\varepsilon i = V_i - U_i$ and $U_i \geq 0$, εi is the constructed error term. The chance of mishap measurement mistakes and other statistical noise are taken into consideration by V_i, while U_i highlights production inefficiencies brought on by producer-controllable factors.

The appropriate cost frontier of the Cobb-Douglas functional form was used as the basis for estimating the allocative efficiencies of the farmers in the area:

$(C) = \propto_o + \propto_1 \ln P_1 + \propto_2 \ln P_2 + \propto_3 \ln P_3 + \propto_4 \ln P_4 + \propto_5 \ln P_5 + \propto_6 \ln Y + \in$ (3)

Where:

C = total cost of production (N).

P_1 = rent on land per hectare (Naira)

P_2 = price of cassava seed per Kg (Naira)

P_3 = average price of fertilizer per Kg (Naira)

P_4 = wage rate of labour per man-day (Naira)

P_5 = average price of agrochemical per litre (Naira)

Y = output

εi = + U_i and $U_i \geq 0$, εi is the constructed error term.

According to Farrell's methodology, Economic Efficiency was determined by multiplying Allocative Efficiency (AE) by Technical Efficiency (EE). EE is equal to TE * AE.

The inefficiency index was regressed against some factors that are likely to influence inefficiency. The relationship is presented in the equation below:

$U_i = b_o + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + \cdots + b_{12} \ln X_{12}$ (4)

Where

U_i = Technical inefficiency as previously defined

X_1 = Age of the farmer (years).

X_2= Farming experience (years)

X_3 = Level of education (years)

X_4= Household size (number)

X_5 = Intercrop (1 = yes; otherwise = 0).

X_6 = Marital Status (1 = married; otherwise = 0)

X_7 = Sex (1 = male; otherwise = 0).

X_8 = Number of contacts with extension agents (Number).

X_9 = Membership of cooperative (1 = member; otherwise = 0).
X_{10} = Use Akilimo Advisory Services (1 = yes; otherwise = 0).

RESULTS AND DISCUSSION

The study's findings indicated that the majority of farmers are between the ages of 41 and 50. Based on the results, it appears that the majority of farmers are of a productive age, which could have a favourable impact on their efficiency and output. More than half (52.2%) of the adopters were male, a larger portion (61.5%) of the non-adopters were female while a larger portion (56.2%) of the pooled sample were female. It is implied that non-adopters were better educated than adopters because more than half (56.5%) of adopters had secondary education, nearly half (46.8%) of non-adopters had higher education, and less than half (48.30%) of the pooled sample had secondary education.

The majority (81.2%) of adopters were married, a larger proportion (66.1%) of the non-beneficiaries were married while the majority (71.9%) of the pooled sample were married indicating that most of the respondents are married. The average household size was found to be between 4-6 people based on pooled data, with adopters' households typically consisting of 0-3 people. Non-adopters' households typically include 4-6 people. Majority of the Adopters (63.8%) have secondary occupation while most of the non-adopters (67.9%) do not have secondary occupation.

The study showed that all (100%) of the adopters of Akilimo had extension visits/contacts, the majority (78.9%) of the non-adopters had extension visits/contacts while the majority (40.4%) of the pooled sample had extension visits/contacts. The result shows that 51.7% of the respondents were aware of Akilimo advisory service while only 38.76% of the respondnets made use of one or more services provided by Akilimo advisory tools. This implied that the level of awareness and adopton of the service is low among cassava farmers in the study area. The respondents perceived ease of understanding of the services ($\bar{x}$= 4.40), relevance of information ($\bar{x}$= 4.00), trust in information ($\bar{x}$= 3.90) and ease of access ($\bar{x}$= 3.90), adopting Akilimo Advisory services is very important among other perceptions.

The socio-economic factors that has the probability of affecting the adoption of Akilimo advisory services were considered using Tobit regression and age($p<0.05$), education status ($p<0.1$), household size ($p<0.05$), and awareness ($p<0.01$), were significant. Age, education level and household size have negative effects on the probability of adoption while awareness has a positive effect on the level of adoption of Akilimo advisory services.

Farm size ($p<0.01$), labour ($p<0.01$), fertilizer ($p<0.01$), seed ($p<0.01$), and agrochemical ($p<0.01$) all affect adopters' output. Similarly, farm size ($p<0.01$) only affects non-adopters output, while farm size ($p<.01$) and labour ($p<0.01$) only affect the output of the pooled respondents. The adopters' technical efficiency is significantly impacted by education ($p<0.01$) and extension contact ($p<0.05$). The level of education ($p<0.1$) and experience ($p<0.1$) significantly affect the technical efficiency of non-adopters. The technical efficiency of the pooled respondents is significantly impacted by age ($p<0.05$) and Akilimo use ($p<0.05$). The average technical efficiency of adopters, non-adopters, and pooled responders was 0.79, 0.61, and 0.71, respectively. It implies that those who embraced Akilimo's advisory services were more technically efficient than those who did not utilize the service and pooled respondents.

It was discovered that differences in cost inefficiency explain 89.3%, 97.4%, and 72.5% of the variance in the total cost production of all respondents, adopters, and non-adopters. The results showed that the costs of land

($p<0.01$), cassava seed ($p<0.01$), fertilizer ($p<0.01$), labour ($p<0.01$), agrochemical ($p<0.01$), and output ($p<0.1$) have an impact on the adopters' overall production costs. The cost-efficiency of non-adopters is influenced by the following factors: land ($p<0.01$), cassava seed ($p<0.05$), fertilizer ($p<0.01$), labour ($p<0.01$), agrochemical ($p<0.01$), and output ($p<0.1$). The overall production cost of the pooled respondents is influenced by the costs of land ($p<0.01$), cassava seed ($p<0.01$), fertilizer ($p<0.01$), labour ($p<0.01$), agrochemical ($p<0.01$), and output ($p<0.01$).The adopters' cost efficiency was influenced by their experience ($p<0.05$), education ($p<0.01$), and cooperative membership ($p<0.05$). Non-adopters' cost efficiency was unaffected by any socioeconomic factors, while the pooled respondents' cost efficiency was influenced by age ($p<0.05$), experience ($p<0.1$), education ($p<0.01$), and household size ($p<0.1$). The analysis showed that the average economic efficiency for respondents who were pooled, non-adopters, and adopters was 0.57, 0.49, and 0.63, respectively. This indicates that the adopters, non-adopters, and pooled respondents achieved 63%, 49%, and 57% of the output at the lowest practical cost, respectively. The results showed that adopters were more economically efficient than non-adopters and that there was room to improve the respective economic efficiencies of adopters, non-adopters, and the pooled respondents by 27%, 51%, and 43%.

CONCLUSION AND RECOMMENDATIONS

Based on the study's findings, it was discovered that there are relatively few cassava farmers who utilize Akilimo advisory services. Most of the beneficiaries are middle-aged and have sufficient agricultural experience.

The age, household size, education level, and awareness of Akilimo advisory services play a key role in determining whether respondents will adopt Akilimo advisory services or not.

The results show that farmers who used Akilimo advisory services were more technically and economically efficient than non-adopters, whereas, both adopters and non-adopters had similar levels of cost efficiency. Based on their mean technical efficiency (TE), mean allocative efficiency, and mean economic efficiency values, farmers can increase their efficiency by use of Akilimo advisory services.

This result implies that access to the use of Akilimo advisory services increases the technical efficiency of the beneficiaries because the Akilimo advisory services guide them in utilizing resources which are a major production input. The more services rendered by Akilimo advisory service that a farmer utilizes, the better the technical efficiency. It is therefore recommended that 1) Policy or activity aimed to create awareness of Akilimo advisory services should be intensified so more people can become aware of the service. 2) The extension agents should be empowered to disseminate information on the importance of Akilimo advisory services to farmers to increase their technical and economic efficiency thereby increasing output.

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IMMUNE RESPONSE AND CAECAL MICROBIAL LOAD OF BROILER CHICKENS ORALLY ADMINISTERED ZINC OXIDE NANOPARTICLES AND INORGANIC ZINC AT VARYING LEVELS

[1]Ogunmefun, F. T., [1]Ayoola, A. A., [1]Yusuf, A.O., [2]Majekodunmi, B. C. and [1]Olatunbosun, O. B.
[1]Department of Animal Production of Health, Federal University of Agriculture, Abeokuta
[2]Department of Animal Physiology
Corresponding Author- ayoolaaa@funaab.edu.ng 08062299054

ABSTRACT

This study was carried out for six weeks to evaluate the effect of oral administration of varying levels of zinc nanoparticles and inorganic zinc on immune response and caecal microbial load of broiler chickens. A total of 216 one-day old broiler chicks were distributed into two groups (nano and inorganic zinc group), which were subdivided into three subgroups each (0, 60 and 80 mg/l of water) to make six treatment group of 36 birds each. Each treatment group was replicated in triplicates of 12 birds. The experimental layout was a 2x3 arrangement comprising of two zinc types included in fresh drinking water at 3 levels. On the 42nd day of the experiment, lymphoid organs and caeca faecal samples were taken from one sacrificed bird per replicate for microbial load evaluation and assessment of immune response, respectively. Data collected were subjected to a general linear model as contained in SPSS version 23. The results showed that microbial load and weight of immune organ did not vary significantly between birds administered the zinc types. However, the weight of bursa increased significantly with increasing zinc levels. It was concluded that zinc administration at various levels showed similar potency as the antibiotics. Hence, this study recommends 60mg/l of either of the zinc types as an alternative to antibiotics for caecal microbial load depopulation and improved immune response in broiler chickens.

INTRODUCTION

Zinc (Zn) is one of the important trace elements for humans and animals. It is involved in various biological activities, immune competence and many metabolic processes. It contributes to the maintenance of growth, skeletal development, and proper immune development and function of broiler chickens (Tomaszewska *et al.*, 2017). Zn is commonly added as a supplement to all formulated poultry diets due to low level of zinc in natural feed ingredients as its deficiency leads to decreased feed intake and collagen formation. These lead to lesions on the skin, long bone malformation, poor feathering and reduced immune function.

The effect of Zn in broiler varies from different sources; organic or inorganic sources. Organic Zn has higher bioavailability of Zn compared to its inorganic form, but the application of organic Zn in animal diets is limited due to its higher cost (Zhao *et al.*, 2014). To meet the Zn requirement in animals, the added concentration of inorganic Zn such as Zn oxide (ZnO) and Zn sulfate ($ZnSO_4$) is 20 to 30-fold higher than the normal requirement due to the low utilization rate of inorganic Zn. High Zn supplementation may affect the balance of other trace elements in the body and reduce the stability of vitamins and other nutrients, and long-term application can cause Zn residue in the animal body (Zhao *et al.*, 2014). Enhancement of Zn bioavailability may reduce the amount of Zn to be supplemented. The use of nanoparticles of mineral elements represents a promising and emerging technology in the animal farming industry that helps in nutrient bioavailability. Therefore, this study was carried out to determine the immune response and caecal microbial load of broiler chickens on oral administration of zinc oxide nanoparticles and inorganic zinc at varying levels.

MATERIALS AND METHODS

Site of Experiment and Source of Test Ingredient

The experiment was carried out at the Directorate of University Farms of the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. Nano zinc oxide and inorganic zinc (zinc sulphate) were sourced from a reputable veterinary outlet.

Experimental Design and management

A total of two hundred and sixteen (216) one day-old broiler chicks were sourced from a reputable hatchery in Ibadan, Nigeria for this study. The birds were balanced for weight and distributed into two

groups (nano zinc and inorganic zinc groups) which were subdivided into three subgroups each (0, 60 and 80 mg/l levels of administration) to make six treatment subgroups of 36 birds each. Each treatment group was replicated in triplicate of 12 birds. The experimental layout was a 2x3 arrangement comprising two zinc types included in fresh drinking water at 3 levels (0, 60 and 80 mg/l). The control group was only administered antibiotics for 3 days every two weeks while zinc was administered in water daily for other treatment groups. The birds were raised in a deep litter system with wood shavings as the bedding material. The birds were brooded for two weeks during which they were provided light, feeds and heat source. The birds were fed *ad libitum* with commercial broiler starter (0- 4 weeks) and finisher (4-6weeks) feed and were given fresh clean water daily. All routine medications and vaccinations were duly done as recommended by the hatchery.

Data collection

Sample Collection

Immune (lymphoid) organ weight

On the 42nd day, one bird with weight close to the average of the birds in each replicate was selected and sacrificed. Lymphoid organs (spleen, thymus and bursa of Fabricus) were removed and weighed using a sensitive scale. They were expressed as a percentage of live weight of the birds

Caeca Faecal Sample Collection and Microbial Load Count

The caeca of the birds were cut open and its content emptied into sample bottle with clear labeling for identification and taken into the laboratory for analysis. Total bacterial count was carried out on a nutrient agar by plate count method as described by Wynn *et al.* (2013).

Statistical analysis

Data collected was arranged in 2x3 factorial layout and subjected to one-way analysis of variance using SPSS version 23. Significant difference among means was separated using Duncan Multiple Range Test as contained in the software.

RESULTS AND DISCUSSION

Main effect of oral administration of different zinc types and their levels on lymphoid organs of broiler chickens is shown in Table 1. Different zinc types had a similar (P>0.05) effect on lymphoid organs. The varying zinc levels did not have significant (P>0.05) effect on thymus and spleen of the birds. However, the bursa of the birds significantly (P>0.05) increased with increasing level of administration.

Table 2 shows the effect of interaction between zinc types and their levels on lymphoid organs of broiler chickens. Oral administration of nano zinc and inorganic zinc at different levels (0, 60 and 80mg/l) had similar (P> 0.05) effect on lymphoid organs weight of the birds.

The main effect of oral administration of different zinc types and their levels on caecal microbial load of broiler chickens is shown in Table 3. The caecal microbial load did not differ significantly (P>0.05) between the two zinc group types. Similarly, the varying zinc levels (0, 60 and 80mg/l) also had no significant (P>0.05) influence on caecal microbial load of the birds.

The effect of interaction between zinc types and their levels on caecal microbial load of broiler chickens is shown in Table 4. The interactive effect of oral administration of different zinc types and their varying levels (0, 60 and 80mg/l) had no significant (P> 0.05) effect on caecal total coliform count and total bacteria count of the birds.

Table 1: Main effect of oral administration of different zinc types and their levels on lymphoid organs of broiler chickens

	Zinc types				Zinc levels				
Parameters (%)	**Nano zinc**	**Inorganic zinc**	**SEM**	**P-value**	**0mg/l**	**60mg/l**	**80mg/l**	**SEM**	**P-value**
Thymus	0.16	0.15	0.03	0.84	0.13	0.15	0.19	0.03	0.45
Bursa	0.08	0.08	0.01	0.91	0.05^{b}	0.08^{ab}	0.10^{a}	0.01	0.03
Spleen	0.08	0.08	0.01	0.87	0.07	0.09	0.08	0.01	0.41

Table 2: Effect of interaction between zinc types and their levels on lymphoid organs of broiler chickens

	Nano zinc			Inorganic zinc				
Parameters (%)	**0mg/l**	**60mg/l**	**80mg/l**	**0mg/l**	**60mg/l**	**80mg/l**	**SEM**	**P-value**
Thymus	0.13	0.10	0.24	0.12	0.19	0.13	0.05	0.16
Bursa	0.05	0.08	0.10	0.05	0.08	0.10	0.02	0.99
Spleen	0.07	0.09	0.08	0.07	0.10	0.08	0.02	0.84

Table 3: Main effect of oral administration of different zinc types and their levels on caecal microbial load of broiler chickens

	Zinc types				Zinc level				
Parameters ($\times10^4$cfu/ml)	**Nano zinc**	**Inorganic zinc**	**SEM**	**P- value**	**0mg/l**	**60mg/l**	**80mg/l**	**SEM**	**P-value**
TBC	1.23	1.01	0.11	0.19	1.03	1.07	1.27	0.14	0.45
TCC	1.16	1.03	0.09	0.36	1.05	1.08	1.15	0.11	0.81

TBC= Total bacteria count, TCC= Total coliform count

Table 4: Effect of interaction between zinc types and their levels on caecal microbial load of broiler chickens

	Nano zinc			Inorganic zinc				
Parameters ($\times10^4$cfu/ml)	**0mg/l**	**60mg/l**	**80mg/l**	**0mg/l**	**60mg/l**	**80mg/l**	**SEM**	**P-value**
TBC	1.13	1.20	1.37	0.93	0.73	1.17	1.87	0.98
TCC	1.17	1.07	1.23	0.93	1.10	1.07	0.16	0.69

TBC= Total bacteria count TCC= Total coliform count

Discussion

Although researchers have found that zinc oxide nanoparticles outweigh conventional Zn sources and positively affect the performance and antioxidant defense of chickens (Eskandani *et al.*, 2021) due to its smaller particle size and higher bioavailability, this present study found no significant difference in weight of lymphoid organs of broiler chickens administered nano zinc and inorganic zinc. The variation could probably be as result of differences in the mode of administration of the zinc (in-feed *vs* in-water). The similar effect on the weight of thymus and spleen and significant increase in weight of bursa with increasing dosage of zinc administration observed in this study indicate the immunological stimulating traits of zinc which could be due to the role of zinc in growth and function of lymphocytes as stated by Underwood *et al*. (2001) that zinc acts as an immunostimulator which enhance both the cellular and humoral immune systems in broilers.

This present study revealed that oral administration of nano zinc and inorganic zinc at varying levels had a similar effect to oral antibiotics on total bacteria and coliform count, which agrees with Arabi *et al*. (2012) that zinc has bactericidal effects on both Gram-positive and Gram-negative bacteria.

CONCLUSION

It was concluded that oral administration of the two zinc types and their varying levels had a similar effect on caecal microbial load and lymphoid organs of birds except bursa, which increased significantly with increased levels of zinc.

RECOMMENDATION

Nano zinc and inorganic zinc at 60mg/l could be used to control caecal microbial load and improve immune response in broiler chickens.

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SUB-THEME TWO:
BREEDING, CULTIVATION AND GEMPLASM DIVERSITY FOR AGRICULTURAL

8th Annual Conference and 67th AGM-ABEOKUTA of The Association of Deans of Agriculture in Nigeria Universities (ADAN), Held at The FUNAAB Red Senate chamber, Abeokuta, Ogun State, Nigeria, from July 7th to 11th, 2024. Theme: Climate Change: Agricultural Innovations and Bio-entrepreneurship for Sustainable Development, Food Sufficiency and Economic Transformation. **Edited by:** A. E. Obayelu, O.M Olosunde, P. B. Abdulsalam-Saghir, O.S. Sowande, E.O. Fakoya and J.J. Atungwu

SEX EFFECTS ON CARCASS CHARACTERISTICS OF COBB BROILER CHICKEN

Adeoye, A. A., Oyeleye, O. O. and Adeboye, O.P.
Department of Animal Production and Health, Olusegun Agagu University of Science and Technology, Okitipupa. Ondo State. Nigeria.
Corresponding Author: adeomoh@yahoo.com

ABSTRACT
Carcass traits play a vital role in determining the overall quality and economic value of broiler chickens. These traits include characteristics such as carcass weight, yield, composition, and meat quality. This study is carried out to determine the effect of sex on the carcass traits of Cobb broiler chicken. A total of sixty (30-males and 30-females) cobb broiler chicken were used to study effect of sex on carcass traits. The results obtained revealed that male birds exhibited statistically higher estimates in all variables, with the exception of heart (7.15) and proventiculus (8.45), which were found to be higher in females. However, these differences were not statistically significant ($p > 0.05$) in most of the traits considered. At eighth week, sex had significant effect ($p<0.05$) in shank length, thigh, head and wing length. Similar trend was observed in drum stick, shank length, head and wings, with higher values in male. In conclusion, this study demonstrates that sex has noticeable effect on some carcass traits in Cobb broiler at 8 and 10 weeks of age.
Keywords: Carcass traits, Age, Cobb Broiler, Sex

INTRODUCTION
The term "broiler" refers to chickens that are raised primarily for meat production, as opposed to laying birds that are bred for egg production. These chickens are typically bred to have larger and faster-growing bodies, (Goliomytis *et al*., 2003) which enables them to reach market weight in a relatively short period of time. Modern broilers are the result of genetic selection, with the selection pressure being focused on high growth rate, extensive muscle development and relatively low feed consumption (Goliomytis *et al*., 2003). These factors combine with improved environmental factors such as nutrition and housing have reduced the slaughter age of contemporary broiler chicken to 42 days and slaughter weight in excess of 2kg (Dafwang 2002).

Carcass traits play a vital role in determining the overall quality and economic value of broiler chickens. These traits include characteristics such as carcass weight, yield, composition, and meat quality. Understanding and improving carcass traits are essential for the poultry industry to meet consumer demands for high-quality poultry products. Carcass weight is a fundamental carcass trait that directly affects the profitability of broiler production. It refers to the weight of the dressed carcass after removing the feathers, head, feet, and internal organs. Several factors influence carcass weight, including genetic potential, nutrition, management practices, and health status.

Differences in the growth rate of male and female broilers have been reported by many researchers (Rodenlli, 2005). However, there are few reports on the practice of separating broiler chicken into sexes while raising them. Laseinde and Oluyemi (1994) reported significant difference in body weight gain and feed intake between separated and mixed –sex –birds; while Verapeen and Driver (2000) reported significant benefits from rearing the broiler sexes separately. They reported that body weight gain and weight of most component carcass parts were significantly heavier in males than the females. Male and female broilers have different growth potentials, which can be enhanced by management. For example, Meijerhof (1988) reported that male broilers utilized feed more efficiently than the female, the female broilers utilize dietary energy more efficiently than the males between week 5 and 8 of the growing period. There is dearth of information on effect of sex on carcass characteristics of cobb broiler chicken. Therefore, the objective of this study is to determine the effect of sex on carcass characteristics of Cobb broilers.

MATERIALS AND METHODS
The study was conducted at Poultry Unit, Teaching and Research Farm of Olusegun Agagu University of Science and Technology, Okitipupa, Ondo State. A total of 60 day – old Broiler chicks (30 males and 30 females) were purchased for this study. Each bird was leg banded for individual identification. The birds were raised in deep litter system and fed with commercial diet *ad libitum*. At 6th, 8th and 10th

week, The birds were fasted overnight and two birds per sex and per age were randomly selected, weighed, slaughtered, and manually de-feathered. The weight of heart, liver, kidneys, proventriculus, gizzard and the intestine of each chicken was determined using an electronic balance (600g) capacity. The dressed weight of each chicken was taken after the removal of the intestine and the visceral organs. The main-cut parts such as the thigh, drumstick, breast were weighed and recorded, other part of the chicken weighed were the head, neck and shank. The dressing percentage was calculated as the ratio of the dressed weight to the live weight of each chicken.

Statistical Analysis

Data collected on carcass traits were subjected to T-test and Pearson correlation was used to determine the relationship among the traits.

The model used was as follow: $Yij = \mu + \alpha i + \epsilon ij$

Where: μ = overall mean αi = Effect of sex, ϵij = random error

RESULTS

Table 1 shows the effect of sex on carcass traits at 6th, 8th and 10th week. At 6th week, sex has no significance difference ($p>0.05$) on all the variables. Similar trend was observed at week 8 except in thigh weight, shank lenght and wing length where higher values were reported in male. Significant difference ($p<0.05$) were observed in drum stick, shank length, wing length and head at week 10 in wish higher values were recorded in male (329.10, 140.93, 235.77 and 79.90, respectively.).

Table 1: Effect of Sex on Carcass Traits of Cobb Broilers

	6 weeks		8 weeks		10 weeks	
Parameters	M	F	M	F	M	F
Live wgt	1505.00^{a}±125.00	1347.00 ^{a}±26.00	2120.00^{a}±111.56	1901.33^{a}±71.39	2598.67^{a}±155.48	2307.67^{a}±6.88
Killed wgt	1484.00^{a}±119.00	1318.00^{a}±23.50	2066.00^{a}±108.50	1854.33^{a}±72.33	2485.00^{a}±138.81	2163.33^{a}±75.09
Def wgt	1447.00^{a}±129.00	1267.00^{a}±19.00	1983.67^{a}±102.33	1785.00^{a}±70.63	2360.00^{a}±130.79	2091.67^{a}±59.18
Dres wgt	1291.40 ^{a}±72.00	1091.00^{a}±19.00	1714.93^{a}±76.04	1568.80^{a}±56.85	2213.33^{a}±133.05	1819.80^{a}±57.85
Breast	306.00^{a}±21.00	303.85^{a}±11.75	472.40^{a}±28.50	423.07^{a}±34.26	623.03^{a}±53.99	563.07^{a}±25.99
Thigh	167.75^{a}±13.75	148.25^{a}±5.45	244.60^{a}±4.99	206.53^{b}±11.56	266.53^{a}±7.82	252.23^{a}±10.73
shank	75.75^{a}±8.35	52.65^{a}±4.15	105.90^{a}±4.90	65.13 ^{b}±8.56	140.93^{a}±1.49	84.80^{b}±4.89
Neck	32.50^{a}±1.50	31.70 ^{a}±4.50	57.53^{a}±5.94	50.47^{a}±3.16	96.73^{a}±6.87	57.40^{a}±13.06
Drumstick	159.85^{a}±14.45	134.30^{a}±4.00	222.43^{a}±13.80	198.43^{a}±10.73	329.10^{a}±29.07	226.40^{b}±5.43
Head	51.65^{a}±5.55	45.35^{a}±3.55	67.67^{a}±3.67	66.40^{a}±5.86	79.90^{a}±3.77	63.17^{b}±4.54
Wings	117.70^{a}±5.20	107.40^{a}±1.10	177.27^{a}±7.50	149.47^{b}±3.66	235.77^{a}±12.51	183.37^{b}±6.73
Back	268.50 ^{a}±53.30	258.60^{a}±9.40	372.53^{a}±9.84	353.67^{a}±20.09	473.23^{a}±38.37	383.00^{a}±9.70
Heart	6.95^{a}±0.65	7.15^{a}±0.95	10.30^{a}±0.76	9.07^{a}±0.67	12.03^{a}±1.47	11.43^{a}±1.04
Liver	30.35^{a}±5.35	32.20^{a}±3.30	35.70^{a}±2.40	33.93^{a}±0.37	49.17^{a}±8.16	42.07^{a}±2.81
Gizzard	36.20^{a}±3.80	34.65^{a}±0.85	46.63^{a}±6.38	45.83^{a}±2.60	54.07^{a}±6.21	54.80^{a}±4.80
Proven	8.25^{a}±0.05	8.45^{a}±0.15	9.50^{a}±1.11	10.70^{a}±0.37	15.43^{a}±1.60	12.17^{a}±0.39
Small intest	64.85^{a}±1.45	61.20^{a}±0.00	77.93^{a}±3.60	78.07^{a}±8.13	102.3^{a}±31.33	72.90^{a}±4.35
Large intest	15.85^{a}±6.45	44.25^{a}±29.15	38.73^{a}±8.34	32.33^{a}±1.44	47.70^{a}±2.76	37.83^{a}±6.96
Dres wgt %	82.00^{a}±0.15	80.10^{a}±2.35	80.97^{a}±0.74	82.57^{a}±2.14	85.17^{a}±0.84	78.85^{a}±2.27

a,b,c : means with different superscript on the same row are significantly ($p<0.05$) different.

Liv wgt: live weight; kil wgt: killed weight; def wgt: defeathered weight; dres wgt: dressed weight; intest: intestine; std. Dev: standard deviation; coeff of var: coefficient of variation.

DISCUSSION

The findings from this study indicate that sex has a considerable impact on carcass traits of Cobb broiler at different ages. At 6 weeks of age, the analysis revealed that male birds exhibited statistically higher estimates in all variables, wish is in line with the findings of Joseph *et al.* (1992) with the exception of heart and proventiculus, which were found to be higher in females. However, these particular differences were not

statistically significant. Similar trend was observed at weeks 8 and 10. At week 8, thigh weight, shank length, and wing length, experienced significant differences in favor of male, indicating sexual dimorphism which is in tandem with the report of Verapeen and Driver (2000). Similarly, the significant difference observed in shank, drumstick, head, and wings at 10th week is in consonance with the report of Verapeen and Driver (2000). Sexual dimorphism in carcass traits of Cobb broiler increases as age increases.

CONCLUSION

It could be concluded that sexual dimorphism become obvious in carcass traits of Cobb broiler as age increased.

RECOMMENDATIONS

For better carcass trait, male cobb broiler is recommended as from 8 weeks of age

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EVALUATION OF SELECTED APICULTURAL PRACTICES IN MITIGATING THE EFFECTS OF CLIMATE CHANGE ON PRODUCTION OF HONEY IN OKITIPUPA

Faleyimu O. O.[1] & Bamigboye E. O.[2]*

[1]Department of Forestry, Wildlife and Environmental Management, Olusegun Agagu University of Science and Technology, Okitipupa, Nigeria
[2]Department of Agricultural Economics and Extension, Olusegun Agagu University of Science and Technology, Okitipupa, Nigeria
*Corresponding author: taayo_bamigboye@yahoo.co.uk

ABSTRACT

Seven apicultural practices were evaluated for their potential to mitigate the effects of climate change in honey production. The study was carried at Agroforestry unit, Olusegun Agagu University of Science and Technology, Okitipupa, Ekiti State, Nigeria between August 2021 and March 2023. The treatment combination consists of five different baiting materials, planting of floral along the apiary alley ways, provision of water during the dry season and provision of additional food source. Randomized Complete Block Designed (RCBD) was used and replicated three times. Data were collected on hive colonization colony weight gain, weight of matured harvested combs and weight of extracted honey from the harvested combs. Statistical analysis of the data was carried out using analysis of variance and mean were separated with turkey,s HSD at 5% level of probability . Average pure honey yield was 12kg from phy top barhives and 17kg from framed hives. Provision of additional water source reduced the rate of absconding during the dry season, 65 percent colonization was achieved with hives baited with foundation wax and provision of additional honey food two months after colonization enhanced the yield of the honey and dryness of combs. There were significant differences ($P < 0.05$) between the rate of absconding and provision of water. In this study, provision of supplement water source for bees enhanced colony stability and honey yield and is therefore recommended as an excellent apicultural practice to mitigate the effect of climate change on colony stability and honey yield

Key words: a*picultural practices, honey production, climate change, environment*

INTRODUCTION

Beekeeping as an agricultural practice has been identified as one of the several ways of achieving sustainable development goals (SDGs), in terms of its potential to improve the living standard in the rural Nigeria through improved food supply, and generation of productive employment (Reference). The success of beekeeping relies heavily on the possibility of establishing a suitable environment necessary for bees to thrive for optimum production. The importance of beekeeping in terms of social and economic benefits such as alleviation of poverty, creation of employment, improved crop yields through bee pollination, use of bee-hive products in health management and incorporation in conservation programmes cannot be underestimated.

Bee keeping with its huge potentials to save the natural forest and earn subsistence income for the rural poor is one agricultural practice that mustbe protected from negative effects ofclimate change (Babarinde, 2015). Globally, beekeeping is an integral part of agriculture and bees are of inestimable value as agents of pollination and many plants are entirely dependent on them. Ogunpaimo(2012) reporteded that many ecosystems depend on the pollination of bees for their existence and for increased genetic diversity (cross-pollination). An estimated eighty percent of flowering plants are entomophilous and depended on insect pollination to reproduce, and half of these pollinators of tropical plants are bees (Reference). Bees pollinate 70% crop species) that feed 90% of the world population (Enzenwa, 2018. Nonetheless, benefit from yield of honey and beeswax has been affected by climate change and global warrming in recent time, especially in rural Nigeria. These changes could affect the biology of bees, their population, health and subsequently, their activities and honey yield. Bees are equally feeling the effects of climate change with evidence of increased temperature and severe drought with

enormous stress on water availability for flora development which is basically the food of bees (Antwi- Agyen and Stringer, 2021). This affects absconding of bees, empty combs, dried combs, pure honey becoming crystallized which eventually lead to low production both in quantity and quality. There is therefore an urgent need to evaluate good apicultural practices that can mitigate the effects of climate change on honey production. Studies on the effects climate change on bee activities and honey is scanty and limited in scope. This studyaim to evaluate selected apicultural practices to mitigatethe effects of climate change on honey production. Bamigboye (2015) investigated the climate change adaptation strategies used among arable crop farmers in South west, Nigeria but no work has been done to evaluate the effects of apicultural practices in mitigating the effect of climate change in honey production, hence this study

MATERIALS AND METHODS

Experimental Sites

The work was carried out at the on-station apiary demonstration (Olusegun Agagu University of Science and Technology, Agroforestry Unit) Okitipupa, Ekiti State, Nigeria. The on-station apiary layout was carried out on a primary forest within bees' friendly environment. The on station experiment was carried out between Oct 2021 and March 2023 to allow for two seasons of honey production. The following plants were found within the experimental site, *Tectona grandis, Irvingia gabonensis, Anana comosus Citrus* species, pit *yrograma calomelanos Elaeis guinensis, Moringa Olefera, Anarcadium occidentale, gmelina arborea*

Experimental Layout and Application of Treatments

The experimental materials consist of Kenyan top bar hives framed hives 10 each and a total of 20 hives were used. for the experiment and were made from Omo tree (Terminalia ivorensis). (Adjare, 1984 and Akanbi 2002) The treatments were applied at interval of 2 weeks and for a period of 4months during the honey swarming season

Randomized Complete Block Designed (RCBD) was used and replicated three times.

Experimental Factors Levels Arrangement ON-STATION

Table 1: Main Factors

	Main Plots	Sub-plots	
	1. Framed hive	2. Top bar hive	3. Practices
Factor Levels	a. Foundation wax b. FermenteLocust beans c. Honey lotion	a. Pure honey b. Perfume c. Slurry	a. H_2O bows b. Multiple floral c. Additional feeds

Table 2: Treatments

Treatment Combination	Treatment Description
1a x 2a x 3a	Foundation wax x pure honey x H_2O bars
1a x 2b x 3a	Foundation wax x perfume x H_2O bars
1a x 2a x 3b	Foundation wax x pure honey x multiple floral
1a x 2b x 3b	Foundation wax x perfume x multiple floral
1a x 2c x 3b	Foundation wax x slurry x multiple floral
1a x 2b x 3c	Foundation wax x perfume x additional feeds
1a x 2c x 3c	Foundation wax x slurry x additional feeds
1b x 2a x 3a	LB x pure honey x H_2O bars
1b x 2b x 3a	LB x perfume x H_2O bars

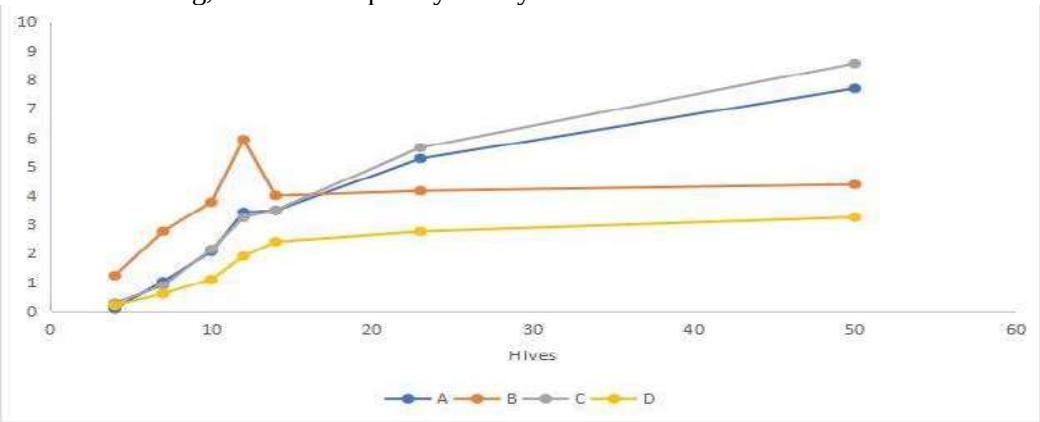
1b x 2a x 3b	LB x pure honey x multiple floral
1b x 2b x 3b	LB x perfume x multiple floral
1b x 2c x 3b	LB x slurry x multiple floral
1b x 2b x 3c	LB x perfume x additional feeds
1b x 2c x 3c	LB x slurry x additional feeds
1c x 2a x 3a	Lotion x pure honey x H_2O bars
1c x 2b x 3a	Lotion x perfume x H_2O bars
1c x 2a x 3b	Lotion x pure honey x multiple floral
1c x 2b x 3b	Lotion x perfume x multiple floral
1c x 2c x 3b	Lotion x slurry x multiple floral
1c x 2b x 3c	Lotion x perfume x additional feeds
1c x 2c x 3c	Lotion x slurry x additional feeds

RESULTS AND DISCUSSION

The following are the results obtained from the research work. It includes the production efficiency of each hive with respect to the colonization, absconding, rate of comb formation, honey yield all measured in kilograms and determination of apicultural practices that helps in mitigating the effect of climate change

Rate of colonization within the Study Period

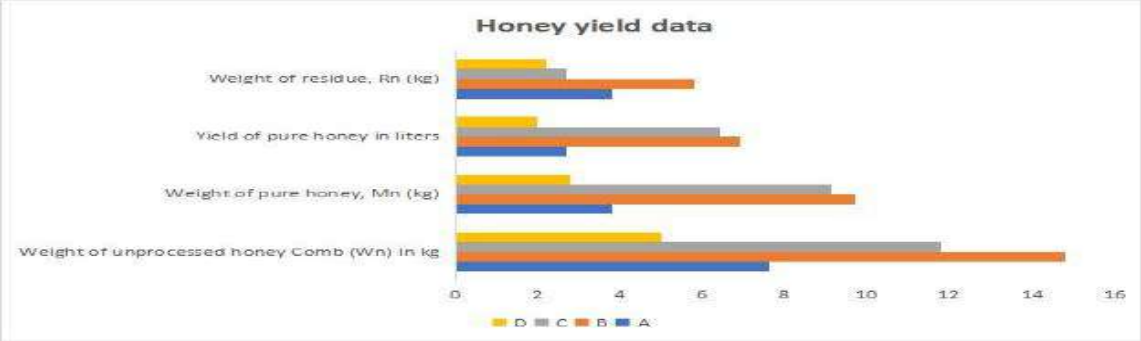
It denotes the growth of the comb recorded at the onset of baiting, and subsequently every two weeks. The figure 1 shows the weekly result of the comb development in each hive listed, of which A-E represents apiculture practices which were replicated three times along with seven baiting materials For the two weeks after baiting, the hives were not colonized and no comb was formed in them. . By the fourth week 5, hives baited with foundation wax were colonized by bees, at varying degrees of activeness. How?Rate of colonization within the Study Period



where is label on the vertical axis?

Honey Yield Data

The hives are represented in this table with respect to the weight of all the proceeds from the processed harvest (Where are the hives in the table). figure 2 shows final results from each hive. As usual, the hive baited with foundation wax which yield 9.3kg is the most productive, while the hive baited with fermented locus beans yield 2.8kg is less productive, the hive in the baited with beeswax were averagely productive.



The result in table 1 of the apiculture practices profile indicated that two of the practices were significant in control of climate change in honey production. High incidence of this practices and colonization justifies their potency. Early colonization and high honey yield observed in foundation wax and additional water supply made it also recommendable to farmers as baiting material and good apiculture practice in combating climate change in honey production

Study was carried out between Oct 2021 and March 2023. Two seasons.

Effect of baiting materials on apiculture practices parameter in mitigating the effect of climate change.

Parameters	Incidence of baiting materials and yield in cm or mm						
	I	II	III	IV	V	VI	S.E
Additional feeds	15.91^{b}	15.79^{b}	16.58^{a}	15.14^{c}	15.94^{b}	15.84^{c}	0.0697
Planting drought res	5.47	5.98	5.33	5.33	5.47	5.48	0.0462
Bee shelter	11.77^{bc}	12.61^{a}	12.15^{b}	11.46^{cd}	11.15^{d}	11.47^{d}	0.1495
Using of different hives	38.53	37.06	37.04	37.01	38.53	38.87	0.5138
Additional water	35.35	34.15	36.03	35.08	34.93	35.25	0.3122
Using of scent tree	35.90^{b}	35.05^{c}	36.13^{b}	34.98^{c}	36.60^{a}	36.70^{a}	0.0506

Means followed by the same letter along the column are not significantly different using Tukeys' HSD at 5% probability level

Conclusions and Recommendation

All the seven evaluated apicultural practices Where are the practices? shows the potential for combating climate change in the study area but provision of additional food source during dry season when there is paucity of floral was ranked best in controlling absconding and provision of water source at the apiary premises helps in reducing rate of comb dryness and crystallization which is one of the problem of ensuring pure honey under austere weather condition. Foundation wax is therefore recommended as the best baiting material to use as it enhances faster colonization and additional source of water must be provided within the apiary as this will reduce the rate of bees absconding and dryness of comb. Also primary forest is the most suitable environment for beekeeping and honey production since bees are attracted quickly.

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ACUTE TOXICITY DETERMINATION AND EVALUATION OF AQUEOUS LEAF EXTRACT OF *STACHYTARPHETA JAMAICENSIS EFFECT* ON SELECTED HAEMATOLOGICAL PARAMETERS OF WHITE NEW ZEALAND RABBIT BUCKS

Fatoba T. A, Ayorinde T. V., Bodunde P. O., Salami R. M., and Yusuf S. I
Department of Animal Production and Health, Olusegun Agagu University of Science and Technolog, Okitipupa, Ondo State
Corresponding author email address: ta.fatoba@oaustech.edu.ng

ABSTRACT
This study was carried out to investigate effect of aqueous leaf extract of *Stachytarpheta jamaicensis* on selected haematological parameters of white New Zealand rabbit bucks. A total of twelve (12) weaners New Zealand white rabbit bucks weighed 540 ±52g were divided into four treatment groups, each with three replicate. The lethal dose was determined, and Treatment includes: saline (control), 1ml/kg bodyweight (Bw), 2ml/kgBw and 3ml/kgBw, Results showed that crude aqueous extract of *Stachytarpheta jamaicensis* does not pose deleterious effect on the animals. Additionally, the extract showed significant effect ($P<0.05$) on haematological parameters as increase in values were obsereved for haemoglobin concentration, packed cell volume and red blood cell count with increased value was observed for white blood cell count. In conclusion, the plants extract improved haematological indices in animals and could be used as anti-anaemic agent. Therefore, the active ingredient of aqueous extract of *Stachytarpheta jamaicensis* leaf could be properly screened to produce a pharmacologically active drugs.

Keywords: Rabbit bucks; extract, haematological parameters *lethal dose, Stachytarpheta jamaicensis*

INTRODUCTION
Rabbit production is very popular as a result of its prolificacy and short gestation period (Ajani *et al*., 2020). This animal is also known for quality meat of high nutritive value. Recently, there has been interest in the utilization of *Stachytarpheta jamaicensis* as a rich alternative source for health care delivery for livestock. The need for development of newer chemotherapeutic agents became necessary as a result of increasing treatment failure rates of microorganism infections recorded, due to drug-resistance to various antibiotics. *Stachytarpheta jamaicensis* leaves have quality attributes that make it a potential ingredient in partial replacement for convectional drugs in livestock management. *Stachytarpheta jamaicensis* can easily be established in the field as it has good coppicing ability, as well as good potential for potent drug production. The aqueous leaf extract, has a very high potential as a source for drug discovery, and thereby produce a variety of compounds of known therapeutic properties (Anwar *et al*., 2007) most of which can enhance growth and reproductive performances. Generally, blood consists of several components that can be used to monitor health status and metabolic activities of farm animals, including humans (NRC, 2012). To this point therefore, serum contents reflect the effects of phytochemicals dietary treatments on the animals in terms of the type and amount of plant extract injected and available for the animal to meet its physiological, biochemical and metabolic activities (Ewuola *et al.*, 2004). The results of our study may provide valuable insights into the potential use of *Stachytarpheta jamaiciensis* extracts in humans and may guide the development of safe and effective treatments for a range of ailments.

MATERIALS AND METHODS
Plant Collection and Identification
The whole plant of *Stachytarpheta jamaicensis* were obtained from Idepe Okitipupa environs, Okitipupa, Ondo State Nigeria and identified in the Herbarium Unit of the Biological Science Department, Olusegun Agagu University of Science and Technology, Okitipupa where a voucher specimen was deposited.

Experimental site
This study was carried out at the rabbitry section of the Teaching and Research Farm, Olusegun Agagu University of Science and Technology, Okitipupa main campus (6^o27^1 N 4^o46^1E), Ondo State, Nigeria.

Acute Toxicity
The per oral route was used for the determination of the acute toxicity (LD_{50}) of the aqueous extract in white albino rats of both sexes weighing 200 –

250g were used for the study with varying doses administered to the animals orally by gastric intubations (Isah *et al*., 2008 and Fatoba, 2012). Animals were observed for mortality over 24 hours. The LD_{50} was then evaluated using the graphical method of Miller and Tainter (1944).

Sample preparation and extraction

The fresh leaves were air- dried and separately ground into powder using mortar and pestle. The procedure of Fatoba *et al* (2015) was adopted for extraction with 250g portions of the powdered plant part separately weighed and soaked in I litre of distilled water for 48 hours. The extract was then filtered using Whatman filter paper (no 1) into a beaker and later poured into volumetric flask and stoppered. The filtrates were evaporated to dryness using evaporating dish at $35^{O}C$ and stored at $-4^{o}C$ for later use in the studies.

Animal management

Twelve New Zealand white rabbit bucks were procured from reliable source and allowed to acclimatize for 14 days and feed were offered with forages supplemented with grower's mash and fresh water given *ad libitum*. The bucks were divided into four treatment groups, each with three animals at a dose of saline (control), 1ml/kgbodyweight (Bw), 2ml/kgBw and 3ml/kgBw of the aqueous extract of *Starchytarpheta jamaiciensis were* administered subcutaneously to rabbit buck subjects in group A, group B, group C, and group D, respectively.

Haematological Parameters.

At the end of the study, blood samples were collected from all the 12 rabbits in each treatment group via their ear veins into ethylene diamine tetra acetate (EDTA) labeled bottles for haematological analyses using Baker and Silverton (1985) method.

Statistical Analysis

Data generated were analyzed using the Completely Randomized Design (CRD) and means tested (Duncan, 1955) in a COSTAT program.

RESULTS AND DISCUSSION

Table 1: Acute toxicity of crude aqueous leaf extract of *Starchytarpheta jamaiciensis*

Route of extract administration	LD_{50} ml/kgBW
Oral	>5000

Table 1 shows the acute toxicity of crude aqueous leaf extract of *Starchytarpheta jamaiciensis*. The finding from this study revealed the acute toxicity of *Stachytarpheta jamaicensis* to be safe and dose-dependent as reported by other workers (Idu *et al*., 2007) who reported that the toxic effect occurs at high dose with specific symptoms and behavioural changes observed in the bucks. Additionally, there is a need for further studies to investigate the safety and efficacy of *Stachytarpheta jamaiciensis* extracts in humans. If found safe, *Stachytarpheta jamaiciensis* extract could serve as a promising herbal remedy or source of active compounds for pharmaceutical development.

Table 2: Effect of *Stachytarpheta jamaiciensis* on haematological parameters of New Zealand white rabbit buck

	Treatments				S/E
Parameters	Control (saline)	1ml/kgBw	2ml/kgBw	3ml/kgBw	
Haemoglobin (Hb) (g/dl)	11.46^{ab}	13.42^{a}	12.27^{bc}	12.36^{c}	1.263
PCV (%)	43.34^{b}	46.71^{a}	48.13^{a}	46.47^{a}	2.241
RBC ($x10^{6/}\mu L$)	5.93^{b}	7.32^{a}	7.47^{a}	7.61^{a}	1.026
WBC ($x10^{3/}\mu L$)	7.32^{c}	8.35^{bc}	11.43^{b}	17.18^{a}	1.162
Ambient temperature ^{o}C	31	31	31	31	--
Bodyweight (g)	1456^{b}	1742^{a}	1348^{b}	1173^{a}	107.4
Ph	7.0	6.2	6.2	6.2	-_

abc: Means with different superscripts within the same row are significantly (P < 0.05) different

Table 2 displays the findings of the impact of *Stachytarpheta jamaiciensis* on the haematological parameters of a white New Zealand rabbit buck. In comparison to the control group, the results revealed greater haemoglobin (Hb), red blood cell count (RBC), and packed cell volume (PCV) and

white blood cell counts (WBC) following the short-term effects of the extract administration and fell within the values reported by Abdurahman *et al*. (2021). It was confirmed that the extract had a positive effect on the blood of New Zealand rabbits and may have a positive effect on human health after prolonged exposure when the RBC, PCV, and haemoglobin values of all exposed rats dropped within the normal range stated by Dettweiler *et al* (2017). According to Jorum *et al* (2016) blood can serve as a pathological and physiological biomarker of animal health. A considerable rise in RBC, WBC, PCV, and haemoglobin levels in this investigation indicated a hemolytic anti-anemic state. This is consistent with earlier research by Holy *et al* (2015) following intraperitoneal plant extract delivery due to an increase in body iron due to anti-oxidative stress. Despite having an acidic pH, the aqueous extract did not pose a threat to the treated animals compared to the control.

Medicinal plants and traditional medicine comprise about 90% of newly discovered pharmaceuticals, thus ensuring the safety, quality, and effectiveness of medicinal plants and herbal drugs that have gained much attention nowadays (Sarker and Nahar, 2007).

Increased in the white blood cells confirm the antioxidant property of the *Starchytarpheta jamaiciensis* as reported as biggest source of free radicals confers good reasons that generally white blood cells use free radicals to destroy bacteria and virus infected cells, these free radicals prevent immediate death from infection.

CONCLUSION AND RECOMMENDATION

The administration of an aqueous extract of *Stachytarpheta jamaiciensis* rabbits resulted in an increase in haematological values and the subsequent support of antioxidant activity in treated rabbits' haematological parameters. There is a need for additional investigation on the safety of locally manufactured plant-based formulations given the high likelihood that the reported effects may be caused by active substances with higher WBC than the control.

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PEARSON CORRELATIONS AMONG CUT-PARTS AND VISCERAL ORGANS OF BROILER CHICKEN

Oyeleye, O. O. *, Adeoye, A. A. & Akinbote, V. T.
Department of Animal Production and Health, Olusegun Agagu University of Science and Technology, Okitipupa, Ondo State, Nigeria.

*Email address/Phone number of corresponding author:olubisi.oluseun@gmail.com/+2348160911765

ABSTRACT
The study investigated the Pearson correlations among cut part and visceral organ weights in broiler chickens. A total of 60-day-old Broiler chicks (30 males and 30 females) were purchased for this study. Each group was replicated thrice (10 birds per replicate) in a completely randomized design (CRD). The cut part weights (breast, thigh, drumstick, wings, and back) and visceral organ weights (liver, heart, lungs, spleen, kidneys, and gizzard) were recorded. The results showed that there were significant positive correlations among all cut part weights. The highest correlation was observed between wing and drumstick weight, followed by back and wing weights. The lowest correlation was observed between head and breast weight. There were also significant positive correlations among all visceral organ weights. The highest correlation was observed between liver and heart weights, followed by proventriculus and liver weights. The lowest correlation was observed between large intestine and small intestine weights. This information can be used to develop breeding and feeding programmes to improve both meat yield and carcass quality.
Keywords: Phenotypic correlation, Cut-parts, Visceral organs, Broiler chicken

INTRODUCTION
Broiler chicken production is one of the most important agricultural industries in the world, providing a major source of protein for human consumption [*FAO*, 2019]. The economic success of the broiler industry is dependent on efficient production systems that maximize meat yield and quality (Zhang and Gao, 2019). One important factor that influences broiler meat yield and quality is the phenotypic correlation between cut-parts and visceral organs (Zhang and Gao, 2019). Phenotypic correlation is a statistical measure of the relationship between two or more traits (Falconer and Mackay, 1996). It is expressed as a correlation coefficient, which ranges from -1 to 1. A correlation coefficient of -1 indicates a perfect negative correlation, meaning that as the value of one trait increases, the value of the other trait decreases. A correlation coefficient of 1 indicates a perfect positive correlation, meaning that as the value of one trait increases, the value of the other trait also increases (Falconer and Mackay, 1996). A correlation coefficient of 0 indicates no correlation between the two traits.

The phenotypic correlation between cut-parts and visceral organs in broilers can be used to improve broiler production efficiency by selecting birds for traits that are positively correlated with meat yield and quality (Aggrey and Karnuah, 2003). For example, if the correlation between breast muscle weight and body weight is high, then selecting birds for high body weight will also result in high breast muscle weight. The phenotypic correlations among cut-parts in broilers have been extensively studied. In general, the correlations between cut-parts are positive, meaning that birds with a higher weight of one cut-part also have a higher weight of other cut-parts. For example, the correlation between breast muscle weight and thigh muscle weight is typically around 0.7-0.8 (Aggrey and Karnuah, 2010). This means that for every 1% increase in breast muscle weight, there is a 0.7-0.8% increase in thigh muscle weight.

The phenotypic correlations among cut-parts can vary depending on the breed, sex, and age of the broilers (Zhang and Gao, 2019). For example, the correlation between breast muscle weight and thigh muscle weight is typically higher in males than in females (Kim *et al.*, 2020). This is because males have a higher proportion of muscle mass than females (Grashorn and Serini, 2006). This is because males have a higher proportion of liver mass than females. The phenotypic correlations between cut-parts and visceral organs in broilers can be used to improve broiler production efficiency in a number of ways (Zhang and Gao, 2019). For example, if a broiler producer wants to increase the breast muscle yield of their flock, they

can select birds for high breast muscle weight or high body weight (Zhang and Gao, 2019). They can also develop a feeding program that provides the birds with the nutrients they need to maximize breast muscle growth. The phenotypic correlations between cut-parts and visceral organs in broilers are an important factor that influences broiler meat yield and quality (Zhang and Gao, 2019). Breeders and broiler producers can use phenotypic correlations to improve broiler production efficiency by selecting birds for traits that are positively correlated with meat yield and quality, and by developing feeding and management programmes that optimize meat yield and quality (Grashorn and Serini, 2006).

MATERIALS AND METHODS

Site Of the Experiment

The experiment was carried out at Adeomoh Farm, which is about 10 Km away from Teaching and Research Farm of Olusegun Agagu University of Science and Technology, Okitipupa. Ondo State. Okitipupa lies between latitude 6.25° and 6.46° N and Longitude 4.35° and 4.50° E within the tropical rainforest zone of Nigeria. Okitipupa covers a landmass of 636 square km and has an estimated population of 233,565 people (Toponavi, 2023).

Experimental Design And Management

A total of 60 day – old Broiler chicks (30 males and 30 females) were purchased for this study. Each group was replicated thrice (10 birds per replicate) in a completely randomized design (CRD). The birds were raised in deep litter system. They were uniformly fed standard diet *ad libitum* formulated to supply nutrient requirements according to NRC recommendation. The cages were properly cleaned and disinfected following which the birds were closely observed for any reaction and adequate measures were taken to ensure their healthy living. All the birds were fed *ad libitum* with commercial standard broiler starter mash containing 24% crude protein for four weeks, and 19% crude protein of finisher feed afterwards throughout the experimental period. The birds were prevented against common poultry diseases and unhealthy animals were promptly treated. All other standard management and health practices were conformed to throughout the duration of the experiment.

Statistical Analysis

All data were analyzed using SAS (2004) to determine descriptive statistics and Pearson correlation among the variables.

RESULTS AND DISCUSSION

Table 1 shows the descriptive statistics of the cut parts and internal organs. The highest co-efficient of variation was recorded in the large intestine which was 73.40 indicating a substantial dispersion in its values within the broiler population while the least co-efficient of variation was 21.87 in gizzard for internal organs. This result is relatively consistent across the broiler chicken population. For the cut part, the highest co-efficient of variation was observed in the neck which was 42.77 while the least value was observed in the head which was 19.74. Table 2 shows the Pearson correlation coefficients among internal organs. From the Table, all the paired organs were positively correlated. However, the highest correlation coefficient was observed between the liver and heart. While the least correlation coefficient was found between the large intestine and small intestine. Table 3 shows the correlation coefficients among the cut part. From the Table, it was observed that the correlation coefficients were very high, significant and positive. This shows that there is strong association among the cut-parts indicating that they are influenced by the same genes and growth in any of the cuts would definitely influence the other cuts (Ayorinde, 1995). Breeders should focus on selecting for traits that are positively correlated with both meat yield and carcass quality. This will help to ensure that improvements in one trait are not accompanied by decreases in other important traits.

Table 1: Mean and co-efficient of variation of cut parts and internal organs of Broiler Chicken

Variables	Mean	SD	N	Min.	Max	CV
BREAST	466.53 g	128.14	16	285.00	681.90	27.47
THIGH	221.36 g	44.83	16	142.80	278.80	20.25
SHANK	90.44 g	31.18	16	48.50	143.90	34.48
NECK	57.18 g	24.45	16	27.20	108.70	42.77
DRUM STICK	219.84 g	66.68	16	130.30	383.60	30.33
HEAD	64.09 g	12.65	16	41.80	84.40	19.74
WINGS	167.99 g	44.6	16	106.30	258.00	26.56
BACK	362.59 g	80.04	16	215.20	531.40	22.08
HEART	9.79 g	2.36	16	6.20	14.10	24.14
LIVER	37.98 g	9.08	16	25.00	62.30	23.90
GIZZARD	46.61 g	10.19	16	22.40	54.00	21.87
PROVENTRICULUS	11.05 g	2.86	16	8.10	18.50	25.90
SMALL INTESTINE	78.97 g	35.28	15	40.80	143.50	32.02
LARGE INTESTINE	36.86 g	16.2	16	9.40	73.40	73.40

Table 2: Pearson correlation among internal organs

	Heart	liver	Gizzard	proven	Small int	Large int.
Heart						
Liver	0.814***					
Gizzard	0.571*	0				
Proven	0.686**	0.732**	0.710**			
Small int	0.608*	0.726**	0.607*	0.649**		
Large int	0.334ns	0.247ns	0.322ns	0.350ns	0.282ns	

*P<0.05;**P <0.01;***P<0.0001

Table 3: Pearson correlation among cut- parts

	Breast	Thigh	shank	neck	drumstic	Head	Wing	back
Breast								
Thigh	0.919***							
Shank	0.752***	0.787**						
Neck	0.828***	0.786**	0.797**					
Drumstic	0.862***	0.833***	0.843***	0.930***				
Head	0.655***	0.711**	0.660**	0.807**	0.757**			
wing	0.942***	0.918***	0.884***	0.888***	0.967***	0.733**		
back	0.887***	0.891***	0.795**	0.833***	0.900***	0.722**	0.919***	

*P<0.05;**P<0.001;P<0.0001

CONCLUSION

This study has provided valuable information on the phenotypic correlations among cut part and visceral organ weights in broiler chickens. All the paired organs were positively correlated and there were also strong correlation coefficients among the cut parts. This information can be used to develop breeding programs to improve both meat yield and carcass quality.

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SEXUAL DIFFERENTIATION IN HAEMATOLOGICAL PARAMETERS AND SERUM METABOLITES OF NOILER CHICKEN

Olorunsola, R.A., Adeoye, A. A. & Oyeleye, O.O.
Department of Animal Production and Health, Olusegun Agagu University of Science and Technology Ondo State Nigeria
Corresponding author: ajiwale2002@yahoo.com; 08035196066

ABSTRACT
Haematological investigation provides the opportunity to clinically study the presence of several metabolites and other constituents in the body of animals and it plays a vital role in the physiological, nutritional and pathological status of an organism. A total of sixty (60) noiler chicken (30 –males and 30 females) were used to study the impact of sex on hematology and serum metabolites in Noiller chicken. Data collected at 6th, 8th, and 10th week on haematological parameters and serum biochemistry were subjected to analysis of variance. At 6th week, sex had no significant effect ($p>0.05$) in both haematology parameters and serum metabolites. Similar trends were observed in the 8th and 10th week except in MCV (80.10, 95.30), MCH(26.70,31.80), AG(0.90, 1.05) and chloride(99.00, 93.35) in which higher values were observed in females at week 8t. At 10th week, higher values were also observed in WBC (12.07,13.50), TP (74.00,68.50) and AST (6.50,11.00). Therefore, this study shows that most of the haemato-biochemical analyzed parameters considered are not sex dependent.
Keywords: noiler chicken, sex, age, serum metabolites, hematology.

INTRODUCTION
Sexual dimorphism is the phenomenon where males and females of the same species exhibit differences in physical and behavioral traits, often related to reproduction. It is a widespread phenomenon in the animal kingdom, occurring in a diverse range of species, including mammals, birds, reptiles, fish, and insects (Cox and John-Alder, 2007). One of the main sources of sexual dimorphism is the sex chromosomes, which determine the sex of an individual, the differential expression of sex-linked genes can result in sex-specific traits and phenotypes (Pallayova *et. al.* 2019). Another major factor that contributes to sexual dimorphism is the sex hormones, which are chemical messengers that regulate various biological processes. The main sex hormones are testosterone in males and estrogen and progesterone in females. These hormones are produced by the gonads (testes and ovaries) and act on target tissues throughout the body. Sex hormones can affect the development, growth, maturation, and function of various organs and systems, such as the brain, bones, muscles, fat, skin, hair, and reproductive organs. Sex hormones can also modulate the behavior, cognition, emotion, and personality of individuals (Schulz *et al.*, 2019). Blood indices are useful indicators of the response of animal to physiological changes due to environmental variations. They are also prognostic for pathological conditions (Ciesla, 2007). Haematological investigation provides the opportunity to clinically study the presence of several metabolites and other constituents in the body of animals and it plays a vital role in the physiological, nutritional and pathological status of an organism (Aderemi, 2004). It also helps in distinguishing normal state from state of stress (Afolabi *et al*., 2010). Odunsi *et al*. (1999) posited that dietary constituents are reflected in the blood picture of the livestock. Therefore, the objective of this study was to investigate the sexual dimorphism in hematological parameters and serum metabolites in Noiler chicken.

MATERIALS AND METHODS
The study was conducted at Poultry Unit, Teaching and Research Farm and Central Laboratory of Olusegun Agagu University of Science and Technology, Okitipupa, Ondo State, Nigeria. Okitipupa lies between latitude $6^0$25 and $6^0$46 N and Longitude $4^0$35 and $4^0$50 E within the tropical rainforest zone of Nigeria. A total of 60 day – old Noiler chicks (40 males and 20 females) were purchased from Amo Hatchery. The birds were randomly allocated to deep litter brooder pens and given a floor space of about 1.45m per bird as suggested by Adejoro, (2002). Each chick was wing - tagged and examined physically to ensure fitness and general body soundness. They were

raised for a period of 10 weeks, placed on the same diets as recommended by NRC (1994) for chick and growing pullet. All the necessary vaccinations and medication were administered to the birds accordingly. The blood samples were collected randomly from males and females at ages 6, 8 and 10 weeks through wing veins into EDTA bottles and plain bottles for hematological and serum biochemical analyses respectively. The samples were placed in a sample container labeled and carried in a flask (cooler) with ice packs and taken to Central laboratory.

Statistical Analysis

Data collected on the hematological parameters and serum metabolites were subjected to analysis of variance (ANOVA) using SAS (v. 9.13) (SAS, 2004), where significant differences occurred in the means, the means were separated using Duncan Multiple Range Test.

RESULTS AND DISCUSSION

Table 1 shows the effect of sex on hematology and serum metabolites of noiler chicken on age basis. In term of sex, at 6 weeks male had higher values in all the traits than the female except platelet, mean cell haemoglobin concentration (MCHC), albumin cobalt binding (ACB), albumin-globulin ratio (AG), and urea which were statistically higher in female and sex had no significant different ($p>0.05$) on the variables. Also at week 8, there was a change in the trend as female exhibited higher estimation in all the traits except total protein (TP), globulin (GLOB.), aspartate aminotransferase (ALT), glucose, urea and creatinine which were higher in male, and there was no significant different ($p>0.05$) in the traits except mean cell volume (MCV), MCHC, AG and Chloride which were significantly the same ($p<0.05$) which indicated that sex had significance on those traits. Then at week 10, there was higher estimation in female except glucose, globulin, TP, MCHC, MCH, platelet, haemoglogin (HB) and packed cell volume (PCV) which were higher in male and there was no significant difference ($p>0.05$) in almost all the traits except white blood cell (WBC) (12.07^b and 13.50^a), TP (74.00^a and 68.50^b), and aspartate aminotransferase (AST) (6.50^b and 11.00^a) which were significantly different ($p<0.05$) among the sexes.

Table 1: Sex Effect on Hematological parameters and Serum Biochemistry of Noiler chicken

	6 WEEKS		8 WEEKS		10 WEEKS	
VARIABLES	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
PCV	40.50±0.87	39.50±0.87	41.50±1.44	43.50±0.87	39.50±0.87	38.00±1.15
HB	13.50±0.29	13.20±0.29	13.85±0.49	14.50±0.29	13.20±0.29	12.67±0.38
RBC	4.45±0.20	4.45±0.09	4.45±0.09	4.60±0.29	4.50±0.12	4.77±0.09
WBC	11.70±0.46	10.80±0.58	13.25±0.32	13.40±0.35	12.07^b±0.38	13.50±0.23
PLATE	30.00±0.23	30.20±0.35	32.80±0.52	35.00±1.39	31.60±1.09	30.10±0.35
MCV	94.55±4.53	85.65±1.99	80.10^b±2.71	95.30±4.09	81.90±0.17	79.97±0.95
MCH	31.70±1.62	28.50±0.72	26.70^b±0.92	31.80±1.39	28.20±0.52	26.60±0.29
MCHC	33.30±0.00	33.35±0.03	33.30±0.00	32.80±0.29	33.27±0.03	33.10±0.06
TP	75.00±0.00	72.50±2.02	75.50±2.02	74.50±2.02	74.00±0.58	68.50^b±0.29
ACB	39.00±0.58	39.50±0.29	36.00±1.15	37.50±0.29	38.50±2.02	40.00±0.00
GLOB	36.00±0.58	33.00±2.31	39.50±0.87	37.00±1.73	35.50±2.59	28.50±0.29
AG	1.10±0.00	1.25±0.09	0.90^b±0.00	1.05±0.03	1.17±0.15	1.40±0.00
AST	9.00±1.15	6.50±0.87	9.50±0.87	7.00±1.15	6.50^b±0.29	11.00±0.00
ALT	8.00±1.15	8.00±0.58	9.50±2.02	5.50±0.87	9.50±0.87	11.00±0.58
ALP	16.00±0.58	14.50±0.87	16.50±0.29	19.00±1.15	17.00±1.15	18.50±1.44
GLUCOSE	5.50±0.35	5.10±0.06	6.05±0.61	5.15±0.03	5.40±0.40	4.77±0.20
CHLORIDE	95.00±0.00	93.50±2.02	99.00±0.58	93.35^b±1.53	95.30±2.14	96.17±0.49
UREA	4.30±0.23	4.65±0.26	6.05±0.61	4.85±0.29	3.87±0.55	4.47±0.09
CREATININE	78.75±0.20	75.75±4.30	85.85±9.15	72.40±0.58	70.87±11.92	80.27±5.69

PCV – Packed Cell Volume; HB - Hemoglobin RBC – Red Blood Cell; WBC – White Blood Cell; plate - platelet;
a, b, means within a row with different superscripts are significantly different ($p<0.05$).
MCV – Mean Corpuscular Volume; MCH – Mean Corpuscular Haemoglobin; MCHC – Mean Corpuscular Haemoglobin Concentration; TP - Total Protein; ACB - Albumin Cobalt Binding; GLOB - Globulin; AG - Albumin Globulin; AST - Asparate Amino Transferase; ALT- Alanine Amino Transferase; ALP - Alkaline Phosphate

At 6 weeks of age, the study found that male chickens had higher values in most of the studied traits compared to females, this was in accordance with (Panigrahy *et al.*, 2017) with some exceptions

such as platelet count, MCHC (Mean Corpuscular Hemoglobin Concentration), ACB (Albumin to Globulin Ratio), AG, and urea, which were statistically higher in females. Importantly, the study determined that there was no significant difference ($p>0.05$) in these traits between the sexes at this age.

However, the trend shifts at 8 weeks of age, where female chickens exhibited higher values in most of the studied traits compared to males. Again, there were exceptions, such as TP (Total Protein), GLOB (Globulin), (Hassan *et al.*, 2016), AST (Aspartate Aminotransferase), ALT (Alanine Aminotransferase), glucose, urea, and creatinine, which were higher in males. Interestingly, similar to the 6-week mark, there was no significant difference ($p>0.05$) in most of these traits between the sexes. The significance ($p<0.05$) observed in MCV (Mean Corpuscular Volume), MCHC, which was observed by (Naveen *et al.*, 2019) AG, and chloride suggests that sex has an impact on these particular traits at this age (Albokhadaim, 2012).

At 10 weeks of age, the study found that female chickens continued to have higher values in most traits compared to males, with some exceptions like glucose, globulin, TP, MCHC, MCH, platelet count, hemoglobin (HB), and packed cell volume (PCV), which were higher in males (Naveen *et al.*, 2019). However, unlike the previous ages, there were significant differences ($p<0.05$) in a few traits among the sexes, namely WBC (White Blood Cell) count, TP, and AST. (Rawnstey, 1977).

In female Noiler chickens, many traits showed their highest values at week 8. This could be indicative of a stage where these chickens are experiencing significant physiological changes or growth spurts. For some traits like RBC, WBC, and AST, there was a progressive increase from week 10 to 4. (Hrabcakova *et al.*, 2014). This suggests that certain physiological changes continue to occur even after the initial growth phase, highlighting the importance of monitoring these parameters over time.

CONCLUSION

These findings suggest that the effect of sex on blood parameters in Noiler chickens becomes more pronounced as they approach 10 weeks of age, with significant differences observed in specific traits which is contrary to the claim of (Shanmathy *et al.*, 2020). These differences may be indicative of the distinct physiological and metabolic characteristics between male and female chickens at this stage of development.

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EFFECT OF PELLETING ON THE TOTAL AFLATOXIN CONCENTRATION IN FISH FEED.

Ilesanmi, A. I[1]*., Bubu-Davies, O. A.[2]., Osemwegie, O.O.[3]., Abu, O. M. G[2]., Dan-Ologe, I. A[4]. and Ayegba, E. O[1].

[1]Department of Fisheries and Aquaculture, University of Agriculture and Environmental Sciences, Umuagwo, Imo State, Nigeria.

[2]Department of Fisheries and Aquatic Environment, Rivers State University, Port Harcourt, Nigeria.

[3]Department of Food Science and Microbiology, Landmark University, Omu-aran, Kwara State, Nigeria.

[4]Department of Biology, Federal College of Education, Abeokuta, Ogun State, Nigeria

*Corresponding author - isaac.ilesanmi@uaes.edu.ng

ABSTRACT

The presence of mycotoxins in feed and food is a major issue due to the health effects it has caused worldwide, especially with the emerging effects of climate change on the environment. The effects of pelleting on the total aflatoxin in mould feed was studied in formulated fish feeds. The fish feeds were contaminated with the *Aspergillus flavus* organism in order to have some level of total aflatoxin secretion. The concentration level of the secreted total aflatoxin in the fish feed was determined using Thin Layer Chromatography (TLC). There are four (4) treatment (A, B, C and D) and three (3) replicates including the control (A – uncontaminated feed) of the experimental feed. The first analysis done was before the contamination and after the contamination of the feed with *Aspergillus flavus*. The second analysis was after the feed passed through the process of pelleting and drying. The results revealed the reducing effect of the pelleting process on the concentration of total aflatoxins in fish feed.

Keywords: *Aspergillus flavus*, Drying, Fish feed, Total aflatoxin

INTRODUCTION

Mycotoxins are naturally occurring harmful substance created as secondary metabolites by contagious moulds or living organism of the fungal (Sani *et al.*, 2013). It is known that filamentous organisms belonging to *Aspergillus*, *Alternaria*, *Penicillium* and *Fusarium* manufacture mycotoxins in a manner that is specific to each strain (Egbuta *et al.*, 2017). Mycotoxin contamination of food and feed is a serious global health hazard that is poisonous to living organisms and humans. Most of the crops cultivated globally are contaminated by these mycotoxins.

There are several methods that have been developed in order to decontaminate and detoxify mycotoxin contaminated food and feed. These include:

Pre-harvest – This includes reduction in plant stress and insect damage, Avoidance of environmental conditions that favour infection in the field (e.g. Drought, insect infestation, and delayed harvesting), good cultural practices, breeding of cultivars resistant to fungal infection, and development of transgenic plants resistant to fungal infection.

Harvest – This includes keeping mechanical damage of seeds to a minimum, timely harvest of field crops so as to reduce moisture level to a point where mycotoxin formation will not occur and immediate transportation of crops.

Post-harvest strategies – This involves the removal of damaged grain and drying of grain to the minimal moisture level, control of insect and rodent activities and maintenance of appropriate moisture levels and temperature, appropriate packaging, frequent cleaning of food/feed delivery systems, and short term storage.

Neme and Mohammed (2017) reported that the concentration of mycotoxins can be reduced with processing methods, although may not be completely removed. The level of mycotoxin contamination can be reduced by softening, because the fungi accumulate on the surface of the granules. The objective of this study is to determine the effect of the processing techniques on the mould fish feed.

MATERIAL AND METHODS

The experiment was conducted at the Departmental Laboratory of Fisheries and Aquatic Environment, Faculty of Agriculture, Rivers State University,

Port Harcourt Nigeria. The feed ingredients were bought from Agro-Allied Company at Mamy market, Bori Camp Rumuokoro Port Harcourt, Rivers State. There are Four (4) treatments (A, B, C and D) and three (3) replicates of the experimental fish feed. The experimental feeds were collected for the total aflatoxin analysis before the inclusion of fungi organism and the mean values were recorded.

The formulated feed (Table 1) was then mixed with a little quantity of distilled water and together with a strain of *Aspergillus flavus* collected from the Microbiology Department of Rivers State University, Port Harcourt. A plastic sac was used to cover the mixed feed to encourage the growth of the mould for 24hours. The feed was pelletized with a pelleting machine and dried immediately with an electric dryer at 60^{o}C for 12hours. Thereafter, the feed were properly packaged and the final total aflatoxin analysis of the A, B, C and D was done to determine the level of total aflatoxin concentration at this stage.

Table 1: The dietary composition of the experiment

Ingredient	Feed (Kg)
Maize	22.5
Groundnutcake	30.50
Fishmeal	15.50
Soya-beanmeal	30.50
Mineral premix*	0.50
Methionine	0.25
Lysine	0.25
Total	**100**

***Contains VitA 4000000IU; Vit D. 800000IU; Vit. E 40000mg; Vit. K3 800mg; Vit. B1 1000mg; Vit. B2 6000mg; Vit. B6 5000m; Vit. B12 25mg; Niacin 6000mg; Patothenic acid 20000mg; Folic acid 200mg; Folic acid 200mg; Biotin 8mg; Manganese 300000mg; Iron 80000mg; Zinc 20000mg; Cobalt 80mg; Iodine 400mg; Selenium 40mg; Choline 800000mg*

The mycotoxin analysis of each feed treatment was done at Aniete Laboratory with thin-layer-chromatography (TLC) (AOAC, 2000).

RESULTS AND DISCUSSION

The analysis of the total aflatoxin present in the feed at the initial stage are ranged from 7.15±0.55 to 238.23±0.08) as stated in the Table 2. The total aflatoxin observed after the pelleting and drying ranged from 3.00±0.13 to 11.00±0.22. The aflatoxin content of the experimental diet is higher than the standard limit level set by European Commission (2003) for complete and compound animal feeds are 10 µg/kg and 20 µg/kg for feed ingredients. It was observed from this study that the pelleting had reducing effect on the concentration of the toxin. This is in support of the report by Neme and Mohammed (2017) stating that the concentration of mycotoxin can be reduced by processing techniquesAlso, that the extrusion technique reduces aflatoxins depending on the processing temperature and granule moisture content reduction.

Table 2: Total Aflatoxin Analysis in the feed

Samples	Initial Total Aflatoxin concentrations (µg/kg)	Total Aflatoxin concentrations (µg/kg)
A	7.15±0.55	3.00±0.13
B	223.85±0.13	11.00±0.22
C	225.17±0.42	10.80±0.15
D	238.23±0.08	11.00±0.08

The concentration of aflatoxin found in the experimental feed purchased directly at feed mill used for this experiment is an indication that there is possibility of the presence of mycotoxins in the fed mill and farm across the nation. This result is in support of the global investigation of the occurrence of mycotoxin in animal feed by Biomin survey (2017) which revealed that about 74% of the ingredients used in compounding aquaculture feed are contaminated with mycotoxins which can have a substantial negative economic impact on the aquaculture industry.

Also, the concentration of aflatoxin in the experimental feed may be affected by the heat treatment during the drying period of the pelleted feed. This is supported by Kabak's (2006) report, which states that heat efficiency in decontaminating mycotoxins in feed depends on the chemical structure and concentration of mycotoxins, temperature, time, moisture content, pH, and ionic concentration during thermal treatment (Kabak, 2006).

In contrast to the results of this experiment, Ryu *et al*. (2003) reported that aflatoxin B1, deoxynivalenol, zearalenone, and fumonisins B1 are compounds that cannot be affected by heat at decomposition temperatures greater than 237, 175, 220, and 150 °C, respectively, making them difficult to eliminate by conventional thermal processing. Nonetheless, thermal treatments consume an excessive amount of energy; also, high temperature-induced Maillard reactions diminish the nutritional content of feed items. This restricted the use of heat treatments in the feed sector (Pankaj *et al*., 2018).

CONCLUSION AND RECOMMENDATIONS

This study has revealed that mycotoxin level in fish feed can be reduced by pelleting process. It can be recommended from this study that every feed should pass through a proper processing method of pelleting because it can be concluded that pelleting has a way of reducing the concentration of mycotoxins.

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HAEMATOLOGICAL INDICES AND SKIN CHARACTERISTICS OF F_2 PROGENY OF ABIA ECOTYPE BIRDS AND THEIR EXOTIC MALE LINE CROSSES IN THE HUMID TROPICS

Olagbegi, A. D., Oke, U. K., Nzeaghara J. M., Obike, O. M., Urum, S.M., Nosike, R. J., Obi C. O., Anieke, Eunice and Ohiaegbe, J. P.

Department of Animal Breeding and Physiology College of Animal Science and Production, Michael Okpara University of Agriculture, Umudike. Abia State Nigeria. Corresponding author**:** ayoglow81@gmail.com

ABSTRACT

Haematological indices and skin characteristics of F_2 progeny of Nigerian indigenous Abia ecotype birds and exotic male line crosses were investigated in this study. A base population of 40 Abia ecotype chicken, Brown (B_1) and Black (B_2) plumage colour was used as female – lines and crossed with two exotic meat type chicken, Cobb (A_1) and Ross 308 (A_2), as male – line, with the objective of producing F_1 crossbred that would become parents for a four – way final crossbred. The mating for the formation of F_2 was set up using a 4x4 diallelic crossing technique and the selection of the most productive progenies of the F_1 were evaluated for further selection as improved Abia Ecotype Chicken. The parameters measured were haematological parameters and skin characteristics of F_2 progeny. Haematological parameters showed significant ($p<0.05$) differences between the genetic groups in PCV and WBC. T_3 progeny (28.40%) and T_4 (28.10%) genetic group recorded a significantly ($P < 0.05$) higher PCV values while the least was recorded by T_1 progeny (25.40%) and T_2 (25.45%). Also, T_3 (26.55×10^3 mm^3), and T_4 (26.11×10^3 mm^3) group recorded a significantly ($P< 0.05$) higher value of WBC while the least was recorded by T_2 (21.95×10^3 mm^3) genetic group. T_3 (36.22pg) recorded the highest value for MCH which was significantly ($P < 0.05$) higher while the least was recorded by T_2 (33.25pg) genetic group. The findings of this study indicate variations in colors (plumage, earlobe, and comb), comb types, skin color, and shank color among indigenous chicken crosses. For the skin color, the white and yellow type skin color was found to be very common in all the crosses. The shank colour observed were yellow and white in all the crosses. From the study, T_3 and T_4 showed distinct characteristics among the indigenous chicken strains. The result therefore indicates that strain significantly affects the blood and phenotypic characteristics of chickens. Efforts are needed to conserve the genetic resources of these chickens.

Keywords: Abia-ecotype birds, exotic birds, haematological indices, skin characteristics.

INTRODUCTION

The indigenous poultry species represents valuable resources for livestock development because their extensive genetic diversity allows for rearing of poultry under varied environmental condition, providing a range of products and functions. Although the local birds are acclimatized to the environment with their hardiness, tough skin, resistance to disease, the exotic birds still outperform them in terms of production such as egg laying, meat quality and reproduction. Blood is important and reliable medium for assessing the physiological and health status of individual animals (Egbe-Nwiyi *et al* 2000). Haematological indices could be utilized in cross breeding programmes to produce individuals that are fit and more productive (Ladokun *et al* 2008). The skin of birds is fundamentally adapted to their life as active homoiothermic animals. It is largely concealed by the feathers, and its properties have been shaped by them. The ordinary skin is usually pale pink or bluish pink, elastic, often translucent, and thinner in birds than in mammals of equal size. The skin is firmly attached with little or no modification on the skull, the wing tips, and other regions. The basic external parts of a chicken include the comb, beak, wattles, ears, earlobes, eyes, eye rings, wings, tail, thighs, hocks, shanks, spurs, claws, and toes. This study is therefore aimed at estimating the characteristics of F_2 progeny of crosses between the local birds and exotic sires using their haematological and skin parameters.

MATERIALS AND METHOD

Experimental site

The experiment was carried out at the Poultry unit of the Teaching and Research farm of Michael Okpara University of Agriculture Umudike, Abia

State, Nigeria. Umudike is located within l**atitude 5° 28' 19.79"** North of the equator and l**ongitude 7° 32' 33.59" East of the Greenwich meridian**. It has an altitude of 122m above sea level. The area falls within the tropical rainforest zone with a relative humidity between 50 and 95% depending on the season.

Experimental animal and management

A base population of 40 indigenous Abia ecotype chicken, Brown (B_1) and Black (B_2) plumage colour obtained from the three senatorial districts of Abia State, Nigeria was used as female – lines with each strain having 10birds per replicate and crossed with two exotic meat type chicken, Cobb (A_1) and Ross 308 (A_2), as male – line, with the objective of producing F_1 crossbred that would become parents for a four – way final crossbred. The mating for the formation of F_2 was set up using a 4x4 diallelic crossing technique and the Selection of the most productive progeny of the F_2 evaluated for further selection as improved Abia Ecotype Chicken.

Table 1 Mating design between cocks (exotic) and hens (local) of two different strains of grandparent stock.

	Hens	
Cock	B1	B2
A1	A1 B1	A1 B2
A2	A2 B1	A2 B2

A1 = Exotic male Arbor Acre birds
A2 = Exotic male Ross 308 birds
B1 = Local female Brown birds
B2 = Local female Black birds

Progenies of the two-grandparent used for the study; A1B1 (T1), A1B2 (T2), A2B1 (T3), A2B2 (T4) T_1 = progenies of Exotic male Arbor Acre birds x Local female Brown birds, T_2 = Exotic male Arbor Acre birds x Local female Black birds, T_3 = Exotic male Ross 308 birds x Local female Brown birds, T_4 = Exotic male Ross 308 birds x Local female Black birds.

Data collection and Analysis

Blood samples were collected five (5) times from groups during the experiment. Blood was obtained (2mls) at two weeks interval during the experiment through the wing vein using 5ml syringe at 3-Dh needle and then transferred into sterile test tubes. The blood was placed in a test tube containing anticoagulant agent ethylene diamine tetra-acetic acid (EDTA) (1.5 mg/ml of blood). The temperature was measured using a thermocouple thermometer. The skin characteristics were observed visually. Data collected were analyzed using analysis of variance (ANOVA). Significant means were separated using Duncan's multiple range test (Duncan 1955). The design was a randomized compete block design (RCBD) and all data generated were analyzed using independent students t-test of SAS (2004) analytical package and significant differences were determined at $p \leq 0.05$.

RESULTS AND DISCUSSION

Haematological parameters of the F_2 progeny of Abia ecotype chickens' x exotic male line.

The haematological parameters of the *F_2* progeny of Abia ecotype chickens x exotic male line is shown in Table 2.

Table 2: Haematological and rectal temperature of the *F_2* progeny of Abia ecotype crosses

Parameters	T_1	T_2	T_3	T_4	SEM
Haemoglobin Hb (g/dl)	10.72	10.66	11.23	10.40	0.11
Packed Cell Volume (%)	25.40^b	25.45^b	28.40^a	28.10^a	1.65
Red Blood Cell ($X10^6mm^3$)	3.15	3.20	3.10	3.00	0.08
White Blood Cell ($X10^3mm^3$)	23.06^b	21.95^c	26.55^a	26.11^a	1.11
Mean Corpuscular Volume Mean MCV (fl)	80.63	79.53	91.61	93.66	0.65
Mean Corpuscular Haemoglobin MCH (pg)	34.17^b	33.25^c	36.22^a	34.67^b	1.17
Mean Corpuscular Haemoglobin concentration MCHC (g/dl)	42.20	41.88	39.54	37.10	0.44
Rectal temperature ^0C	40.50	41.15	41.20	40.30	0.33

^{abc}Means within the rows with different superscripts are significantly different (P<0.05); SEM-Standard error of the mean.

T_3 and T_4 genetic group recorded a significantly ($P < 0.05$) higher PCV values while the least was recorded by T_1 and T_2. The range of PCV values (24.40 - 28.40%) obtained in this study agrees with the reference value of 22.00 – 35.00% (Jain, 1993). Also, T_3, and T_4 group recorded a significantly ($P< 0.05$) higher value of WBC while the least was recorded by T_2 genetic group. The WBC obtained in this study were within the normal range of 9.0-26.0 $x10^3$ /dl) reported by Mitruka and Rawnsley (1997). The high values recorded by T_3 and T_4 group suggest greatest ability of the birds in fighting infections, compared to other genetic groups. This may be responsible for their highest population and adaptability amongst the three genotypes across Nigeria.T_3 recorded the highest value for MCH which was significantly ($P < 0.05$) higher while the least was recorded by T_2 genetic group. The MCH range obtained in this study was higher the range (22.97 – 27.72pg) reported in Fayoumi chicken breed (Islam *et al*, 2004) but lower than the reference range (43.00 – 47.00 pg) (Jain 1993). The difference in values of MCH may be as a result of the difference in age of experimental birds as MCH value decreases gradually with advancement in age (Islam *et al* 2004). However, the observed differences across the genetic groups and higher PCV, Hb and MCH in T_3 than T_4 progeny agree with previous studies (Chineke *et al* 2006) for Nigerian indigenous chickens. The result obtained also revealed that there was no significant difference ($p>0.05$) in the rectal temperature of F2 progenies. The temperature range observed was between 40.30 to 41.20^0C. The similarity recorded suggests that the traits effectiveness in combating heat stress has been passed on to the crosses from their parents. Generally, the comfortable and normal body temperatures of broilers range between 21-26°C and 41-42°C (Nosike *et.al*, 2018).

Skin characteristics of F_2 progeny of Abia ecotype chickens x exotic male line crosses

The skin characteristics include the skin colour, shank colour, comb colour, comb intensity, etc

Table 3: Skin Characters of *F_2* progeny of Abia ecotype chickens x exotic male line Crosses

Parameters	T_1	T_2	T_3	T_4
Comb Size	Medium	Medium	Large	Medium
Comb Type	Single	Single	Single	Single
Comb Color	Red	Red	Red	Red
Comb Intensity	Medium	Medium	Dark	Medium
Skin Color	White	White	White	White
Shank Color	White	White	Yellow	Yellow
Eye Color	Black	Brown	Brown	Brown
Ear Lope	White	White	White	White

The findings of this study on skin characters of F_2 progeny of Abia ecotype chickens x exotic male line as presented in Table 3 above indicate variations in colors (plumage, earlobe, and comb), comb types, skin color, and shank color among indigenous chicken crosses. Various plumage colors were observed in the study. These findings agree with previous studies in Africa (Melesse and Negesse, 2011). Indigenous chickens anatomically have diverse plumage colors that aid in camouflage against predators.

CONCLUSION

T_3 and T_4 ecotype showed distinct phenotypic characteristics among the F2 strains. It is therefore recommended that these strains could earn the opportunity of being considered for incorporation into a meat producing indigenous chickens in Nigeria if improved upon.

Acknowledgement

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RESPONSE OF TOMATO VARIETY (UC-82B) TO COLCHICINE ($C_{22}H_{25}NO6$) TREATMENT ON MORPHOLOGICAL CHARACTERIZATION FOR IMPROVED GROWTH AND YIELD RELATED TRAITS IN DRY AND WET SEASONS

Alkali A.U.*[1], Zainab. S.Z.[2] and Bashir,. A[3].
[1]1ntegrated Science Department
[2.] Biology Department
[3.] Chemistry Department
[1.]Biology Department, College of Education and Preliminary studies, Kano State
*Corresponding Author: Email: aminuyahayafagge@gmail.com GSM: +2347035347997

ABSTRACT
The Response of Tomato Variety (UC-82B) to Colchicine Treatment for Improved Growth and Yield related Traits was investigated with the aim of inducing variability that could be exploited in the improvement of some quality traits in Tomato in Dry and Wet season. The seed of the tomato variety (*UC-82B)* was treated with three different concentrations of colchicine (1.0mM, 1.5mM, 2.0mM and 0.0mM as control). The result indicated that, the (UC-82B) variety respond more to the mutagenic treatments during the rainy season. It showed that, seedlings height, height at maturity and pericarp thickness of the controls have the highest response during the dry season. However, all the mutants treated with 1.0mM concentration showed highest response in all the selected traits during rainy season except fruit diameter. Similarly, all the 1.5mM treated mutants showed highest response during rainy season except in leaf area where highest response was found in dry season. Similar result was found in 2.0mM treated mutant. It was concluded that 1.0Mm on (UC-82B) tomato variety shows highest response in both seasons.
Key Words: Colchicine, UC82B, Rainy season, Dry season, Mutation.

INTRODUCTION
Tomato is one of the most highly recognized vegetables consumed widely and it is a major source of vitamins and minerals. It is one of the most popular salad vegetables and is taken with great relish. Tomatoes and tomato products are rich in health related food components as they are good source of carotenoids (lycopene and -carotene), ascorbic acid (vitamin C), vitamin A, vitamin E, folate, flavonoids, minerals, proteins and dietary fibre (Beecher, 2001and Davis, *et al* (2003). Regular consumption of tomatoes has been correlated with a reduce risk of various types of cancer and heart disease. These positive effects are believed to be attributable to the anti-oxidant particularly the carotenoid, flavonoids, ascorbic acid and phenolic compounds Giovanelli, *et al* (2006).

In Nigeria, especially at the Southern or Western region, tomato production is highly seasonal and mostly weather dependent, which has led to surfeit during the favorable season and scarcity during the unfavorable season. The demands for high quality, moderate sized, red colored tomato with more fruit, pleasing appearance and good taste is increasing, while grower prefer high yielding, higher fruit weight, indeterminate growth habit and resistance to pest and diseases. The solution to these is to find suitable varieties for growing that will meet the consumers demand under a controlled environment.

Colchicine is a chemical mutagen and has been one of the most powerful mutagens in crop plants. The mutagen city is mediated through the production of an organic metabolite compound. This metabolite enters into the nucleus, interacts with DNA and creates point mutation in the genome. Kozgar et *al.*, 2011; Mustafa, (2011). It has also proved its worth as chemical lmutagens to induce genetic variability. Thus, this chemical mutagen has become important tool to enhance agronomic traits of crop plants (Khan, 2006). Presently, imported varieties tomatoes are introduced into the market; greenhouse vegetable growers use this variety without full knowledge of the performance under controlled environment. The main aim of this study was to investigate response of tomato variety (UC-82B) to colchicine and seasonal variations for improved growth and yield related traits.

MATERIALS AND METHOD

Study Site

The research was conducted at the Green House of the Botanical Garden of the Department of Biological Sciences, Hamada Bello University Zaria (Let 11^0 12^1N, Long 7^0,37^1E, Alt 550-700 m above sea level) in 2014.

Sources of the Seeds

Seed of the cultivated tomato (*UC*-82B) was collected from the Institute for Agricultural Research (I.A.R), Hamada Bello University Zaria, Nigeria.

Treatment and Experimental Design

The seed of the UC82B tomato variety was treated with three different concentrations of colchicine (1.0mM, 1.5mM, 2.0mM and 0.0mM as control). The variety was said to be successfully flourishing more during dry season. The treated variety was grown in 45 polythene bags arranged in a Completely Randomized Design (CRD) with three replications in each season as described in McVoy (2005).

Data Analysis

All the data collected were subjected to Analysis of Variance, and the means were separated using Duncan's Multiple Range Test, (DMRT).

Effects for Interaction of Concentration, Variety and Seasons on some Selected Tomato Traits on UC-82B tomato variety

Concentration (mM)	Variety	Season	Germination % (2 WAP)	Seedlings Height (cm)	Survival Rate (%)	Height at Maturity (cm)	Number of Leaves	Leaf Area (cm^2)	Number of Fruits	Pericarp Thickness (mm)	Fruit Diameter (cm)	Root DW (g)
0.0	**UC**	**Dry**	40.51[a]	22.83[a]	44.29[a]	37.73[a]	15.11[a]	9.83[a]	2.77[a]	0.40[a]	0.39[a]	1.66[a]
	UC	**Rainy**	40.66[a]	19.44[a]	23.70[a]	30.81[a]	12.44[a]	11.50[a]	1.77[a]	0.30[a]	0.42[a]	2.60[a]
1.0	**UC**	**Dry**	83.11[a]	33.07[b]	83.11[a]	55.50[a]	20.33[a]	31.83[a]	9.33[a]	0.28[b]	0.15[a]	3.04[a]
	UC	**Rainy**	73.70[b]	34.97[a]	62.66[b]	50.35[b]	17.55[b]	30.66[b]	4.77[b]	0.50[a]	0.14[b]	2.90[b]
1.5	**UC**	**Dry**	75.77[a]	29.07[b]	73.66[a]	47.31[a]	18.77[a]	25.94[a]	6.22[a]	0.25[b]	0.28[b]	2.77[a]
	UC	**Rainy**	64.37[b]	29.78[a]	49.92[b]	41.54[b]	16.33[b]	23.33[b]	3.22[b]	0.28[a]	0.30[a]	2.58[b]
2.0	**UC**	**Dry**	64.48[a]	27.54[a]	58.88[a]	43.46[a]	17.77[a]	17.72[a]	4.55[a]	0.21[b]	0.36[b]	2.47[a]
	UC	**Rainy**	53.40[b]	25.66[b]	38.81[b]	38.32[b]	14.33[b]	14.83[b]	2.44[b]	0.32[a]	0.45[a]	2.26[b]

N.B: *[1] Means within the columns with the same letter(s) are not significantly different (P≤0.05)

RESULT

The result of the interaction of concentration by season is presented in the Table above. The result indicated that, the interaction makes the (*UC-82B)* variety of tomato to respond more to the mutagenic treatments during the rainy season than the dry season. Similarly, all the 1.5mM treated mutants showed highest response during rainy season except in leaf area where highest response was found in dry season. Similar result was found in 2.0 m treated mutants.

DISCUSSION

The distinct differences observed in most of the quantitative and qualitative traits among the colchicine induced mutants of (UC-82B) tomato evaluated showed significant improvements in the selected traits. Although there were few traits with no significant differences in responses to the applied treatments; the ability of the mutants to germinate faster after one and two weeks of planting in respect to the controls showed that the mutagenic treatments induced increase enzymatic activities, which could be responsible for the early germination. This finding is in agreement with the findings of Mensah *et al*. (2007) who reported decreased in germination with increase in the dose of chemical mutagens. In the present investigation, germination, plant heights and number of leaves and area decreased with increasing concentration of colchicine. This finding conformed to the earlier report by Ahloowalia and Maluszynski (2001) that, the viable mutants observed are mainly dependable measure of genetic effect in mutagen. The increased in the number of leaves, fruit number and plant heights due to colchicine treatments is also in conformity with the work of Adamu and Aliyu (2007) who reported increased in growth and yield parameters of tomato due to colchicine treatments. Reductions in germination percentages and diameter of the fruit due to the effects of mutagens

on various crop plants have earlier been documented by Mensah and Kamiah (1997) and Mensah *et al*. (2005).

The increased in the leaf area and seedling height among the mutants signifies the ability of the mutagen (colchicine) to initiate more foliar buds. This finding agrees with the work of Maluszynski *et al.* (2001), who independently reported an increase in leaf number and leaf area among *Zeamays* mutants.

More so, the improvement in the growth and yield components of tomato due to colchicine treatments stressed the effect of mutation on the growth and yield of plants. This is in conformity to the work of Adamu *et al*. (2002) when groundnut was treated with gamma rays and Sheeba*et al*. (2005) when gamma rays and EMS were used to treat *Sesanumindicum* L. where seed germination, seedling, survival, plant height and pollen fertility were reduced significantly with an increase in dosage levels of both mutagens. However, in contrast, Sasi *et al*. (2005), showed that all plant mutant types registered lower yields compared to their parents in the study of the effects of diethylsulphate and EMS on Okra (*Abelmoschusesculentum* (L.) var. MDU-1).

The increased in fruit quality, such as pericarp thickness due to induced mutagenesis by colchicine signifies the vital role played by the mutagen in improving the quality traits of tomato. The increased in dry weights of the tomato varieties due to sodium azide treatments is in contrast to the findings of Ikhajiagbe, *et al*. (2012). Significant improvements were found among the mutant tomatoes in both the dry and wet seasons.

CONCLUSION

It was found that 1.0mM concentration of colchicine has the highest effect on (*UC-82B)* tomato variety. Significant difference was found in the response of the variety UC responding more significantly to colchicine treatment in both rainy and dry seasons. It was found that, there was significant difference in the effect of colchicine on the growth and yield components of the (UC-82B) tomato variety under study.

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MUTAGENIC EFFECT ON MORPHOLOGICAL CHARACTERIZATION ON THREE VARIETIES OF TOMATO (*Lycopersicon esculentum Mill*.) by Sodium Azide (NaN_3) AND GRAFTING

***Ahmed H. I., Yassar., Z.R. and Balaraba., M.**
Biology Department
College of Education and Preliminary studies, Kano State
*Corresponding Author: Email: aminuyahayafagge@gmail.com GSM: +2347035347997

ABSTRACT
The Effect of Sodium Azide and Grafting on Vegetative Growth and Yield Parameters on Tomato in Wet Season, was investigated with the aim of inducing variability that could be exploited in the improvement of some quality traits in Tomato. The seeds of three varieties of tomato: (*Roma-VF, UC82B* and *Local varieties)* were treated with three different concentrations of sodium azide (0.2mM, 0.4 mM, 0.6 mM and 0.0 mM as control). The result showed a highly significant difference ($P \leq 0.01$) on the effects of concentrations of sodium azide on all the selected traits except on the fruit diameter. Highly significant difference ($P \leq 0.01$) was found on the effects of grafting and sodium azide singly and in combine dosage as treatments on germination percent (1 and 2 WAP), plant heights and on number of leaves/plant. Significant difference ($P \leq 0.05$) was found On the survival rate, while, no significant difference was found on the effects of the treatments on the number of fruits, fruit diameter, and pH. More so, in the interactions of variety and treatments on the number of leaves produced per plant, highly significant difference ($P \leq 0.01$) was found. It was generally concluded that, 0.1mM concentration of sodium azide (NaN_3) and grafting are significant in the improvement of highly economic crops like tomato.
Keywords: Sodium azide Grafting, Roma, UC82, Local Rainy, season, Mutation**.**

INTRODUCTION
The prime strategy in mutation breeding has been to upgrade the well-adapted plant varieties by altering one or two major traits which limit their productivity or enhance their quality. Tomato is an important crop of the world, one way of creating variability in such a self-pollinated crop is attempting crosses between two genotypes complementing the characters of each other but due to autogamous nature of the crop, hybridization at appropriate time is a difficult process. The only alternative left for breeders to create variability is mutation breeding.. This method can be used as a potential source of creating variability (Novak and Brunner, 1992). Mutations have played a great role increasing world food security, since new food crop varieties embedded with various induced mutations have contributed to the significant increase of crop production (Kharkwal and Shu, 2009).

Mutation induction offers the possibility of inducing desired attributes that either cannot be found in nature or have been lost during evaluation. Treatment with mutagens alters genes or breaks chromosomes. Gene mutations occur naturally as errors in DNA replication. Most of these errors are repaired but some may pass to the next cell division to become established in the plant offspring as spontaneous mutations. Gene mutations without phenotypic expressions are usually not recognized. Consequently, genetic variation appears rather limited and breeders have to resort to mutation induction (Novak and Brunner, 1992). Chemical mutagenesis is regarded as an effective and important tool in improving the yield and quality characters of crop plants. In general alkyl ting agents are very effective mutagens in higher plants.

However, One of chemical mutagens is sodiu m azide (NaN3) which isknown to be highly m utagenic in several organisms, including plants a nd cause genetic diversity that affect plantgrowt h and productivity Addai,*al*:.(2006). A chemic al mutagen generally produces an induced mu tations leading to thesubstitution, for sodium azi de substitutions occurs especially amino acid changes that alter,protein function.

This chemomutagen induces a widevariation in morphology and agronomiccharacters whencom pared to normal plants Ahloowalia, *et al:* (2001).The main objective of this research is to discover the mutagenic effect of Sodium azide and Grafting in some selected Traits on Three varieties in Tomato *Solanum lycopersicum mill* in Wet season.

MATERIALS AND METHOD

Study Site

The research was conducted in the Green House of the Botanical Garden of the Department of Biological Sciences, Ahmadu Bello University Zaria (2014). (Lat 11^0 12^1N, Long 7^0,37^1E, Alt 550-700 m above sea level).

Sources of the Seeds

Seeds of three varieties of cultivated tomato (*Roma, UC*82B and a *local variety*) were collected from the Institute for Agricultural Research (I.A.R), Ahmadu Bello University Zaria, Nigeria.

Treatment and Experimental Design

The treatments used in the research are mutation using various concentrations of sodium azide, grafting and combination of grafting and sodium azide. Some seeds of the three tomato varieties were treated with four different concentrations of Sodium Azide (0.2mM, 4.0mM, 6.0mM and 0.0mM as control) respectively. The three varieties used were Roma, UC-82B and one local variety. Roma was said to flourish successfully during the rainy season while UC-82B flourishes and grows successfully during the dry season. Three different treatments were formed: Chemically treated with sodium azide, grafted and combination of grafting and sodium azide treated plants were grown during the rainy season and dry season. The treated plants were grown in 45 polythene bags arranged in a Completely Randomized Design (CRD) with three repetitions in each season.

The seeds used for rootstocks were planted 2 days prior to that of the shoots. Tongue grafting approach was used. This is due to the relative advantage of the method over others such as its being used on larger plants, three times faster than other techniques, high success rate and is easy to handle. After two weeks of planting, and a day prior to grafting, the plants used for grafting were watered fully to make them turgid. One-fourth of the plants used for rootstock were cut at slant early in the morning. The shoot was also cut in the same way. The two cut ends were placed in direct contact and use a small clip to hold the cut surfaces together. This was repeated in the 3rd and 4th week of planting, while the remainder was left as control as described in McVoy (2005) protocol.

After two weeks of planting, the plants treated with the mutagen that germinated were grafted by transferring the scions of one variety to the stock of another variety. Similarly, the plants that are not treated with the mutagen were grafted. More so, the plants that are treated with the mutagen only were allowed to grow without grafting. The untreated plants were allowed to grow as control.

Mean Squares for the Effects of Grafting and Sodium Azide on Some Varieties of Tomato in Wet Season

Sources of Variation	DF	Germination % (1 WAP)	Germination % (2 WAP)	Seedlings Height (cm)	Survival Rate (%)	Number of Leaves	Number of Fruits/plant	Fruit Diameter (cm)	pH
Replication	**2**	442.51^{ns}	219.42^{ns}	105.25*	881.07*	53.86**	4.39^{ns}	0.36*	0.03*
Concentration	**3**	12191.08**	6386.37**	1226.32**	7181.49**	171.27**	99.38**	0.19^{ns}	0.40**
Variety	**2**	2248.15*	4525.46**	725.50**	2823.29**	6.69^{ns}	33.12**	0.08^{ns}	0.21**
Treatments	**2**	12824.68**	7275.75**	1068.59**	790.88*	45.44**	7.70^{ns}	0.22^{ns}	0.02^{ns}
Conc x Variety	**6**	206.41^{ns}	122.25^{ns}	38.54^{ns}	34.16^{ns}	1.71^{ns}	6.06^{ns}	0.04^{ns}	0.009^{ns}
Conc x Treatment	**6**	668.55^{ns}	185.93^{ns}	67.63*	88.22^{ns}	4.53^{ns}	3.83^{ns}	0.06^{ns}	0.004^{ns}
Variety x Treatment	**4**	1917.81^{ns}	632.57^{ns}	59.81*	287.79^{ns}	33.72**	11.45^{ns}	0.03^{ns}	0.01^{ns}
Conc x Variety x Treatment	**12**	169.41^{ns}	131.94^{ns}	8.86^{ns}	123.29^{ns}	2.05^{ns}	3.89^{ns}	0.04^{ns}	0.002^{ns}
Error	**142**	395.64	196.89	13.17	143.01	3.58	3.05	0.07	0.008

Keys: ns= No significant difference * = Significant difference (P≤0.05) **= Highly significant difference (P≤0.01)

RESULTS

The result for the analysis of variance of the Effects of Sodium Azide and Grafting on Three Varieties of Tomato during the wet season was presented in the table above. The result showed the presence of highly significant difference (P≤0.01) in the effects

of different concentrations of sodium azide on almost all the selected traits except on the fruit diameter. More so, the result indicated highly significant difference (P≤0.01) among the varieties on the selected traits except in germination percentage (1 WAP); where significant difference (P≤0.05) was found and in number of leaves and fruits diameters where no significant difference exists among the varieties. Furthermore, highly significant difference (P≤0.01) was found on the effects of grafting and sodium azide singly and in combine dosage as treatments on germination percentages (1 and 2 WAP) and number of leaves. Significant difference (P≤0.05) was found on the effects of these treatments on the survival rate, while, no significant difference was found on the effects of the treatments on the number of fruits, fruit diameter and PH and on seedlings height, where significant differences (P≤0.05) were found and in the interactions of variety and treatments on the number of leaves where highly significant difference (P≤0.01) was found.

DISCUSSION

The distinct differences observed in most of the quantitative and qualitative traits among the sodium azide induced mutants of tomato evaluated showed significant improvements in the selected traits. Although there were few traits with no significant differences in responses to the applied treatments; the ability of the mutants to germinate faster after one and two weeks of planting in respect to the controls showed that the mutagenic treatments induced increase enzymatic activities, which could be responsible for the early germination. This finding is in agreement with the findings of Mensah *et al*. (2007) who reported decreased in germination with increase in the dose of chemical mutagens. In the present investigation, germination, survival percentage, and number of leaves decreased with increasing concentration of sodium azide. This finding conformed to the earlier report by Ahloowalia and Maluszynski (2001) that, the viable mutants observed are mainly dependable measure of genetic effect in mutagen. The increased in the number of leaves, and number of fruits per plant due to sodium azide treatments is also in conformity with the work of Adamu and Aliyu (2007) who reported increased in growth and yield parameters of tomato due to sodium azide treatments. There were reductions in the germination and survival percentages with increasing concentrations for both chemicals in the generation. Reductions in germination and survival percentages due to the effects of mutagens on various crop plants have earlier been documented by Mensah and Akomeah (1997) and Mensah *et al*. (2005).

Similarly, it has been reported by Kumar *et al*. (2009), that chemical mutagens induce physiological damages (injury), gene mutations and chromosomal mutations in the organisms in M_1 generation (which can be measured by seed germination, survival reduction [lethality], plant height reduction (due to injury), fertility reduction or sterility (reduction in pod and seed formation). This also agrees with the findings of Deepalakshmi (2000) and Thanga Hamavathy (2002) who independently reported similar effects of mutagens in black gram and Kumar *et al*. (2009) in cowpea. The increased in the number of leaves and leaf area among the mutants signifies the ability of the mutagen (sodium azide) to initiate more foliar buds. This finding agrees with the work of Maluszynski *et al.* (2001) and Pasztor *et al.* (1985) who independentlyreported an increase in leaf number and leaf area among *Zeamays* mutants.More so, the improvement in the growth and yield components of tomato due to sodium azide treatments stressed the effect of mutation on the growth and yield of plants. This is in conformity to the work of Adamu *et al*. (2002) when groundnut was treated with gamma rays and Sheeba *et al*. (2005) when gamma rays and EMS were used to treat *Sesanum indicum* L. where seed germination, seedling survival, and pollen fertility were reduced significantly with an increase in dosage levels of both mutagens.

However, in contrast, Sasi *et al*. (2005) showed that all plant mutant types registered lower yields compared to their parents in the study of the effects of diethylsulphate and EMS on Okra (*Abelmoschus esculentus* (L.) var. MDU-1). The increased in fruit quality such as pH and number of fruits due to induced mutagenesis by sodium azide signifies the vital role played by the mutagen in improving the quality traits of tomato. The increased in dry weights of the tomato varieties due to sodium azide treatments is in contrast to the findings of Ikhajiagbe *et al*. (2012).

The increased in the survival rates of the grafted tomato recorded showed excellent percentage of

grafting success after 12 days in the incubation. This is similar to the earlier report by Anonymous (2011) that the percentage of survival ratios of all types of grafting was 97, 98 and 99% for splicing, top and tongue respectively. The survival rate of grafted plants depends on compatibility between scion and rootstock, quality and age of seedlings, quality of the joined section, and post-grafting management. Different grafting techniques are adapted for different scions and rootstocks depending on grafting objectives, farmer's experience, and post-grafting management conditions as described by Hang *et al*. (2005).

Higher fruit yield parameters found in this study could be due to the fact that grafting combines novel traits of the two grafted plants after grafting operation. This has also been reported by Tsouvaltzis *et al*. (2004). The increased pH of the juice I n grafted plants is in contrast to the findings of Leoni *et al*. (1990) and Romano and Paratore (2001) who found that fruit descriptive and qualitative characteristics were not affected by grafting. But Lee (1994) found an increase in yield which was attributed to the vigour of the rootstock and the higher uptake of water and nutrients. Passam *et al*. (2005) found that eggplants grafted on to two tomato rootstocks gave a higher yield and bigger fruit size than those grafted on two eggplant rootstocks, but the mineral composition of fruits from grafted plants did not differ from that of non-grafted plants.

The fruit characteristics of grafted plants were compared with those of non-grafted plants. The results showed that the fruit index (diameter and number of fruits) were significantly influenced by grafting. The results agree with those reported by Lee (1994) who concluded that fruit shapes are influenced by rootstocks. Pogonyi *et al*. (2005) reported that when Lemance F_1 was grafted onto Beaufort rootstock, increased yield was caused mainly by higher average fruit weight. Ibrahim *et al*. (2014) also found that the total number of fruits per truss in non-grafted plants was statistically different from the total for grafted plants.

The results of the study showed that tomato grafting on suitable rootstocks had positive effects on the yield. In grafted combinations, the total fruit yield per plant increased significantly in comparison with that of the control plants. Ibrahim *et al*. (2001) observed similar results in grafted and non-grafted tomato plants. These investigators suggested that the higher yield of fruit from grafted tomato plants was most likely an effect of the vigorous root system of the rootstock. According to Lee (1994), the increased yield of grafted plants is also believed to be due to enhanced water and mineral uptake. Similarly, Osvald (2004) reported that tomato grafting on suitable rootstocks has positive effects on cultivation performance, especially under greenhouse conditions.

The pH value also plays an important role in determining fruit quality characteristics. Many studies focused on pH as a key element in tomato selection as stressed by Hong Tsou (1998). The analyzed results showed that the pH values of tomato fruit increased among the grafted plants. This is in conformity to the findings of Kuzucu *et al*. (2004) who also reported that Koral, Mobil and H-2274 (fresh tomato) have a pH value of 4.31, 4.33 and 4.33, respectively; but is contrary to the work of Khah *et al*. (2006) who found that fruit pH values were not affected by grafting.

CONCLUSION

It was generally concluded that, 0.1mM concentration of sodium azide (NaN3) and grafting are significant in inducing variability that could be exploited in the improvement of highly economic crops like tomato. It was also concluded that, the mutants and grafted tomato can be grown all the year round.

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AGRONOMIC RESPONSE TO THREE DIFFERENT CONCENTRATIONS OF COLCHICINE ($C_{22}H_{25}NO6$) ON SELECTED TRAITS IN TWO VARIETIES OF EGG PLANT (*Solanum melongena L.*.)

***Sadiya. I., Zainab. S.Z. and Hussain. A.**
Biology Department
College of Education and Preliminary studies, Kano State
*Corresponding Author: Email: aminuyahayafagge@gmail.com GSM: +2347035347997

ABSTRACT
The effect of Colchicine induced mutation on the growth and yield of two varieties of Eggplant was investigated with the aim of inducing variability that could be exploited in the improvement of some quality traits in Egg plants. Three different treatments of Colchicine were applied on to the two Egg plant varieties. The seeds of the two varieties of Eggplant: *White Eggplant* and *Green Apple* varieties were treated with three different concentrations of Colchicine (0.1mM, 1.0 mM, 2.0 mM and 0.0 mM as control). The result showed significant improvement in almost all the selected traits with decrease in the mutagen concentration for all the two varieties except in the fruit diameter where an increase in the mutagen concentration was observed. It was generally observed that, 0.1mM concentration of colchicine is significant in inducing variability that could be exploited in the improvement of highly economic crops like Eggplant. It was concluded that, the mutant of Eggplant can be grown all the year round.
Keywords: Colchicine, Green apple eggplant, (1 WAP) Germination percentage, Plant height, survival rate, White eggplant**,**

INTRODUCTION
The prime strategy in mutation breeding has been to upgrade the well-adapted plant varieties by altering one or two major traits which limit their productivity or enhance their quality. The increasing demand of eggplants has gone along with the rapid growth of population. This is due to the increasing awareness toward the benefit of vegetables in fulfilling the nutrient of the family (Jumini and Marlia, 2009). Gandhi and Sundari (2012) described that eggplant can also be utilized as medicine to reduce cholesterol in blood and it is suitable as diet to regulate hypertension. Owing to high nutrient content of the eggplant,
Eggplant production for the last 3 yearshas decreased. In 2013, the national productionof eggplants reduced 509,380 ton from 519,481ton in 2011 (Directorate General of Horticulture,2014). One of the main causes of such reductionis the decreasing fertility of the soil and organicmatters in the soil (Ullah *et al* 2008). Accordingto Waseem *et al.* (2013), the use of inorganicfertilizer in longterm has reduced physical,chemical, and biological traits, as well as organicmatters in the soil, and of course, they will affectefficiency of nutrients absorption.

Excessive,application of inorganic fertilizers woulcontaminate environment and the food yield thatmay harm human health (Jagatheeswari, 2013.

The demand of nutrients for the eggplant could not be fulfilled completely through theapplication of organic fertilizers. Sutanto (2002)described that the only application of organicfertilizer might redue the production, whereastheuse of chemical fertilizers withou organicfertilizers could damage the environment. Effortstoincrease vegetable production will keep relyingonthe use of outer input, including organic andchemical fertilizers. Colchicine is a mutagen that prevents formation of microtubules and which is usuallyused for doubling the chromosome number. Thus, it isroutinely utilized in polyploid planformation. Colchicine effectively functions as a“mitotic poison,” leading to noticeablemutagenic effects. Colchicine has been used to induce usefulmutations in several economic ornamental plant species, such as *Datura*, *Portulaca*, *Petunia*,*Allium*, and *Cucurbita*. Apart from the phenotypic traits,the mutagenic effects can be assessed more precisely using molecular markers. Jagatheeswari, 2013 However, little information is available for using mutation in the

improvement of certain plants of economic interests in Nigeria. The main objective of this research is to discover the mutagenic effects of Colchicine in some selected traits on two varieties of Egg plants *Solanum melongena l* .

MATERIALS AND METHODS

Study Site

The research was conducted in the Botanical Garden of the Department of Biological Sciences, Ahmadu Bello University Zaria (Lat 11^0 12^1N, Long 7^0,37^1E, Alt 550-700 m above sea level).

Sources of the Seeds

Seeds of two varieties of cultivated Eggplant (*White and Green apple varieties)* were collected from the Institute for Agricultural Research (I.A.R), Ahmadu Bello University Zaria, Nigeria.

Treatment and Experimental Design

The seeds of two Egg plant varieties (*White and Green apple varieties*) were treated with three different concentrations of Colchicine (0.1mM, 1.0mM, 2.0mM and 0.0mM as control) via pre-soaking for four hours as described by Asmahan (1993). The controls were pre-soaked in distill water. The treated plants were washed in running water for one hour and allowed to dry under room temperature for 24 hours. The seeds were then sown in polythene bags arranged in a Completely Randomized Design (CRD) with three repetitions and grown during the 2013 rainy season.

Data Analysis

Data were obtained from Germination percentages, number of fruits/plant, diameter of the fruits, Survival rate and plant height. The means of significant treatment were separated using Duncan's Multiple Range Test.

RESULTS

The result of the combination of variety and colchicine concentrations on some selected traits of Eggplant is presented in the table below. The result showed significant improvement in almost all the selected traits with decrease in the mutagen concentration for all the two varieties except in the fruit diameter where an increase in the mutagen concentration was observed.

Effects of the Interaction of Variety and Colchicine Concentrations on some Selected Traits of Egg plant

Variety	Concentration (mM)	Germination % (1 WAP)	Germination % (2 WAP)	Survival Rate (%)	Height at Maturity(cm)	Number of Fruits	Fruit Diameter (cm)
White egg plant	**0.0**	28.35^{d}	42.36^{d}	31.29^{d}	30.94^{d}	2.16^{d}	0.28^{d}
	0.1	74.87^{a}	83.11^{a}	69.94^{a}	51.87^{a}	7.11^{a}	0.20^{b}
	1.0	57.20^{b}	72.05^{b}	56.33^{b}	41.52^{b}	4.33^{b}	0.21^{a}
	2.0	39.55^{c}	59.59^{c}	44.33^{c}	37.17^{c}	3.00^{c}	0.18^{c}
Green egg plant	**0.0**	27.42^{d}	40.59^{d}	33.99^{d}	34.27^{d}	2.27^{d}	0.41^{d}
	0.1	77.57^{a}	78.40^{a}	72.88^{a}	52.92^{a}	7.05^{a}	0.14^{c}
	1.0	57.18^{b}	70.07^{b}	61.79^{b}	44.42^{b}	4.72^{b}	0.29^{b}
	2.0	46.01^{c}	58.94^{c}	48.85^{c}	40.89^{c}	3.50^{c}	0.40^{a}
	Mean	52.77	61.77	48.38	40.96	3.85	0.25

DISCUSSION

The distinct differences observed in most of the quantitative and qualitative traits among the Colchicine induced mutants of Eggplant evaluated showed significant improvements in the selected traits. Although there were few traits with no significant differences in responses to the applied treatments. Similar result was also reported by Nura et al. (2013) on the effect of chemical mutagen in improving the number of fruits and size of sesame leaves. The above results in general agree with other research who found that yield and qualitative characteristics of the eggplants fruit were not affected by colchicine concentrations, on the contrary to (Bletsos et al.,2003; Khah, 2011; Romano and Paratore, 2001).The differences in quality, yield and earliness could be attributed to the different growth characteristics of the cultivar and to their different affinity to mutation and compatibility with the rootstock. Thus, (Suzuki & Morishita, 2002; Sebahattin et al, 2009, showed that *Solanum torvum* is a vigorous rootstock, and a mutagen combination of a vigorous cultivar with an equally vigorous rootstock reduces the amount of fertilizer required for the same yield. Earliness could also be associated with the high vigour of the rootstock. Gisbert et al. (2011) have mentioned that the earliness was observed mainly in the interspecific hybrids, respective between *S. melongena and S. aethiopicum or S. incanum.* The increased in fruit quality on fruit number due to induced mutagenesis by Colchicine signifies the vital role played by the mutagen in improving the quality traits of Eggplant.

CONCLUSION

It was found that, there is significant difference in the effects of various concentrations of colchicine on the selected quality traits of eggplant. The effect of the mutagen was significant in inducing variability that could be exploited in the improvement of highly economic crops like eggplant. Lower concentration of Colchicine (0.1 mM) was found to be more effective in improving the quality traits of Eggplant. It was also concluded that, the mutant Eggplant can be grown all the year round.

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EFFECTS OF GROWTH REGULATORS ON THE REGENERATION OF EXPLANTS OF *Citrullus lanatus* (Thunb.) Matsum and Nakai and *Citrullus colocynthis* (L.) Schrad

[1]Ojo E. S., [2]Olosunde Olatunde O. M, [3]Agboola, D. A.

[1]Department of Biological Sciences, Augustine University, Ilara – Epe, Lagos State, Nigeria
[2]Department of Horticulture, Federal University of Agriculture, Abeokuta, Nigeria
[3]Department of Pure and Applied Botany, Federal University of Agriculture, Abeokuta, Nigeria

Correspondence: shalomojo@gmail.com

ABSTRACT

This study investigated effects of botanicals on the regeneration of the explants of *Citrullus lanatus* and *Citrullus colocynthis* to increase its multiplication, high survival rate, better acclimatization and post-vitro performance. The experiment was carried out at the Biotechnological Centre, Federal University of Agriculture, Abeokuta Nigeria between 2018 and 2019. The cotyledonary explants of *Citrullus lanatus* and *Citrullus colocynthis* were cultured in vitro on MS basal medium combined with vitamins, 3% (w/v) sucrose and augmented with different botanicals (*Bryophyllum pinnatum* leaf extract and Coconut water), Indole acetic acid (IAA) and Gibberellic acid (GA_3) concentrations (0.5 mg/l, 1.0 mg/l, 1.5 mg/l, 2.0 mg/l and 2.5 mg/l). Data generated were subjected to Analysis of Variance and treatment means were separated using Duncan's Multiple Range Test at 5% probability using SAS software package version 9.3. Application of 0.5 mg/l and 2.5 mg/l of *Bryophyllum pinnatum* leaf extract had a significantly higher number of shoots per explant (4.67±0.08), shoot regeneration (100.00±1.88 %) and regeneration frequency (46.67±3.33%) for *C. lanatus* and *C. colocynthis* (18.00±0.44, 100.00±1.98% and 180.00±4.14 %), respectively. *Bryophyllum pinnatum* leaf extract is a substitute for the IAA and GA_3 to enhance regeneration and post-vitro performance of *C. lanatus* and *C. colocynthis.*

Key words: *in vitro*, micropropagation, Plantlets, Acclimatization, Post-vitro, Plant regeneration

INTRODUCTION

Citrullus lanatus and *Citrullus colocynthis* are important vegetables of the Cucurbitaceae family which contains 125 genera and 980 species of both wild and cultivated plants that have been able to extensively adapt to different locations of the world. It originated from the Mediterranean Basin, Asia going through North Africa.These melons grow horizontal along the ground with their creeping stem and coiled tendrils (Ajuru and Nmom, 2017).

They are food crops rich in carbohydrates, iron carotene, folic acid, potassium, vitamins, oxalic acid, phosphorus and mineral, water, oil and protein. *C. lanatus* is grown globally, popular as cooked vegetable, fruit in salad and juices, sweet dessert, having low calorie content (Compton *et al*., 2004) but *C. colocynthis* is widely grown for its seeds, oil and by products. Cultivation of these crops generate income, profit and provide employment for farmers at large especially in Sub-Saharan Africa.

Plant tissue culture is a technique that utilizes small parts of plants tissues called explants for propagation on an artificial growth medium under sterile condition. Plant regeneration using cotyledon, hypocotyls and seedling shoot apices under different hormones regulation have been reported (Compton *et al*., 2004; Gnamien *et al*., 2013), but the use of botanical is not yet popular. Micropropagation is faced with challenges of high cost of production, contamination, scarcity and high cost of materials. Some of these challenges can be reduced with the development of an efficient protocol that incorporates the use of botanical. Therefore, in this study a protocol utilizing hormones and botanical was developed for *C. lanatus* and *C. colocynthis*.

MATERIALS AND METHODS

This study was carried out at the Biotechnological Centre, Federal University of Agriculture, Abeokuta Nigeria (latitude 7^0 15'N, longitude 3^0 25'E) between 2018 and 2019. Treatments were each of *C. lanatus* and *C. colocynthis*

micropropagated at different concentrations (0.5, 1.0, 1.5, 2.0 and 2.5 mg/l) of IAA, GA_3, *B. pinnatum* leaf extract and Coconut water. The culture flasks made up of 10 explants per treatment were arranged in a Completely Randomized Design (CRD) and replicated 3 times.

Matured fruits of *C. lanatus* and *C. colocynthis* were sourced from Osiele market in Abeokuta, Ogun State (latitude 7º 10' 60" N and longitude 3º 27' 0" E). Seeds of *C. lanatus* were extracted manually by cutting matured fruit through longitudinally with a medium metal knife while fruits of *C. colocynthis* were further broken after cutting longitudinally to release pulp. Then, it was left for three (3) days for fermentation to take place and their seeds to be completely released. Seeds from *C. lanatus* and *C. colocynthis* were washed out separately in distilled water and air dried at room temperature before their seed coats were removed manually (i.e decoated) (Wang *et al*., 2013). In an aseptic condition of the luminar air flow cabinet, the decoated seeds were surfaced sterilized for 25 minutes in 1.6 % sodium hypochlorite with a drop of Tween 20. The decoated seeds were rinsed six times with sterile distilled water and sown in well labeled culture flasks, each containing 20 ml of hormone free MS basal medium (Wang *et al*., 2013) supplemented with vitamins, 3 % (w/v) sucrose and solidified with 7 g/L agar (Phytagel). pH of the medium was adjusted to 5.7 before the addition of agar and autoclave at 121 ˚C for 20 minutes. Sown seeds were incubated in the dark for five days at 28 ˚C±2 ˚C for germination (Gnamien *et al*., 2013). Fifty seeds were sown in each culture flask and replicated three times. The appearance of radicle indicated successful germination and germinated decoated seeds with strong cotyledons were considered acceptable as explant source. The hypocotyl was cut off close to the cotyledons, the cotyledons were then cut in half crosswisely to give a proximal and a distal part. Subsequently, each part (distal parts and proximal parts of the cotyledons with hypocotyl segment) were separated with the help of a scalpel blade. The apical bud of the seedling on the proximal part was removed carefully. This resulted in a cotyledon distal and proximal parts with hypocotyl segment explants (Gnamien *et al*., 2013).

Explants of *C. lanatus* and *C. colocynthis* were cultured in well labelled culture flasks, each containing 25 ml of MS medium supplemented with vitamins, 3 % (w/v) sucrose and addition of each treatment combinations shown above. pH of the medium was first adjusted to 5.7 before it was solidified with 7 g/L agar (Phytagel) afterwhich it was autoclaved at 121 ˚C for 20 minutes. These culture flasks were then incubated under 50 $mol/m^2/s$ light provided by cool white fluorescent lamps for a photoperiod of 12 hours at 28 ˚C±2 ˚C for shoot induction.

Data collected on number of sprouted explants, shoots per explant, shoot regeneration, regeneration frequency, length of shoot and root of *C. lanatus* and *C. colosynthis* were subjected to Analysis of Variance (ANOVA). Means of the treatments were separated using Duncan's Multiple Range Test (DMRT) at 5 % probability using SAS software package version 9.3.

RESULTS AND DISCUSSION

Number of sprouted explants and shoot regeneration percentage of *C. lanatus* were significantly higher at 0.5 mg/l, 1.5 mg/l and 2.5 mg/l of *B. pinnatum* leaf extract, at 1.5 mg/l GA_3, 2.5 mg/l GA_3 and 1.0 mg/l IAA (Table 1). At 0.5 mg/l, *B. pinnatum* leaf extract significantly increased the regeneration frequency percent (46.67±3.33 %) (Table 1) and number of shoots per explant (4.67±0.08) in *C. lanatus* (Table 2) while the highest length of shoot (12.27±0.17 cm) and length of root (6.00±0.07 cm) in *C. lanatus* were observed at 1.0 mg/l GA_3 and 1.5 mg/l of *B. pinnatum* leaf extract, respectively (Table 2).

Similarly, the different concentrations 0.5 mg/l – 2.5 mg/l of *B. pinnatum* leaf extract, 0.5 mg/l and 1.0mg/l Coconut water and 0.5 mg/l, 1.5 mg/l, 2.0 mg/l and 2.5 mg/l GA_3 greatly stimulated explant sprouting in *C. colocynthis* resulting in 100 % shoot regeneration (Table 1). Though the number of sprouted explants (3.33±0.33) and shoot regeneration % (33.33±3.33) was lowest at 1.0 mg/l IAA (Table 1). Regeneration frequency % (180.00±4.14 %) (Table 1) and number of shoots per explant (18.00±0.46) (Table 2) in *C. colosynthis* were also higher at 2.5 mg/l of *B. pinnatum* leaf extract while 1.5 mg/l of *B. pinnatum* leaf extract and 0.5 mg/l of Coconut water greatly enhanced the length of shoot (16.17±0.17 cm) and length of root (6.07±0.18 cm) in *C. colocynthis*, respectively (Table 2) in line with the report of Krug *et al*. 2005 who observed that at low concentration of hormones mobilization of endosperm reserves and

morphogenesis were increased. Eftekhari *et al*. 2012 also observed that a successful *in vitro* culture establishment is critical since it will determine if subsequent stages will be possible or not. The concentration of growth promoters or regulators and composition of the induction media plays a vital role in the regeneration of explants (Danswrang *et al*., 2010). Incorporating botanical such as *Bryophyllum pinnatum* leaf extract and coconut water were found efficient as part of the regeneration protocol for *C. lanatus* and *C. colocynthis* as observed in this study.

Table 1: Effects of hormone and botanical concentrations on number of sprouted explants, shoot regeneration and frequency of *C. lanatus and C. colosynthis*

Treatment	*C. lanatus*			*C. colosynthis*		
	Number of sprouted explants	Shoot regeneration (%)	Regeneration frequency	Number of sprouted explants	Shoot regeneration (%)	Regeneration frequency
0.5 mg/l of IAA	4.00±2.20^{e}	40.00±0.11^{e}	20.00±0.31^{c}	4.00±0.12^{e}	40.00±0.61^{e}	30.00±1.11^{l}
1.0 mg/l of IAA	10.00±0.01^{a}	100.00±0.16^{a}	20.00±0.41^{c}	3.33±0.33^{f}	33.33±3.33^{f}	40.00±1.48^{k}
1.5 mg/l of IAA	6.33±0.33^{c}	63.33±3.33^{c}	20.00±0.30^{c}	5.33±0.33^{d}	53.33±3.33^{d}	40.00±2.11^{k}
2.0 mg/l of IAA	5.00±0.02^{de}	50.00±0.19^{de}	20.00±0.30^{c}	7.00±1.07^{c}	70.00±2.11^{c}	60.00±3.34^{j}
2.5 mg/l of IAA	9.00±0.58^{ab}	90.00±5.77^{ab}	20.00±0.31^{c}	5.00±1.11^{d}	50.00±3.41^{d}	40.00±3.11^{k}
0.5 mg/lof GA_3	5.00±0.03^{de}	50.00±1.00^{de}	10.00±0.11^{d}	10.00±0.98^{a}	100.00±1.30^{a}	106.67±3.33^{de}
1.0 mg/l of GA_3	6.00±0.11^{cd}	60.00±1.21^{cd}	30.00±0.91^{b}	4.33±0.33^{e}	43.33±3.33^{e}	110.00±5.11^{d}
1.5 mg/l of GA_3	10.00±0.91^{a}	100.00±1.61^{a}	20.00±0.48^{c}	10.00±0.49^{a}	100.00±2.90^{a}	83.33±3.33^{hi}
2.0 mg/l of GA_3	8.67±0.33^{b}	86.67±3.33^{a}	20.00±0.51^{c}	10.00±0.50^{a}	100.00±3.00^{a}	86.67±8.82^{hi}
2.5 mg/l of GA_3	10.00±0.41^{a}	100.00±2.11^{a}	20.00±0.69^{c}	10.00±0.47^{a}	100.00±3.11^{a}	110.00±2.11^{d}
0.5 mg/l of *B. pinnatum*	10.00±0.66^{a}	100.00±1.88^{a}	46.67±3.33^{a}	10.00±0.52^{a}	100.00±3.11^{a}	80.00±4.61^{i}
1.0 mg/l of *B. pinnatum*	9.00±0.13^{ab}	90.00±3.11^{ab}	20.00±1.01^{c}	10.00±0.47^{a}	100.00±2.14^{a}	96.67±3.33^{fg}
1.5 mg/l of *B. pinnatum*	10.00±0.17^{a}	100.00±2.91^{a}	30.00±1.46^{b}	10.00±0.49^{a}	100.00±1.98^{a}	100.00±5.01^{ef}
2.0 mg/l of *B. pinnatum*	4.00±0.58^{e}	40.00±5.77^{e}	13.33±3.33^{d}	10.00±0.52^{a}	100.00±1.99^{a}	90.00±5.77^{gh}
2.5 mg/l of *B. pinnatum*	10.00±0.34^{a}	100.00±4.01^{a}	20.00±1.61^{c}	10.00±0.44^{a}	100.00±1.98^{a}	180.00±4.14^{a}
0.5 mg/l of Coconut water	9.33±0.67^{ab}	93.33±6.67^{ab}	30.00±2.01^{b}	10.00±0.46^{a}	100.00±1.01^{a}	80.00±4.00^{i}
1.0 mg/l of Coconut water	9.67±3.33^{ab}	96.67±3.33^{ab}	33.33±3.33^{b}	10.00±0.49^{a}	100.00±2.11^{a}	163.33±6.67^{b}
1.5 mg/l of Coconut water	4.33±0.88^{e}	43.33±8.82^{e}	30.00±1.41^{b}	8.67±0.33^{b}	86.87±3.33^{b}	120.00±3.41^{c}
2.0 mg/l of Coconut water	5.67±0.67^{cd}	56.67±6.67^{cd}	30.00±5.77^{b}	0.00±0.00*	0.00±0.00*	0.00±0.00*
2.5 mg/l of Coconut water	0.00±0.00*	0.00±0.00*	0.00±0.00*	0.00±0.00*	0.00±0.00*	0.00±0.00*

Means with different superscripts in columns are significantly different at $p < 0.05$

IAA (Indole acetic acid), GA_3 (Gibberellic acid), *Bryophyllum pinnatum* (*Bryophyllum pinnatum* leaf extract), * (No growth observed)

Table 2: Number of shoots and length of shoot and root of *C. lanatus and C. colosynthis*as affected by hormone and botanical concentrations

Treatment	*C. lanatus*			*C. colosynthis*		
	Number of shoots per explant	Length of shoot (cm)	Length of root (cm)	Number of shoots per explant	Length of shoot (cm)	Length of root (cm)
0.5 mg/l of IAA	2.00±0.06c	4.17±0.27ef	0.00±0.00d	3.00±0.61i	6.00±0.16i	0.00±0.00f
1.0 mg/l of IAA	2.00±0.03c	2.33±0.17g	0.17±0.17d	4.00±0.89i	5.00±0.17j	0.00±0.00f
1.5 mg/l of IAA	2.00±0.05c	3.00±0.06fg	3.67±0.19bc	4.00±0.80i	6.00±0.19i	5.33±0.17b
2.0 mg/l of IAA	2.00±0.01c	6.83±0.44d	3.57±0.07bc	6.00±1.00h	6.50±0.29hi	6.00±0.26a
2.5 mg/l of IAA	2.00±0.09c	4.17±0.17ef	0.00±0.00d	4.00±0.98i	4.17±0.17k	0.00±0.00f
0.5 mg/lof GA3	1.00±0.02d	8.20±0.15c	3.33±1.67c	10.67±0.33d	11.37±0.32d	5.10±0.10bc
1.0 mg/l of GA3	3.00±0.07b	12.27±0.15a	4.03±0.03bc	11.00±0.61d	9.27±0.15f	6.03±0.03a
1.5 mg/l of GA3	2.00±0.03c	12.17±0.17a	4.00±0.02bc	8.33±0.33g	7.20±0.76gh	5.00±0.44c
2.0 mg/l of GA3	2.00±0.01c	8.00±0.09c	4.13±0.09bc	8.67±0.88g	8.00±0.67g	4.13±0.09d
2.5 mg/l of GA3	2.00±0.02c	2.43±0.23g	0.83±0.44d	11.00±0.51d	9.43±0.23f	4.17±0.17d
0.5 mg/l of *B. pinnatum*	4.67±0.08a	11.67±1.20a	4.83±0.17ab	8.00±0.11g	10.33±0.33e	4.83±0.17c
1.0 mg/l of *B. pinnatum*	2.00±0.11c	11.67±0.33a	4.83±0.44ab	9.67±0.33ef	14.67±0.33b	5.33±0.17b
1.5 mg/l of *B. pinnatum*	3.00±0.36b	10.50±0.50b	6.00±0.07a	10.00±0.10de	16.17±0.17a	5.00±0.11c
2.0 mg/l of *B. pinnatum*	1.33±0.33d	1.17±0.17h	0.00±0.00d	9.00±0.58fg	15.33±0.33ab	6.00±0.61a
2.5 mg/l of *B. pinnatum*	2.00±0.11c	8.10±0.15c	5.87±0.19a	18.00±0.44a	15.93±0.12a	6.00±0.21a
0.5 mg/l of Coconut water	3.00±0.31b	4.40±0.21e	0.00±0.00d	8.00±0.76g	12.37±0.32c	6.07±0.18a
1.0 mg/l of Coconut water	3.33±0.33b	9.83±0.60b	3.77±0.15bc	16.33±0.67b	9.13±0.24f	1.17±0.17e
1.5 mg/l of Coconut water	3.00±0.14b	3.17±0.17fg	0.00±0.00d	12.00±0.81c	7.57±0.23g	0.00±0.00f
2.0 mg/l of Coconut water	3.00±0.58b	3.83±0.44ef	0.00±0.00d	0.00±0.00*	0.00±0.00*	0.00±0.00*
2.5 mg/l of Coconut water	0.00±0.00*	0.00±0.00*	0.00±0.00*	0.00±0.00*	0.00±0.00*	0.00±0.00*

Means with different superscripts in columns are significantly different at $p < 0.05$

IAA (Indole acetic acid), GA_3 (Gibberellic acid), *Bryophyllum pinnatum* (*Bryophyllum pinnatum* leaf, extract),

* (No growth observed)

CONCLUSION AND RECOMMENDATION

Pretreatment of seeds of *C. lanatus* and *C. colocynthis* with varying concentrations of IAA, GA_3, *B. pinnatum* leaf extract and Coconut water greatly enhanced shoot regeneration of explants of *C. lanatus* and *C. colocynthis*. There were significant increase in the number of sprouted explants, shoot regeneration, regeneration frequency, number of shoot per explant, length of shoot and root. Therefore, the use of *Bryophyllum pinnatum* leaf extract at 0.5 – 2.5 mg/l as substitutes for GA_3 and IAA is recommended for use in shoot regeneration of explants of of *C. lanatus* and *C. colocynthis*.

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COMPARATIVE ASSESSMENT OF GENETIC DIVERSITY CLUSTERING ANALYSIS IN CASSAVA GENOTYPES (*Manihot esculenta* Crantz) FROM DIFFERENT POPULATION FOR NUTRITIONAL QUALITIES

[1]Abah S. P., [2]Nkaa Francis A., [2]Onyekwere K. and [1]Onyenali T.C.,
1. National Root Crops Research Institute, Umudike, Nigeria.
2. Michael Okpara University of Agriculture, Umudike, Abia State
Corresponding author: abahsp@gmail.com

ABSTRACT
Understanding the diversity and genetic relationships among and within cassava germplasm is invaluable for genetic improvement. This study assessed genetic diversity in a panel of 40 cassava genotypes using dendogram clustering analytical method. Forty (40) diverse cassava genotypes including three (3) checks were established in this experiment which was laid out in randomized complete block design with three replications. The plot size was 0.8 x 5m with 25cm cuttings of genotypes planted on ridges at an interspacing of 1m by intraspacing of 0.8m. The trials were established in 2022/2023 cropping seasons. In order to identify the yield performance in cassava genotypes, storage roots from each plant genotype were sampled or harvested at 12 MAP. The following cassava storage root traits were measured: total root weight; number of root; fresh root yield (FRYD), harvest index (HI), dry matter content (DMC), and starch content (SC). In order to account for the variance components, analysis of variance was carried out for all the traits. Statistics were analyzed using the ggbiplot2 package in R statistical software for the diversity analysis. The result of the Dendogram clustering analysis allows for identifying and grouping the accessions into 6 different categories for various characters. These groups were unique for the valuable attributes of yield, dry matter content and starch content which could serve for selection process.
Keywords: cassava, genetic diversity, clustering, germplasm, morphology

INTRODUCTION
Cassava contributes to ensure the food security of poor rural communities, it is necessary to use the morphological tools to characterize different accessions with respect to their nutritional and quality traits. Little is known about the genetic variability in nutritional and quality traits of the roots (Chavez et al. 2005) since the crop grows well under harsh conditions, and such areas are increasing worldwide (El-Sharkawy 2004), this issue should not be overlooked.

Comparative studies of different dissimilarity matrices, as well as hierarchical clustering methods, have been conducted to identify the appropriate approach for genetic diversity assessment in many crops, including sweetpotato (Andrade, 2017), switchgrass (Cortese, et al., 2010), and maize (Meyer *et al.,* 2004), but not fully covered for nutritional qualities in cassava. The objective of this study was to assess the genetic diversity of cassava genotypes for nutritional qualities using morphological data.

MATERIALS AND METHODS
Forty (40) diverse cassava genotypes including three (3) checks from National Root Crops Research Institute (NRCRI) were established in this experiment. They were laid out in randomized complete block design with three replications. The plot size was 0.8 x 5m with 25cm cuttings of genotypes planted on ridges at an interspacing of 1m by intraspacing of 0.8m. The trials were established in 2022/2023 cropping seasons. In order to identify the yield performance in cassava genotypes, storage roots from each plant genotype were sampled or harvested at 12 MAP. The following cassava storage root traits were measured: total root weight; number of root; fresh root yield (FRYD), harvest index (HI), dry matter content (DMC), and starch content (SC). In order to account for the variance components, analysis of variance was carried out for all the traits. Statistics were analyzed using the lme4 package in R statistical software and GenSTAT 12 Edition software for other meta-analyses, such as Principal component analysis (PCA) and diversity analysis.

RESULTS
Quantitative characteristics of 40 cassava genotypes in Nigeria
Table 3 provides the quantitative evaluation of the characteristics of the 40 cassava genotypes. The result of the selection index revealed that NR050667, NR100451, Nwageri, AR145, IITA-

TMS-MM990477 and NR100216 were all better than the national checks: TMEB419, NR8082 and TMS30572. The value of the dry matter content across the genotypes ranged from 25.08 – 42.94% with the highest dry matter content (42.94%) recorded for Nwageri, followed by NR100451 (34.83%) while the least dry matter content was recorded for TMS63397. The value of the fresh root yield across the genotypes ranged from 5.58 – 28.15 with the highest fresh root yield (28.15ton/ha) recorded for AR145, followed by TMS63397 (25.65ton/ha) while the least fresh root yield was recorded for NR090088. The value of the Harvest Index across the genotypes ranged from 0.37 – 0.71 with the highest Harvest Index (0.71) recorded for AR145, followed by IITA-TMS-ZAR950633 (0.68) while the least Harvest index was recorded for NWAGERI. The value of the plant height across the genotypes ranged from 113.33 – 210.33 with the highest plant height (210.33) recorded for NR100451, followed by NR050667 (202.00) while the least plant height was recorded for TMS050752. The value of the Root number across the genotypes ranged from 3.68 –7.13 with the highest root number (7.13) recorded for NR110337, followed by IITA-TMS-ZAR950633 (6.84) while the least fresh root yield was recorded for B150. The value of the starch content across the genotypes ranged from 9.09 –32.88 with the highest starch content (32.88) recorded for NWAGERI, followed by NR090088 (26.64) while the least starch content was recorded for TMS63397

Table 1: Quantitative characteristics of 40 cassava genotypes in Nigeria at 12 months after planting.

Code	Genotype	DMC (%)	FRYD (ton/ha)	HI	PLTHT (cm)	RTNO	SC (%)	Is	Rank
1	NR050667	30.84	17.35	0.64	202.00	6.00	21.20	1668.29	1
2	NR100451	34.83	11.03	0.41	210.33	4.96	22.07	1666.47	2
3	NWAGERI	42.94	5.58	0.37	164.00	5.20	32.88	1521.82	3
4	AR145	29.68	28.15	0.71	151.00	4.65	19.66	1515.00	4
5	IITA-TMS-MM990477	31.18	10.60	0.58	193.67	5.34	17.21	1512.80	5
6	NR100216	31.98	20.40	0.62	163.33	5.04	18.28	1492.53	6
7	**TMEB419**	**30.72**	**18.01**	**0.60**	**165.00**	**5.48**	**16.60**	**1450.77**	**7**
8	TMS13F1060P0014	28.26	15.08	0.60	172.33	6.00	13.32	1408.90	8
9	IITA-TMS-ZAR950633	30.91	19.63	0.68	149.00	6.84	16.85	1400.94	9
10	TMS961432	25.66	21.33	0.66	164.33	5.50	9.86	1393.19	10
11	NR11083	32.52	21.72	0.63	136.33	6.82	19.00	1392.24	11
12	B150	29.75	13.35	0.53	164.67	3.68	15.31	1365.58	12
13	NR100235	27.39	11.70	0.59	174.00	6.32	12.17	1361.97	13
14	TMS13F2110P0002	28.90	20.74	0.68	148.33	4.04	14.17	1359.42	14
15	TMS13F2077P0003	28.56	9.28	0.54	174.33	6.33	13.73	1356.16	15
16	TMS13F1332P0015	28.71	18.49	0.58	150.33	6.54	13.92	1350.83	16
17	TMS13F1160P0004	27.78	11.26	0.60	168.67	4.55	12.68	1328.42	17
18	AR9-46	31.03	9.97	0.57	155.00	7.31	17.01	1318.85	18
19	TMS982123	29.32	19.92	0.63	139.00	4.89	14.74	1314.81	19
20	TMS920326	28.11	12.26	0.62	158.67	5.77	13.12	1302.85	20
21	**NR8082**	**29.53**	**17.26**	**0.67**	**142.00**	**4.54**	**15.02**	**1300.24**	**21**
22	AR182	30.37	21.10	0.60	128.33	4.77	16.14	1294.52	22
23	NR100329	29.82	14.94	0.62	143.67	5.69	15.41	1291.65	23
24	TMS13F1336P0011	29.89	8.28	0.59	158.33	4.99	15.49	1282.55	24
25	ADEBERECHI	25.39	15.22	0.63	156.67	5.10	9.51	1274.46	25
26	B515	33.72	7.35	0.47	143.33	5.82	20.59	1271.25	26
27	TMS011206	32.17	12.88	0.59	135.33	6.16	18.53	1271.05	27
28	TMS970211	30.25	12.35	0.58	143.67	5.09	15.98	1265.28	28
29	TMS13F2110P0017	31.70	11.69	0.60	138.00	6.20	17.91	1261.73	29
30	**TMS30572**	**31.43**	**14.74**	**0.52**	**131.33**	**4.99**	**17.55**	**1253.47**	**30**
31	TMS050303	26.39	15.97	0.61	146.00	5.93	10.84	1252.86	31
32	COB477	30.75	13.95	0.37	136.00	5.22	15.52	1245.88	32
33	NR090088	38.26	5.28	0.42	122.33	4.40	26.64	1218.82	33
34	NR110337	33.97	9.45	0.38	127.33	7.13	19.80	1218.13	34
35	TMS63397	25.08	25.65	0.67	119.67	6.10	9.09	1213.98	35
36	TMS070602	28.99	19.81	0.66	114.33	6.21	14.29	1190.66	36
37	B519	31.31	7.67	0.53	125.00	5.36	17.39	1136.59	37
38	NR110372	31.25	7.01	0.40	126.33	5.35	17.31	1133.44	38
39	TMS050752	28.53	15.97	0.61	113.33	6.24	13.69	1131.03	39
40	W940006	25.52	12.09	0.55	115.00	5.40	9.67	1031.89	40

DMC = Dry matter content, FRYD = Fresh root yield, HI = Harvest Index, PLTHT = Plant Height, RTNO = number of Root, SC = Starch Content, Is = Selection Index

Result of the Clustering Analysis

Figure 4.2 showed the clustering of the 40 genotypes with respect to their similarities and differences across the traits.From the result, there were 6 clustering showing that those genotypes within a cluster are similar while characteristics between clusters are different from each other. Genotypes labels are represented in the Appendix 1.

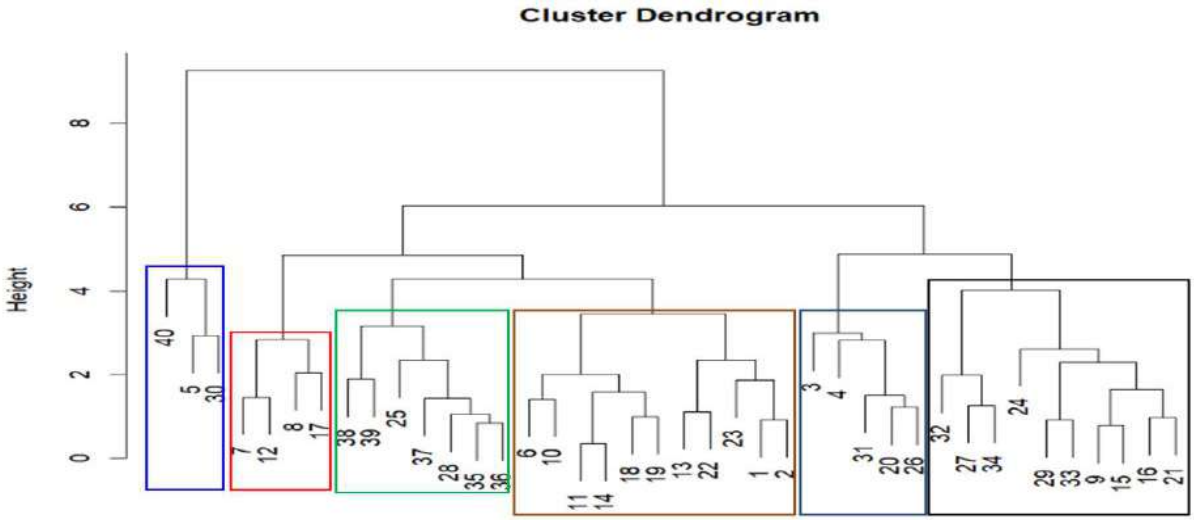

Figure 1 Clustering analyses of the 40 genotypes using Dendogram

DISCUSSION

The current study, aimed at highlighting the variations and identify germplasms for plant breeding and also to make available of superior cassava genotypes for farmers Quantitative characteristics of 40 cassava genotypes in Nigeria at 12 months after planting, shows the evaluation of the characteristics of the 40 cassava genotypes, the values of the dry matter content, fresh root yield, plant height, number of root, harvest index and starch content were showed and the values where ranged from the least to the highest in this study and this kind of similar result were obtained also by Diaguna, *et al.*, 2022. With regard to the performance of individual genotypes with respect to each trait showed that these sixe superior genotypes selected were best in one trait to others. Which implies the genotypes could also be selected based on their specific performance for a particular trait of interest..

From the result on clustering analysis, there were 6 clustering showing that those genotypes within a cluster have similar characteristics while characteristics between clusters are different from each other. This simply implies that these similar genotypes could be used for the same purpose or aim and they share similar functions. The current findings are similar to other findings (Ampong-Mensah, 2000; Fregene *et al.*, 2000; Carvalho and Schaal, 2001; Elias *et al.*, 2001; Raghu *et al.*, 2007) who used stem girth, tuber length, tuber girth, yield per plant, tuber attachment on parent cuttings, tuber inner skin color, tuber outer skin color, tuber surface texture and pulp color and yield for genetic diversity studies in cassava.

CONCLUSION AND RECOMMENDATION

The present investigation observed significant variations among the cassava genotypes from different background for nutritional qualities. The ranking analysis showed the superior genotypes as NR050667, NR100451, NWAGERI, AR145, IITA-TMS-MM990477, and NR100216 which need to be selected during yield improvement process. Diversity studies using dendogram analysis generated six clusters and revealed the existence of diversity among the selected genotypes. Based on the observed results, superior genotypes from the study can be utilized for the initial steps in the cassava breeding programme

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YIELD AND YIELD RESPONSES OF LOWLAND RICE CULTIVARS TO NITROGEN RATES AND VARIATIONS AT DIFFERENT GROWTH STAGES IN DERIVED SAVANNAH OF NIGERIA.

Ajao[1] O. A*., Sakariyawo[1] O. S., Oyekanmi[1] A. A., [2]Adejuyigbe[2] C. O.,

[1]Department of Plant Physiology and Crop Production, Federal University of Agriculture, Abeokuta, P.M.B. 2240, Alabata, Ogun State, Nigeria.
[2]Department of Soil Science and Land Management, Federal University of Agriculture, Abeokuta, P.M.B. 2240, Alabata, Ogun State, Nigeria
* Corresponding author: ajaoolufemi23@gmail.com

ABSTRACT
Field experiments (2020 and 2021) were conducted at the Teaching and Research Farms, FUNAAB. The effects of N rates, in different proportions, at different growth stages were evaluated on lowland rice varieties in derived Savannah. Nitrogen rates (0 kg, 60 kg, 90 kg and 120 kg N ha^{-1}) (main plot), variations in its proportion at different growth stages [50% transplanting (TP) + 50% tillering (TL), 50% TP + 25% TL +25% panicle initiation (PI), 33.3% TP + 33.3% TL + 33.3 PI] (sub plot) and varieties (NERICA L-19 and WITA 4) (sub-sub plot).
The experiments were in randomized complete block design in three replicates. Data were subjected to An alysis of Variance; treatment means were separated using Least Significant Difference at the 5% probability level. At 120 kg N ha^{-1}, highest grain yield (8.6 t ha^{-1} and 5.37 t ha^{-1}) was produced in both years. Split N application at 33.3% TP + 33.3% TL + 33.3 PI significantly ($P \leq 0.05$) improved rice grain yield (7.81 t ha^{-1} and 3.69 t ha^{-1}) in both years. Application of 120 kg N ha^{1} at 33.3% TP + 33.3% TL + 33.3 PI enhanced yield components and grain yield in derived Savannah of Nigeria.

INTRODUCTION:
Nitrogen constitutes a major macronutrient in the productivity of lowland rice. (Shrestha *et al*., 2020). It is a highly mobile nutrient (Malvi, 2011) and constitutes a major biophysical constraint in the cultivation of lowland rice. (An *et al*., 2018). This could be ascribed to its mobility in the soil and its susceptibility to losses such as leaching, surface-runoff and volatilisation. It was reported that synchrony of the N demand with its supply would ameliorate these losses. (Fan *et al*., 2019) Other components of integrated nutrient management have also been suggested in the literature such as the source, rate and time of N application. Grain yield in cereals is dependent on the sink strength. Sink strength is a function of the sink size and filling efficiency (Xiao-*li et al*., 2022).
Bandyopadhyay *et al*. (2020) reported that there is a trade-off in this relationship, which informs the time of N application during the growth stages. Where the panicle size is large with small filling efficiency, it was suggested that N should be applied at spikelet initiation. Conversely, in cases where the panicle size is small with a large grain filling efficiency N should be applied at panicle initiation. Considering that, the yield components of cereals display hierarchy of plasticity under stress, the question remains unanswered which of the yield components contribute to grain yield in lowland rice under N deficiency (Saieed *et al*., 2023).
Furthermore, the sink size of the lowland rice cultivars used in this experiment has not be determined under N deficiency; there is the need to explicate the time of N application during their growth stages. This experiment seeks to further determine the effect of varietal variations on the grain yield and its attributes in a derived Savannah.

MATERIALS AND METHODS
Two field experiments were conducted consecutively during early seasons of the years 2020 and 2021 in the inland valley of Federal University of Agriculture, Abeokuta, Nigeria. The location lies at the South-Western Nigeria (Latitude 7˚ 15'N, Longitude 3˚ 28'E, 75 m and altitude 144 m above the sea level). The area falls within the derived Savannah with bimodal rainfall pattern.

The experiments consisted of nitrogen (N) rates (0, 60, 90, 120 kg N ha^{-1}) applied in different proportions at different growth stages [50% at transplanting + 50% tillering (TL); 50% at transplanting + 25% TL + 25% panicle initiation (PI); 33.3% at Transplanting + 33.3% at TL + 33.3% PI] on lowland varieties (NERICA L-19 and WITA 4). Tillering and Panicle Initiation were observed that 3 and 6 Weeks after Transplanting (WAT) respectively. The experiment was laid out in split-split arrangement, fitted into a randomized complete block design, replicated three times. The N rates constituted the main, variations in the proportion of N applied at different growth stages was made up of the sub-plot while rice varieties constituted the sub-sub-plot. On 27th of May 2020 and June 6th 2021, pre-germinated seeds were sown on the nursery bed by drilling method. The total land area was 41.5 m × 27.5 m (1141.3 m^2). The gross plot size was 4 m × 3 m (12 m^2) with 0.5 m within the plot and 1m between the replicates. The rice seedlings were transplanted at 3 weeks after planting on 17th June 2020 and 27th June 2021 at one seedling per hill to a depth of 3 cm with a spacing of 20 cm × 20 cm making 300 hills per plot.

Data on yield components and grain yield were collected from five tagged plant within the net plot (2 m × 3 m) at harvest on the panicle weight (Ohe *et al*., 2010), 1000-grain weight (Osman, 2012), number of grains Per panicle (Hirzel *et al*., 2011), number of panicle Per m^2 (Das *et al*., 2014), and grain yield t ha^{-1} (Wang *et al*., 2015).

Mixed Model Analysis of Variance (ANOVA) of the measured parameters was performed and the treatment means were separated using Least Si gnificant Difference (LSD) at the 5% level of pro bability using GENSTAT 12th Edition (Payne *et al.*, 2009).

RESULTS

There was a significant ($P \leq 0.05$) increase in panicle weight, number of grains/panicle, 1000-grain weight, number of panicle Per m^{-2} and grain yield of lowland rice varieties with increase in application rate of N (both years). Variations in the proportion of N applied significantly ($P \leq 0.05$) affected panicle weight (2021), number of grains Per panicle (2020), Number of panicle Per m^{-2} (2020) and grain yield (t/ha) (both years). WITA 4 significantly had higher 1000-grain weight, than NERICA L-19 (2020). In the succeeding year, a converse pattern was observed with NERICA L-19 having significantly higher panicle weight than WITA 4. (Table 1)

DISCUSSION

Increased yield components due to increasing N application rates in both years could have suggested the availability of N to support the growth and development of lowland rice in this agroecology. N constitutes a major component of macromolecules such as protein and chlorophyll. (Liefer *et al*., 2019). Increased activity of proteins especially in the light harvesting complex of photosystem could aid in the interception of light towards increased canopy photosynthesis. The observed pattern of panicle weight and number of grains Per panicles with increasing N application could have been associated with number of panicles Per m^{-2}. Panicle weight and number of grains Per panicle could have contributed to the observed 1000-grain weight in this context. This observed pattern with increasing N application rates could have contributed significantly to the sink strength of lowland rice with increasing N application rates, thus the observed grain yield. White *et al*. (2016) reported that increasing sink strength is capable of simulating source activity this creating a reinforcing loop towards a high photosynthetic activity in crop.

Under stress yield components of cereals display hierarchy of plasticity (Mohammadi, 2014). It was reported that weight of the yield components are better conserved than number. In this study, it was observed that lowland rice sown N in the proportion of 33.3% at transplanting + 33.3% tillering + 33.3 Panicle initiation compared to other lowland rice established with different proportion of N at different growth stages had significantly higher number of grains Per panicle and number of panicles Per m^{-2}. This could have suggested synchrony of N demand with its supply at this growth stage in equal proportion of N. Since number of the aforementioned yield components were conserved it could be interpreted that there was no deficiency of N to lowland rice (2020). The observed grain yield under this condition in lowland rice could have resulted from the aforementioned yield components. However in the succeeding year, performance of lowland rice cultivars sown with N in the proportion of 33.3% at

transplanting +33.3% tillering + 33.3 Panicle initiation when compared to other N proportions at different growth stages indicated that it was the panicle weight that contributed most to the grain yield of lowland rice. This could be attributed to variations in the weather condition in both years. The lowest grain yield was observed from split when N was applied at 50% at transplanting + 50% tillering (T1) suggesting probably a trade-off in the sink size and filling efficiency of the lowland rice. In the case where the sink size of the cultivars unknown at the start of the experiment, application of N in this proportion at this growth stage could have indicated high sink size with low filling efficiency. There is the need to further validate this. Varietal variations were observed in both years on 1000-grain weight and panicle weight suggesting the effect of differences in weather conditions in both years.

CONCLUSION

Increased N application rates increased yield components and grain yield of lowland rice cultivars. This could have suggested increased Nitrogen availability to support reproductive growth in both years. Lowland rice sown with N in the proportion of 33.3% at transplanting +33.3% tillering +33.3 Panicle initiation compared to others sown in different proportions at different growth had better performance in both years albeit with variations in the contributions of the yield components. Similarity in grain yield observed between WITA 4 and NERICA-L19 could have suggested compromised sink size (similar number of panicle Per m^{-2} and reduced panicle weight of WITA 4 than NERICA L-19).

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Table 1: Yield and yield components of lowland rice varieties as affected by nitrogen rates and variations in the proportion of N applied at different growth stages in early

	2020					2021				
	Panicle weight (g)	Number of grains Per panicle	1000-grain weight (g)	Number of panicle Per m^2	Grain yield (t ha^{-1})	Panicle weight (g)	Number of grains Per panicle	1000-grain weight (g)	Number of panicle Per m^2	Grain yield (t ha^{-1})
Nitrogen rates (N)										
0 kg N ha^{-1}	4.10	108.00	27.10	108.80	4.40	2.13	103.52	15.30	99.70	0.72
60 kg N ha^{-1}	4.40	129.00	32.20	225.00	6.40	4.99	120.96	26.20	196.30	1.78
90 kg N ha^{-1}	4.50	147.00	32.90	249.20	7.00	3.76	127.89	28.70	249.20	2.45
120 kg N ha^{-1}	5.00	169.00	33.00	311.50	8.60	3.32	130.87	30.90	258.40	3.47
LSD ($P \leq 0.05$)	0.40*	11.60*	1.80*	32.5*	2.30*	0.41*	4.31*	1.60*	55.96*	0.40*
Variations in N proportion applied at different growth stages (P)										
50% at transplanting + 50% tillering	4.60	133.00	31.40	210.00	5.60	3.31	119.36	25.20	192.80	1.97
50% at transplanting +25%tillering +25% Panicle initiation	4.30	139.00	33.00	222.00	6.50	3.60	121.78	24.90	201.40	2.02
33.3% at transplanting +33.3% tillering +33.3 Panicle initiation.	4.50	142.00	24.30	238.90	7.80	3.75	121.28	25.68	208.60	2.32
LSD ($P \leq 0.05$)	Ns	11.60*	Ns	20.30*	1.20*	0.16**	Ns	Ns	Ns	0.29*
Varieties (V)										
NERICAL L-19	4.30	137.00	28.80	231.00	6.70	3.67	119.51	25.60	209.90	2.10
WITA 4	4.70	139.00	33.80	217.00	6.60	3.43	122.11	25.00	191.90	2.11
LSD ($P \leq 0.05$)	Ns	Ns	1.30*	Ns	Ns	0.20*	Ns	Ns	Ns	Ns
Interaction ($P \leq 0.05$)										
N × P	Ns	Ns	Ns	44.7*	Ns	0.45*	5.95*	Ns	Ns	Ns
N × V	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
P × V	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	0.35*
N × P × V	1.20*	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

cropping seasons (2020 and 2021)

LSD-Least Significant Differences, Ns- Not Significant, *-Significant at 5% V-Varieties, N-Nitrogen rates, P-Variations in the proportion of N applied at different growth stages.

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Ajao O. A[1]*., Sakariyawo O. S[1]., Oyekanmi A. A[1]., Adejuyigbe C. O[2].,
[1]Department of Plant Physiology and Crop Production, Federal University of Agriculture, Abeokuta, P.M.B. 2240, Alabata, Ogun State, Nigeria.
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* Corresponding author: ajaoolufemi23@gmail.com

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Two field experiments were conducted consecutively during early seasons of the years 2020 and 2021 in the inland valley of Federal University of Agriculture, Abeokuta, Nigeria. The location lies at the South-Western Nigeria (Latitude 7° 15'N, Longitude 3° 28'E, 75 m and altitude 144 m above the sea level). The area falls within the derived Savannah with bimodal rainfall pattern.

The experiments consisted of nitrogen (N) rates (0, 60, 90, 120 kg N ha^{-1}) applied in different proportions at different growth stages [50% at transplanting + 50% tillering (TL); 50% at transplanting + 25% TL + 25% panicle initiation (PI); 33.3% at Transplanting + 33.3% at TL + 33.3% PI] on lowland varieties (NERICA L-19 and WITA 4). Tillering and Panicle Initiation were observed that 3 and 6 Weeks after Transplanting (WAT) respectively. The experiment was laid out in split-split arrangement, fitted into a randomized complete block design, replicated three times. The N rates constituted the main, variations in the proportion of N applied at different growth stages was made up of the sub-plot while rice varieties constituted the sub-sub-plot. On 27th of May 2020 and June 6th 2021, pre-germinated seeds were sown on the nursery bed by drilling method. The total land area was 41.5 m × 27.5 m (1141.3 m^2). The gross plot size was 4 m × 3 m (12 m^2) with 0.5 m within the plot and 1m between the replicates. The rice seedlings were transplanted at 3 weeks after planting on 17th June 2020 and 27th June 2021 at one seedling per hill to a depth of 3 cm with a spacing of 20 cm × 20 cm making 300 hills per plot. Data on yield components and grain yield were collected from five tagged plant within the net plot (2 m × 3 m) at harvest on the panicle weight (Ohe *et al*., 2010), 1000-grain weight (Osman, 2012), number of grains Per panicle (Hirzel *et al*., 2011), number of panicle Per m^2 (Das *et al*., 2014), and grain yield t ha^{-1} (Wang *et al*., 2015).

Mixed Model Analysis of Variance (ANOVA) of the measured parameters was performed and the treatment means were separated using Least Si gnificant Difference (LSD) at the 5% level of prob ability using GENSTAT 12th Edition (Payne *et al.*, 2009).

RESULTS

There was a significant ($P \leq 0.05$) increase in panicle weight, number of grains/panicle, 1000-grain weight, number of panicle Per m^{-2} and grain yield of lowland rice varieties with increase in application rate of N (both years). Variations in the proportion of N applied significantly ($P \leq 0.05$) affected panicle weight (2021), number of grains Per panicle (2020), Number of panicle Per m^{-2} (2020) and grain yield (t/ha) (both years). WITA 4 significantly had higher 1000-grain weight, then NERICA L-19 (2020). In the succeeding year, a converse pattern was observed with NERICA L-19 having significantly higher panicle weight than WITA 4. (Table 1)

DISCUSSION:

Increased yield components due to increasing N application rates in both years could have suggested the availability of N to support the growth and development of lowland rice in this agroecology. N constitutes a major component of macromolecules such as protein and chlorophyll. (Liefer *et al*., 2019). Increased activity of proteins especially in the light harvesting complex of photosystem could aid in the interception of light towards increased canopy photosynthesis. The observed pattern of panicle weight and number of grains Per panicles with increasing N application could have been associated with number of panicles Per m^{-2}. Panicle weight and number of grains Per panicle could have contributed to the observed 1000-grain weight in this context. This observed pattern with increasing N application rates could have contributed significantly to the sink strength of lowland rice with increasing N application rates, thus the observed grain yield. White *et al*. (2016) reported that increasing sink strength is capable of simulating source activity this creating a reinforcing loop towards a high photosynthetic activity in crop.

Under stress yield components of cereals display hierarchy of plasticity (Mohammadi, 2014). It was reported that weight of the yield components is better conserved than number. In this study, it was observed that lowland rice sown N in the proportion of 33.3% at transplanting + 33.3% tillering + 33.3 Panicle initiation compared to other lowland rice established with different proportion of N at different growth stages had significantly higher number of grains Per panicle and number of panicles Per m^{-2}. This could have suggested synchrony of N demand with its supply at this growth stage in equal proportion of N. Since number of the aforementioned yield components were conserved it could be interpreted that there was no deficiency of N to lowland rice (2020). The observed grain yield under this condition in lowland rice could have resulted from the aforementioned yield components. However, in the succeeding year, performance of lowland rice cultivars sown with N in the proportion of 33.3%

at transplanting +33.3% tillering + 33.3 Panicle initiation when compared to other N proportions at different growth stages indicated that it was the panicle weight that contributed most to the grain yield of lowland rice. This could be attributed to variations in the weather condition in both years. The lowest grain yield was observed from split when N was applied at 50% at transplanting + 50% tillering (T1) suggesting probably a trade-off in the sink size and filling efficiency of the lowland rice. In the case where the sink size of the cultivars unknown at the start of the experiment, application of N in this proportion at this growth stage could have indicated high sink size with low filling efficiency. There is the need to further validate this. Varietal variations were observed in both years on 1000-grain weight and panicle weight suggesting the effect of differences in weather conditions in both years.

CONCLUSION

Increased N application rates increased yield components and grain yield of lowland rice cultivars. This could have suggested increased Nitrogen availability to support reproductive growth in both years. Lowland rice sown with N in the proportion of 33.3% at transplanting +33.3% tillering +33.3 Panicle initiation compared to others sown in different proportions at different growth had better performance in both years albeit with variations in the contributions of the yield components. Similarity in grain yield observed between WITA 4 and NERICA-L19 could have suggested compromised sink size (similar number of panicle Per m^{-2} and reduced panicle weight of WITA 4 than NERICA L-19).

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SCREENING OF COWPEA (*Vigna unguiculata* L.) GENOTYPES FOR RESISTANCE TO BRUCHID (*Callosobruchus maculatus* F.)

Oladipo, M.S.,[1*] Akintunde, A.T., [1] Oloyede-Kamiyo, Q. O. [1] and Ayo-Vaughan, M.A.[2]

[1] Grain Legume Improvement Programme, Obafemi Awolowo University, Institute of Agricultural Research and Training, Ibadan

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

**Corresponding author email: oladipoms@gmail.com*

ABSTRACT

Post-harvest losses in cowpea are mostly caused by the infestation of *Callosobruchus maculatus*, a storage pest. It can cause up to 90% yield loss of stored grains. The objective of this study was to assess 15 cowpea genotypes from Institute of Agricultural Research and Training (IAR&T) and International Institute of Tropical Agriculture (IITA) to determine their resistance level to *Callosobruchus maculatus* F. The experiment was laid out in a Completely Randomized Design (CRD) with four replications. Data were collected on initial seed weight, percentage weight loss, percentage bruchid emergence, percentage pest tolerance and percentage seed damage. Data collected were subjected to analysis of variance and Pearson's correlation analysis. Genotype Tvu-4564 had moderate resistance, Tvu-11953, Tvu-2027, modupe and bbt-brown were least susceptible, IT81D-994, Tvu-6464, bbt-white, Tvu-801 and Tvu-16765 were moderately susceptible and IT84S-2246-4, Tvu-4348, Tvu-17114, Tvu-4516 and Tvu-1607 were highly susceptible to cowpea bruchids. Percentage weight loss was highly significant and positively correlated with all the other traits except for initial seed weight and percentage pest tolerance. Furthermore, Tvu-4564 can be incorporated in breeding programs to serve as source of resistance to bruchid infestation.

Keywords: *Callosobruchus maculatus*; Correlation; Cowpea and Resistance;

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) is one of the major grain legumes widely consumed in sub-Saharan Africa. It is also an important source of staple food in the region. *Callosobruchus maculatus* (Bruchid) is one of the major post-harvest pest affecting the crop and it is found throughout the tropical and subtropical regions. It is a destructive pest of stored cowpea seeds capable of causing up to 90% grain loss, resulting in severe economic loss (Amusa *et al.*, 2014).

The use of resistant genotypes in insect pest management is considered a good and viable control method (Affram *et al.*, 2022). Screening of cowpea accessions can help to identify new sources of resistance to cowpea bruchid, which can be useful as donors of resistant traits (Siyunda *et al.*, 2022). Therefore, the objectives of the study were to evaluate 15 cowpea genotypes for resistance to *C. maculatus* and determine the genotypes that can be considered as source of resistance to bruchid.

MATERIALS AND METHODS

Fifteen cowpea genotypess were used which comprised three newly released cowpea (Bbt-Brown, Bbt-White and Modupe) varieties. Bbt-Brown, Bbt-White were bred for resistance to brown blotch while modupe was developed for early maturity and reduce insecticidal spray by Institute of Agricultural Research and Training (IAR&T) and twelve cowpea (IT81D-994, IT84S-2246-4, Tvu-11953, Tvu-1607, Tvu-16765, Tvu-17114, Tvu-2027, Tvu-4348, Tvu-4516, Tvu-6464, Tvu-801 and Tvu-9058) accessions from International Institute of Tropical Agriculture (IITA), Ibadan. The screening evaluation was carried out at the Entomology Laboratory of IAR&T, Ibadan and done according to the method described by Amusa *et al.*, (2014) with little modifications. Twenty seeds from each genotype was weighed and put into different petri dishes. Ten pairs of newly emerged adult bruchids (5 males and 5 females) was then introduced into each petri dish with 4 replications.

The following data were collected based on the recommendation of Amusa *et al.*, (2014): Initial Seed Weight (ISW) (weight of the seeds before the start of the experiment), Percentage Weight Loss (PWL) (initial seed weight-final seed weight/100), Percentage Bruchid Emergence (PBE) (number of emerged adult insect/number of eggs laid x 100), Percentage Pest Tolerance (PPT) (number of initial

seeds-number of damaged seeds/total number of initial seeds x 100), Percentage Seed Damage (PSD) (number of damaged seeds/number of initial seeds x 100) was used to determine the level of resistance of the genotypes according to the suggestion of Deshpande *et al.*, (2011), 0- 20% (highly resistant), 21 - 40% (moderately resistant), 41 - 60% (least susceptible) 61-80% (moderately susceptible) 81-100% (highly susceptible). All the data collected were subjected to analysis of variance, means were separated using Duncan Multiple Range Test (DMRT) and Pearson's correlation analysis was done to determine the relationship between the parameters. All analysis were carried out using SAS software version 9.0.

RESULTS AND DISCUSSION

Genotype resistance is one of the potential option to minimize losses caused by *C. maculatus* during storage because it is easy to utilize, less expensive and is compatible with other control methods. The result from the analysis of variance (Table 1) revealed that significant difference was observed among the cowpea genotypes for most of the parameters and this indicates the presence of variation in their response to *C. maculatus* infestation. The non-significant difference observed among the genotypes for PBE indicates non-discrimination by *C. maculatus* for the trait among the genotypes screened and this was in contrast to the findings of Affram *et al.,* (2022).

Table 1: Mean squares of the measured traits evaluated for resistance to *C. maculatus*

SoV	df	PWL	PSD	PBE	PPT	ISW
Genotypes (G)	14	444.09**	1234.92**	516.84	1237.92**	3.19**
Rep (R)	3	101.75	173.89	701.98	173.89	0.15
Error	42	101.10	373.00	364.42	373.00	0.15

*, ** Significant at P<0.01 and P<0.05 respectively.

SoV: Source of variation, PWL: Percentage weight loss, PSD: Percentage seed damage, PBE: Percentage bruchid emergence, PPT: Percentage pest tolerance, ISW: Initial seed weight.

PBE and PWL are some of the most reliable indicators for resistance of cowpea to bruchid attack (Affram *et al.,* 2022). Tvu-4564 had the lowest PWL (6.9%) which indicates its resistance to *C. maculatus* while genotype Tvu-6464 recorded the highest PWL with 39.18% weight loss after bruchid infestation, which revealed its high susceptibility to *C. maculatus* (Table 2). Deshpande *et al.,* (2011), reported that variation in seed weight loss by *C. maculatus* occurs mainly due to the variations in adult bruchid emergence. TVu-4564 had the lowest percentage of emerged bruchid (13.12%) followed by IT81D-994 (13.75%). TVu-4516 (47.20%) had the highest value for the parameter closely followed by TVu-17114 (47.07%) while the other genotype ranged from 21.03% to 44.97% and were not significantly different. The resistance of TVu-4564 and IT81D-994 may be attributed to varying sorts of reserve protein which cannot be metabolized by the midgut proteinases of the insect, thereby reducing the food supplied to the larvae and interfering with the adult bruchid development (Senthilraja and Patel, 2021).

The PPT ranged from 3.75% (TVu-1607) to 66.25% (TVu-4564). This shows that TVu-4564 had the highest tendency to tolerate bruchid infestation while TVu-1607 had the lowest tendency of tolerating bruchid infestation. The weight of the genotypes screened varied significantly ranging from 1.43 to 4.68g. TVu-2027 had the highest ISW while TVu-16765 possessed the lowest ISW before the start of the experiment. In this study, a seed with at least a perforation from an emerged adult bruchid is considered as a damaged seed. The majority of the cowpea genotypes used in this study showed varying level of seed damage, which indicates that the genotypes possess different level of resistance. Genotypes with high PSD are considered to be susceptible to cowpea bruchid.

PSD by *C. maculatus* among different cowpea genotypes screened, varied from 33.75% (TVu-4564) to 96.25% (TVu-1607). Using the classification described by Deshpande *et al.,* (2011), Tvu-4564 can be classified as moderately resistant. These released varieties (modupe and

bbt-brown) alongside Tvu-11953 and Tvu-2027 can be classified as least susceptible, IT81D-994, Tvu-6464, bbt-white, Tvu-801 and Tvu-16765 can be classified as moderately susceptible and IT84S-2246-4, Tvu-4348, Tvu-17114, Tvu-4516 and Tvu-1607 can be classified as highly susceptible genotypes to cowpea bruchids. Most of the genotypes that were classified as susceptible had low PPT values ranging from 3% - 18% and PWL values ranging from 18% - 33%. The results in the present study are also in conformity with the result of Deshpande *et al.*, (2011) who reported that none of the cowpea genotypes screened in their study were completely resistant to bruchid attack. The variation in the susceptibility and resistant levels of the cowpea genotypes could be linked to the association between some physiochemical characteristics of the cowpea seeds.

Table 2: Mean performance of fifteen (15) cowpea accessions against *Callosobruchus maculatus* infestation

Genotype name	PWL	PBE	PPT	ISW	PSD
Bbt-Brown	15.97bcde	21.03ab	42.50abcd	2.65fg	57.50bcde
Bbt-White	27.72abcd	39.00ab	35.00abcde	3.30cde	65.00abcde
IT81D-994	7.02e	13.75b	38.75abcd	3.93bc	61.25bcde
IT84S-2246-4	22.26abcde	30.45ab	18.75cde	3.75c	81.25abc
Modupe	12.38cde	24.19ab	50.00abc	2.78ef	50.00cde
Tvu-11953	10.34cd	24.58ab	53.75ab	3.80c	46.25de
Tvu-1607	33.48ab	38.36ab	3.75e	3.13def	96.25a
Tvu-16765	31.55ab	21.57ab	31.67bcde	1.43h	76.25abcd
Tvu-17114	32.27ab	47.07a	16.25de	3.50cd	83.75ab
Tvu-2027	10.54de	28.13ab	53.75ab	4.68a	46.25de
Tvu-4348	18.89bcde	44.97ab	17.50de	4.48ab	82.50ab
Tvu-4516	20.48bcde	47.20a	16.25de	3.55cd	83.75ab
Tvu-4564	6.90e	13.12b	66.25a	3.33cde	33.75e
Tvu-6464	39.18a	21.39ab	36.25abcd	2.18g	63.75bcde
Tvu-801	28.87abc	32.41ab	35.00abcde	2.08g	65.00abcde
MEAN	21.19	29.82	33.83	3.24	66.17
CV (%)	66.20	68.55	70.45	28.86	36.02

PWL: Percentage weight loss, PBE: Percentage bruchid emergence, PPT: Percentage pest tolerance, ISW: Initial seed weight, PSD: Percentage seed damage

The correlation coefficients in table 3 revealed that 7 of the 10 correlation coefficient values were significant (Table 3). PWL was highly significant and positively correlated with all the other traits except for ISW (-0.31) which had significant and negative correlation with PWL, PPT (-0.68) had highly significant negative correlation with PWL. Also, an increase in the PWL will lead to a simultaneous increase in PWL and PPT. Also, PPT had highly significant negative correlation with all the other traits except for ISW that had non-significant negative correlation with PPT. ISW had negative significant correlation with PWL while its correlation with other traits were not significant. PBE was highly significant with PWL and PSD, significant correlation with ISW while it was negative and highly significant with PPT. The result obtained from this study was in conformity with the result obtained in the research of Siyunda *et al.*, (2022), they also obtained a highly significant and positive correlation between PSD and PWL.

Table 3: Pearson's correlation coefficients among *C. maculatus* resistance traits in 15 cowpea genotypes

	PWL	PSD	PBE	PPT	ISW
PWL	1	0.68**	0.33**	-0.68**	-0.31*
PSD		1	0.34**	-1.00**	0.04
PBE			1	-0.34**	0.17
PPT				1	-0.04
ISW					1

*, ** Significant at P<0.01 and P<0.05 respectively.

PWL: Percentage weight loss, PSD: Percentage seed damage, PBE: Percentage bruchid emergence, PPT: Percentage pest tolerance, ISW: Initial seed weight.

CONCLUSION AND RECOMENDATION

The most tolerant genotype across all parameters investigated was Tvu-4564. It could further be assessed for the possible presence of bio-chemical and genetic parameters that could explain the basis of its resistance to *Callosobruchus maculatus*. Also, Tvu-4564 can also be incorporated in the breeding program to serve as source of resistance gene for bruchid infestation.

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GENETIC PARAMETERS AND THEIR IMPLICATIONS ON SEED YIELD IN BAMBARA GROUNDNUT (*Vigna subterranea* (L) Verdc)

Adaraloye M. O., *Odumuyiwa, O. E. & Efunwole, O. P.

Mujeeb Adaraloye – mujeebadaraloye@gmail.com International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State

[2]Oludare E. Odumuyiwa - oludareodumuyiwa@gmail.com Institute of Agricultural Research and Training (IAR&T), Ibadan, Oyo State

[2]Olawumi P. Efunwole - olawumiefunwole@gmail.com Institute of Agricultural Research and Training (IAR&T), Ibadan, Oyo State

*Corresponding Author: oludareodumuyiwa@gmail.com Tel: +234 8130601583

ABSTRACT

Bambara groundnut is an underutilised legume crop with great potential as a tool for food security especially in SSA. Genetic parameters such as heritability, genetic correlation, and genetic gain play a crucial role in crop breeding programmes that enhance yield and other desirable qualities. This study was conducted at the Teaching and Research field of FUNAAB to determine heritability, variability and association among traits at both genotypic and phenotypic levels using the 'Agricolae' and 'Variability' Statistical packages in R Studio. The study results revealed a significant variation level among the Bambara germplasm studied. The genetic parameters assessed also revealed considerable genetic variability within the population and low heritability for most of the traits assessed. However, seed weight per pod recorded a positive and significant relationship with each of number of leaves, number of branches, number of pods per plant, number of pods with 2 or more seeds, fresh pod weight, and dry pod weight at both genotypic and phenotypic levels indicating that these traits can be used in selecting for yield improvement in Bambara.

Keywords: Genetic parameters, germplasm, food security, genetic variability, yield improvement.

INTRODUCTION

Bambara groundnut (*Vigna subterranea* L. Verdc) is an underutilised grain legume that belongs to the family of Fabaceae (Khan *et al.* 2020). It is a close relative of cowpea and also morphologically fits into the same niche as groundnut as a geocarpic crop. The crop is grown mostly in Africa with Nigeria being the leading producer, with an annual production of about 100 thousand metric tons (Majola *et al.* 2021).

Bambara groundnut is highly nutritious, making it relevant in the nutritional formulation of people who cannot afford expensive protein sources, especially animal-based protein (Muhammad *et al.*, 2020). The seed of Bambara groundnut is composed of 61–69% carbohydrates, 17–27% protein, 3.3–6.4% fibre, 3.1–4.4% ash, and 3.6–7.4% fat, making it a valuable source of nutrition. The plant also contains a significant amount of minerals, including sodium, calcium, and potassium (Jideani and Jideani, 2021). In addition, being a legume, it can fix atmospheric nitrogen in its root nodules which can be used by plants and can be left in the soil as residue after harvesting thereby aiding soil fertility. Bambara groundnut is also considered a resistant and robust plant due to its multiple advantages, including its great tolerance to drought, capacity to thrive in poor fertile soil and high nutritional properties (Majola *et al.*, 2021).

In recent years, there has been a growing recognition of the potential of Bambara groundnut as a food crop in arid regions. However, the crop still faces challenges in terms of a lack of improved cultivars and established best agricultural practices (Majola *et al.*, 2021). Also, the productivity of Bambara groundnut is currently below its maximum potential due to the paucity of studies indicating the implication of genetic parameters for yield (Olanrewaju *et al.*, 2021). Genetic parameters such as heritability, genetic correlation, and genetic gain play a crucial role in crop breeding programmes that attempt to enhance yield and other desirable qualities (Olanrewaju *et al.*, 2021). Comprehending these factors in Bambara groundnut is crucial for formulating effective breeding tactics to improve its productivity. This study aims to determine heritability, variability and association among selected Bambara groundnut traits at both genotypic and phenotypic levels.

MATERIALS AND METHODS

The seeds of the 30 genotypes were obtained from the Genetic Resource Centre of the International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria. After clearing, ploughing and marking into 3 blocks (1m apart), the seeds were sown at an inter and intra-row spacing of 1.0m x 0.5m. This study utilized a Randomized Complete Block Design with each of the 30 genotypes of Bambara groundnut replicated thrice on a 187.5m^2 (15m by 12.5m) land area at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta.

Standard cultural practices for Bambara groundnut such as supplying, thinning, and weeding were done when necessary. Data were collected on agro morphological characters including Days to Emergence, Emergence (%), Days to 50% flowering, Plant height (cm), Number of leaves per plant, and Number of branches per plant and subsequently subjected to several statistical analyses including ANOVA, Genetic parameters, using the 'Agricolae' and 'Variability' statistical packages of the R programming language.

RESULTS AND DISCUSSION

Mean squares values revealed significant differences ($P<0.05$) among the thirty genotypes for characters like days to emergence, emergency percentage, number of seeds germinated, plant height at 97 days, and number of pods with 2 or more seeds indicating that the Bambara genotypes studied can be distinguished by the aforementioned characters. The blocking effect was detected in all the characters measured (Table 1).

Table 1: Mean squares from analysis of variance

Source of Variation	DF	DOE	Emergency%	NOSG	PH @ 97days	NL	NB	NPP	NPWS	FPW (g)	DPW (g)	SWP (g)
Genotypes	29	0.56*	679.80**	11.99**	14.78*	2265	223.50	24.86	0.84*	466.50	4.152	2.22
Replication	2	1.73**	7224.30**	127.14**	408.92**	115,615**	12,530.10**	594.08$_{**}$	5.23**	6,043.80**	128.427***	47.22**
Error	58	0.27	312.1	5.60	8.32	1,676	179.7	21.00	0.43	429.0	5.57	2.37

*DOE - Days to Emergence, NOSG – Number of seeds germinated; PH – Plant Height; NL – Number of Leaves; NB - Number of branches; NPP – Number of Pods per plant; NPWS - No. of pods with 2/more seeds; FPW – Fresh pod weight (g); DPW – Dry Pod Weight; SWP – Seed weight per plant.

The Grand Mean, estimates of genotypic and phenotypic variances (GV and PV), genotypic and phenotypic coefficients of variation (GCV and PCV), broad sense heritability (H^2), genetic advance (GA) and genetic advance as percentage of the mean (GAM%) are presented in Table 2. The number of leaves at 97 days had the highest GV and PV (196.49 and 1872.47) followed by emergency (%) with GV and PV of 122.55 and 434.68. The lowest GV value (0.05) was observed for seed weight per plant (g) while days to emergence had the lowest PV value (0.37). GV depicts the variation due to genetic differences while PV captures all sources of variation in the traits measured including genetic and environmental factors (Thakur *et al.*, 2022).

The GCV and PCV values also ranged from 6.54% and 12.84% (Days to emergence) to 92.20% and 187.87% (Number of pods with two or more seeds). Dry pod weight (28.32% and 92.92%), Number of pods per plant (23.20% and 96.56%), and Fresh pod weight (23.13% 137.31%) recorded the next leading GV and PV respectively. Days to emergence had low GCV, Emergency, NOSG, PH at 97 days, NL, NB, and SWP had moderate GCV while NPP, FPW, DPW, while NPWS recorded high GCV. Also, only days to emergence had moderate PCV while the remaining characters recorded high PCV by the classification by Sivasubramanian and Madhavamenon (1978). The high PCV and PV indicate significant phenotypic variability for selection.

The GCV is believed to best describe population variability since it considers mean values and units of measurement (Jonah *et al.*, 2010).

The estimates of broad sense heritability range from 2% for seed weight per plant (g) to 28% for the number of seeds germinated and emergency percentage. Days to emergence (26%), Number of pods with two or more seeds (24%), plant height (21%) and number of leaves (10%) also recorded relatively low broad sense heritability. The large differences between the GCV and PCV corroborate

the low heritability results confirming that the traits are largely controlled by the environment.

Table 2: Estimates of Genetic Parameters in 30 Bambara groundnut genotypes

Genotypes	GM	GV	PV	GCV (%)	PCV (%)	H^2 (%)	GA	GAM (%)
Days to Emergence	4.73	0.10	0.37	6.54	12.84	0.26	0.32	6.86
Emergency (%)	73.56	122.55	434.68	15.05	28.34	0.28	12.11	16.46
No. of Seeds germinated	9.79	2.13	7.73	14.90	28.41	0.28	1.58	16.11
Plant Height @ 97days	10.42	2.16	10.47	14.09	31.06	0.21	1.37	13.17
No. of leave @97days	109.36	196.49	1872.47	12.82	39.57	0.10	9.35	8.55
No. of branches@97 days	36.56	14.60	194.28	10.45	38.13	0.08	2.16	5.90
No. of pods/plant	4.89	1.29	22.28	23.20	96.56	0.06	0.56	11.49
No. of pods with 2/more seeds (g)	0.4	0.14	0.56	92.20	187.87	0.24	0.37	93.2
Fresh pod weight (g)	15.30	12.52	441.49	23.13	137.31	0.03	1.23	8.02
Dry pod weight (g)	2.43	0.47	5.10	28.32	92.92	0.09	0.043	17.78
Seed weight/plant (g)	1.52	0.05	2.32	15.02	100.14	0.02	0.07	4.64

*GM – Grand Mean, GV – Genotypic Variance, PV – Phenotypic Variance, GCV – Genotypic Coefficient of Variation, PCV – Phenotypic Coefficient of Variation, H^2 – Broads sense heritability, GA – Genetic Advance, GAM – Genetic Advance by mean.

The low heritability indicates that only a few proportion of the total variance was due to the genotypic variance showing high environmental influence for the characters evaluated. The estimates of heritability together with GA and GCV provide a profound advantage over the use of heritability alone (Onwubiko *et al.*, 2019). Most of the characters evaluated had low broad sense heritability along with low GA indicating the actions of non-additive genes. This implies that selection will yield low results with most of these characters measured. Also, the large difference between the GCV and PCV and the corresponding low heritability observed for all the evaluated characters indicates that selection would be ineffective for these characters thereby suggesting that selection for the improvement of any of these characters be delayed until genetic influence increases in line with the findings of Onwubiko *et al.*, (2019). The genotypic and phenotypic correlation coefficients estimated for the selected characters are presented on Table 3. In general, the magnitude of the genotypic correlation coefficient was higher than the corresponding phenotypic coefficient indicating thereby a strong inherent association between various traits under study. Days to emergence had a significant and positive association with Plant height (0.63), Number of leaves (0.69), Number of branches (0.87), and number of pods per plant (0.92) at the genotypic level.

Table 3: Genotypic and phenotypic correlation coefficients

				GV						
Characters	DOE	Emergency%	NOSG	PH	NL	NB	NPP	NPWS	FPW (g)	DPW (g)	SWP (g)
Days to Emergence	1	0.14	0.13	0.63**	0.69**	0.87**	0.91**	-0.29	-0.03	0.12	-0.23
Emergency (%)	-0.08	1	0.93**	-0.12	042*	0.85**	0.90**	0.87**	0.79**	0.62**	0.57**
No. of Seeds germinated	-0.07	0.89**	1	-0.09	0.43*	0.83**	0.88**	0.88""	0.91**	0.65**	0.68**
Plant Height @ 97days	0.12	0.17	0.16	1	0.33	0.32	0.93**	-0.14	0.87**	0.56**	0.52**
No. of leaves @97days	0.13	0.20	0.21*	0.33**	1	1.00**	0.91**	0.41*	0.87**	0.61**	0.63**
No. of branches@97 days	0.18	0.17	0.18	0.35**	0.93**	1	0.84**	0.36	0.96**	0.94**	0.91**
No. of pods/plant	0.06	0.13	0.14	0.07	0.48**	0.46**	1	0.77**	0.13	0.88**	0.92**
No. of pods with 2/more seeds (g)	-0.09	0.22*	0.21	-0.03	0.29**	0.33**	0.52**	1	0.80**	0.83**	0.77
Fresh pod weight (g)	0.11	0.13	0.14	-0.06	0.74**	0.37**	0.70**	0.37**	1	0.94**	0.89**
Dry pod weight (g)	0.03	0.05	0.06	0.10	0.39**	0.39**	0.78**	0.42**	0.66**	1	0.93**
SeedW/P	-0.02	0.01	0.10	0.06	0.34**	0.32**	0.83**	0.38**	0.63**	0.92**	1
				PV							

Number of pods per plant also had a significant and positive relationship with number of pods with two seeds or more (0.77), dry pod weight (0.88) and seed weight per pod (.92). Also, dry pod weight (g) recorded a significant and positive association with fresh pod weight (.94) and seed weight per pod (.92) both at the genotypic level. SWP also had a similar association with FPW (.89).

At the phenotypic level, Seed weight per pod recorded a positive and significant relationship with each of the number of leaves (.34), number of branches (.32), number of pods per plant (.83), number of pods with 2 or more seeds (.38), fresh pod weight (.63) and dry pod weight (.92) indicating that these traits can be used in selecting for yield improvement in Bambara. These results are similar to the findings of Khan et al., (2022)

CONCLUSION AND RECOMMENDATIONS

The study reveals a significant level of variation among the thirty Bambara genotypes used for various traits. The results also revealed considerable genetic variability with environmental factors contributing largely to the variation observed within the population studied. The traits measured recorded low to moderate heritability accompanied by low to medium genetic advance indicating ineffective selection for these characters.

Traits such as number of leaves, number of branches, number of pods per plant, number of pods with 2 or more seeds, fresh pod weight, and dry pod weight are suggested to be employed as selection indices in breeding programmes targeted towards seed yield improvement in Bambara. However, the study also suggests that selection for the improvement of any of these characters be delayed until genetic influence increases due to a possibility of ineffective selection.

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EVALUATING THE CONCENTRATION OF HEAVY METALS ON CEREALS CROPS GROWN ALONG HADEJIA JAMA'ARE RIVER JIGAWA STATE

Garko, M. S[*1]., Yawale M. A[2]. Zakari S. A[3]. Zuru S. A[4].

[1 & 3] Department of Crop Science, Faculty of Agriculture and Natural Resource Management, Sule Lamido University Kafin Hausa, Jigawa State, Nigeria.

[2, & 4] Department of Crop Science, Kano University of Science and Technology, Wudil, Kano Nigeria.

***Corresponding author:** muhammad.sgarko@slu.edu.ng

ABSTRACT

Uptake of heavy metals by plants is a path for their entry into the human food chain, leading to negative impacts on both animal humans; hence, monitoring the uptake of excess heavy metals in plants is crucial. This study is aims to assess the concentration of heavy metals in leaves of cereals crops cultivated along Hadejia Jama'are River, which traverses the Miga Auyo and Hadejia of Jigawa State. The study analyses heavy metals concentration in cereals grown the river during 2021 and 2022 rainy season. The experiment consisted of four cereals crops Rice (*Oryza sativa*), Millet (*Pennisetum typhoides*), Sorghum (*Sorghum bicolor* L. Moench) and Maize (*Zea mays* L.), three different locations (Miga, Auyo and Hadejia) were selected. The experiment was factorially combined using completely randomized block design. The study reveals varying heavy metals concentration in cereals grown along the river with the millet and rice showing the highest levels of Zn and Mn, this emphasizing the importance of the ongoing monitoring to address potential contamination. The study areas were found to be polluted by heavy metals, while crops were contaminated with some heavy metals. This study showed that the use of the river valley for agricultural purposes at the time of the study was unsafe and the consumption of the crops from that areas could be hazardous for animal and human health. Farmers are advised to make soil evaluation every season so as to know the status of the soil before planting in order to control excessive assemblage of those heavy metals.

Keywords: Cereals Crops, Heavy Metals, Hadejia Jama'are River and WHO Tolerable limit.

INTRODUCTION

Heavy metals are natural component of the soil and are present in nearly all aspects of modern life and can be defined as a group of elements having density higher than representative of soil minerals, plants, organic matter, about 5g/cm. Iron (Fe) may be the most common as it accounts for 90% of all refined metals and Platinum may be the most ubiquitous given it is said to be found in, or used to produce 20% of all consumer goods (Ibrahim *et al.*, 2015). Some common uses of heavy metals depend on the general characteristics of metals such as electrical conductivity and reflectivity or the general characteristics of heavy metals such as density, strength, and durability. Other uses depend on the characteristics of the specific atomic properties. A few heavy metals are important as trace elements for physiological processes in plants growth and development (Nagajyoti *et al*., 2010).

Accumulation of heavy metals in agricultural soils through waste or contaminated irrigation water at extreme stage, may not only result in soil contamination, but also lead its uptake by the crops at higher percentage and thus affect food and feed quality as well as safety of its use, however, accumulation in plants depends on plant species and the efficiency of different plants in absorbing metals is evaluated by either plant take up or soil-to plant transfer factors of the metals (Ibrahim *et al.*, 2015). Heavy metals like Cu, Fe, Mn, Ni and Zn are essential as micronutrients for plants, while many other metals like Cd, Cr and Pb have no known physiological activity. Akenga, *et al*. (2016) pointed out that sources of heavy metals in this context include mining, and industrial wastes; vehicle emissions; lead-acid batteries; fertilizers and paints.

Heavy metals can degrade air, water, and soil quality, and subsequently cause problems in plants growth and development, which leads to reduction in yield and health issues to farmers and their animals, when they become concentrated (Akenga, *et al.*, 2016). Feed materials as well as animal feed can be spoiled or contaminated with unwanted materials, which may initiate from the production process surrounding the environment as a result of the water use for irrigation during dry season, they are also absorbed get bio accumulated in to the roots, stem, leaves, fruits and grains (Akenga, *et*

al., 2016). Animals that take in those contaminated feed can relocate it to food originated from animal, which comprise of meat, milk and liver (Sulyman, *et al.*, 2015).

Heavy Metals and Crop productivity

Metals in terrestrial ecosystems are important for their influence on growth and development of plants (Hall & Williams, 2003). However, soils are contaminated with heavy metals by human-induced activities (Munzuroglu & Geckil, 2002). A toxic concentration of heavy metals is not known in agricultural soils; however, land disposal of wastes as soil amendments or used of waste irrigation water for crop production is responsible for accumulation of heavy metals in soil and once present in the soil the heavy metals are persistent (Khan, *et al.*, 2013).

Jigawa State is a partially agrarian state with an adequate population growth. Soils are intensively cropped to meet the increasing demand for food production. However, soils of Jigawa are inherently low in adequate/fertility to support increase in population/economic crop production (Ibrahim *et al.*, 2015). Due to high cost of chemical fertilizers and shortage of water bodies in the state municipal and industrial wastes is widely used as a source of nutrients and organic matter for growing cereal crops especially by poor farmers that reside along the river Hadejia Jama'are.

Hall & Williams, (2003) pointed out that, copper is one of the most important micronutrient, essential for plant growth and also it is an integral component of numerous enzymes, and is actively involved in lignification. Zinc, on the other hand, is a non-redox micronutrient element, which has key structural and catalytic roles in many proteins and enzymes involved in energy metabolism and also found that Lead is neither an essential nor a beneficial element for plant growth (Hall & Williams, 2003). However, temporal accumulation of the heavy metals in waste amended agricultural soils at higher concentration can be toxic for plant growth due to their adverse effects on plant development and growth (Hall & Williams, 2003). Growing cereal crops on unregulated waste amended agricultural soils or waste irrigation water may become a food security problem because toxic concentration of heavy metals may accumulate in the food chain (Munzuroglu & Geckil, 2002) and or cause failure of crops. In addition, crops which have the ability to tolerate may accumulate greater concentration of heavy metals and become environmental and public health issues (Munzuroglu & Geckil, 2002).

MATERIALS AND METHODS

Three villages each (Miga, Auyo and Hadejia) were selected along the river during the raining seasons of 2021 and 2022, Latitude 11º 48'N and Long. 09º 18´E), 400 - 430m above the sea level, Temperature of 33º – 45º C, Average rainfall of 800 mm. The experiment consist four major cereals crops grown (Rice, Millet, Sorghum and Maize) along the river. The experiment was laid out in a factorial combination using complete randomized block design locations represent the replications while crop types represents the treatments. The soil sample was collected randomly from 0-15 cm depth using a soil auger and analyzed for physico-chemical properties.

Samples Collection

Data were collection from target crop (Rice, Millet, Sorghum and Maize) in the three selected farms in each of the three different villages and were used for the assessed of heavy metals. The first step is that healthy green leaves without sign of deformity or diseases symptoms were collected at 50% flowering stages of each crop three leaves samples were collected by removing it from three (3) plants in each farm (3 leaves X 4 crops types X 3 locations X 2 sampling seasons) making a total of 72 leaf samples, they were analysed for some of the heavy metals.

Sample Preparation and Analysis

Leaves were cleaned with distilled water, rinsed thoroughly. They were put into polythene bags and transported to laboratory; the samples were then air-dried for seven days. They were then separately ground (SM-450-C grinder) and sieved (nylon 0.425 mm). Sample preparation and analysis were done following procedures described by with minor modifications for boiling time and hot water extraction volumes. For the determination of total metal concentration, three powdered samples (2 g each) were weighed into Teflon vessels. A 12 ml concentrated acid mixture (69% HNO_3 and 70% $HClO_4$ at ratio of 3:1 v/v) was used for digestion over a sand bath in a fume hood until it became clear.

The cooled digests were filtered into a 100 ml volumetric flask and made to the mark with 5% HNO_3. For hot water extraction, three similar

powdered leaf samples from the same site were each separately added to boiling distilled water (250 ml) for five minutes over a hot plate, cooled, and filtered (Whatman's No.42) under gravity. To determine the fraction of element extracted by infusion of leaf samples in boiling water, three 2 g leaf samples were separately added to each of a third set of three conical flasks in which 250 ml of boiling distilled water were added. They were allowed to stand for 5 minutes, cooled, filtered under gravity, and evaporated to near dryness. The residues were acid-digested and the final volume adjusted as described above. Ten sample solutions were analysed for their elemental concentrations alongside a reagent blank solution using flame atomic absorption spectrometry. Data collected were subjected to one way analysis of variance (ANOVA) to test for significant difference among the means. Treatment mean were separated using students New-men's Keuls (SNK).

RESULTS AND DISCUSSION

The results of the soil analysis at the experimental sites during both seasons revealed that soil textural class of the experimental site was sandy loam (Table 1). The soil had pH (6.43) which is a slightly acidic; the soil had medium organic carbon 5.07 g kg^{-1}(Gram per kilogram per hacter). Total nitrogen content of 0.15g kg^{-1}. The available phosphorus content was low 0.11mg kg^{-1} (Milligram per kilogram per hacter) while the total phosphorus was 11.5mg kg^{-1}. The heavy metals [Zn, Pb, Ni, Mn, Cd, Cu and Fe] were ranging from medium to higher levels as indicated below. The EC of the soil analysis was slightly higher 4.47 dS/cm^{-1} (decimetre per centimetre per hacter).

Heavy Metal Content in Leaves of Cereals Crops

The combined result on heavy metals concentration on leaves of major cereals grown along River Hadejia Jama'are in 2021 and 2022 raining season is presented in Table 2. The results showed that, the concentrations were significant on the evaluated heavy metals and statistically highest concentration of Zn (33.0) was observed on millet. Similar pattern was observed on other heavy metals like Pb had statistically higher concentration on millet and maize (14.3 and 12.0). Rice had significantly the least Zn (11.8) concentration. Similar pattern was observed on Mn (62.5) and (58.2) on rice and millet that has statistically the same higher mean. Sorghum had significantly the least Mn (19.9). While Ni (3.1) and Cd (0.4) has significantly higher concentration on millet. Rice had significantly the least Ni and Cd (1.4) and (0.2) respectively. The result was in consonance with the finding of Ibrahim *et al.* (2015) and Owiti, (2015) when he assessed uptake of Cu, Zn and Cd on plants grown along river.

Table 1: Combined Physico-chemical Properties of the soil at Experimental site, during 2021 and 2022 Raining Seasons.

Soil Properties	0 – 30 cm	WHO Tolerable limit
Physical (%)		
Sand	73.0	-
Clay	11.60	-
Silt	15.40	-
Textural Class	Sandy-Loam	
pH (H_2O)	7.92	-
Organic Carbon (gkg^{-1})	5.07	-
Total Nitrogen (gkg^{-1})	0.15	-
Available P ($mgkg^{-1}$)	0.11	-
Total phosphorus ($mgkg^{-1}$)	11.5	-
Heavy Metal (mg/kg)		
Zn	43.56	10.00 - 50.00
Pb	32.16	00.20 - 50.00
Ni	5.49	1.300 - 05.00
Mn	43.01	20.00 - 40.00
Cd	0.53	00.02 - 00.70
Cu	33.51	00.27 – 100
Fe	11.97	00.15 - 7.00
EC (dS/cm^{-1})	4.47	-

WHO = World Health Organization, 2001), Analysed in the Laboratory of Soil and Land Management Department Sule Lamido University Kafin Hausa.

Mn on Sorghum resulted on lower mean values that were not statistically similar on all other crops evaluated, while lower mean values of Cd was recorded on rice as compared to that of other crops across the seasons. In a related development that indicate heavy metals in some instant (Cu, Fe, Mn, Ni and Zn) are essential as micronutrients for life processes in plants and microorganisms, while many other metals like Cd, Cr and Pb have no known physiological activity (Shahid, *et al.*, 2012). In a similar Observations by WHO, (2011) differences in elemental concentrations for leaf samples in these studies could be due to factors that influence their uptake such as water in the river and soil characteristics and properties of elements.

Table 2: Combined Concentrations of Different Heavy Metal (mg/kg) in Leaves of Cereals Crops Grown along Hadejia Jama'are River, 2021 and 2022 Raining Seasons.

Treatments	Zn	Pb	Ni	Mn	Cd
Rice	11.8c	8.6b	1.4c	62.5a	0.2c
Millet	33.0a	14.3a	3.1a	58.2a	0.4a
Maize	24.0b	12.0ab	2.4b	40.4b	0.3b
Sorghum	22.8b	11.0b	2.4b	19.9c	0.3b
SE ±	1.80	0.94	0.14	4.53	0.02
Significance Level	**	*	**	**	**

Means with the same letter (s) in the same column (s) of any set of treatments are not significantly different using SNK (students Newman-Keuls test), SE ± = Standard Error, LSD = Least significant differences, CV = coefficients of variation, (**) = Highly Significant P <.001, (*) = Significant $P < 0.05$.

Comparison of Heavy Metals in Leaves with WHO/FAO Standards

The heavy metal concentrations from the leaves of four different cereals crop samples along river during the two seasons were compared to the recommended WHO/FAO standards and presented in Figure 1, The results showed that, the mean combined concentrations of Pb and Ni were less than the acceptable limits as laid down by (WHO/FAO, 2013) on all crops evaluated. Zn, and Mn (on sorghum) were also found to be less than the standard limit. Concentration of Zn and Mn were barely beyond the standards on all other crops evaluated. However, rice had the highest gap difference followed by millet and then maize to the standard limit. Mn on sorghum leaves are within the limit. This is similar to the findings of Nagajyoti *et al*. (2010) who worked on rice and observed a wide difference to the standard limit when Mn was identified to be less. Zn had higher gap on millet, maize and sorghum to the standard limit as compared with the all other metals evaluated. The result is in corroborates with the finding of Ibrahim *et al.* (2015) who assessed heavy metal concentration (Pb, Cd, Cu, Fe, Zn, Ni) in plant parts (*Zea mays*) and found their accumulation on leaves above the maximum levels. The lowest gap to the standard limit was observed with the Pb on all crops evaluated as indicated below Fig 1. Cd and Ni did not result in any higher concentration. In a similar earlier report Akenga, *et al.* (2016) pointed out that sources of heavy metals in this context include mining, and industrial wastes. The study could not detect any concentration of Cd in maize grains form Nigeria, the concentrations were similar to what was observed in this study.

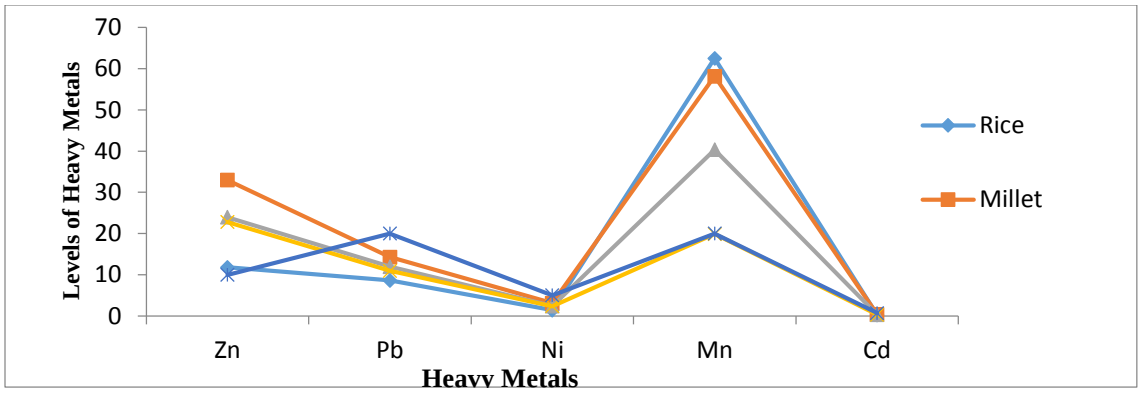

Figure 1. Mean heavy metal combined concentration in leaves of some selected cereals crops

CONCLUSION AND RECOMMENDATIONS

Based on the results obtained it can be concluded that, the study area was polluted by Zn, Pb, Ni, Mn and Cd while crops were contaminated with Zn, Mn, Pb, Cd and Ni. The level of Cd, and Ni was below the toxic level in plant leaves. This study showed that the use of the river valley for agricultural purposes as at the time of the study was unsafe and the consumption of the crops from that areas could be hazardous for animal and human health. This study particularly revealed that the area was polluted by some of those heavy metals. The level of Zn and Mn were above the acceptable limits recommended by WHO/FAO standard, while Cd and Ni were within the range. This is therefore hazardous for agricultural purposes since plants are known to take up and accumulate heavy metals from contaminated soils.

Farmers in the study are advised to make soil evaluation. Frequent examination of heavy metals in cereals along with other foodstuffs (vegetables) must be done so as to control excessive assemblage of the heavy metals in the food chain of human beings.

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EFFECT OF SALINITY STRESS ON WATER CONTENT AND GROWTH VARIABLES OF MAIZE (*ZEA MAYS*) SEEDLINGS

Adeboye, K. A.*,. Awopegba, T. O. & Emmanuel, O. E.
Department of Agricultural Technology, Ekiti State Polytechnic, Isan 371106, Nigeria
*Corresponding author: adeboye@daad-alumni.de; +2348061698998

ABSTRACT
Salinity stress poses a significant challenge to plant growth and development. This study aimed to investigate the effect of salinity on water content and growth parameters of maize seedlings. Seeds of eleven maize (*Zea mays)* varieties obtained from the Institute of Agricultural Research and Training (IAR&T), Ibadan, Nigeria, were germinated in Petri dishes lined with filter papers. The salinity treatment was induced by moistening the filter papers with 150 mM NaCl (0.15 M NaCl;), while the control treatment was moistened using deionized water. The experiment followed a completely randomized design. Analysis of variance (ANOVA) revealed a significant reduction in the water content of maize seedlings exposed to salt solutions ($P < 0.001$). Furthermore, significant variety-dependent differences were observed in response to salinity stress. Notably, LNTP-Y displayed superior performance under both control and stress conditions, emerging as the most resilient genotype. Based on the findings from this study, LNTP-Y is recommended for optimum performance under salinity stress. Our results highlight the diversity within existing maize germplasm for salinity tolerance. LNTP-Y's promising performance warrants further investigation to understand the underlying molecular mechanisms of its resilience.
Keywords: plant-water relation; salt stress; seedling dry weight; seedling fresh weight; water uptake

INTRODUCTION
Plants, as sessile organisms, encounter various abiotic stresses including salinity, drought, temperature extremes, and more, posing significant threats to crop production worldwide (Dos Santos et al., 2022). Salinity, in particular, affects approximately 20% of cultivated areas globally, with nearly half of irrigated lands being impacted. The introduction of salt-tolerant plants is a strategy to utilize saline water and lands. Salinity stress affects plants through reduced water potential, ion toxicity, and nutrient imbalance, inhibiting growth and reproduction (Arif et al., 2020).

Maize (*Zea mays* L.), being the third most vital cereal globally, exhibits moderate sensitivity to salinity, especially during seed germination and seedling establishment. Salinity stress hinders seed germination and vigor, altering water imbibition, enzyme activity, protein metabolism, hormonal balance, and seed reserve utilization (Ali & Elozeiri, 2017). Additionally, salinity may affect root and shoot elongation, water uptake, and plant water relations, ultimately diminishing plant yield (Arif et al., 2020).

This study aims to evaluate the effect of salinity on water content in maize seedlings and identify the most resilient maize varieties under salinity stress. We utilized eleven maize varieties sourced from the Institute of Agricultural Research and Training (IAR&T), Moore Plantation, Ibadan, which have not been previously examined for their responses to salinity stress during germination. This research represents a novel exploration of these specific varieties under such conditions. Understanding the response of maize to salinity stress is crucial for developing resilient crop varieties and effective management strategies. The findings from this study will contribute to filling the existing knowledge gap and provide valuable insights for breeding programs focused on enhancing salinity tolerance in maize.

MATERIALS AND METHODS
Experimental Procedure

Maize (*Zea mays*) seeds used in the experiment were sourced from the Institute of Agricultural Research and Training (IAR&T), Moore Plantation, Ibadan (Table 1). The experiments were conducted in the Laboratory of the Department of Agricultural Technology, Ekiti State Polytechnic, Isan Ekiti, using a completely randomized design. Seeds were sterilized with a 70% ethanol solution for one minute, rinsed with sterile distilled water, and blotted briefly. They were then placed on two layers of filter paper in a petri dish.

Salinity treatments were conducted in three replications by watering the seeds with 150mM NaCl (0.15M NaCl; Sodium Chloride). Deionized water was applied as a control treatment. The seeds were placed in a test chamber for 10 days.

Data Collection

Data collected from the experiment included seedling fresh weight (SFW in g) and seedling dry weight (SDW in g), recorded by weighing harvested seedlings at day 10 after sowing. SDW was obtained by drying the fresh weight at an average of 80 degrees Celsius for 72 hours using a sensitive weighing balance (Model ML124A: Changsha Lonroy Technology Co., Ltd. Hunan, China) Seedling water content percentage (WCP in %) was calculated using the formula:

WCP (%) = ((SFW-SDW/SFW) x 100 (Sayed et al., 2021)

Statistical Analysis

Data recorded from both salinity and controlled treatments were subjected to analysis of variance (ANOVA) using a completely randomized design (CRD). Significant means were separated based on Tukey's Honestly Significant Difference (HSD) test. The statistical analysis was conducted using Statistical Tool for Agricultural Research (STAR) software v2.0.1 by the International Rice Research Institute (IRRI).

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) results in Table 2 revealed significant effects ($p < 0.05$) of salinity treatment, maize variety, and their interaction on seedling fresh weight, dry weight, and water content percentage (Table 2). This indicates that maize varieties responded differently to salinity stress in terms of seedling water content percentage. Seedling fresh weight, dry weight, and water content percentage all showed significant differences among maize varieties (Table 2). This is consistent with previous research that has demonstrated that different variables, including seedling water contents are affected by salinity stress and the extent of this effect is dependent on the genetic variation the crop germplasm (Sayed et al., 2021).

The impact of salinity stress was also significant for all three measured traits (Table 2). Salinity is known to hinder water uptake by reducing the osmotic potential of the growth medium, thereby increasing dehydration and Na toxicity. (Ali & Elozeiri, 2017; Arif et al., 2020).

The interaction between salinity treatment and variety significantly affected seedling dry weight and water content percentage, but not seedling fresh weight (Table 2). This suggests that the impact of salinity stress on dry weight and water content varied among the tested varieties. Increased salinity likely stunted seedling growth and potentially injured embryos, leading to reduced root weight (Sayed et al., 2021). According to (Ali & Elozeiri, 2017) and (Arif et al., 2020) salinity can also alter water imbibition by seeds due to the lower osmotic potential of the germination media, resulting in decreased germination rates.

The observed decrease in water content percentage of seedlings under salt stress for all varieties (Tables 3 & 4) aligns with the established principle that salinity resulted in restriction in water absorption which may be responsible for decrease in biomass (Ali & Elozeiri, 2017). Under escalating sodium chloride concentrations, osmotic pull creates additional stress for the developing seedlings. The decrease in water content might be attributed to the combined effects of high osmotic pressure limiting water uptake and the toxic effects of elevated salt concentrations on embryos, thereby hindering seed reserve mobilization and embryonic axis growth (Cárdenas-Pérez et al., 2022).

CONCLUSION AND RECOMMENDATION

This study unveils previously unknown responses of eleven maize varieties to salinity stress during germination. We observed significant variation in seedling fresh weight, dry weight, and water content percentage, highlighting the genotypic diversity in tolerance to salt exposure. Notably, the variety LNTP-Y displayed superior performance under both control and stress conditions, emerging as the most resilient genotype within this germplasm collection.

These findings underscore the importance of exploring untapped potential for salinity tolerance within existing maize varieties. Further research should delve into the molecular mechanisms underlying LNTP-Y's resilience, potentially leading to the identification of key genes or pathways for breeding programs. Based on this initial assessment, LNTP-Y is a promising candidate for breeding salt-tolerant maize cultivars, ultimately contributing to enhanced agricultural productivity in areas affected by salinity.

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Table 1: List of varieties used in the study

Designation	Variety
G1	ILE-1-OB-W
G2	T2PB-SR-W
G3	DMR-ERS-Y
G4	SUWAN-1-SR-M
G5	BR-9928-DMR-SR-Y
G6	PRO-VIT-A-Y
G7	ART/98/SW6-OB-W
G8	BR-9943-DMR-SR-W
G9	LNTP-Y
G10	ART/98/SWI-Y
G11	DMR-SR-Y

Table 2: Analysis of variance (mean square) of seedling fresh and dry weight and water content percentage.

Source	DF	SFW (g)	SDW (g)	WCP (%)
Treatment	1	2.1855***	0.7193***	298.4139**
Variety	10	1.4606***	0.4006***	1326.7291**
Treatment*Variety	10	0.3799ns	0.1999**	1656.8675***

DF: Degree of freedom, SFW: seedling fresh weight, SDW: seedling dry weight, WCP: water content percentage. *, ** and ***: probability of significance at $P < 0.05$, 0.01 and 0.001 respectively.

Table 3: Performance of eleven maize varieties under salinity stress treatment

Variety	SFW (g)	SDW (g)	WCP (%)
G1	0.77b	0.3433c	55.47ab
G2	0.91ab	0.4300bc	52.44abc
G3	0.72b	0.3933c	44.10bcd
G4	1.22ab	0.6100abc	49.86abcd
G5	1.23ab	0.6867ab	43.54cd
G6	1.00ab	0.5500abc	44.72bcd
G7	1.15ab	0.4800abc	58.19a
G8	1.14ab	0.4867abc	57.72a
G9	1.43a	0.5733abc	60.29a
G10	1.25ab	0.7467a	40.14d
G11	1.10ab	0.4933abc	55.25ab

SFW: seedling fresh weight, SDW: seedling dry weight, WCP: water content percentage. Means with similar letter(s) in each trait is not significantly different and means with different letter(s) in each trait is significantly different at 5% probability level according to Turkey's HSD Test.

Table 4. Performance of eleven maize varieties under control treatment

Variety	SFW (g)	SDW (g)	WCP (%)
G1	0.6600a	0.2200b	66.57a
G2	0.5633ab	0.2700ab	47.89a
G3	0.5700ab	0.2133b	62.28ab
G4	0.7033c	0.3167ab	55.25c
G5	0.6100ab	0.2933ab	51.02ac
G6	0.7600bc	0.4133ab	45.32a
G7	0.7367bc	0.3100ab	57.62a
G8	0.6900a	0.3667ab	47.00ab
G9	0.9433ab	0.4367a	54.10ab
G10	0.8500ab	0.3000ab	64.37ab
G11	0.8333a	0.3567ab	57.08b

SFW: seedling fresh weight, SDW: seedling dry weight, WCP: water content percentage. Means with similar letter(s) in each trait is not significantly different and means with different letter(s) in each trait is significantly different at 5% probability level according to Turkey's HSD Test.

8th Annual Conference and 67th AGM-ABEOKUTA of The Association of Deans of Agriculture in Nigeria Universities (ADAN), Held at The FUNAAB Red Senate chamber, Abeokuta, Ogun State, Nigeria, from July 7th to 11th, 2024. Theme: Climate Change: Agricultural Innovations and Bio-entrepreneurship for Sustainable Development, Food Sufficiency and Economic Transformation. **Edited by:** A. E. Obayelu, O.M Olosunde, P. B. Abdulsalam-Saghir, O.S. Sowande, E.O. Fakoya and J.J. Atungwu

EFFECT OF SABKE DAM IRRIGATION PROJECT ON NIGERIAN AGRICULTURAL GROWTH SCHEME AGRO POCKETS (NAGs-AP) TO SMALLHOLDER WHEAT FARMERS OF KATSINA STATE.

Sani I. I.[1*], Ibrahim F. S.[2] & Hussaini M. A.[3]

[1&2]Department of Agricultural Economic and Extension, Faculty of Agriculture, Umaru Musa Yar'adua University, Katsina, Katsina State, Nigeria.
[3] Department of Crop Science, Faculty of Agriculture, Bayero University, Kano, Kano State, Nigeria.
[*]Corresponding Authors Email: ibrahim.saniibrahim@umyu.edu.ng

ABSTRACT
Wheat cultivation facilitated by irrigation farmers from the Sabke dam represent a significant shift in agricultural practices, potentially contributing to enhanced food security, economic prosperity and sustainable water resources management. The objective of the study are to: Determine the socio-economic characteristics of the wheat farmers, Examine the production quantity of wheat yield before and after the programme and find out the problems/Challenges faced by the wheat farmers in the study area. Multi-stage sampling techniques was use to arrive at sample size of eight hundred (800) wheat farmers. Data obtained through the aid of a structured questionnaire was analyzed using both descriptive (frequency count, percentage, mean and standard deviation) and inferential statistics (t-test analysis). The findings revealed that the majority of the respondents (77%) were married, and (99%) were males who engaged themselves in wheat production. The majority of the wheat farmers were influenced to practice wheat irrigation because the emphasized by technology-related factors, and membership associations. The t-test result shows that, there is significant differences in wheat yield after the programme than before at ($P < 0.001$) level of probability in the study area. Most of the constrains faced by the farmers were pest and diseases, inadequate water supply and lack of proper and standard agricultural extension personnel. It was concluded that water user's efficiency of the wheat irrigation farming should consider both the agricultural out food and conservation of water resources management in to the socio-economic changes within the farming communities.

Keywords: Irrigation Project, Effect, Sabke Dam, Small Holder, Wheat Farmers.

INTRODUCTION
Policymakers are showing a renewed interest in wheat cultivation, because they recognize Nigeria's capacity to produce enough wheat to feed itself (FAO, 2003). As important as wheat is, however, we are unable to pinpoint the precise amount grown in the nation, due to inconsistent data coming from various sources. A recent assessment was conducted to estimate Katsina States wheat production (NAGS,-AP 2023). Eighty thousand (80,000) hectares is the most recent official estimate of wheat acreage and it was made in 2008 since then, a lot has changed, and this study gave an assessment of Nigeria's wheat output as it is today. The wheat production survey was conducted across (6) LGA in Katsina State, which covered (Sandamu, Daura, Maiadua, Baure, Dutsi, and Zango) in 2023/2024 dry season farming by the NAGS-AP wheat production through the collaboration with Federal Ministry of Agriculture (NAGS-AP, 2023).

According to de San Celedonio et al., (2004), the purpose of this irrigation is to meet the needs of plants throughout crucial growth stages, such as crown root initiation, tilling, jointing and flowering. Application can be made every 12 to 18 days until the soft dough stage in arid areas where irrigation system provides water availability.

Twenty years after it was build, the federal Government of Katsina State commissioned the abandoned Sabke Dam to increase irrigation farming in the State. The project, which is situated in the states Maiadua Local Council, was constructed by the nowdefuct Petroleum Special Trust Fund (PTF, 1998).

Problem of Statement
Nigerians economy heavily depends on the agricultural sector, which has enormous potential to reduce poverty, increase job opportunities and ensure food security (FOA, 2003). Wheat has undoubtedly grown to be one of the most significant agricultural products in Nigeria. Over the last few decades, wheat in Nigeria has declined to be a minor crop with an a yearly output of roughly 50,000 MT, in contrast to rising imports that come with an approximate annual cost of N635 billion. The nation average wheat grain output is roughly 2.0 tons per hectare, but research indicates that this can easily triple with the right cultivars and crop management practices. Therefore, the primary source

of foreign exchange earnings, employment and revenue during the 1960s was from agricultural industries in Nigeria.

According to Azih, (2011), wheat requires an average 350-600 mm of water to reach physiological maturity and its potential yield. In many places, their needs are met by the winters rains. While reaching the overall amount of water required is critical distributing that effectively is just as crucial for excellent yield. It is advice to water crops four to six times during the growing season in regions with insufficient rainfall, particularly when cultivators employ winter wheat varieties with high yield. Its in view of these, this research is to find the effect of Sabke Dam Irrigation Project on (NAGs-AP) to Small Holders Farmers of Katsina State.

Objective of the Study

The broad objective is to determine the effect of Sabke Dam Irrigation Project on (NAGs-AP) to Small Holders Farmers of Katsina State. The specific objectives are to.

a. Determine the socio-economic characteristics of the wheat farmers.
b. Examine the production quantity of wheat yield before and after the programme.
c. Find out the problems/Challenges faced by the wheat irrigation farmers in the study area.

Hypothesis

There's no significant relationship between farmers wheat yield before and after the programme in the study area.

METHODOLOGY

This study was carried out under Daura Sabke Dam Iriigation Project, Katsina State. The Sabke Dam Daura is one of the abandoned irrigation projects under Katsina State. It covers a geographical location of 2400M accuracy. It has the latitude of N 12^0 59 41 and longitude of E 7^0 36 42. The maximum and minimum temperature of the area 38^0C and 16^0C with an average temperature of 27^0C. The maximum and minimum rainfall of the project area is 900 and 500mm with the average rainfall 700mm.

The dry season area is hot and dry with the Harmatern period between Decembers to March. Most of the crops cultivated in the irrigation area include, Wheat, Rice and Cowpea etc.

Sampling Procedure and Sampling Size

It was realized that Zone II of Katsina state possessed the highest number of wheat irrigation farmers in the zone. Based on the survey, Multi-stage sampling techniques was used to arrive at sample size of the study. National Agricultural Growth Scheme Agro-Pocket (NAGs-AP) has six selected Local Government Areas in the zone, which includes; (Daura, Zango, Baure, Sandamu, Dutsi and Maiadua) and a sample frame of 800 farmers was obtained from the selected villages in the LGAs. It is based on this premise that; multistage sampling technique was used to arrive at the sample size of the study.

In the first stage, Zone II of Katsina state was purposively selected for this study due to the large number of wheat farmers in the zone. In the second stage, purposive selection of six Local Government Areas (Daura, Zango, Baure, Sandamu, Dutsi and Maiadua) was applied to obtain the LGAs out of all the Local Government Areas in Katsina state Zone II due to the high concentration of wheat farmers in the area. The third stage involved random selection of 133.3 farmers from the selected LGAs, thus the sample size of the study constituted 800 wheat farmers.

Data Collection and Analysis

The data for the study were obtained from primary sources.While secondary data was obtained from textbooks, journals, and books of p roceedings, primary data was directly gathered from wheat farmers using a standardized questionnaire. Both descriptive (frequency count, percentage, mean, and standard deviation) and inferential (t-test analysis) statistics were used to examine the data t hat were obtained.

T-test

This type of t-test is also referred to as related group, matched groups, dependent sample or correlated sample. It can be applied when respondents or farmers has two scores or comparison.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1}{n_1} + \frac{s_2}{n_2}}}$$

Where;

t= calculated t- value

$\bar{x}_1$= mean value of wheat farmers yields before wheat irrigation

$\bar{x}_2$= mean value of wheat farmers yields after irrigation farming

s_1 = standard deviation of wheat farmers yield before the irrigation farming

s_2= standard deviation of wheat farmers yield after irrigation farming

n_1= sample size of farmers before wheat irrigation

n_2= sample size of farmers after wheat irrigation

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Respondents

This is a concept that describes both the economic and social factors that have important influence on social change and overall improvement of socio-economic status of individual farmers.

Table 1: Distribution of the Respondents Based on Socio-economic Characteristic (n=800)

Sex	**Frequency**	**Percentage**
Male	792	99
Female	8	1.0
Marital Status		
Married	616	77.0
Single	174	21.8
Widowed	10	1.2
Farm Size (ha)		
1 – 2	720	90
3 – 4	62	7.8
5 hectare and above	18	2.2

Source: *Survey*, 2023.

Table 2: Distribution of Respondents According to their Quantity of Yield Before and After the programme (n=800)

Yield (kg)	Mean	S.D	S. E	D.F	P-value	Yield Before	84.26	55.25	4.658
Yield After	136.8	89.87	6.992	767.5	0.000***				
Differences	52.53	35.62							

Source: *Survey, 2023* Significant level = 0.001%

Hypotheses: There's no significant relationship between farmers wheat yield before and after the programme in the study area.

The t-test analysis result presented in Table 2 above shows that there is significant differences in wheat yield after the programme than before at ($P < 0.001$) level of probability in the study area. Therefore, it was concluded that wheat yield had significant influence on wheat irrigation farmers. Hence, null hypothesis is rejected.

Table 3: Distribution based on the Constraints Faced by Respondents (n= 800)

Constraints	**Frequency**	**Percentage**	**Mean**	**Rank**
Pest and Diseases	428	53.5	6.576	1st
Inadequate Water Supply	426	53.2	6.532	2nd
Climate Change	53	6.6	0.811	4th
Lack of Extension Personnel's	188	23.5	2.888	3rd
Insufficient Farm Size	11	1.4	0.166	5th

Source: *Survey*, 2023 *** 1,106** * Multiple Response

Result presented in Table 3 revealed that 53.5% of the respondents faced constraints of pest and diseases, 53.2% of the respondents faced a problem of inadequate water supply and 23.5% of the respondents had a problem of lack of agricultural extension personnel. This study revealed that, Pest and diseases had the highest mean and were ranked first, indicating that, it's the most pressing constraint faced by respondents in the study area fallowed by inadequate water supply and lack of agricultural extension workers. It was reported by Pawa (2010), that the notable constraints faced by rice farmers in the field in Nigeria are weed infestation, disease influence, floods, lack of credit facilities, climate change, water scarcity and temperature.

CONCLUSION AND RECOMMENDATION

Based on the findings of this study, it is concluded that majority of the respondents were males and married and most of them practice smallholder farming. Based on the findings, it was concluded that there is significant differences in wheats yield after the programme than before at ($P < 0.001$) level of probability in the study area. It's concluded that the constraints faced by the wheat irrigation farmers in the study area were pest and diseases, inadequate water supply and lack of standard agricultural extension personnel's.

Katsina state government shall provide with good agricultural extension workers so as to help the wheat and cereals irrigation farmers toward practicing their farming irrigation in their areas. Also, well enough water should be supply to the irrigation farmers for better yield growth in the state.

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EFFECT OF OSMOPRIMING ON THE PHYSIOLOGICAL QUALITY OF RICE (*Oryza sativa* L.) SEEDS

[1]Badmus, Z.O*., [2]Kehinde, T.O., [3]Ayodeji, O.A., [4] Okunlola, P.O., [5]Olanrewaju, B.O. & [6]Sanyaolu, M. O

[1]Department of Plant Breeding and Seed Technology, FUNAAB.
[2]Department of Plant Breeding and Seed Technology, FUNAAB.
[3]Department of Plant Breeding and Seed Technology, FUNAAB.
[4]Department of Plant Breeding and Seed Technology, FUNAAB.
[5]Ekiti State University, Ado-Ekiti, Nigeria (EKSU).
[6]Department of Agri-food Economics and Trade, Poznan University of Life Sciences, Poland.

ABSTRACT

Poor germination, especially under dry-seed broadcasting conditions, poses a common issue for Nigerian rice growers. This study investigated the effect of osmo-priming using $CaCl_2$ on the physiological qualities (germination percentage and seedling vigor) of rice seeds sourced from various locations in North and Southwest Nigeria for 0 (control), 12 (T1) and 24 hours (T2) using Analysis of Variance (ANOVA) with SAS (version 9.0). Means were separated using Tukey's Studentized Range (HSD) Test at 5% probability level. Significant variability in germination percentage and seedling vigor index were observed, correlating with priming duration. Seed source significantly influenced all measured traits, reflecting both genetic and environmental impacts on seed quality and response to priming. Seeds from Keffi and Kaduna South exhibited high germination percentage and vigor (87.11%, 92.44% and 5.24, 4.39 respectively), whereas Suleja and Ogun Waterside seeds failed to germinate under any condition (0.00, 0.00 and 0.01, 0.00 respectively). This variability showed the absence of a universally optimal priming duration, with performance varying significantly by origin. While osmo-priming shows potential to improve germination and growth by enhancing metabolic activity, stress resistance, and seedling vigor, its efficacy heavily depends on seed source. Thus, considering seed origin is crucial when applying pre-sowing treatments like osmo-priming to enhance seed.

Keywords: Seed invigoration, pre-sowing treatment, osmo-priming, seedling establishment, seed quality.

INTRODUCTION

Rice (*Oryza sativa* L.) is an important cereal crop and a staple food for more than half of the world's population (Wani *et al*., 2012). Rice said to have debatably originated from Asia is wildly cultivated in almost all parts of the world. Globally, the top three rice producing country are China, India, and Indonesia accounting for an average of 148.277 million tonnes, 120.544 million tonnes and 30.960 million tonnes respectively, this ranking also goes for the top three consumers of rice.

There are numerous varieties of rice that are cultivated in Nigeria and they include the indigenous red grain species (Oryza glaberrina), fadama rice, upland rice, and lowland rice. The process involved in rice cultivation depends on the geographical and ecological factors of the locality. Rice requires a fertile soil with a moderately high water holding capacity. Heavy soils characteristic of river valleys and fadamas are suitable soil, but lands having clayey soils are considered most desirable (Oko *et al*., 2012).

Seed priming is a pre-sowing treatment that typically involves hydrating the seeds to allow metabolic processes to begin, but stopping short of allowing them to actually germinate. Seed priming has emerged as an effective approach for increasing seed vigour and germination synchronization, as well as, seedling growth and high field establishment under adverse environmental conditions. The beneficial effects of seed priming have been attributed to pre-enlargement of the embryo and biochemical changes such as enzyme activation (Farooq *et al*., 2006) and improvement of germination rate particularly in old seeds.

By using calcium chloride, a specific type of osmotic agent, seeds undergo a regulated imbibition process, which prevents the seeds from absorbing enough water for radicle protrusion, thus suspending the seeds in the lag phase (Taylor *et al*., 1998). Osmo-priming with calcium chloride is particularly beneficial in agriculture, as it promotes early, uniform germination and stronger plant growth, leading to improved crop yields and quality, and it is effective in stress resistance management. Seed priming has been commonly used to reduce the time between seed sowing and seedling emergence and to synchronize emergence. On the other hand, good seedling establishment increases competition against weeds, increases tolerance to

drought periods, increases yields and avoid the time-consuming need for re-sowing which is not economical.

f high-quality is a critical input in crop production, which determines the productivity and farmer's success. Seed quality is a sum total of many aspects, including genetic, physical, physiological, and health quality. Empirical evidence has shown that use of quality certified seed increases crop yields.

Since rice is the most commonly cultivated cereal crop in Nigeria among commercial farmers, there is need for proper seed test in the laboratory before embarking on a large-scale planting on the field as rice growers often face problem of poor germination, especially under dry-seed broadcasting conditions. Different varieties of rice in Nigeria gives rise to different seed physiological trait which their germinations maybe dependent on the geographical and ecological factors of their localities. Report has shown that seed priming treatment such as osmo-priming can lead to better germination and establishment in many crops such as maize, wheat, rice, and canola. The study therefore becomes imperative. The objective of this study aimed to determine the effect of osmo-priming using $CaCl_2$ on the germination percentage and seedling vigour of rice seeds.

MATERIALS AND METHODS

The research was conducted at the Department of Plant Breeding and Seed Technology's laboratory, College of Plant Science and Crop Production, Federal University of Agriculture, Abeokuta (FUNAAB), Nigeria. Rice seeds were sourced from seven states in Nigeria, including Adamawa, Kaduna, Kwara, Nasarawa, Niger, Ogun, and Oyo, with multiple local governments represented. Samples were obtained from local farmers, seed companies, and markets. The seeds underwent priming in 3% $CaCl_2$ solution for 12 hours (T1) and 24 hours (T2), followed by 12 hours of air-drying. A control group (T0) received no priming. Primed seeds were sown on germination paper, watered, and placed in a growth chamber at a temperature of 25 ± 2°C. The experiment utilized a Completely Randomized Design (CRD) with three replicates for each treatment (T1, T2, and T0). Data

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Sourcing seeds o

on germination percentage, seedling vigour index, seedling length, fresh weight were collected and analyzed using SAS (version 9.0). Mean comparisons were conducted using Tukey's Studentized Range (HSD) Test at a 5% probability level.

RESULTS AND DISCUSSION

Table 1 provides the mean square values of physiological traits evaluated in rice varieties after osmo-priming showing the significant differences in germination percentage and seedling vigour index due to priming duration and seed source, with highly significant interactions between priming hours and seed source for both traits. Table 2.0 displayed the mean performance of seed across different seed sources, with Keffi exhibiting the highest germination rate and seedling index vigour index of 87.11 and 5.24 respectively. Table 3.0 demonstrated the interactive effect of seed source and priming hour on germination percentage, with Kaduna South 94.00 (0 hour), 75.00 (12 hours), 91.67 (24 hours) and Keffi with 94.67 (0 hour), 75.00 (12 hours), 24 hours (91.67), consistently exhibiting high germination rates across all the priming hours. Table 4.0 depicted the interactive effects of seed source and priming hour on vigour index, highlighting variations among sources and priming durations.

Overall, the study found significant variability in germination percentage and seedling vigour index among rice seeds from different sources subjected to osmo-priming with $CaCl_2$. While seeds from locations like Keffi and Kaduna South exhibited high germination rates and vigour, those from Suleja, Obafemi Owode, and Ogun Waterside showed poor responses to priming. The results underscored the influence of genetic and environmental factors on seed quality and physiological responses to priming treatments. Moreover, the study highlights the importance of considering seed source and priming duration for effective osmo-priming strategies in rice cultivation, as certain seeds may not respond uniformly to priming treatments

Table 1. Mean Square Values of Physiological Traits Evaluated in Rice Varieties After Osmo-Priming.

SOV	DOF	G %	SVI
Priming Duration (P)	2	5463.10*	10.69
Seed source (S)	13	9114.78**	34.05**
P×S	41	3532.52**	14.33**
Error	84	93.17	2.07

*Significant at 5% (0.05) probability level ** Highly significant at 1% (0.01) probability level. PD- Priming Duration.

Table 2.0. Mean Performance of Seed Quality Traits on Rice Seeds After Osmo-Priming

Seed Source	G %	SVI
Keffi	87.11a	5.24a
Kaduna South	92.44a	4.39abc
Irewole	65.67ab	4.16a-d
Ede North	65.78ab	4.81ab
Offa	45.89bc	1.86cde
Girei	35.78c	1.60de
Ganye	25.22cd	1.27e
Akwanga	25.78cd	0.39e
Kotangora	39.11bc	2.10b-e
Kaduna North	13.89cd	0.66e
Oke Ero	2.22d	0.14e
Suleja	0.00d	0.01e
Obafemi	0.22d	0.00e
Waterside	0.00d	0.00e

Means with the same alphab*et al*ong column are not significantly different from one another at 5% probability level according to Tukey's Studentized Range (HSD) Test. G%: Germination Percentage, SVI: Seedling Vigour Index.

Table 3.0. Interactive Effect of Seed Source and Priming Duration on Germination Percentage

	Priming Duration (Hours)		
Source	0	12	24
Keffi	94.67a	75.00a-d	91.67ab
Kaduna South	94.00a	91.67ab	91.67ab
Irewole	72.00a-d	68.33a-d	56.57cde
Ede North	87.33abc	50.00def	60.00b-e
Offa	49.33def	35.00efg	53.33def
Girei	50.67def	33.33e-h	23.33f-i
Ganye	70.67a-d	3.33ghi	1.67hi
Akwanga	60.77b-e	8.33ghi	8.33ghi
Kotangora	54.00def	30.00e-i	33.33e-h
Kaduna North	54.67def	3.33ghi	1.67hi
Oke ero	0.00i	0.00i	6.67ghi
Suleja	0.67i	0.00i	0.00i
Obafemi	0.00i	0.00i	0.00i
Waterside	0.00i	0.00i	0.00i

Means with the same alphab*et al*ong column are not significantly different from one another at 5% probability level according to Tukey's Studentized Range (HSD) Tes

Table 4.0: Interactive Effect of Seed Source and Priming Duration on Seedling Vigor Index (SVI).

	Priming Duration (Hours)		
Source	0	12	24
Keffi	7.91a	3.59a-e	4.23a-e
Kaduna South	3.53a-e	3.73a-e	5.92abc
Irewole	2.01b-e	4.15a-e	6.3ab
Ede North	7.18a	2.06b-e	5.18a-d
Offa	1.84b-e	1.56b-e	2.17b-e
Girei	1.72b-e	1.70b-e	1.29cde
Ganye	3.45a-e	0.26e	0.08e
Akwanga	0.48de	0.31e	0.39e
Kotangora	3.21a-e	1.43cde	1.67b-e
Kaduna North	1.71b-e	0.13e	0.13e
Oke ero	0.00e	0.00e	0.43de
Suleja	0.33e	0.00e	0.00e
Obafemi	0.00e	0.00e	0.00e
Waterside	0.00e	0.00e	0.00e

Means with the same alphab*et al*ong column are not significantly different from one another at 5% probability level according to Tukey's Studentized Range (HSD) test .

CONCLUSION AND RECOMMENDATION

Priming significantly impacted the seed quality of rice seeds, with Kaduna South seeds showing significant germination percentage improvements. Keffi seeds exhibited superior seedling vigour. To enhance germination and vigour, priming is crucial for rice seeds. Further research using different osmo-priming materials and durations is advisable. Additionally, sourcing seeds from reputable outlets is recommended to ensure optimal physiological quality.

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RESPONSE OF AMARANTH (*Amaranthus cruentus* L.*)* TO FOLIAR AND SOIL APPLICATION OF LIQUID NPK FERTILIZER IN SUDAN SAVANNAH, NIGERIA

Hussaini, M.A., *Shittu, E.A., & Bature, M.A
Department of Agronomy, Bayero University P.M.B 3011, Kano, Nigeria
*Corresponding author's email; seabaraham.agr@buk.edu.ng

ABSTRACT
Plants can receive vital nutrients more easily and effectively from water-soluble fertilizers, which may also improve plant growth, production, and resource efficiency. This study examined the effects of various liquid fertilizer application rates on the growth and leaf yield of Amaranth. The treatments consisted of ten liquid fertilizer levels, applied in two ways: foliar application (0.5, 1.0, 1.5, and 2.0 g/L) and soil application (0.5, 1.0, 1.5, and 2.0 g/L) as well as a control group (no fertilizer and NPK). The experiment was set up using a completely randomized design (CRD) with three replications. Findings revealed that liquid fertilizer application significantly ($p < 0.001$) enhanced plant height (54.0-62.6 cm) and chlorophyll content (34-40.1). Compared to the control and NPK groups, the application of liquid fertilizer often significantly ($p <0.001$) increased the fresh (46.0, 46.4 and 43.7 g) and dry weight (12.2, 12.8 and 12.3 g) of all plant sections (stem, root, and leaf, respectively), especially at higher concentrations (1.5 to 2.0 g/L). This implies that amaranth can benefit greatly from the use of liquid fertilizer as a strategy to increase overall biomass production. The observed variations in growth parameter responses highlight the need for site-specific trials and optimization of application rates, timings, and methods. Further research should explore potential synergies with other nutrient sources or agricultural practices, investigate impacts on nutritional quality and bioactive compounds in amaranth.
Keywords: Amaranth, foliar, soil, liquid fertilizer, growth characters

INTRODUCTION
Amaranth (Am*aranthus spp*.) is an ancient crop that has regained interest due to its high nutritional value and adaptability to various environmental conditions (Rastogi and Shukla, 2013). Adding to the challenges, even chemical fertilizers are hard to find and too costly for these farmers, who rely on amaranth as a food source (Hochmuth *et al.*, 2018; Stewart, 2024). This implies that repeated planting without replenishing nutrients in the soil poses another challenge. This ignorance is a result of the scarce resources in these rural regions of the savannas of southern to northern Guinea and the Sudan, where farmers face challenges related to deteriorating soil quality and a lack of organic fertilizer, which is necessary for crops to grow healthily. Amaranth is a demanding crop, requiring a high amount of minerals to grow well. It is therefore crucial to explore alternative ways to provide the nutrients it needs. Unfortunately, many farmers cannot afford or access fertilizers or manure for their amaranth crops. This lack of nutrient replenishment leads to consistently low yields due to depleted soil. Ultimately, this translates to lower profits for the farmers.

Soil application of fertilizer is the traditional method where liquid fertilizer is directly added to the soil around the plant's roots. Studies have shown it can significantly boost amaranth's growth and yield (Rashid *et al*., 2020; Ullah *et al.*, 2021). On the other hand, foliar application is a newer approach where fertilizer is sprayed directly onto the leaves. This method acts as a supplement to the nutrients in the soil and can address any deficiencies the plant might have (Atiqah *et al*., 2019; Sánchez-Nieba *et al*., 2021). Studies have shown that amaranth's response to liquid fertilizers depends on environmental conditions, soil characteristics, and crop management practices (Ullah *et al.*, 2021; Moyo *et al.*, 2022). However, the effectiveness of foliar and soil-applied fertilizer can vary based on factors like timing, concentration, and fertilizer source (Moyo *et al.*, 2021; Solanki *et al.*, 2022). Therefore, this study aimed to investigate the response of *Amaranthus cruentus* to different levels of inorganic liquid fertilizer applications applied in two different forms.

MATERIALS AND METHODS
The study was conducted at the Faculty of Agriculture Phase III Bayero University Kano, located in the Sudan Savanna Agro-ecological Zone of Nigeria (Latitude 11°58.814' N; Longitude 8°25.463' E, with an altitude of 476 m above sea level). The area is characterized by a monomodal rainfall pattern with a mean annual rainfall of 657 mm and a daily range of 15–34 °C (Sowunmi and Akintola, 2010). The soil of the experimental site is very well drained, with sandy loam on the

surface and loamy sand on the subsurface (Samndi *et al.,* 2014). The treatments consisted of ten liquid fertilizer levels, applied in two ways: foliar application (0.5, 1.0, 1.5, and 2.0 g/L) and soil application (0.5, 1.0, 1.5, and 2.0 g/L) as well as a control group (no fertilizer and NPK). The experiment was set up using a completely randomized design (CRD) with three replications. In total, thirty pots were used in the experiment. Approximately 10 kg of a uniform topsoil mixture were contained in each pot. The liquid fertilizer is composed of the following macro nutrients N + P_2O_5 + K_2O = 60% in a balanced proportion of 20% each, and micro nutrients Fe + Mn + Zn + B in the proportion of 0.1, 0.1, 0.2 and 0.05%, respectively. The experiment utilized Tuwaris, a local amaranth variety with a broad, lance-shaped leaf and dense cluster of red to purple flowers, and edible, nutty-flavored seeds, which thrive in various climates and soil types.

Cultural Practices

Soil preparation, sowing and irrigation

River sand, top soil, and cow dung were mixed together and used for the experiment at a ratio of 3:3:1, respectively. The filled pots were watered 24 hours prior to planting. The *A. cruentus* seeds were sown using the broadcasting method and later thinned to two stands per pot. Regular watering was done every morning and evening. Sowing was done on September 19, 2023. Weeds were removed manually by hand-picking any undesirable plants found within the boundaries of the pots. A treatment-based application of Growbett Water Soluble Fertilizer 20-20-20+TE was made to the crop. The foliar and soil applications were done repeatedly on a weekly basis from 2 WAS to 7 WAS.

Data Collection and Data Analysis

Data were collected on the different pots subjected to levels of fertilizer applications in the experimental treatments. The data collected comprised plant height, number of leaves, number of branches, leaf area, chlorophyll content, stem girth, and fresh and dry weight of the plant. The data collected were subjected to Analysis of Variance (ANOVA) using the Statistical Analysis System (SAS) software. Significant treatment means were compared using Student-Newman-Keuls (SNK) at a 5% probability level.

RESULTS AND DISCUSSION

Table 1 presents the physical and chemical properties of the soil used for the experiment. The results indicate that the soil has a relatively high sand content (66.12%), moderate amounts of clay (23.31%), and a low silt content (10.58%). This classifies it as a sandy loam texture according to the USDA textural triangle. Sandy loam soils generally have good drainage and aeration but may have a lower water holding capacity compared to soils with a higher clay content (Brady & Weil, 2020). The soil has a pH of 5.94, which is slightly acidic. This falls within the range suitable for most plant growth, but some crops may benefit from lime application to raise the pH slightly (Havlin *et al*., 2014). The values for organic carbon (0.74%) and total nitrogen (0.05%) indicate a moderate level of organic matter content in the soil. Organic matter is crucial for soil fertility, nutrient retention, and structure (Mandal *et al.,* 2016). Practices that promote organic matter accumulation, such as composting and cover cropping, could be beneficial for this soil. The available phosphorus (7.86 mg kg^{-1}) value suggests a low level of readily available phosphorus for plants. Phosphorus fertilization strategies may be needed depending on specific crop requirements (Havlin *et al*., 2014). The micronutrients in soil are comprised of iron (Fe) content (170.4 mg kg^{-1}) which is relatively high, and common in many soils. Similarly, the manganese (Mn) and copper (Cu) levels (25.59 mg kg^{-1} and 2.96 mg kg^{-1}, respectively) are within expected ranges for most soils. Furthermore, the exchangeable bases revealed that the calcium (Ca) and magnesium (Mg) content is moderate (2.03 cmol kg^{-1}) and low (0.51 mg kg^{-1}). A moderate level of Ca is essential for plant nutrition. The low magnesium (Mg) content is potentially requiring magnesium supplementation for certain crops. Potassium (K) content (0.40 mg kg^{-1}) is also low, suggesting potential limitations for crops with high potassium requirements. The sodium and exchangeable aluminum (EA) contents are very low (0.06 mg kg^{-1} and 0.02 mg kg^{-1}) and unlikely to pose problems for most plants. The effective cation exchange capacity (ECEC) value of 3.01 (cmol kg^{-1}) indicates the soil's capacity to hold positively charged nutrients (cations) for plant uptake. A moderate ECEC suggests the soil has some ability to retain essential plant nutrients.

The effect of liquid fertilizer on some growth characters of vegetable amaranth is shown in Table 2. Results shows that liquid fertilizer application significantly ($p<0.001$) increased plant height compared to the control. There were no significant differences in plant height between fertilizer application methods (foliar and soil). Generally, all fertilized groups had taller plants compared to the NPK group, suggesting the liquid fertilizer may be more effective in promoting plant height growth than the standard NPK fertilizer. This finding is in

agreement with those of v Rashid *et al*. (2020) and Ullah *et al.* (2021), who reported an increase in the growth and yield of amaranth owing to liquid fertilization. The number of leaves per plant, number of branches, and leaf area per plant were not significantly ($p > 0.05$) affected by the fertilizer treatments. However, the chlorophyll content showed a marginally Significant difference ($p < 0.05$) among treatments, where the 0.5 g/L soil application and the NPK group had the highest chlorophyll content, while the control group had the lowest. These findings suggest that liquid fertilizer application, particularly at lower concentrations, could be a beneficial strategy for enhancing vegetable amaranth growth during dry seasons. This also corroborates the observations of Sánchez-Nieba *et al*. (2021) and is likely attributed to the presence of plant growth regulators and beneficial compounds in liquid organic fertilizers and seaweed extracts (Atiqah *et al*., 2020; Sánchez-Nieba *et al.,* 2022). Table 3 presents the effect of liquid fertilizer on some yield characteristics (plant biomass) of amaranth. Results indicated that both fresh and dry stem weight significantly ($p < 0.001$) increased with increasing fertilizer concentrations for both foliar and soil application methods. All liquid fertilizer treatments exhibited higher stem weight compared to the control and NPK groups, suggesting a positive effect on stem growth. Similarly, fresh and dry root weight showed a significant ($p < 0.001$) increase with increasing fertilizer concentration for both application methods. All fertilized groups had greater root weight, although at par with the 0.5 g/L soil application compared to the control and NPK groups, indicating improved root development with fertilizer use. Similar to the reported stem and root weights, the fresh and dry leaf weights showed a significant ($p < 0.001$) response to fertilizer application. Compared to the control and NPK groups, the application of liquid fertilizer often greatly increased the fresh and dry weight of all plant sections (stem, root, and leaf), especially at higher concentrations (1.5 to 2.0 g/L). This implies that amaranth can benefit greatly from the use of liquid fertilizer as a strategy to increase biomass production overall. This result supports the findings of Patel *et al*. (2018) and Paudel *et al*. (2020), who examined the effects of granular and liquid fertilizers on amaranth growth and nutrient uptake and found that the liquid outperformed the granular fertilizer.

CONCLUSION

The study revealed that liquid fertilizer application significantly ($p < 0.001$) enhanced plant height, chlorophyll content, and fresh and dry weights of roots, stems, and leaves. Compared to the control and NPK groups, the application of liquid fertilizer often significantly ($p < 0.001$) increased the fresh and dry weight of all plant sections (stem, root, and leaf), especially at higher concentrations (1.5 to 2.0 g/L). This implies that amaranth can benefit greatly from the use of liquid fertilizer as a strategy to increase overall biomass production. The observed variations in growth parameter responses highlight the need for site-specific trials and optimization of application rates, timings, and methods. Further research should explore potential synergies with other nutrient sources or agricultural practices, investigate impacts on nutritional quality and bioactive compounds in amaranth.

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Table 1. Physical and Chemical Properties of Soil (0-30 cm) Depth of the Experimental Site

Parameter	Value
Physical properties	
Sand (%)	66.12
Silt (%)	10.58
Clay (%)	23.31
Chemical properties	
pH (1:1)	5.94
Organic Carbon (%)	0.74
Total N (%)	0.05
Available P (mg kg^{-1})	7.86
Fe (mg kg^{-1})	170.40
Mn (mg kg^{-1})	25.59
Cu (mg kg^{-1})	2.96
Exchangeable bases	
Ca (cmol kg^{-1})	2.03
Mg (mg kg^{-1})	0.51
K (mg kg^{-1})	0.40
Na (mg kg^{-1})	0.06
EA (mg kg^{-1})	0.02
ECEC (mg kg^{-1})	3.01

Table 2: Effect of Liquid fertilizer on Plant height, Number of leaves per plant, Number of branches, Leaf area per plant and Chlorophyll content of Vegetable Amaranth grown during 2023 dry season at BUK

Treatment	Plant height (cm)	Number of leaves per plant	Number of branches per plant	Leaf area (cm^2)	Chlorophyll content (SPAD)
Liquid Fertilizer (g/l)					
Foliar application					
0.5	60.5a	31.0	12.3	32.9	35.9ab
1.0	54.0a	30.3	14.0	33.6	38.1a
1.5	56.6a	29.7	11.3	32.9	34.1ab
2.0	62.6a	29.3	13.0	33.8	39.1ab
Soil application					
0.5	60.5a	31.3	13.7	36.9	40.1a
1.0	56.1a	28.7	11.3	32.2	40.1a
1.5	61.4a	29.3	12.0	34.3	38.9a
2.0	58.5a	30.7	12.7	34.9	35.9ab
NPK	55.8a	30.0	27.6	34.5	38.2a
Control (Zero fertilizer)	48.6b	27.0	10.7	30.4	29.6b
Mean	57.48	29.73	13.86	33.65	37.01
P-value	0.001	0.1055	0.2810	0.599	1.850
Level of significance	**	NS	NS	NS	*
SE±	1.774	1.024	0.783	1.891	1.850

Means connected by the same alphabet (s) in a column are not significantly different at 5% probability level according to Students Newman Keuls (SNK) Test. **= significant at 1%, *=significant at 5%, NS= Not significant

Table 3: Effect of Liquid fertilizer on Fresh stem weight, Dry stem weight, Fresh root weight, Dry root weight, Fresh leaf weight and Dry leaf weight of Amaranth grown during 2023 dry season at BUK

Treatment	Fresh stem weight (g)	Dry stem weight (g)	Fresh root weight (g)	Dry root weight (g)	Fresh leaf weight (g)	Dry leaf weight (g)
Liquid Fertilizer (g/l)						
Foliar application						
0.5	38.8ab	9.9a	41.5ab	11.0ab	37.8a	10.2ab
1.0	40.9ab	10.7a	42.3ab	11.2ab	39.5a	10.2ab
1.5	43.6ab	12.2a	45.1ab	12.6a	42.2a	11.6a
2.0	44.3a	12.2a	46.4a	12.8a	43.7a	12.3a
Soil application						
0.5	35.1bc	8.6ab	36.9bc	9.5bc	34.2abc	8.7ab
1.0	39.8ab	10.3a	40.7ab	11.3ab	39.6a	10.5ab
1.5	39.3ab	10.1a	41.3ab	11.2ab	36.9ab	9.4ab
2.0	46.0a	11.6a	45.2ab	12.7a	43.3a	11.9a
NPK	30.6cd	6.9bc	33.3cd	7.8cd	29.9c	7.1c
Control (Zero fertilizer)	27.0d	5.4c	29.1d	6.6cd	27.c	5.8c
Mean	38.56	9.81	440.18	10.8	37.44	9.77
P-value	<0.001	0.001	<0.001	<0.001	0.0001	0.0002
Level of significance	**	**	**	**	**	**
SE±	1.948	0.792	1.879	0.671	1.961	0.772

Means connected by the same alphabet (s) in a column are not significantly different at 5% probability level according to Students Newman Keuls (SNK) Test. **= significant at 1%.

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PHYSIOLOGICAL GROWTH CHARACTERS, YIELD AND QUALITY RESPONSE OF CUCUMBER (*Cucumis sativus* L) AS IMPACTED BY MANURE TEA OF DIFFERENT SOURCES IN KANO, SUDAN SAVVANA ECOLOGY

***Shittu, E.A., Hussaini, M.A., & Garba, A**
Department of Agronomy, Bayero University P.M.B 3011, Kano, Nigeria
*Corresponding author's email; seabaraham.agr@buk.edu.ng

ABSTACT
Compost tea and horse manure tea are effective fertilizers for plant growth, providing essential nutrients and reducing environmental impact due to their low toxicity. Therefore, this study examined the impact of compost tea (CT) and horse manure tea (HMT) on cucumber growth, yield, and quality in both net house and open field environments. The experimental treatments comprised of tea sources (compost manure and horse manure) at four concentrations (0, 100, 125 and 150 ml/L**)** which were factorially combined and laid in a randomized complete block designed with four replications. Compost tea (CT) at 150 ml/L significantly ($p < 0.001$) improved dry matter content, leaf area index (LAI), fruit yield, crop growth rate (CGR), vitamin C content, and Brix value (sugar content) in the net house compared to the control. In the open field, CT at 150 ml/L primarily boosted fruit yield and vitamin C content. Horse manure tea application of 125 and 150 ml/L and 100-150 ml/L significantly ($p < 0.001$) increased fruit yield and vitamin C in both environments, but its influence on other parameters was minimal. Based on these findings, the application of 150 ml/L and 125 ml/L could be recommended for compost tea manure and horse tea manure, respectively. These findings suggest CT as a valuable tool for promoting cucumber growth, yield, and quality, particularly in controlled settings.
Key words: Crop growth rate, dry matter, Compost tea, horse manure tea, Vitamin C, Brix

INTRODUCTION
Balancing food security with environmental and socioeconomic sustainability is a pressing issue. We need to find ways to produce enough healthy food for a growing population without harming the environment or creating social and economic inequalities (Basnet *et al.*, 2023). According to Krasilnikov *et al.* (2022), for agricultural soils to provide food, fiber, and energy, a balance of chemical nutrients, physical characteristics, and soil organisms must be maintained. In order to preserve soil health, sustainable practices are required as overuse of synthetic fertilizers can upset this equilibrium.

Although, synthetic fertilizers and monoculture farming initially seemed beneficial, their overuse has had negative consequences. The soil has become less healthy (degraded), environmental issues have arisen, and new diseases that live in the soil have emerged (Zhang, 2023). Reduced environmental harm and soil degradation can be achieved by sustainable agriculture practices such as crop rotation, permaculture, organic farming, urban farming, polyculture, natural pest control, and biodynamic agriculture (Sridha *et al.*, 2023). Organic farming eschews synthetic fertilizers, pesticides, and genetically modified organisms. Instead, it emphasizes composting, manure, and green waste as long-term soil health boosters that encourage soil bacteria, lower machinery use, and water conservation. Composting, a natural process using microorganisms to break down organic waste, is a valuable soil amendment for farms. It improves plant growth by providing nutrients and making them resistant to harsh conditions and diseases. Compost also traps harmful chemicals (Yao *et al.*, 2023).

Cucumber (*Cucumis sativum* L.) is one of the most important vegetable fruits in the Curbitaceae family (Khatiwad and Adhikari, 2020; Zhang *et al.*, 2021). According to Ndubuisi and Yduma (2021), Nigerian's cucumber fields yield less per hectare than the world average because of poor farming practices, changing weather patterns, pests, disease outbreaks, insufficient funding, difficult transportation, and a lack of available land. Similarly, Iwalewa and Amujoyegbe, (2019) stated that the production of cucumber suffers a setback due to the unavailability of inorganic fertilizer coupled with its high cost, which in turn facilitates inadequate application rates at the detriment of the crop plant. On the other hand, N either in organic or inorganic form is universally accepted as a key component to high yield in vegetable crop production (Timsina, 2018; Akanmu *et al.*, 2023). Therefore, N deficiency can reduce cucumber yield and its nutrition substantially (Iwalewa and Amujoyegbe, 2019).

The application of compost tea manure on vegetable crop production is very easy and simple, because it is environmentally friendly, less tedious/ laborious, very cheap compared to crude manure, even the rate of assimilation is very fast, and the occurrence of diseases, pest and pathogens was minimal since the compost tea is in liquid form (Ramírez-Gottfried *et al*., 2023). Hence, this research was carried out with the aim of determining the physiological growth characters, yield and quality response of cucumber as influenced by compost and horse manure teas.

MATERIALS AND METHODS

The experiment was conducted at two different locations; Open field (Latitude 11'98 N and Longitude 8'426 E) and net house (Latitude 11'98 N and Longitude 8'415 E) within the Centre for Dryland Agriculture (CDA) Training and Research farm located in the Sudan savannah ecological zone of Nigeria during 2020/2021 wet season. The experimental treatments comprised of two tea sources (compost manure and horse manure) at four concentrations (0, 100, 125 and 150 ml/L which were factorially combined and laid in a randomized complete block designed with 4 replications. The experimental plots consisted of 6 ridges by 5 m long. The gross plot size was (4.5 m × 5 m) =22 .5 m². The net plots were the 2 inner ridges (1.5 m × 4 m) = 6 m². There was an alley of 0.75 m between each plot and 1.0 m between replications for easy movement.

Manure Teas Preparation Procedure

The compost manure tea that was utilized in the trials was made by gathering 20 kg of compost, packing it tightly within a jute bag, and then submerging the bag inside a container. The mixture was then stirred twice daily after being added 20 liters of water. By adding 1 liter of dissolved molasses, the microbial activity was activated, and they continued for 3 days. Then, in accordance with the procedures outlined by Igham *et al*. (2013), manure tea was gathered and diluted in a 2:1 ratio (2: clean water and 1: concentrated manure tea). Following the collection of fresh horse droppings, the preparation and extraction of horse manure tea were conducted using a similar procedure.

Cultural Practices

By using a 50 cm space between plants in row^{-1}, the cucumber seeds were manually sowed at a depth of 2 cm at a rate of 2 seeds per hole, and afterwards thinned to one plant per stand. Further, at intervals of two weeks, the plots received applications of the compost tea and horse manure tea according to the treatment level. During the trials, timely pest and disease control was undertaken by employing appropriate manual, physical, and chemical methods for controlling weeds, insects, and diseases, respectively. When the fruit achieved physiological maturity, it was manually harvested by severing the ripe fruit from the vine with a sharp knife.

Data Collection and Data Analysis

Data were collected from five randomly tagged plants chosen from the net plot area. The features of the physiological growth characters such as Net assimilation rate (NAR), Relative growth rate (RGR), Crop growth rate (CGR) and dry matter content as described by Radford (1967), Watson (1956) and Williams (1946), respectively, as well as the quality traits of Vitamin C as described by Ramana *et al.* (2011) and Brix using the refractor meter (LED-RHB-32) and values recorded were determined. The collected data was subjected to an Analysis of Variance using GENSTAT 17th edition and significant treatment means were separated using the Student-Newman-Keuls test at 5% probability level

RESULTS AND DISCUSSION

The impact of compost and horse manure teas on the dry matter content and leaf area index of cucumbers grown in open fields and net houses is shown in Table 1. The application of compost tea was found to have a highly significant ($P < 0.001$) impact on the leaf area index and dry matter during the sample periods in both the open field and the net house. For plants treated with CT, there was a substantial ($p < 0.001$) increase in dry matter and LAI when compared to the control (no tea) at all treatment rates (0, 100, 125, and 150) in both sites. This implies that using CT encourages improved cucumber development. While dry matter was very significant ($p<0.001$) in both the open field and the net house, the application of HTM was significant on LAI at 4 WAS in the net house only. Applying 125 mL increase LAI significantly, but it was still comparable to other therapies. However, compared to other rates, the dry matter content increases significantly ($p<0.001$) at higher rates (125 and 150 mls). Findings generally show that because CT has a higher nutrient content than HMT, it is more effective at boosting crop development. This is consistent with the findings of three independent studies on the effectiveness of compost tea in promoting lung growth and

development: Eudixie and Martin (2019), Bali *et al.* (2021), and Pilla *et al.* (2023).

The result in Table 2 demonstrate that the application of CT had no significant ($p > 0.05$) effect on RGR in the nethouse and NAR in open field and nethouse conditions. However, a significant ($p<0.001$) effect was observed on CGR in both net house and open field settings, where the application of 150 ml/L gave higher CGR in both locations and RGR in the open field. The improved nutrient availability, greater soil microbial activity, or hormone stimulation brought on by CT application could all be responsible for the higher CGR. The results matched those of Moyo *et al.* (2022). Within the nethouse environment, HMT only had a significant effect on CGR. The best outcomes were observed at a rate of 100 ml/L, but this was comparable to other rates. This raises the possibility that, in contrast to CT, HMT's impact on cucumber development may depend more on circumstances.

Table 3 presents the impact of compost and horse manure teas on fruit yield and quality of cucumber at the net house and open field. The result shows that the application of compost tea was highly significant ($p <0.001$) on the above-mentioned characters. The application of 150 ml/L CT significantly resulted in a higher yield than other rates at both the net house and the open field. Similarly, the application of 100–150 ml/L of CT significantly ($p<0.001$) increased vitamin C content in both the net house and the open field compared to 0 ml/L, which resulted in a lower value. Furthermore, CT application significantly improved the Brix value (indicating higher sugar content) in the net house at all CT concentrations compared to the control. Although the application of 150 mL/L gave the highest value, A slight increase in Brix was observed in the open field with CT application, but it was statistically similar except for the control, which had the least Brix. However, compared to the control, which had the lowest value, the application of HMT significantly increased fruit production (t ha) in both locations, with the most notable benefit occurring at 125 ml/L concentration in the net house and at all concentrations in the open field. The application of HMT did not cause a significant difference ($p > 0.05$) in the vitamin C and Brix content in the net house and the vitamin C in the open field. In comparison to the 0 ml/L that produced a lower value in the open field, the application of 100–150 ml/L of HMT produced higher vitamin C levels.

Generally, CT and HMT applications resulted in a more pronounced positive effect on cucumber yield and quality in the net house compared to the open field. This could be due to the more controlled environment in the net house, with less fluctuation in temperature, humidity, and light, allowing plants to better utilize the nutrients and growth stimulants potentially present in the teas. The positive impact of compost tea on fruit yield aligns with the findings of Zhao *et al*. (2019), who reported an increase in the growth and yield of tomatoes due to the application of compost tea. Similarly, the potential link between compost tea application and increased vitamin C content in some crops is supported by the research of Li *et al*. (2020) and Zahid *et al*. (2022), who studied the quality and antioxidant potency of strawberries owing to fertilization levels and the period of application.

CONCLUSION

This study suggests that application of CT can be a valuable tool for promoting cucumber growth, yield, and quality, particularly in controlled environments like net houses. HMT also shows promise for enhancing fruit yield, although its effects are less pronounced than CT. Based on this finding, the application of 150 ml/L and 125 ml/L could be recommended for compost tea manure and horse tea manure respectively. By optimizing the use of CT and HMT and understanding their underlying mechanisms, growers can potentially improve cucumber production and quality while promoting sustainable agricultural practices.

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Table 1. Effect of Compost and Horse Manure Teas on Leaf Area Index and Dry matter content of Cucumber at the Net House and Open Field

Treatment	Net house			Open field		
	Leaf Area Index		Dry matter (g)	Leaf Area Index		Dry matter (g)
	4 WAS	6 WAS	6 WAS	4 WAS	6 WAS	6 WAS
Compost Tea (CT) [mls/L]						
0	1.37d	2.02c	6.13d	1.32c	1.92b	5.76d
100	1.96c	2.39b	6.99c	1.89b	2.39a	6.66c
125	2.08b	2.48ab	9.04b	1.95b	2.42a	8.74b
150	2.21a	2.57a	10.56a	2.13a	2.54a	10.11a
P-value	<.001	<.001	<.001	<.001	<.001	<.001
S.E ±	0.04	0.05	0.22	0.05	0.05	0.28
Horse Tea (HT) [mls/L]						
0	1.85b	2.31	7.33b	1.74	2.31	6.96b
100	1.86b	2.33	7.41b	1.91	2.36	7.20b
125	1.99a	2.39	9.12a	2.13	2.38	8.78a
150	1.91ab	2.39	8.86a	1.96	2.21	8.33a
P-value	0.040	0.714	<.001	0.097	0.078	<.001
S.E ±	0.04	0.05	0.22	0.05	0.05	0.28
Interaction						
CT × HT	<.001	<.001	<.001	<.001	<.001	<.001

Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK Test.

Table 2. Effect of Compost and Horse Manure Teas on Net Assimilation Rate, Relative Growth Rate and Crop Growth Rate of Cucumber at the Net House and Open Field

	Net House			Open Field		
Treatments	NAR	RGR	CGR	NAR	RGR	CGR
Compost Tea (CT) [mls/L]						
0	0.091	0.142	14.21c	0.047	0.053b	14.84c
100	0.081	0.106	22.57b	0.059	0.074b	21.42b
125	0.209	0.121	21.16b	0.059	0.073b	19.72b
150	0.170	0.094	36.38a	0.059	0.143a	35.34a
P-value	0.422	0.737	<.001	0.410	0.002	<.001
SE±	0.06	0.03	0.98	0.006	0.02	1.54
Horse Tea (HT) [mls/L]						
0	0.177	0.102	21.63b	0.053	0.076	20.87
100	0.179	0.136	26.18a	0.051	0.111	25.12
125	0.047	0.135	24.10ab	0.048	0.080	23.16
150	0.149	0.090	22.41b	0.054	0.076	22.17
P-value	0.417	0.673	0.010	0.919	0.383	0.058
SE±	0.06	0.03	0.98	0.006	0.02	1.54
Interaction						
CT × HT	0.902	0.374	<.001	0.287	0.082	0.003

Means followed by the same letter(s) are not significantly different at 5% level of probability.

Table 3: Effect of Compost and Horse Manure Teas on Fruit yield, Quality of Cucumber at the Net House and Open Field

	Net House			Open field		
Treatments	Fruit yield (t ha^{-1})	Vit. C	Brix	Fruit yield (t $ha^{-1)}$	Vit. C	Brix
Compost Tea (CT) [mls/L]						
0	1.60d	2.361b	1.7c	1.01c	2.332b	1.5c
100	4.50c	2.718a	2.0b	3.93b	2.543a	1.8b
125	6.07b	2.736a	2.2b	4.89b	2.516a	1.9ab
150	8.89a	2.817a	2.5a	7.82a	2.636a	2.1a
P-value	<.001	<.001	<.001	<.001	<.001	<.001
SE±	0.37	0.07	0.09	0.43	0.04	0.08
Horse Tea (HT) [mls/L]						
0	3.89c	2.499	2.0	3.08b	2.381b	1.8
100	4.14c	2.749	2.0	3.36b	2.561a	1.8
125	7.54a	2.712	2.2	6.03a	2.525a	1.8
150	5.49b	2.672	2.1	5.27a	2.636a	1.8
P-value	<.001	0.054	0.112	<.001	0.010	0.727
SE±	0.37	0.07	0.09	0.43	0.04	0.08
Interaction						
CT × HT	0.004	0.057	0.089	0.016	0.191	0.336

Means followed by the same letter are not significantly different at 5% level of probability.

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GENETIC POTENTIAL AND DIVERSITY IN BAMBARA GROUNDNUT (*Vigna subterranea* (L.) Verdc.) GENOTYPES BASED ON AGRONOMIC TRAIT

Okunlola, P. O.,* Oduwaye, O. A., Badmus, Z. O., Ayodeji, O. A. & Ogunnaiya, B.
Department of Plant Breeding and Seed Technology, Federal University of Agriculture, Abeokuta, Nigeria. (FUNAAB)
***Corresponding address:** okunlolapeter98@gmail.com

ABSTRACT
Bambara groundnut (*Vigna subterranea* (L.) Verdc.) is the third most significant food legume after groundnut (*Arachis hypogaea* L.) and cowpea (*Vigna unguiculata* (L). Walp.). Availability of diverse genotypes of the crop is important to its genetic development. Thirty genotypes of Bambara groundnut were evaluated at the Teaching and Research Farm of the Federal University of Agriculture Abeokuta, Ogun State, Nigeria. The study assessed genetic diversity among the genotypes for desirable yield related traits. Randomized complete block design in 3 replicates was used. Data collected on agronomic traits were subjected to analysis of variance and means were separated with Least Significant Difference. Significant ($p \leq 0.05$; 0.01) variation was observed for most of the traits measured including seed yield. CMRBG19-042B (207.47 g), CMRBG19-055B (191 g) and CMRBG19-043A (184.07 g) were among the genotypes selected for high yield. Multivariate analysis identified seven homogenous clusters that were largely separated by variation in seed yield and number of leaves. CMRBG19-027, CMRBG19-042B, CMRBG19-043A and CMRBG19-055B, all members of group VII were characterized as high yielding in terms of seed yield, 100-seed weight and number of leaves. Genetic diversity exists in the Bambara groundnut genotypes evaluated indicating prospects in the development of improved varieties through hybridization and selection.
Keywords: Bambara groundnut, divergence, nuts, seed yield, variation

INTRODUCTION
Bambara groundnut (*Vigna subterranea* (L.) Verdc.) is the third most significant food legume after groundnut (*Arachis hypogaea* L.) and cowpea (*Vigna unguiculata* (L) Walp.). It belongs to the Fabaceae family and the Faboideae subfamily (Ntundu *et al*., 2006). Bambara groundnut is a legume crop that does well in both Africa and Asia, and typically recognized as "women's crop" due to their much involvement in the cultivation and processing of the crop (Oyugi *et al*., 2015). Bambara groundnut is an underutilized pulse crop with underground pods. The common name is derived from a place called “Bambara” located in upper valley of Norrtheastern Nigeria and Northern Cameroon where it is said to have originated (Majola, 2021). There are two botanical varieties of Bambara groundnut viz; *Vigna subterranea* var. *spontanea* mainly consisting of the wild varieties and *Vigna subterranea* var. *subterranea* consisting of cultivated varieties.

The annual production of Bambara groundnut is estimated to be 0.2 MT from an area of 0.25 million hectares worldwide (Majola *et al.,* 2021). Sub – Saharan Africa is the largest producer of Bambara groundnut, while a small quantity is produced in the Southeast Asia (Thailand and Indonesia), the United States of America (USA), and Australia. West Africa is the main Bambara groundnut production region in Sub-Sahara Africa, where Burkina-Faso, Niger and Cameroon are the leading producers, contributing to 74% of global production (Majola *et al.,* 2021). As a rich-nutrient legume, Bambara nut is frequently referred to as a "complete balanced diet" due to its high nutrient content. Dried Bambara seeds are high in micronutrients including K (11.44 - 19.35 mg/100 g), Fe (4.9 - 48 mg/100 g), Na (2.9 - 12.0 mg/100 g) and Ca (95.8 - 99 mg/100 g), as well as carbohydrates (64.4%), protein (23.6%), fat (6.5%) and fiber (5.5%) (Lin *et al*., 2020; Paliwal *et al*., 2021).

The production of Bambara groundnut is limited due to lack of improved varieties, and there has been limited research efforts for the varietal improvement the crop (Anchirinah *et al*., 2001; Lacroix *et al*., 2003). Availability of plant resources with genetic potential for desirable traits related to yield is critical to any crop improvement programme. Furthermore, success in developing

improved crop varieties depends on the extent of genetic variability available in it. Higher genetic variability provides much choice for potential parents for improvement through hybridization. The objectives of this study were to identify Bambara groundnut genotypes with genetic potential for grain yield and assess their genetic diversity.

MATERIALS AND METHODS

The experiment was carried out at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta (FUNAAB). Thirty genotypes of Bambara groundnut sourced from the Plant Genetic Resource Unit of the International Institute of Tropical Agriculture (IITA), Ibadan, were used for the study (Table 2). The experimental design used was randomized complete block design in three replicates. A two-row plot, 2 m x 1.5 m, was used and the rows were separated at 0.75 m. Two seeds per hole were sown at 0.50 m on the rows and the seedlings were thinned to one plant per hole at 2 weeks after planting. Five randomly tagged plants per plot were evaluated for days to 50% emergence, days to first and 50% flowering, number of leaves, petiole length (mm), plant height (mm), terminal leaf length and width (mm), number of pods/plant, pod length and width (mm), seed length and width (mm), number of seeds/plant, pod weight (g), seed yield (g) and 100-seed weight (g) at the flowering stage. The data collected were subjected to analysis of variance and mean performance of the genotypes were separated with least significant difference at 5% probability. FASTCLUS procedure of Statistical Analysis System (SAS, 2002) was used to distribute the genotypes into homogenous clusters.

RESULTS AND DISCUSSION

Significant ($p \leq 0.05$, $p \leq 0.01$) differences exist among the Bambara groundnut genotypes for the traits evaluated (Table 1). This indicated that, at least, two genotypes will be different for most of the traits evaluated which provide the opportunity to identify and select genotypes with high and superior performance for the traits.

The mean performances of the thirty genotypes of Bambara for 14 traits are presented in Table 2. It was observed that no single genotype has superior performance for all the traits. Days to the emergence of the seedlings were similar for most of the genotypes (7 days) and earlier than CMRBG19-027A and CMRBG19-055 (8 days). Earliness to flowering was indicated for CMRBG19-022A, CMRBG19-037, CMRBG19-054A with fewer days to first and 50% flowering. High vegetative growth in respect of plant height, length and breadth of the leaves, and petiole length was a feature of CMRBG19-008A, CMRBG19-014 while number of leaves was superior in CMRBG19-043A, CMRBG19-042B, CMRBG19-027B, CMRBG19-029A and CMRBG19-054 (88 - 97). High number of pods/plant was observed in CMRBG19-008A (51), then CMRBG19-055 (42) and CMRBG19-029B (39). These genotypes also had high number of seeds per plant (40 to 54 seeds) than the other genotypes with 16 to 37 pods/plant and 16 to 38 seeds/plant. Promising genotypes that can be selected and developed for high seed yield include

Table 1. Mean squares for traits evaluated in 30 genotypes of Bambara groundnut

Source of variation	Block(df = 2)	Genotype (df = 29)	Error (df = 58)
Days to 50% emergence	0.01	0.28**	0.05
Days to first flowering	6.88	6.61*	3.80
Days to 50% flowering	8.14	6.72*	3.32
Number of leaves	230.45	534.00**	99.84
Petiole length (mm)	63.40**	5.99**	2.77
Plant height (mm)	77.07**	15.13**	2.91
Terminal leaf length (mm)	0.13	0.76**	0.21
Terminal leaf width (mm)	0.84**	0.25**	0.06
Number of pods/plant	61.52	170.05**	64.47
Pod length (mm)	13.64**	6.35**	1.65
Pod width (mm)	14.66**	2.67**	0.69
Number of seeds/plant	23.40	188.12**	67.71
Seed yield (g)	5371.49*	4041.16**	1500.95
100-seed weight (g)	1741.06*	522.98	439.22

*significant at 5% probability, **significant at 1% probability

Table 2. Mean performance of 30 genotypes of Bambara groundnut evaluated for agronomic traits

Genotype	Days to 50% emergence	Days to first flowering	Days to 50% flowering	Number of leaves	Petiole length (mm)	Plant height (mm)	Terminal leaf length	Terminal leaf width	Number of pods /plant	Pod length (mm)	Pod width (mm)	Number of seeds /plant	Seed yield (g)	100-seed weight (g)
CMRBG19-004	7.00	31.00	33.00	70.00	16.36	28.11	6.47	3.09	28.40	18.30	13.25	29.40	127.27	61.77
CMRBG19-007	7.00	31.33	33.33	63.27	16.91	27.69	6.69	3.15	22.77	17.65	13.45	24.03	107.73	50.20
CMRBG19-008A	7.00	36.00	39.00	46.67	20.67	34.91	8.58	4.23	50.87	17.67	12.75	54.40	108.63	46.67
CMRBG19-014	7.00	35.00	37.00	52.13	18.39	30.85	7.40	3.95	28.60	20.70	13.18	35.47	160.60	73.13
CMRBG19-019A	7.00	31.67	33.67	66.47	16.11	26.54	6.43	2.88	24.40	16.58	13.24	25.60	59.77	37.50
CMRBG19-020A	7.00	31.67	34.00	70.93	15.68	23.73	6.32	2.87	18.07	17.42	14.21	18.27	85.07	44.00
CMRBG19-020B	7.00	31.33	34.33	75.60	17.21	28.22	7.09	3.27	32.07	18.23	14.14	32.93	93.00	54.47
CMRBG19-022A	7.00	29.33	32.00	71.20	17.07	27.71	6.68	3.10	35.73	18.76	14.37	37.27	135.07	61.47
CMRBG19-026A	7.00	33.67	35.67	62.13	16.05	27.51	6.65	2.93	19.00	18.07	13.84	20.40	78.57	24.60
CMRBG19-027A	8.33	30.67	33.00	72.47	16.16	26.07	6.37	3.22	26.60	17.79	13.96	27.67	124.97	62.87
CMRBG19-027B	7.00	31.33	34.00	95.47	15.73	26.81	6.50	3.11	31.00	20.51	16.21	32.60	173.87	77.70
CMRBG19-029A	7.00	32.33	34.67	92.33	17.05	25.81	6.14	2.95	28.20	17.40	14.59	28.93	151.67	75.07
CMRBG19-029B	7.00	33.00	35.33	79.60	17.04	28.93	6.86	3.17	38.53	17.59	13.83	39.93	115.07	45.83
CMRBG19-032B	7.00	32.33	34.33	63.73	16.44	28.15	6.99	3.24	31.60	19.07	14.65	33.13	112.53	48.20
CMRBG19-033	7.00	32.33	35.33	54.53	17.47	27.21	6.47	3.01	22.27	17.40	14.12	22.93	65.93	40.97
CMRBG19-037	7.00	29.33	31.67	57.27	16.15	24.69	6.17	2.83	26.47	18.11	13.28	26.73	108.37	50.43
CMRBG19-037A	7.33	30.00	32.67	66.93	15.97	26.36	6.35	3.13	26.07	18.49	14.07	27.47	128.13	58.23
CMRBG19-042	7.00	30.33	33.00	70.40	17.44	29.56	7.37	3.41	34.00	18.30	14.31	35.07	102.67	47.87
CMRBG19-042B	7.00	31.00	33.67	87.80	15.67	27.04	6.45	3.21	29.73	20.08	14.85	30.67	207.47	69.67
CMRBG19-043	7.00	32.00	34.67	76.53	17.55	27.63	6.62	3.16	31.80	18.43	14.32	33.53	148.20	40.77
CMRBG19-043A	7.00	32.33	34.67	88.00	15.35	26.64	6.35	3.14	29.93	17.92	14.95	30.07	184.07	66.90
CMRBG19-046A	7.33	33.00	35.00	70.13	16.33	25.88	6.49	3.10	25.00	18.06	14.47	27.13	87.60	57.43
CMRBG19-047A	7.00	33.00	35.67	57.20	16.65	27.97	6.67	3.05	36.47	19.37	13.97	38.20	138.93	57.83
CMRBG19-047B	7.00	32.33	34.67	66.60	13.44	24.29	6.47	2.94	22.40	18.61	16.24	23.67	98.00	55.90
CMRBG19-050B	7.00	31.67	34.33	63.53	15.10	25.33	6.94	3.02	23.67	20.64	13.55	25.87	90.40	38.67
CMRBG19-054	7.33	32.00	34.33	96.80	16.42	28.23	6.26	3.09	15.60	24.31	16.87	16.40	85.20	31.97
CMRBG19-054A	7.00	29.67	32.00	53.87	14.07	23.73	6.23	3.11	24.60	18.27	14.89	25.73	129.87	61.97
CMRBG19-055	8.00	32.00	35.00	66.27	19.61	29.79	6.91	3.29	41.80	18.35	13.98	43.07	117.50	49.97
CMRBG19-055A	7.00	31.67	34.33	67.73	15.66	25.93	5.98	2.94	17.53	18.77	15.36	19.53	98.50	62.23
CMRBG19-055B	7.00	33.00	35.33	93.73	15.73	28.94	6.29	3.09	29.47	18.60	14.86	31.80	191.00	73.03
LSD (α – 0.05)	0.35	3.18	3.40	16.33	2.72	2.79	0.74	0.41	13.12	2.10	1.36	13.45	63.32	34.25

CMRBG19-042B (207.5 g) CMRBG19-055B (191 g), CMRBG19-043A (184 g), CMRBG19-027B (174 g), CMRBG19-014 (161 g), CMRBG19-029A (152 g) and CMRBG19-043 (148 g).

Table 3. Genetic distribution of 30 genotypes of Bambara groundnut into seven clusters

Characters	I	II	III	IV	V	VI	VII	R^2
	022A, 029A, 043	054	008A, 055	014, 047A, 054A	019A, 020A, 026A, 033, 050B	004, 007, 020B, 027A, 029B, 032B, 037, 037A, 037A, 046A, 047B, 055A	027B, 042B, 043A, 055B	
Days to Emergence	7.00 (0.00)	7.33 (0.00)	7.50 (0.71)	7.00 (0.00)	7.00 (0.00)	7.17 (0.39)	7.00 (0.00)	0.21
Days to first flowering	31.22 (1.65)	32.00 (0.00)	34.00 (2.83)	32.56 (2.69)	32.20 (0.87)	31.36 (1.17)	31.92 (0.92)	0.24
Days to 50% flowering	33.78 (1.54)	34.33 (0.00)	37.00 (2.83)	34.89 (2.59)	34.60 (0.86)	33.72 (1.10)	34.42 (0.74)	0.32
Number of leaves	80.02 (10.99)	96.80 (0.00)	56.47 (13.86)	54.40 (2.58)	63.52 (6.05)	68.64 (5.88)	91.25 (3.93)	0.80
Petiole length	17.22 (0.28)	16.42 (0.00)	20.14 (0.75)	16.37 (2.17)	16.08 (0.87)	16.26 (1.04)	15.62 (0.18)	0.57
Plant height	27.05 (1.07)	28.23 (0.00)	32.35 (3.62)	27.52 (3.58)	26.06 (1.55)	26.99 (1.68)	27.36 (1.07)	0.42
Terminal leaf length	6.48 (0.30)	6.26 (0.00)	7.75 (1.18)	6.77 (0.59)	6.56 (0.24)	6.61 (0.40)	6.40 (0.10)	0.41
Terminal leaf width	3.07 (0.11)	3.09 (0.00)	3.76 (0.66)	3.37 (0.50)	2.94 (0.07)	3.12 (0.16)	3.14 (0.05)	0.47
Number of pods	31.91 (3.77)	15.60 (0.00)	46.34 (6.41)	29.89 (6.04)	21.48 (2.82)	27.62 (5.72)	30.03 (0.67)	0.67
Pod length (mm)	18.20 (0.71)	24.31 (0.00)	18.01 (0.48)	19.45 (1.22)	18.02 (1.56)	18.25 (0.45)	19.28 (1.22)	0.67
Pod width (mm)	14.43 (0.14)	16.87 (0.00)	13.37 (0.87)	14.01 (0.86)	13.79 (0.40)	14.25 (0.87)	15.22 (0.66)	0.52
Seed length (mm)	11.77 (0.22)	15.21 (0.00)	11.56 (0.59)	12.02 (0.34)	12.46 (2.42)	11.75 (0.78)	12.65 (0.72)	0.30
Seed width (mm)	9.74 (0.56)	11.32 (0.00)	9.07 (0.68)	9.55 (0.41)	9.51 (0.57)	10.16 (1.78)	10.60 (0.36)	0.16
Number of seeds/plant	33.24 (4.18)	16.40 (0.00)	48.74 (8.01)	33.13 (6.56)	22.61 (3.29)	28.89 (5.60)	31.29 (1.13)	0.68
Pod weight (g)	37.41 (6.44)	25.13 (0.00)	31.84 (0.10)	29.83 (1.98)	23.80 (5.24)	29.55 (8.68)	35.51 (3.26)	0.32
Seed yield (g)	144.98 (8.76)	85.20 (0.00)	113.07 (6.27)	143.13 (15.79)	75.95 (12.86)	108.65 (13.45)	189.10 (14.12)	0.90
100-seed weight (g)	59.10 (17.27)	31.97 (0.00)	48.32 (2.33)	64.31 (7.91)	37.15 (7.44)	54.62 (6.04)	71.83 (4.65)	0.72

Coefficient of determination (R^2)

The thirty Bambara genotypes were separated into six homogenous groups based on FASTCLUS procedure of SAS, a multivariate analysis (Table 3). Seed yield (90%), number of leaves (80%), 100-seed weight (72%), number of seeds/plant (68%), number of pods/plant and pod length (67%) with high coefficient of determination contributed more to the divergence among the seven clusters. Other traits contributed 16% (seed width) to 57% (petiole length) of the genetic diversity. Cluster VII with CMRBG19-027, CMRBG19-042B, CMRBG19-043A and CMRBG19-055B is characterized as high yielding group in terms of seed yield, 100-seed weight and number of leaves. CMRBG19-054 (cluster II) also has a feature for high number of leaves by low yielding. High pod and seed bearing genotypes include CMRBG19-008A and CMRBG19-55 in cluster III. Clusters I and IV can also be exploited as promising high yielding groups. Genetic diversity revealed among the genotypes can be maximized through hybridization between the clusters. In conclusion, the genetic diversity detected in the Bambara groundnut is an indication of potential for improvement of further breeding work.

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GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* (L). Moench) AS INFLUENCED BY PLANT POPULATION AND WEED CONTROL STRATEGIES IN ABEOKUTA

Osunleti, S. O[1] and Oni, O. E[2]

[1]Department of Agricultural Technology, Edo State College of Agriculture and Natural Resources, Iguoriakhi, Edo Stae.

[2]Department of Plant Physiology and Crop Production, Federal University of Agriculture, Abeokuta, Ogun State.

Corresponding author: Oni Olanrewaju Emmanuel (onioe@funaab.edu.ng; 07033713525)

ABSTRACT

The field trials were conducted at the growing season of 2021 at the Federal University of Agriculture, Abeokuta. The objective of the study was to evaluate influence of okra stand density and different weed control strategies on growth and yield of okra. Split-plot arrangement in a randomized complete block design with three replicates was adopted in the trials. Main plot treatments were three levels of plant populations at 20,000 plants/ha, 26,666 plants/ha and 40,000 plants/ha, while sub plots treatments consisted of six weed control strategies. Data collected were subjected to analysis of variance and treatment means were separated using least significant difference at $p \leq 0.05$. The results showed that planting okra at 40,000 plants/ha reduce weed density and increase okra yield. Various weed control strategies reduce weed density and enhanced crop growth which resulted in higher yield compared to weedy check. Maximum crop yield was recorded with application of Metolachlor at 1.0 kg a.i/ha + hoe weeding and weeding thrice at 3, 6 and 9 WAP. Therefore, okra should be planted at 40,000 plants/ha with application of Metolachlor at 1.0 kg a.i/ha + hoe weeding as this reduced weed competition, enhanced crop yield and saves resources in terms of weed control.

Keywords: Metolachlor, Okra, Populations, weed, Yield

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is a fruit vegetable cultivated widely and found in almost every market in Nigeria. Okra is of great value as it has a lot of uses. Okra has several benefits for human consumption, being a good source of carbohydrates, proteins, fats, minerals and vitamins, which aroused interest in growing this vegetable on a large scale (Sindhu and Puri 2016). Weed infestation is a major problem in the production of okra as uncontrolled weed growth throughout the life cycle of okra could reduce pod yield by 92.2 to 96.3% (Adeyemi *et al*., 2022). One of the major aspects of crop ecology, production and management which limit crop production is improper crop spacing in the field (Islam *et al*., 2011). Therefore, our present study is to evaluate the effect of plant population and weed control strategies on growth and yield of okra

MATERIALS AND METHODS

The experiment was conducted in the early wet season of 2021 at Federal University of Agriculture, Abeokuta, Ogun State. The experiment was laid in a split-plot arrangement in a randomized complete block design in three replicates. Main plot treatments were three levels of plants population viz: 20,000 plants/ha (100 cm x 50 cm), 26,666 plants/ha (75 cm x 50 cm) and 40,000 plants/ha (50 cm x 50 cm). The sub plot consisted of six weed control strategies, viz: Metolachlor at 1.0 kg a.i/ha, Metolachlor at 1.0 kg a.i/ha + hoe weeding (HW), HW at 3, 6 and 9 WAP, HW at 3 and 6 WAP, HW at 3 WAP and weedy. The field was ploughed and harrowed to ensure a loose and clean field. Layout was done, and okra seeds were planted according to the treatments.

Data Collection and Analysis

Data on plant height, fruit length, fruit girth, number of fruits, fruit yield and weed density were analyzed using the GENSTAT procedures. Least significant difference (LSD) was used to separate significant means at a 5% level of probability.

RESULTS

Table 1: Effect of okra stand density and weed control strategies on okra height

	Plant Height (cm)			
Treatments	3 WAP	6 WAP	9 WAP	12 WAP
Plant Population/ha				
20,000	9.2	25.8	53.2	62.5
26,666	9.9	26.8	53.3	59.1
40,000	9.2	24.7	49	55
Lsd	1.78ns	3.475ns	12.31ns	15.97ns
Weed Control Strategies				
Metolachlor at 1.0 kg a.i/ha	9.4	30.2	61.7	68.1
Metolachlor at 1.0 kg a.i/ha + HW	9.0	29.9	64.9	73.7
HW at 3 6 9 WAP	8.8	25.3	70.8	80.3
HW at 3 6 WAP	10.6	29.4	55.2	62.4
HW at 3 WAP	10.4	29.9	38.7	47.8
Weedy	8.7	15.1	19.7d	20.1
Lsd	0.95	3.41	14.36	15.97

Table 1 shows the effect of plant population and weed control strategies on plant height. Throughout the period of observation, plant population had no significant effect on plant height, while weed control strategies had significant effect on plant height. At 3 WAP, hoe weeding at 3 WAP and hoe weeding at 3, 6 WAP resulted in taller okra plants than all other weed control strategies. At 6, 9 and 12 WAP, the shortest okra plants were recorded in the weedy check plots. At 6 WAP, application of Metolachlor at 1.0 kg a.i/ha + HW, Metolachlor at 1.0 kg a.i/ha alone and hoe weeding at 3, 6 WAP produced taller okra plants than hoe weeding at 3 WAP. At 9 and 12 WAP, application of Metolachlor at 1.0 kg a.i/ha + HW and Metolachlor at 1.0 kg a.i/ha alone resulted in comparable okra heights to the tallest of those hoe weeded at 3, 6 and 9 WAP. Also at 9 and 12 WAP, weeding okra once at 3 WAP alone caused reduction in okra height (Table 1).

Table 2: Effect of okra stand density and weed control strategies on yield and yield components

	Yield and Yield Components			
Treatments	Fruit Length (cm)	Fruit Girth (mm)	Number of Fruits/ha	Fruit Yield (kg/ha)
Plant Population/ha				
20,000	5.0	1.3	216494	3096
26,666	4.6	1.0	309462	3857
40,000	4.5	0.7	352347	4091
Lsd	0.165	0.113	37211	633
Weed Control Strategies				
Metolachlor at 1.0 kg a.i/ha	5.1	1.0	388272	4503
Metolachlor at 1.0 kg a.i/ha + HW	5.3	1.2	406790	5579
HW at 3 6 9 WAP	5.3	1.3	409136	5854
HW at 3 6 WAP	5.2	1.1	341764	4310
HW at 3 WAP	4.2	0.9	201940	1794
Weedy	3.1	0.5	8707	48d
Lsd	0.0879	0.0841	24250.8	514

Plant population and weed control strategies had significant effect on yield and yield components of okra (Table 2). Planting okra at 20,000 plants/ha produced longer and bigger fruit compared to planting okra at higher populations.

Conversely, planting okra at 40,000 plants/ha produced significantly higher number of fruit and yield than planting at 20,000 plants/ha. The shortest fruit, smallest fruit and lowest okra yield was recorded on the weedy check plots. Application of Metolachlor at 1.0 kg a.i/ha + HW and hoe weeding at 3, 6, 9 WAP resulted in similar okra yield significantly higher than all other weed control strategies (Table 2).

Table 3: Effect of okra stand density and weed control strategies on weed density

	Weed Density/ha			
Treatments	Broadleaves	Grasses	Sedges	Total
Plant Population/ha				
20,000	354109	291111	193049	838269
26,666	232952	197214	154743	584909
40,000	312050	206917	154503	673470
Lsd	113383.3ns	68196.8	62146.5ns	138152.4
Weed Control Strategies				
Metolachlor at 1.0 kg a.i/ha	379200	276778	180833	836811
Metolachlor at 1.0 kg a.i/ha + HW	83745	58045	33416	175206
HW at 3 6 9 WAP	84877	54444	43605	182926
HW at 3 6 WAP	89124	56349	44263	189736
HW at 3 WAP	471153	346040	259512	1076705
Weedy	690123	598827	442963	1731914
Lsd	82291	74694.6	44298.1	106924.1

Plant population had significant effect on grass and total density, with okra planted at 20,000 plants/ha having higher value, while similar values were recorded with okra planted at 26,666 and 40,000 plants/ha. The highest broadleaves, grasses, sedges and their total were recorded on the weedy check plots, while application of Metolachlor at 1.0 kg a.i/ha + HW, weeding for at least 3 and 6 WAP recorded the lowest (Table 3).

DISCUSSION

Higher okra yield on plots planted at 40,000 plants/ha could be ascribed to the higher plant population on the plots. This treatment also caused reduction in weed density. This results is similar to earlier report of Osunleti *et al*. (2023) who reported higher crop yield with increase in plant population. This shows that crop maximize their potentials in the absence of weeds. Application of pre emergence herbicide, with or without post emergence treatment and hoe weeding for at least twice also reduce weed density and increase crop yield. Lowest okra yield of the weedy check plots could be due to uninterrupted weed infestation which could have led to competition between the crop and weed. Competition for soil nutrient, moisture, space between crop and weed had been reported by several researchers to caused serious reduction in yield (Adeyemi *et al*., 2022). Uncontrolled weed infestation throughout crop growth in this study resulted in 99.1% yield reduction.

CONCLUSION AND RECOMMENDATION

Our study showed that okra yield can be increased by 32.1% by increasing plant population from 20,000 plants/ha to 40,000 plants/ha. Weeding at 3, 6 and 9 WAP and Metolachlor at 1.0 kg a.i/ha + hoe weeding gave maximum okra yield, while the later saves time and other farm input. Therefore, planting okra at 40,000 plants/ha with application of Metolachlor at 1.0 kg a.i/ha + hoe weeding for weed control is recommended.

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VARIABILITY, HERITABILITY AND GENETIC ADVANCE OF SIX AGRONOMIC CHARACTERS IN GOLDEN MELON (*Cucumis melo* L.)

Ayodeji, O. A[1]*., Ayo-vaughan, M. A., Badmus, Z. O., Okunlola, P. O. & Egbukichi, E. O[2].
[1]Department of Plant Breeding and Seed Technology, Federal University of Agriculture, Abeokuta, Nigeria. (FUNAAB)
[2]Department of Economics, University of Lagos, Nigeria.
***Corresponding Author**: ayodejiomobaba@gmail.com

ABSTRACT
Twenty genotypes of Golden melon (*Cucumis melo* L.) were evaluated on the field in a randomized complete block design with three replications to assess variability and genetic parameters in six agronomic characters namely days to 50% emergence, vine girth, vine length, number of branches, number of nodes and days to 50% flowering. Analysis of variance revealed significant differences among the genotypes for all the characters evaluated except for number of nodes. Vine girth was the most variable character with genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) of 46% and 50%, respectively. Days to 50% flowering was the least variable with GCV and PCV of 8% and 10%, respectively. All the characters except number of nodes exhibited larger genotypic variance than environmental variance indicating that the phenotypic variation observed among the genotypes was more of genetic contribution than the environment. Vine girth had the highest heritability estimate (83.56%) while number of nodes exhibited the lowest (31.41%). High GCV, heritability estimates and genetic advance observed for days to 50% emergence, vine girth, vine length and number of branches indicated that the characters are under additive genetic control and there is prospect for genetic improvement through selection for these characters.
Keywords: Additive gene, crop improvement, genetic advance, genetic variability, heritability.

INTRODUCTION
Golden melon (*Cucumis melo* L.) is an annual, drooping herbaceous plant distinguished by a short angular-stem, woody rootstock with bristly hairs on the leaves; largely belonging to the family of Cucurbitaceae (Cucurbit), one of the most genetically diverse groups of food plants that are drought-tolerant (Ajuru and Okoli, 2013).
Nutritionally, golden melon is a great constituent of essential minerals and nutrients such as vitamin C, pantothenic acid, calcium, zinc, vitamin B6, fibre, magnesium, iron, potassium, vitamin A and omega-3 and 6 (Raji, and Orelaja, 2014).
Genetic variability is an obvious feature of considerable importance in crop improvement. It is the basic necessity for determining the most effective breeding procedure (Ariyo, 1995). The knowledge of existing variability with respect to yield and yield attributing traits in the germplasm of a crop is the basic requirement in order to select the desirable types (Augustina *et al*, 2013).
Heritability of a character indicates the extent to which the character can be transmitted from one generation to another (Balouch *et al*., 2003) and is a valuable tool to predict the magnitude of genetic gain that follows selection for a character.
Research on variability and the heritability of golden melon traits is essential for breeding and agricultural research initiatives as it offers insightful information about its genetic diversity, assisting breeders in identifying desired features and choosing superior cultivars. Breeding techniques are now informed by an understanding of heredity, which results in more effective and focused crop development. This is particularly crucial for maintaining food security and adjusting to changing environmental conditions. Furthermore, this study has the potential to improve golden melon's general production and quality, which would benefit growers and consumers alike.
The study aimed to quantify the extent of variation among the genotypes of golden melon as well as to partition the overall variation into heritable and non heritable components, thus providing insights into their genetic control for targeted breeding efforts and crop improvement.

MATERIALS AND METHODS
This study was carried out at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria during the rainy season (July – November, 2023). Seeds of twenty genotypes used for this study were sourced from local markets in different locations in Oyo and Ogun states, Nigeria. After land preparation
by ploughing and harrowing, seeds of the 20 genotypes were sown in single row plots of 1.75m long and 60cm apart. Within row spacing was 35cm and each row had five stands of golden melon. The experiment was laid out in a Randomized Complete Block Design with three replications. Staking of individual plants was done at

4weeks after planting. Insecticide, Sharpshooter (a. i. Profenofos 40% + Cypermethrin) was applied at the rate of 90mls in 16 litres of water to control field pests. Weeding was done when necessary.

Data collected on days to 50% emergence, vine girth (mm), vine length (cm), number of branches per plant, number of nodes per plant and days to 50% flowering were subjected to analysis of variance to check for significance differences among the golden melon genotypes used for the experiment. Means performance were compared using Duncan's Multiple Range Test at 5% probability level. Phenotypic variation for each character was partitioned into genetic and non-genetic factors according to methods suggested by Burton (1952). These components of variance were used for the estimation of genotypic and phenotypic coefficients of variation (GCV and PCV, respectively). Broad-sense heritability and expected genetic advance were computed using the formula suggested by Allard (1960).

RESULTS AND DISCUSSION

The mean squares for six agronomic characters evaluated in 20 genotypes of golden melon are presented in Table 1. Significant variation exists among the genotypes for all the characters evaluated except for number of nodes per plant. This indicated that variability existed among the golden melon genotypes used in this study, which conforms to the results of Venkatesan *et al.* (2016) who also studied variation in golden melon genotypes for growth, yield and quality traits and observed variation on the basis of the characters evaluated. The presence of variability in crop is important for improvement through selection.

Table 2 presents the mean performances of the twenty genotypes for agronomic characters evaluated. Bodija and Eleweran had the latest days to emergence of 7.33 days, while Lafenwa and Olomore had the earliest days to emergence (3.67 days). Lafenwa was the earliest to flower (33.67 days) amongst the genotypes while Eleweran had the latest days to flowering of 47days. The highest value for vine girth was recorded for Osiele (5.80mm), however, Eleweran had the lowest vine girth of 0.41mm. Kuto recorded the least number of branches while Osiele had the highest number (2.67, 5.67 respectively).

Table 3 presents the means, phenotypic and genotypic variances, phenotypic and genotypic coefficients of variation, broad-sense heritability estimates and genetic advance for the six characters. All the characters except number of nodes exhibited larger genotypic variance than environmental variance indicating that the phenotypic variation observed among the genotypes was more of genetic contribution than the environment. The genotypic and phenotypic coefficients of variation explain the magnitude of variation that exists within a population. The phenotypic coefficient of variation ranged from 10.0% (days to 50% flowering) to 50.0% (vine girth) while the genotypic coefficient of variation ranged from 8.0% (days to 50% flowering) to 46.0% (vine girth). Vine girth was the most variable character with genotypic coefficient of variation (gcv) and phenotypic coefficient of variation (pcv) of 46% and 50%, respectively. Days to 50% flowering was the least variable with gcv and pcv of 8% and 10%, respectively. For characters like days to emergence, vine girth and vine length whose gcv and pcv were relatively higher than other characters evaluated, implied the existence of greater magnitude of variability in these characters and possibility for their improvement through selection. The broad sense heritability explains the contribution of genetic makeup to phenotypic variation; vine length (83.21%), vine girth (83.56%), number of branches (73.91%), days to 50% flowering (64.06%) and days to 50% emergence (69.71%) had high heritability. However, heritability combined with genetic advance provides a more reliable index for selection of characters. Days to emergence, vine length, vine girth and number of branches per plant which combined high genetic advance and heritability suggest the influence of additive gene effect for inheritance of these characters and therefore lead to fast genetic improvement through selection.

Table 1: Mean squares from analysis of variance of characters evaluated in golden melon.

Source of variation	df	Days to 50% emergence	Days to first flowering	Vine girth (mm)	Vine length (mm)	Number of nodes	Number of branches
Block	2	1.52	65.15*	0.16	477.32	1.52	0.22
Genotype	19	3.50**	43.77**	7.24**	4920.47**	74.47	2.30**
Error	38	1.06	15.73	1.19	825.93	51.08	0.60

*, ** = Significant at 5% and 1% probability levels respectively.

Table 2. The mean performances of the twenty genotypes for six agronomic characters.

Accession	Days to 50% emergence	Days to 50% flowering	Vine girth (mm)	Vine length (cm)	Number of nodes	Number of branches
BODIJA	7.33a	46.67a	2.44d-k	208.00d-f	35.33a-d	3.67cd
CAMP 1	4.33bc	37.00b-d	3.58b-g	194.33d-g	33.33a-d	4.00b-d
CAMP 2	4.00bc	38.00b-d	3.44b-h	224.67b-e	35.33a-d	4.00b-d
CHALLENGE	5.33bc	39.67a-d	1.68g-k	189.00e-g	33.00a-d	3.00d
ELEWERAN	7.33a	47.00a	0.41k	193.00d-g	28.67a-d	3.67cd
ELEYELE	4.33bc	37.00b-d	2.60d-j	225.67b-e	30.00a-d	5.00a-c
GATE	6.00ab	40.67a-d	4.29a-e	264.00a-c	36.33a-d	5.33ab
IJEBU ODE	4.67bc	44.67ab	3.72b-g	246.00a-d	37.67a-c	4.00b-d
ITA OSHIN	4.00bc	37.00b-d	0.95jk	154.00fg	26.67a-d	3.67cd
KUTO	5.67abc	46.00a	1.10i-k	150.00g	23.00d	2.67d
LAFENWA	3.67c	33.67d	5.24a-c	282.00a	40.00a	5.00a-c
MOLETE	5.00bc	36.00cd	3.95a-f	218.67b-e	31.67a-d	4.67a-c
OJE	4.00bc	37.67b-d	2.10f-k	247.00a-d	24.00cd	4.67a-c
OLOMORE	3.67c	36.33cd	4.07a-f	215.33c-e	36.00a-d	3.67cd
OLUWO	5.33bc	39.33a-d	3.16c-i	159.33fg	29.67a-d	3.00d
OMI ADIO 1	6.00ab	40.00a-d	1.42h-k	182.00e-g	25.67b-d	3.00d
OMI ADIO 2	5.67abc	42.67a-c	2.27e-k	208.00d-f	33.67a-d	4.67a-c
OSIELE	4.67bc	37.67b-d	5.80a	283.67a	38.67ab	5.67a
PANSEKE	5.67abc	41.33a-d	5.36ab	233.33a-e	34.00a-d	4.00b-d
SOMORIN	4.67bc	37.67b-d	4.51a-d	272.67ab	38.00a-c	5.33ab

Table 3. Estimate of genetic parameters for six agronomic characters of golden Melon.

Character	**Mean**	**Phenotypic var.**	**Genotypic var.**	**Envr var.**	**PCV (%)**	**GCV (%)**	**Heritability (%)**	**Genetic advance**
Days to 50% emergence	5.07	1.17	0.81	0.35	21 0	18.0	69.71	30.60
Days to 50% flowering	39.80	14.59	9.35	5.24	10.0	8.0	64.06	12.67
Vine girth (mm)	3.10	2.41	2.02	0.40	50.0	46.0	83.56	86.26
Vine length (cm)	217.53	1640.16	1364.85	275.31	19.0	17.0	83.21	31.91
Number of nodes	32.53	24.82	7.80	17.03	15.0	9.0	31.41	9.91
Number of branches	4.13	0.77	0.57	0.20	21.0	18.0	73.91	32.28

GCV - Genotypic Coefficient of Variability, PCV - Phenotypic Coefficient of Variability, Envr. Var. - Environmental variance.

CONCLUSION

The results revealed that variability existed among the six characters evaluated and may be due to diverse genetic background of the golden melon genotypes studied. High genotypic coefficient of variation, heritability estimates and genetic advance observed for days to 50% emergence, vine girth, vine length and number of branches indicate that the characters are under additive genetic control and there is prospect for genetic improvement through selection for these characters. However, low gcv, high heritability and low genetic advance estimates observed for days to flowering and low gcv, heritability and genetic advance estimates for number of nodes per plant suggest limited scope for improvement of these characters through selection.

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CHARACTERIZATION OF CASSAVA (*Manihot esculenta* Crantz) GENOTYPES FOR NUTRITIONAL AND QUALITY TRAITS

[1]Abah S. M. [2]Nkaa F. A.
1. National Root Crops Research Institute, Umudike, Nigeria.
2. Michael Okpara University of Agriculture, Umudike, Abia State
Corresponding author: abahsp@gmail.com

ABSTRACT
Cassava has a crucial role in benefiting smallholder famers as main food and income source in eastern part of Nigeria, The main objective of this study was to characterize 40 improved different cassava genotypes for their nutritional, quality and agronomic traits using morphological markers. Forty (40) diverse cassava genotypes including three (3) checks were established in this experiment which was laid out in randomized complete block design with three replications. The plot size was 0.8 x 5m with 25cm cuttings of genotypes planted on ridges at an interspacing of 1m by intraspacing of 0.8m. The trials were established in 2022/2023 cropping seasons. In order to identify the yield performance in cassava genotypes, storage roots from each plant genotype were sampled or harvested at 12 MAP. The following cassava storage root traits were measured: total root weight; number of root; fresh root yield (FRYD), harvest index (HI), dry matter content (DMC), and starch content (SC). In order to account for the variance components, analysis of variance was carried out for all the traits. Statistics were analyzed using the lme4 package in R statistical software and GenSTAT 12 Edition software for other meta-analyses, such as Principal component analysis (PCA) and diversity analysis. The result of the association between the traits showed significant variations between the various traits. The broad sense heritability shows high significant values which signified that the morphological traits studied can be transfer from parents to their offsprings. Out of the 40 cassava genotypes, best 6 superior accessions (NR050667, NR100451, NWAGERI, AR145, IITA-TMS-MM990477, and NR100216) with good morphological characteristic were selected. The morphological characteristics were the dry matter content, fresh root yield, plant height, number of root, and starch content. These superior genotypes can be recommended for the breeder advancement or farmers for release, if it meets the released required.
Keywords: cassava, nutrition, quality traits, agronomy, morphology

INTRODUCTION
Cassava is the most important staple food in Africa. For instance, 50% of Nigeria population eats cassava at least once a day. In the rest of sub-Saharan Africa, the same scenario applies to as many as 30 to 70% (ca. 400 million people) of the region inhabitants (FAOSTAT, 2005). Cassava is also assuming a new role not only as an important animal feed and industrial raw material, but also in the emerging biofuel economy.
Characterization techniques can aid in the conservation and sustainable use of cassava genetic resources. Understanding the genetic diversity and population structure of cassava genotypes can support the development of conservation strategies and the identification of valuable traits for future breeding efforts. Investigating the influence of environmental factors on the expression of nutritional and quality traits in cassava genotypes can contribute to understanding the plant's adaptation mechanisms. This knowledge can be utilized to develop climate-resilient cassava varieties that thrive under different environmental conditions, ensuring food production stability in the face of climate change and varying agroecological contexts. Overall, the study's significance lies in its potential to contribute to improving food security, nutrition, and sustainable agriculture by harnessing the genetic diversity of cassava genotypes for the development of improved varieties with enhanced nutritional and quality traits (El-Sharkawy 2004),.
The main objective of the study is to characterize the improved cassava genotypes for their nutritional, quality and agronomic traits using their morphological markers. The specific objectives of the study are as follows: (i) to determine the diversity of the improved cassava varieties using the morphological characteristics. (ii) to select the best genotypes for both high nutritional and quality characteristics.

MATERIALS AND METHODS
Study area and experimental design:
Forty (40) diverse cassava genotypes including three (3) checks from National Root Crops Research Institute (NRCRI) were established in this experiment. They were laid out in randomized complete block design with three replications. The plot size was 0.8 x 5m with 25cm cuttings of genotypes planted on ridges at an interspacing of 1m by intraspacing of 0.8m. The trials were established in 2022/2023 cropping seasons.
Phenotypic measurements

In order to identify the yield performance in cassava genotypes, storage roots from each plant genotype were sampled or harvested at 12 MAP. The following cassava storage root traits were measured: total root weight; number of root; fresh root yield (FRYD), harvest index (HI), dry matter content (DMC), and starch content (SC).

Statistical analysis

In order to account for the variance components, analysis of variance was carried out for all the traits. Statistics were analyzed using the lme4 package in R statistical software and GenSTAT 12 Edition software for other meta-analyses, such as Principal component analysis (PCA) and diversity analysis.

RESULTS AND DISCUSSION

Result of the Correlation between the traits:

The result in Table 1 showed the correlation analysis among the cassava traits in Nigeria. The dry matter content showed negative and significant (P<0.01) correlation with the fresh root yield (r = -0.332) and harvest index (r = -0.522) but showed positive and significant (P<0.001) correlation with starch content (r = 0.972). The correlation value of 0.698 was between fresh root yield and harvest index was positive and significance.

Table 1: Result of the association between the traits

	Dry matter content	Fresh root yield	Harvest index	Number of root	Plant height	Starch Content
Dry matter content	1					
Fresh root yield	-0.332	1				
Harvest index	-0.522	0.698	1			
Number of root	-0.021	0.049	0.054	1		
Plant height	0.118	0.180*	0.111	-0.1	1	
Starch Content	0.972	-0.277	-0.468	-0.011	0.135	1

Result of the Variance component

Table 2 shows the analysis of variance component of the different traits. The result showed that there was significant (P<0.001) difference among the 40 genotypes for dry matter content with a variance value of 64.49 while it showed high broad sense heritability value (73%). The result on Fresh root yield also showed that the genotypes have significant (P<0.001) variance value of 89.47 with high (80%) broad sense heritability value. The genotypes also showed significant (P<0.05) variation for harvest index (8.025), number of root (21.46), plant height (12.06) and starch content (61.73) with high broad sense heritability value of 73%, 61%, 85% and 64% respectively.

Table 2: Analysis of Variance component of the different traits

Traits	Genotypic variance	Error variance	Broad sense Heritability	P-value	%CV
Dry matter content	64.49	23.54	0.73	<0.001	14.26
Fresh root yield	89.47	21.81	0.80	<0.001	15.84
Harvest index	8.025	3.016	0.73	0.048	22.05
Number of root	21.46	13.64	0.61	0.036	16.45
Plant height	12.061	2.175	0.85	0.003	18.43
Starch Content	61.73	34.46	0.64	0.026	17.54

%CV means percentage coefficient of variation

Selection of Superior Genotypes

The result of the selection index for the superior genotypes shown in Figure 1 revealed that the performances of the genotypes varied. The superior genotypes (AR145, IITA-TMS-MM990477, NR050667, NR100216, NR100451, NWAGERI) were those above the threshold which were selected based on multivariate values of the dry matter content, fresh root yield, harvest index, number of root, plant height and starch content. These genotypes were also selected because they were better than the national check used (TMEB419, TMS30572 and NR8082)

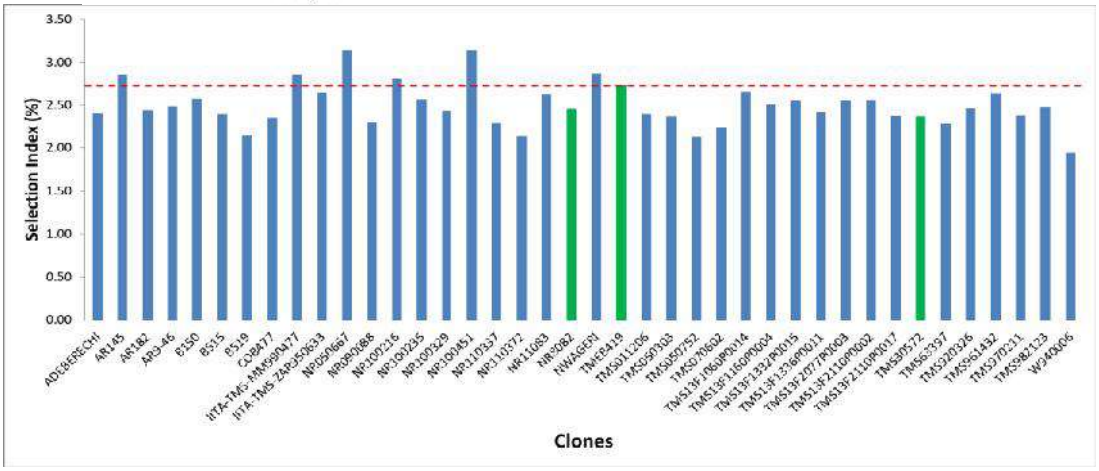

Figure 1: Selection of the genotype with superior characteristics

DISCUSSION

The current study on the morphological characterization of cassava genotypes, aimed tat highlighting the variations and identify germplasms for plant breeding and also to make available of superior cassava genotypes for farmers. This study permitted to evaluate the level of cassava variability in Nigeria by using morphological and agronomic traits.

The analysis of result of the association between the traits, showed a significant variation between the various traits in this study, the significant levels were identify, increase in dry matter content tends to decrease the fresh root yield and harvest index, while the increase in fresh root yield also increase the harvest index. Similar result was obtained by Elias *et al.,* (2001) and Diaguna, *et al.* (2022), who reported relationship of an increase dry matter content with that of yield and harvest index in cassava.

The analysis of Selection index of Superior Genotypes in Figure 4.1 shows the best 6 cassava genotypes (NR050667, NR100451, NWAGERI, AR145, IITA-TMS-MM990477, and NR100216) from the 40 varieties of cassava genotypes that was studied, the genotypes which is accepted in Nigeria as the national check was identify with green colour and they are known as the comparison for standard genotypes which were TMEB419, TMS30572 and NR8082. These superior selected genotypes can be used by the breeders for advancement in the breeding pipeline or recommended to the farmers. This study was in agreement with a study conducted on famers and the breeders' related study carried out by Wongtiem (2013) and Diaguna, *et al.*, 2022.

The result on the broad sense heritability showed the all the traits evaluated have high heritability which implies that the traits were majorly influenced by the genetic materials and the phenotypes were controlled majorly by the genotype and not the environment.

CONCLUSION

The aim of this study was to characterize and evaluate 40 cassava accessions in order to provide useful information for breeding programs and conservation. In this regard, the evaluated accessions or genotypes showed the superior cassava genotypes to be made available for breeding programs or farmers. The broad sense heritability shows high significant values which signifies that the morphological traits studied can be transfer from parents to their offsprings.

Out of the 40 cassava genotypes, best 6 superior accessions (NR050667, NR100451, NWAGERI, AR145, IITA-TMS-MM990477, and NR100216) with good morphological characteristic were selected. The morphological characteristics were the dry matter content, fresh root yield, plant height, number of root, and starch content.

RECOMMENDATIONS

These superior genotypes can be recommended for the breeder advancement or farmers for release, if it meets the released required. Further molecular characterization could be done on these materials to support the morphological characterization.

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COMPARATIVE ASSESSMENT OF GENETIC DIVERSITY CLUSTERING ANALYSIS IN CASSAVA GENOTYPES (*Manihot esculenta* Crantz) FROM DIFFERENT POPULATION FOR NUTRITIONAL QUALITIES

[1]Abah S. M, [2]Nkaa Francis A., [2]Onyekwere K. and [1]Onyenali T.C.,

1. National Root Crops Research Institute, Umudike, Nigeria.
2. Michael Okpara University of Agriculture, Umudike, Abia State

Corresponding author: abahsp@gmail.com

ABSTRACT

Understanding the diversity and genetic relationships among and within cassava germplasm is invaluable for genetic improvement. This study assessed genetic diversity in a panel of 40 cassava genotypes using dendogram clustering analytical method. Forty (40) diverse cassava genotypes including three (3) checks were established in this experiment which was laid out in randomized complete block design with three replications. The plot size was 0.8 x 5m with 25cm cuttings of genotypes planted on ridges at an interspacing of 1m by intraspacing of 0.8m. The trials were established in 2022/2023 cropping seasons. In order to identify the yield performance in cassava genotypes, storage roots from each plant genotype were sampled or harvested at 12 MAP. The following cassava storage root traits were measured: total root weight; number of root; fresh root yield (FRYD), harvest index (HI), dry matter content (DMC), and starch content (SC). In order to account for the variance components, analysis of variance was carried out for all the traits. Statistics were analyzed using the ggbiplot2 package in R statistical software for the diversity analysis. The result of the Dendogram clustering analysis allows for identifying and grouping the accessions into 6 different categories for various characters. These groups were unique for the valuable attributes of yield, dry matter content and starch content which could serve for selection process.

Keywords: cassava, genetic diversity, clustering, germplasm, morphology

INTRODUCTION

Cassava contributes to ensure the food security of poor rural communities, it is necessary to use the morphological tools to characterize different accessions with respect to their nutritional and quality traits. Little is known about the genetic variability in nutritional and quality traits of the roots (Chavez et al. 2005) since the crop grows well under harsh conditions, and such areas are increasing worldwide (El-Sharkawy 2004), this issue should not be overlooked.

Comparative studies of different dissimilarity matrices, as well as hierarchical clustering methods, have been conducted to identify the appropriate approach for genetic diversity assessment in many crops, including sweetpotato (Andrade, 2017), switchgrass (Cortese, *et al.*, 2010), and maize (Meyer *et al.*, 2004), but not fully covered for nutritional qualities in cassava. The objective of this study was to assess the genetic diversity of cassava genotypes for nutritional qualities using morphological data.

MATERIALS AND METHODS

Forty (40) diverse cassava genotypes including three (3) checks from National Root Crops Research Institute (NRCRI) were established in this experiment. They were laid out in randomized complete block design with three replications. The plot size was 0.8 x 5m with 25cm cuttings of genotypes planted on ridges at an interspacing of 1m by intraspacing of 0.8m. The trials were established in 2022/2023 cropping seasons. In order to identify the yield performance in cassava genotypes, storage roots from each plant genotype were sampled or harvested at 12 MAP. The following cassava storage root traits were measured: total root weight; number of root; fresh root yield (FRYD), harvest index (HI), dry matter content (DMC), and starch content (SC). In order to account for the variance components, analysis of variance was carried out for all the traits. Statistics were analyzed using the lme4 package in R statistical software and GenSTAT 12 Edition software for other meta-analyses, such as Principal component analysis (PCA) and diversity analysis.

RESULTS

Quantitative characteristics of 40 cassava genotypes in Nigeria

Table 3 provides the quantitative evaluation of the characteristics of the 40 cassava genotypes. The result of the selection index revealed that NR050667, NR100451, Nwageri, AR145, IITA-TMS-MM990477 and NR100216 were all better than the national checks: TMEB419, NR8082 and TMS30572. The value of the dry matter content across the genotypes ranged from 25.08 – 42.94% with the highest dry matter content (42.94%) recorded for Nwageri, followed by NR100451 (34.83%) while the least dry matter content was recorded for TMS63397. The value of the fresh root yield across the genotypes ranged from 5.58 – 28.15 with the highest fresh root yield (28.15ton/ha) recorded for AR145, followed by

TMS63397 (25.65ton/ha) while the least fresh root yield was recorded for NR090088. The value of the Harvest Index across the genotypes ranged from 0.37 – 0.71 with the highest Harvest Index (0.71) recorded for AR145, followed by IITA-TMS-ZAR950633 (0.68) while the least Harvest index was recorded for NWAGERI. The value of the plant height across the genotypes ranged from 113.33 – 210.33 with the highest plant height (210.33) recorded for NR100451, followed by NR050667 (202.00) while the least plant height was recorded for TMS050752. The value of the Root number across the genotypes ranged from 3.68 –7.13 with the highest root number (7.13) recorded for NR110337, followed by IITA-TMS-ZAR950633 (6.84) while the least fresh root yield was recorded for B150. The value of the starch content across the genotypes ranged from 9.09 –32.88 with the highest starch content (32.88) recorded for NWAGERI, followed by NR090088 (26.64) while the least starch content was recorded for TMS63397

Table 1: Quantitative characteristics of 40 cassava genotypes in Nigeria at 12 months after planting.

Code	Genotype	DMC (%)	FRYD (ton/ha)	HI	PLTHT (cm)	RTNO	SC (%)	Is	Rank
1	NR050667	30.84	17.35	0.64	202.00	6.00	21.20	1668.29	1
2	NR100451	34.83	11.03	0.41	210.33	4.96	22.07	1666.47	2
3	NWAGERI	42.94	5.58	0.37	164.00	5.20	32.88	1521.82	3
4	AR145	29.68	28.15	0.71	151.00	4.65	19.66	1515.00	4
5	IITA-TMS-MM990477	31.18	10.60	0.58	193.67	5.34	17.21	1512.80	5
6	NR100216	31.98	20.40	0.62	163.33	5.04	18.28	1492.53	6
7	TMEB419	30.72	18.01	0.60	165.00	5.48	16.60	1450.77	7
8	TMS13F1060P0014	28.26	15.08	0.60	172.33	6.00	13.32	1408.90	8
9	IITA-TMS-ZAR950633	30.91	19.63	0.68	149.00	6.84	16.85	1400.94	9
10	TMS961432	25.66	21.33	0.66	164.33	5.50	9.86	1393.19	10
11	NR11083	32.52	21.72	0.63	136.33	6.82	19.00	1392.24	11
12	B150	29.75	13.35	0.53	164.67	3.68	15.31	1365.58	12
13	NR100235	27.39	11.70	0.59	174.00	6.32	12.17	1361.97	13
14	TMS13F2110P0002	28.90	20.74	0.68	148.33	4.04	14.17	1359.42	14
15	TMS13F2077P0003	28.56	9.28	0.54	174.33	6.33	13.73	1356.16	15
16	TMS13F1332P0015	28.71	18.49	0.58	150.33	6.54	13.92	1350.83	16
17	TMS13F1160P0004	27.78	11.26	0.60	168.67	4.55	12.68	1328.42	17
18	AR9-46	31.03	9.97	0.57	155.00	7.31	17.01	1318.85	18
19	TMS982123	29.32	19.92	0.63	139.00	4.89	14.74	1314.81	19
20	TMS920326	28.11	12.26	0.62	158.67	5.77	13.12	1302.85	20
21	NR8082	29.53	17.26	0.67	142.00	4.54	15.02	1300.24	21
22	AR182	30.37	21.10	0.60	128.33	4.77	16.14	1294.52	22
23	NR100329	29.82	14.94	0.62	143.67	5.69	15.41	1291.65	23
24	TMS13F1336P0011	29.89	8.28	0.59	158.33	4.99	15.49	1282.55	24
25	ADEBERECHI	25.39	15.22	0.63	156.67	5.10	9.51	1274.46	25
26	B515	33.72	7.35	0.47	143.33	5.82	20.59	1271.25	26
27	TMS011206	32.17	12.88	0.59	135.33	6.16	18.53	1271.05	27
28	TMS970211	30.25	12.35	0.58	143.67	5.09	15.98	1265.28	28
29	TMS13F2110P0017	31.70	11.69	0.60	138.00	6.20	17.91	1261.73	29
30	TMS30572	31.43	14.74	0.52	131.33	4.99	17.55	1253.47	30
31	TMS050303	26.39	15.97	0.61	146.00	5.93	10.84	1252.86	31
32	COB477	30.75	13.95	0.37	136.00	5.22	15.52	1245.88	32
33	NR090088	38.26	5.28	0.42	122.33	4.40	26.64	1218.82	33
34	NR110337	33.97	9.45	0.38	127.33	7.13	19.80	1218.13	34
35	TMS63397	25.08	25.65	0.67	119.67	6.10	9.09	1213.98	35
36	TMS070602	28.99	19.81	0.66	114.33	6.21	14.29	1190.66	36
37	B519	31.31	7.67	0.53	125.00	5.36	17.39	1136.59	37
38	NR110372	31.25	7.01	0.40	126.33	5.35	17.31	1133.44	38
39	TMS050752	28.53	15.97	0.61	113.33	6.24	13.69	1131.03	39
40	W940006	25.52	12.09	0.55	115.00	5.40	9.67	1031.89	40

DMC = Dry matter content, FRYD = Fresh root yield, HI = Harvest Index, PLTHT = Plant Height, RTNO = number of Root, SC = Starch Content, Is = Selection Index

Result of the Clustering Analysis

Figure 4.2 showed the clustering of the 40 genotypes with respect to their similarities and differences across the traits.

From the result, there were 6 clustering showing that those genotypes within a cluster are similar while characteristics between clusters are different from each other. Genotypes labels are represented in the Appendix 1.

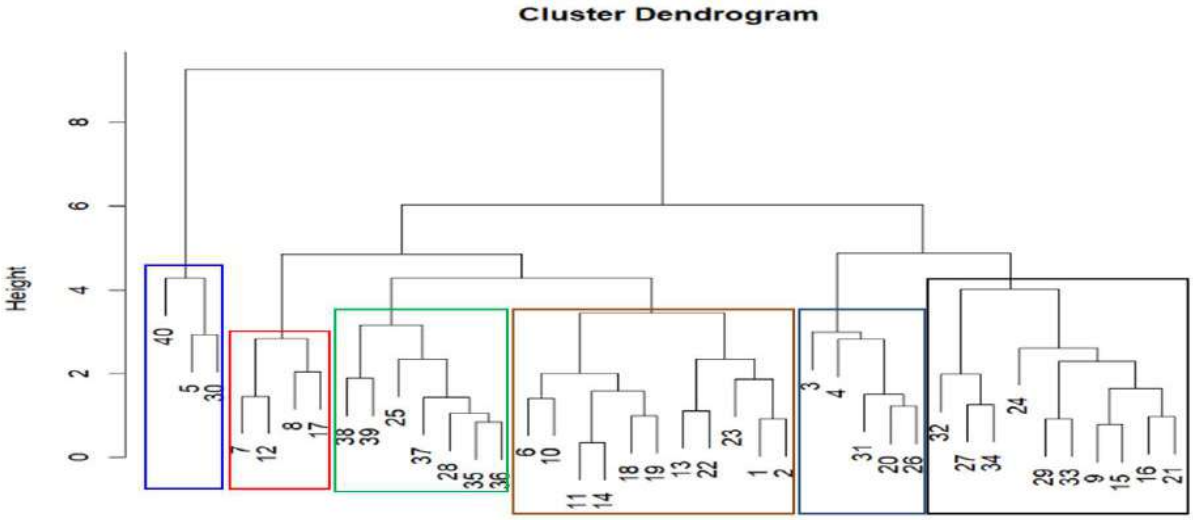

Figure 1 Clustering analyses of the 40 genotypes using Dendogram

DISCUSSION

The current study, aimed at highlighting the variations and identify germplasms for plant breeding and also to make available of superior cassava genotypes for farmers Quantitative characteristics of 40 cassava genotypes in Nigeria at 12 months after planting, shows the evaluation of the characteristics of the 40 cassava genotypes, the values of the dry matter content, fresh root yield, plant height, number of root, harvest index and starch content were showed and the values where ranged from the least to the highest in this study and this kind of similar result were obtained also by Diaguna, *et al.,* 2022. With regard to the performance of individual genotypes with respect to each trait showed that these sixe superior genotypes selected were best in one trait to others. Which implies the genotypes could also be selected based on their specific performance for a particular trait of interest..

From the result on clustering analysis, there were 6 clustering showing that those genotypes within a cluster have similar characteristics while characteristics between clusters are different from each other. This simply implies that these similar genotypes could be used for the same purpose or aim and they share similar functions. The current findings are similar to other findings (Ampong-Mensah, 2000; Fregene *et al.,* 2000; Carvalho and Schaal, 2001; Elias *et al.,* 2001; Raghu *et al.,* 2007) who used stem girth, tuber length, tuber girth, yield per plant, tuber attachment on parent cuttings, tuber inner skin color, tuber outer skin color, tuber surface texture and pulp color and yield for genetic diversity studies in cassava.

CONCLUSION AND RECOMMENDATION

The present investigation observed significant variations among the cassava genotypes from different background for nutritional qualities. The ranking analysis showed the superior genotypes as NR050667, NR100451, NWAGERI, AR145, IITA-TMS-MM990477, and NR100216 which need to be selected during yield improvement process. Diversity studies using dendogram analysis generated six clusters and revealed the existence of diversity among the selected genotypes. Based on the observed results, superior genotypes from the study can be utilized for the initial steps in the cassava breeding programme

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Sub-Theme Three
Climate Smart Agriculture, Adaptations and Technology for Food Sufficiency

8th Annual Conference and 67th AGM-ABEOKUTA of The Association of Deans of Agriculture in Nigeria Universities (ADAN), Held at The FUNAAB Red Senate chamber, Abeokuta, Ogun State, Nigeria, from July 7th to 11th, 2024. Theme: Climate Change: Agricultural Innovations and Bio-entrepreneurship for Sustainable Development, Food Sufficiency and Economic Transformation. **Edited by:** A. E. Obayelu, O.M Olosunde, P. B. Abdulsalam-Saghir, O.S. Sowande, E.O. Fakoya and J.J. Atungwu

BLUE ECONOMY AND THE ECOLOGICALIZATION OF PORTS AS RESPONSIBLE INNOVATIVE MEANS OF CLIMATE CHANGE MITIGATION

OGUNSUSI, K.
Department of Forestry, Wildlife and Environmnetal Management, Olusegun Agagu University Of Science And Technology, Okitipupa
EMAIL: k.ogunsusi@oaustech.edu.ng

ABSTRACT
Ports are strategic to national economic and social development, but are however faced with aggravating challenges and pressure which are further compounded by climate change. To reduce these challenges, governance and ports management must pursue rapid national economic and social development through sustainable development of ports using innovation as the driving force. This can be achieved through the construction of green ports to reduce the environmental impact of maritime operations and enhance the sustainability of port activities. The subject matter of an ecological port, therefore, is to find a balance point between environmental, social impacts and economic interests.
Keywords: Blue economy, climate change, ecologicalization, green ports, innovation, sustainability

INTRODUCTION
Ports within the blue economy development framework are important infrastructure and strategic resources in the economic and social development of nations. The blue economy contributes to climate change mitigation through the development of renewable energies on the high seas, the decarbonization of maritime transport, and ecologicalization of ports. Ports and coastal ecosystems are sources of resources and processes which benefit mankind in the forms of food, construction materials, and alternative energy resources, opportunities for industries, transport, and tourism. Regulatory processes of ports and coastal ecosystems include coastal protection, carbon sequestration, water quality regulation and temperature regulation. The non-material benefits include recreation, research and education, cultural heritage and exchange and aesthetic value. Ports and coastal cities also offer supporting ecosystem services as they provide habitat for animals and plants.

Ports and delta cities like Lagos port are, however, environments where high resource depletion, pollutant emissions and human population density are concentrated. This constitutes a real challenge regarding reducing pressures like contamination, sewerage, land reclamation, construction and dredging, regulation of water levels and shipping on the environment and society. These activities can hitherto cause physical alterations of the port environment, which subsequently can lead to problems such as unnaturally high sedimentation rates or a decrease in fish migration opportunities. Due to climate change and the associated (enhanced) sea level rise, the pressure on ports and delta cities will further increase. In the low-carbon economy era, the concept of Green Port development has become the important field of sustainable development in the world transportation today due to the occurrence of abnormal global environmental change. A Green Port or an ecological port is a sustainable development port, which meets the environmental requirements, and also raises their social and economic interests.

Objectives: The objectives of the study are to review the:

i. Process of transforming green port into a responsible innovation port
ii. Attribute characteristics of green port
iii. Sustainable criteria for green ports

METHODOLOGY
Qualitative research methodology was adopted for this study. Secondary data was collected through literature search. Aspects of green port development were qualitatively discussed.

RESULTS AND DISCUSSION
Green Port Development and Its Transformation into Responsible Innovation Port
The concept of sustainable port development effort is to construct a green port which is aimed at solving the challenges in ports and delta cities in such a way that ecological, economic and societal benefits are combined. Green port can for example contribute to reducing the ecological

footprint of port infrastructures, while developing (new) ports (e.g. by enhancing the nursery function for fish), and can be applied to reduce flood risk and improve sediment management (e.g. by creating natural slopes, enhancing wave attenuation, optimising dredging strategies and flow patterns). Additional benefits include the creation of attractive, green living environments within the densely populated cities as "more and more port cities across the world seem to consider a reorientation and sustainable port development projects" (Wang *et al*., 2020). The question then is whether a green port can be transformed into a responsible innovation port. In understanding the concept of responsible innovation, there are at least three kinds of understanding within this concept that were reviewed –

i. **Responsible innovation in America:** Responsible innovation lays particular emphasis on its real impact in the process of technology innovation, including the stakeholders' effective participation, choices, evaluation, supervision and management in America.

ii. **Responsible Research and Innovation (RRI) in Europe:** Responsible research and innovation (RRI) refers to the comprehensive approach of proceeding in research and innovation in ways that allow all stakeholders that are involved in the processes of research and innovation at an early stage, (a) to obtain relevant knowledge on the consequences of the outcomes of their actions and on the range of options open to them; (b) to effectively evaluate both outcomes and options in terms of societal needs and moral values; and (c) to use these considerations (under (a) and (b)) as functional requirements for design and development of new research, products and services in Europe. The RRI approach has to be a key part of the research and innovation process and should be established as a collective, inclusive and system-wide approach" (Winke *et al*., 2016).

iii. **Scientific and technological innovation in China:** Scientific and technological innovation is the strategic support for enhancing social productivity and comprehensive national strength, and must be placed at the core place of national development" (Arduino *et al*., 2011). It also stressed the need to adhere to the path of independent innovation and implementation of innovation-driven development strategies in China.

The first two definitions of responsible innovation that emanated from America and Europe were mostly concerned with rapid economic growth. The third definition of responsible innovation shows that the Chinese government was, however, not only concerned with rapid economic growth through port, but also pursued this within the context and goal of sustainable development using innovation as the driving force. Sustainable development in port can then be pursued via environmental protection which is mainly reflected in the construction of a green port, which takes energy conservation and emissions reduction as their contents.

Attribute Characteristics of Green port

Through rational utilization of resources, ports can achieve environmental protection by deepening the understanding of the three attributes of economy, society and environment.

1) **Economic attribute:** The economic attribute is the basic index in the evaluation index system of green port, which can fully reflect the economic development level of a port. The characteristics of port economic benefits can be drawn from the indexes of port GDP, profit and tax ratio, input output ratio, etc.

2) **Society attribute:** On the premise of ensuring proper economic development, social attribute of port include promotion of regional social development as well as the employment of the population in the port area and improving the quality of the population near the port area.

3) **Environment attribute:** In essence, the development of green port is resource-efficient and environment-friendly. Resource-efficiency involves conservation of energy, land, coastline and materials, while the environment-friendliness involves objects such as atmosphere, water, sound and ecology.

Sustainable Criteria for Green Ports

Proposed sustainable criteria for green ports are presented in Table 1.

Table 1: Sustainable Criteria for Green Ports

Economic benefit	Port GDP
	Investment profit rate
	Input-output ratio
Social efficiency	Cargo throughput
	Passenger throughput
	Port employment
Ecological environment	Qualified rate of wastewater discharge
	Air quality qualification rate in harbor area
	Qualified rate of noise pollution in port area
	Marine ecological protection
	Biological system preservation
	Low-carbon and energy-saving management
	Green degree of port area
	Establishment of green port organizational management

CONCLUSION

Green port strategy is a comprehensive approach to reduce the environmental impact of maritime operations and enhance the sustainability of port activities. It involves implementing various measures to improve energy efficiency, reduce emissions, manage waste, protect biodiversity, and promote social responsibility. The Nigerian government can hitherto borrow a leaf from the Chinese government for ecologicalization of its ports.

It is therefore, recommended that empirical study be carried out on economic, societal and environmental benefits and criteria for sustainable green port development in Nigeria.

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ENHANCING CLIMATE RESILIENCE: ASSESSING CLIMATE-SMART AGRICULTURAL PRACTICES AMONG ARABLE CROP FARMERS IN ONDO STATE, NIGERIA

Oyebode L. A
Department of Agricultural Economics and Extension, Olusegun Agagu University of Science and Technology (OAUSTECH), Okitipupa, Ondo state, Nigeria.
la.oyebode@oaustech.edu.ng (+234- 8067405322)

ABSTRACT
Climate-smart agricultural practices enhance productivity when deployed to mitigate the effects of climate change. In light of the above, the study assessed the knowledge and utilization of climate-smart agricultural practices for mitigating the effects of climate change by arable crop farmers in Ondo state, Nigeria. A total of eighty-six arable crop farmers were sampled using a multi-stage sampling procedure. A significant proportion (65.7%) of the respondents was knowledgeable of climate-smart agricultural practices. Planting of drought-resistant variety ($\bar{x}$ = 1.78), integrated cultivation of trees along with crops on farmland ($\bar{x}$ = 1.78), and mulching ($\bar{x}$ = 1.68) ranked highest as practices utilized. Significant and positive relationship (r=0.544, p= 0.000) between respondents' knowledge of climate-smart agricultural practices and utilization of the practices. The sustenance of knowledge transfers of climate-smart agricultural practices and other related practices to enhance productivity is advocated as its utilization is guaranteed
Keywords: Arable crop farmers, knowledge, utilization, and climate-smart agricultural practices

INTRODUCTION
Agriculture activities are closely dependent on climatic factors, hence climatic changes experienced affect these activities. (Food and Agriculture Organization, 2020). Integrating the effects of climate change on agricultural development planning is therefore a major challenge as climate change would likely leave many more farmers vulnerable to poverty. Moreover, the effects of climate change such as temperature increases, irregular and variable rainfall patterns, flooding of riverbanks, drought and desertification, more frequent extreme weather events, and loss of biodiversity have further affected the productivity of smallholder farms.

The concept of Climate Smart Agriculture (CSA) offers a suite of approaches for transforming and reorienting agriculture systems to support food security in the face of climate change, by focusing on the potential synergies and trade-offs between agricultural productivity and food security, adaptive capacity, and mitigation benefits (Campbell *et al*.,2014). In addition, there is the need to move beyond small incremental changes, there is also a need to move from working with small numbers of farmers to achieving outcomes among large portions of the farming population, in efficient and effective ways. Agriculture in Nigeria must undergo a major transformation in the coming decades to meet the intertwined challenges of achieving food security, reducing poverty, and responding to climate change without depletion of the natural resource base.

Climate-smart agriculture includes proven practical techniques like; mulching, intercropping, conservation of agriculture, crop rotation, integrated cop-livestock management, agro-forestry, improved grazing, and improved water management. It aims to "sustainably increase agricultural productivity and incomes, build resilience and capacity of agricultural and food systems to adapt to climate change, and reduce or remove greenhouse gases while enhancing national food security". The objectives of the study were to:

(i) ascertain the respondents' knowledge of climate-smart agricultural practices;
(ii) examine the respondents' utilization of climate-smart agricultural practices.

METHODOLOGY
The study was carried out in Ondo state, Nigeria. The target population for the study was arable crop farmers in the State. Multi-stage sampling procedure was used to select the respondents. The first stage involved the purposive sampling o Akoko and Ondo Agricultural Development Project (ADP) Zones out of the four present in the state acknowledging them as clusters of arable crop farmers. The second stage involved the random sampling of fifty percent (50%) of the blocks in each of the zones sampled. The third stage involved the random sampling of fifty

percent (50%) of the cells in the zones earlier sampled. The final stage involved the random sampling of thirty percent (30%) of the farmers across the cells sampled. In all a total of eighty-six (86) arable crop farmers were selected for this study. Knowledge of smart climatic agricultural practices was measured using knowledge statements of tests. The correct responses were assigned a score of 1 and 0 for the incorrect statements. A knowledge index was calculated by categorizing it into knowledgeable and unknowledgeable. Respondents' utilization of smart climate agricultural practices was measured on a 12-item with a response format of always (2), occasionally (1) and never (0) respectively. The mean scores was used to isolate practices utilized. Both descriptive (frequency, percentage and mean) and inferential statistics (Pearson Product moment Correlation) of the Statistical Package for Social Sciences (SPSS 24) analysis software were used to analyze the data.

RESULTS AND DISCUSSION

Knowledge of Climate-smart agricultural practices

Many (65.7%) of the (Figure 1) respondents were knowledgeable of climate-smart agricultural practices. Their knowledge of the practice is attributable to their exposure of these practices over time. It is acknowledged that the impact of climate change on the productivity of the farmers will have been felt. Hence, they would have explored avenues to seek the knowledge of sustainable practices for mitigating the effect of climate change.

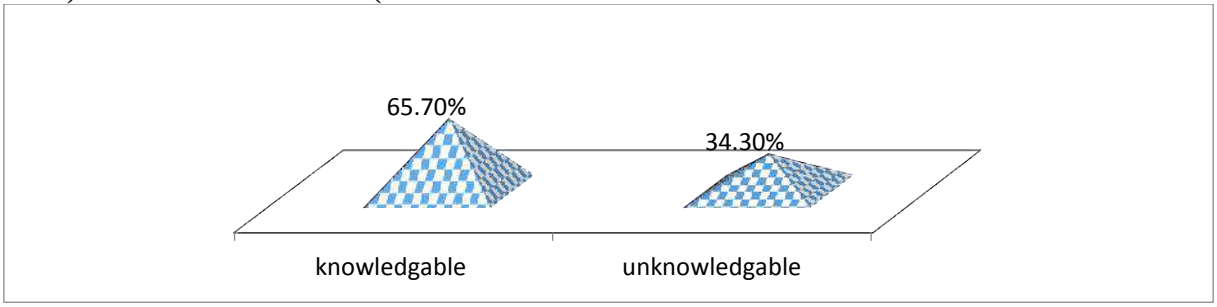

Figure 1: Knowledge of climate-mart agricultural practices
Source: Field Survey, 2023

Utilization of Climate-Smart Agricultural Practices for mitigating the effects of climate change

As shown in Table 2, the planting of drought-resistant variety ($\bar{x}$ = 1.78), integrated cultivation of trees along with crops on farmland ($\bar{x}$ = 1.78), and mulching (x □= 1.68) ranked highest as practices utilized. The mitigating effects observed and their productivity are attributable to their enhanced utilization of these practices. Similarly, (Naswem et al. 2016) attest that the foremost strategy adopted by farmers to deal with climate change was to plant drought-resistant varieties. Also acknowledged as practices utilized were planting of disease-resistant varieties ($\bar{x}$ = 1.64), planting of pets resistant varieties ($\bar{x}$ = 1.49) and the use of drip/sprinkler erosion ($\bar{x}$ = 1.38). According to Tiamiyu et al. (2017) the adoption of CSAPs included climate-smart approaches such as planting of drought tolerant and early maturing varieties, application of organic compost, use of cultural practices such as intercropping and crop rotation, composting rather than burning, and erection of terraces on sloppy/hilly farmland.

Table 2: Utilization of Climate-Smart Agricultural Practice for mitigating the effects of climate change

Climate-smart agricultural practices	Mean
Intercropping	1.57[a]
Planting of drought-resistant varieties	1.78 [a]
Planting of disease-resistant varieties	1.64 [a]
Planting of pest-resistant varieties	1.49 [a]
Crop rotation	1.02
Farm yard manure	1.04
Green manure	0.64
Zero tillage	1.32
Drip/sprinkler erosion	1.38 [a]
Mulching	1.68 [a]
Construction of terrace on hilly/sloppy farmland	0.64
Integrated cultivation of tress along with crops on farmland	1.78 [a]

Source: Field survey, 2023.
[a]: Climate smart practices utilized

Relationship between knowledge and utilization of climate smart practices

Data reveal that there was a significant and positive relationship (r=0.544, p= 0.000) between respondents' knowledge of climate-smart practices and utilization of the practices. This suffices that their knowledge of the practice enhanced its deployment. The plausible reason for this relationship is ascribed to their exposure to the attributes of these practices in the past hence, they have established its effectiveness, thus utilizing the practices.

Table 2: Relationship between knowledge and utilization of climate smart practices

Variable	r	p
Knowledge and utilization of climate smart practices	0.544	0.000

Source: Field survey, 2023.

CONCLUSION AND RECOMMENDATION

The study concludes that the arable crop farmers in Ondo state have knowledge of climate-smart practices for mitigating the effects of climate change. Planting of drought-resistant varieties and integrated cultivation of trees along with crops on farmland were climate-smart agricultural practices utilized most. A relationship was also established between arable crop farmers' knowledge of climate-smart agricultural practices and their utilization of these practices. The sustenance of knowledge acquisition of climate-smart agricultural practices and other related practices to enhance productivity is advocated as its utilization is guaranteed.

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FACTORS INFLUENCING UTILIZATION OF HERBICIDES AMONG CASSAVA FARMERS IN OKITIPUPA LOCAL GOVERNMENT AREA OF ONDO STATE

Owombo P. T.
Department of Agricultural Economics and Extension, Olusegun Agagu University of Science and Technology, Okitipupa, Ondo State
Corresponding author: owombopaul@gmail.com

ABSTRACT
This study investigates factors influencing utilization of herbicides among cassava farmers in Okitipupa Local Government Area of Ondo state, Nigeria. A 2-stage sampling procedure was used to select one hundred and twenty cassava farmers. Information was elicited on the socioeconomic characteristics of farmers, herbicides adoption, and other associated variables with the aid of structured questionnaire. Data obtained were analyzed using descriptive statistics and logistic regression model. The results revealed that most of the cassava farmers were male, with low access to credit and extension. Age and education of farmers and farm size were significant determinants of herbicides utilization. Efforts geared towards cassava farmers' access to education and raising farm size are advocated.
Keywords: Adoption, herbicides, cassava, farmers.

INTRODUCTION
Cassava *(Manihot esculenta crantz*) is an important world food security because it is widely adapted to marginal soils and irregular rainfalls conditions,that ordinarily limits most conventional crops (Adjebeng and Kantanka, 2013). Weed is a major factors limiting the yield of crops, cassava inclusive (Asipazu *et al*. 2010). The challenge becomes enormous if weeds are poorly managed. Weeds contribute to low yield of characteristics crop in terms of size, weight and number of roots (Adjebeng and Kantanka, 2013)
The predominant weeds control practices among smallholder famers is hand and hoe weeding because of the size of holdings (Adjebeng and Kantanka, 2013). The use of hand and hoe weeding takes 50-80 percent of labour budget in cassava production in Nigeria (IITA, 2014). IITA (2014) stressed that hand and hoe weeding makes cassava production labour intensive, such that weeding one hectare of requires about 500 hours of labour where the women and children are risk of this job. In addressing the labour intensive nature of weed control in cassava production as well as the high cost of weed control, cassava farmers adopted the used of herbicides. Herbicides are agrochemicals used to manipulate or control undesirable vegetation (U. S EPA (2023). Herbicides are broadly classified into selective and non-selective, where selective is one that kills weeds leaving valuable plants while non-selective is one that kills all vegetation in an area.
Herbicides use reduces labour, time, and cost of production as well as raises cassava crop yield (IITA, 2020). Despite the advantages of the use of herbicides over hand and hoe weeding, the use is low among smallholder farmers (Ajah, 2023). The study was therefore conducted to investigate the herbicides used as well as socioeconomic factors influencing adoption of herbicides in the study area.

RESEARCH METHODLOGY
Study area
The study was carried out in Okitipupa Local Government Area of Ondo state, Nigeria. Ondo state is made up of 18 local government areas and it is located in the south western zone of Nigeria. The state lies between longitudes 4"30" and 6" east of the Greenwich meridian, 5"45" and 8"15" north of the equator. This means that the state lies entirely in the tropics. It is bounded in the north by Ekiti/Kogi state, in the east by Edo state, in the west by Oyo and Ogun state and in the south by the Atlantic Ocean. The climate is tropical with two distinct seasons viz the rainy season (April-October) and the dry season (November-March). Cassva is a major arable crop grown in the area.
Sampling procedures
A 2 – stage sampling procedure was employed for the study. In the first stage, six cassava producing villages were selected purposively. In the final

stage, twenty cassava farmers were selected using simple random sampling technique. A total of 120 respondents were selected for the study. Data for the study were from primary source. Primary data were collected with the aid of self-designed structured questionnaire. Data were collected on socio-economic variables of cassava farmers, farm size and herbicides utilization, among others.

Method of data analysis

Data was analyzed using descriptive statistics and binary logistics regression model.

Descriptive statistics

Descriptive statistics such as simple percentage, frequency, mean and standard deviation were used to summarize socioeconomic characteristics of respondents.

Binary logistic regression model

The binary logistic regression model assumes that the underlying stimulus (Ii) is a random variable which predicts the probability of farmers adopting herbicides.

$$P_i = \frac{e^{Ii}}{1+e^{Ii}}$$

Conceptually, the behavioral model employed to examine factors influencing utilization of herbicides among cassava farmers in Okitipupa was given by

$$Y_i = g(I_i)$$

$$I_i = b_o + \bullet\, b_j X_{ji}$$

Where, Yi is the observed response for the i respondent, Y =1, for adopter, Y = 0, for non-adopter. Ii is an underlying stimulus index for the i observation (Generally, there is a critical threshold {I *} for each respondent, if I < I *, the farmer is observed to be non-adopter and if I > I *, the farmer is observed to be adopter; g is the functional relationship between the field observation (Y) and the stimulus index (I) which determines the probability of herbicide adoption).

Empirical model specification

The probability of herbicide adoption (DA) is expressed as a function of socioeconomic factors. It is represented as follows:

0.02. This implies that just about 2 percent of the respondents had access to extension visits. The mean home-farm distance was 5.1±1.7km.

$DA = f(X, X\ldots X) + gi$

The general model of herbicides adoption in the study area is

$P_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \mu_i$

Where

P_i = adoption (1 = yes, 0 = No) X_1 = Age of the farmers (year)

X_2 = Education (years) X_3 = Education of spouse (year)

X_4 = Farming experience X_5 = Household size

X_6 = Farm size (hectare) X_7 = Credit (dummy)

X_8 = Extension visit (absolute) X_9 = Home-farm distance (km)

RESULTS AND DISCUSSION

Summary statistics of respondents

The study examines the socioeconomic characteristics of the respondents in the study area (Table 1). The results in the table showed that the mean age of the farmers was 55±15.2 years. The implication of this is that the farmers were in their active ages. The mean of the sex of respondents was 0.69±0.3. This implies that that 69 percent of the cassava farmers in the area were male. The mean year of education was 12.4±4.1 years. This showed that an average cassava farmer in the area had secondary school education. The mean year of education of respondents' spouses was 8.3±2.7 years. This implies that the respondents' spouses only completed primary education. The mean year of farming experience was 31±7.7 years. The implication of this is that the farmers have put decades into farming as an occupation. The mean household size in the area 6±2.1. This implies that an average household in the area had six members, hence, had access to family labour. The mean size of cassava farm was 17±1.1 hectare. This implies that cassava farming enterprise in the area is being operated at very small scale. The mean credit access among the respondents in the area was 0.06. This implies that just 6 percent of the respondents had access to credit in the study area. The mean number of extension visit was

This implied that cassava farmers in the area travelled distances to their farms.

Table 1: Summary statistics of respondents

Variables	Mean ± Std Dev.
Age (year)	55±15.2
Sex (dummy)	0.69.±0.3
Education of respondents year)	12.4±4.1
Education of spouse (year)	8.3±2.7
Farming experience (year)	31±7.7
Household size (year)	6±2.1
Farm size (hectare)	1.7±1.1
Credit access (dummy)	0.06
Extension visit (absolute)	0.02
Home-farm distance (km)	5.1±1.7

Source: Field survey, 2023

Multiple responses

Herbicides used

Table 2 presents the results of herbicides used by cassava farmers in the study area. According to the table, majority of the respondents, 91.2% used Weedoff, 85.3% used Dragon, 50% used Sarosate, 79.4% used Force up, 35.3% used Para-force, while 35.3% used Uproot. This implied that the herbicides users used both contact and systemic herbicides.

Table 2: Herbicides used

Common name	Active ingredients	Frequency	Percentage
Force up	Glyphosate	27	79.4
Paraforce	Paraquat dichloride	12	35.3
Weedoff	Paraquat	31	91.2
Uproot	2,4-D aryloxyacids & triclopyr	12	35.3
Sarosate	Glyphosate	17	50
Dragon	Paraquat dichloride 276g	29	85.3

Source: Field survey, 2023

Socioeconomic factors influencing adoption of herbicides

Table 3 presents the logistic regression results model for the socioeconomic factors influencing adoption of herbicides among cassava farming households in the study area. The Log-likelihood and Wald values -113.69 and 13.436, respectively. These diagnostic parameters indicated the fitness of the model for the explanation of the socioeconomic factors influencing adoption of herbicides among cassava farmers in the study area. The results in the table showed that age of respondents, education level of household size, and farm size were positive determinants of herbicides adoption in the study area while household size and home farm distance were negative determinants of herbicides adoption in the study area. Age and level of education of household head were significant at 1 % alpha level. A rise in the age by a year would reduce probability of adoption by 1.3 % while and increase in the year of education by a year would raise probability of adoption by 2.2 %. Farm size and credit access were also significant at 5 % alpha level each. A rise in the farm size by a unit would raise adoption probability by 1 % while a rise in the amount of credit access by a unit would also raise probability of adoption by 2.1%.

Table 3: Binary logit results of socioeconomic factors influencing adoption of herbicides

Variable	Coefficient	Standard error	Sig	ME
Constant	1.313***	0.335	0.000	
X_1AGE	0.112***	0.042	0.008	0.013
$X_2EDUHEAD$	0.042***	0.012	0.000	0.022
$X_3EDUSPOU$	0.139	0.206	0.498	0.103
$X_4FARMEXP$	0.007	0.013	0.184	0.001
X_5HHSZ	-0.053**	0.027	0.037	0.011
$X_6FARMSZ$	0.118**	0.060	0.040	0.091
$X_7CREDIT$	0.033	0.115	0.023	0.202
X_8EXTEN	0.001	0.282	0.996	0.000
$X_9HMFARMDIS$	-0.021**	0.011	0.017	0.009
Log likelihood	-113.69			
Wald	13.436			
N	120			

Source: Field data analysis, 2023

CONCLUSION

The study concluded that herbicides use in the study area was low. Age of respondents, education of respondents and farm size were positive determinants of herbicides adoption.

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A LITERATURE REVIEW ON THE DETERMINANTS OF FOOD INFLATION AND THE LESSONS FOR NIGERIA

Osuagwu, C. O[1*] , Nzeh, I. C[1.] & Apeh C. C[3].
[1]Department of Agricultural Economics, University of Agriculture and Environmental Sciences Umuagwo, Imo State, Nigeria
[2]Department of Cooperative and Rural Development, University of Agriculture and Environmental Sciences Umuagwo, Imo State, Nigeria.
[3]Department of Agricultural Extension, University of Agriculture and Environmental Sciences Umuagwo, Imo State, Nigeria
***Corresponding Author**: E-mail: oliviakelechiosuagwu@gmail.com ORCID: 0000-0002-9549-480x Phone Number: +234-8033752012

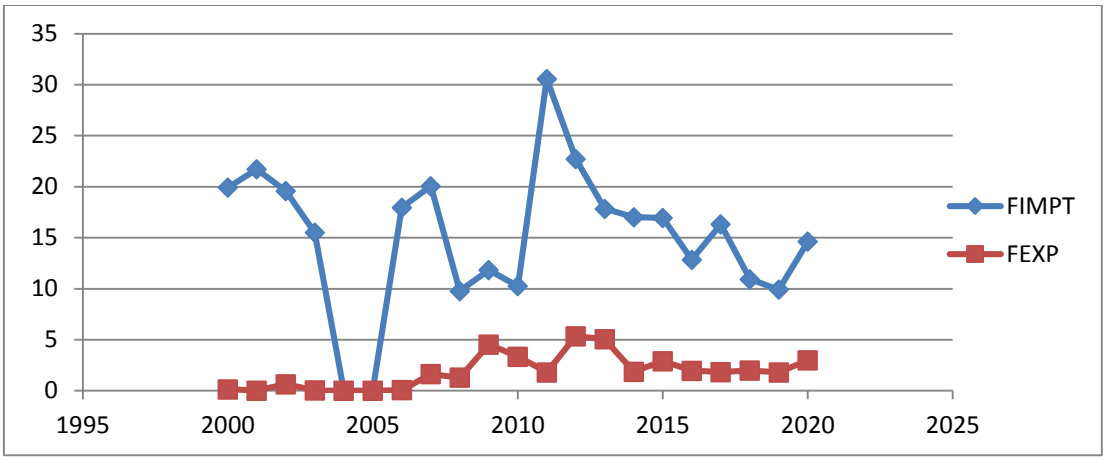
ABSTRACT
Food supply is very essential for the wellbeing of individuals. However, rising food prices which is a major issue in developing countries should give concern to policy makers. In this study, the focus was to carry out a review of literature on the factors that determine food inflation across different locations. This study is paramount as every country has its own peculiar factors that determine food inflation apart from the common factors. The study provided some graphical presentations of relevant variables in Nigeria. The study reviewed only papers that were peered reviewed and published in journals that are indexed in the Web of Science, Google Scholars and others. The findings from the review have shown that food inflation is a function of factors such as food import, money supply and food taxes which means that there is need for integrated policies to tackle them. In particular, policy makers in Nigeria are advised to intervene in the foreign exchange market to reduce the volatility in the naira exchange rate. This is to enable the country to import some basic foods to augment local supply in the short-run, while the long-run objective should be directed at improving food production using several measures.
Keywords: Agricultural productivity, exchange rate, food importation, food inflation

INTRODUCTION
The term food inflation is associated with the persistence rise in the price of majority of food items which make their access to be beyond the reach of low income earners (Egwuma, Ojeleye, & Adeola, 2017). The menace of rising food prices has become a major issue that calls for policy attention, especially by policy makers in developing countries. Sekhar, Roy and Bhatt (2017) observed that food inflation has strong impact on the welfare of the people, especially that of the poorer section of the society. The study went further to note that rising food prices has reduced the real income of those on fixed income such that they can hardly afford three square meals a day. So many factors have been identified in literature as the causes for rising food prices over the years. These factors such as food import, supply and demand for food and food taxes (Sekhar, *et al.* (2017; Ismaya & Anugrah, 2018) are mainly concerned with food supply in addition to other factors that enhance food movement from areas of production to areas of demand. In another vein, volatility in foreign exchange has been identified as another factor that influences food price, mainly imported food and agricultural inputs (Akinbode, Olabisi, Adekunle & Jimoh, 2021). Countries which import foods from abroad usually suffer food supply constraints if the local currency appreciates and that is the base of most developing countries.

The focus of this paper is to examine past literatures on the determinants of food inflation with a view to proffer solutions to rising food prices in developing countries, especially Nigeria. To appreciate the state of food production in Nigeria, stylized facts on some relevant variables are graphically presented in the study. This is necessary in the study as it is often said that pictures speak volumes.

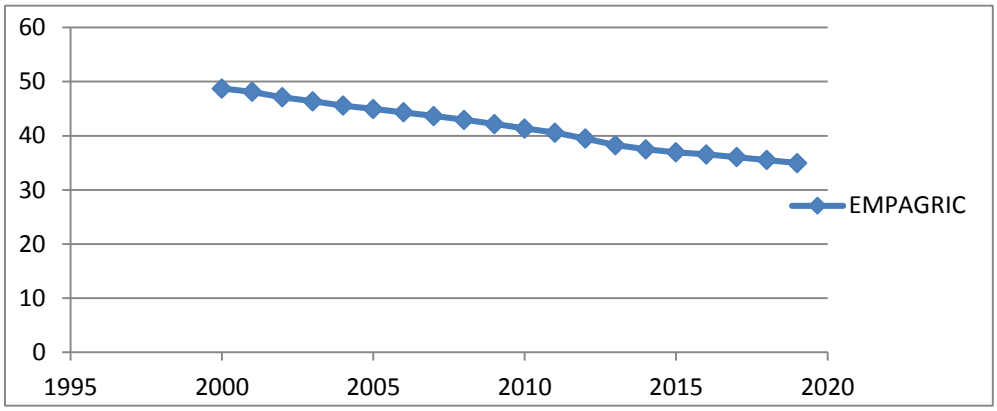
Trends in Food Import, Food Export, Employment in Agriculture, Urban and Rural Population in Nigeria

Nigeria is a net importer of food which is necessary to augment local food supply. Despite the abundance of arable land in Nigeria, the country still imports more than it exports. Figure 1 below shows that food import trended high while food export trended low within the sample period. The trend of food export was almost flat in all the periods, except in years such as between 2009 and 2012. However, all through the sample period, food import was high comparatively.



Note: FIMPT - food imports measured as a percentage of merchandise imports
FEXP- food export measured as a percentage of merchandise exports
Fig. 1 Trend in food import and export
Source: Authors' compilation

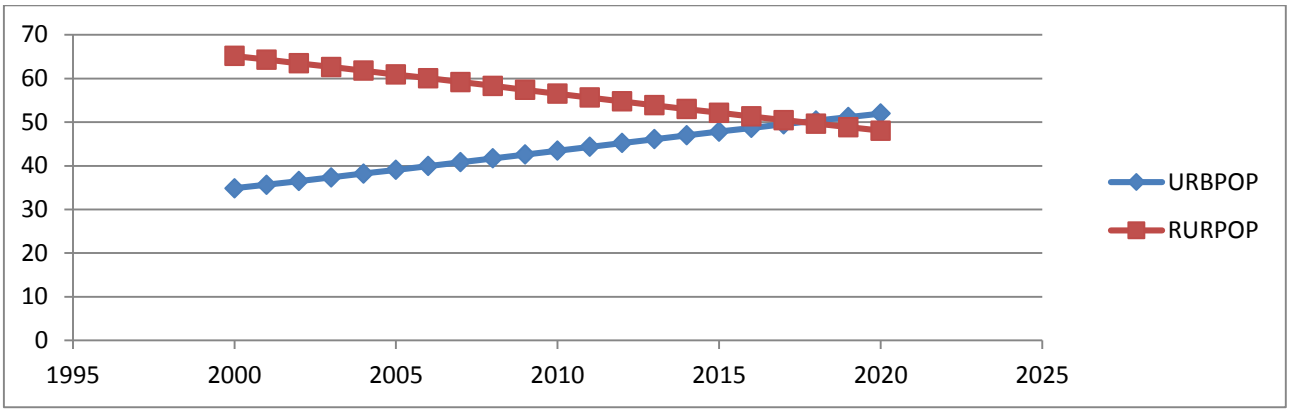
Figure 2 shows that the trend in employment in the agricultural sector was very low all through the study period. Such trend implies that the number of people who engage in agricultural activities is very few, thus accounting for part of the reasons why food production is low in the country.



Note: EMPAGRIC - employment in agriculture measured as a percentage of total employment
Fig. 2 Trend of Employment in Agriculture
Source: Authors' compilation

Apart from the fact that very few are engaged in food production, rural-urban migration, especially among the youths is equally a factor that contributes to low productivity of agricultural output. Figure 3 confirms the above assertion as it reveals that, while the trend in urban population is high, the trend of rural population is low. The implication of this skewed trend is that few hands

are available in the rural areas to engage in farming.



Note: URBPOP - urban population, RURPOP - rural population. All measured as a percentage of total population

Fig. 3 Trend in urban and rural population
Source: Authors' compilation

Figure 4 reveals that food inflation exhibited fluctuations within the sample period. Evidence shows that in October 2005, it trended high but descended to a trough in April, 2007. However, from 2008 it began to trend up but from 2011 through 2015 it trended very low. In May 2017 it got to a peak, descended from December 2017 and began to rise in 2019. In summary, volatility in food price is a phenomenon in Nigeria.

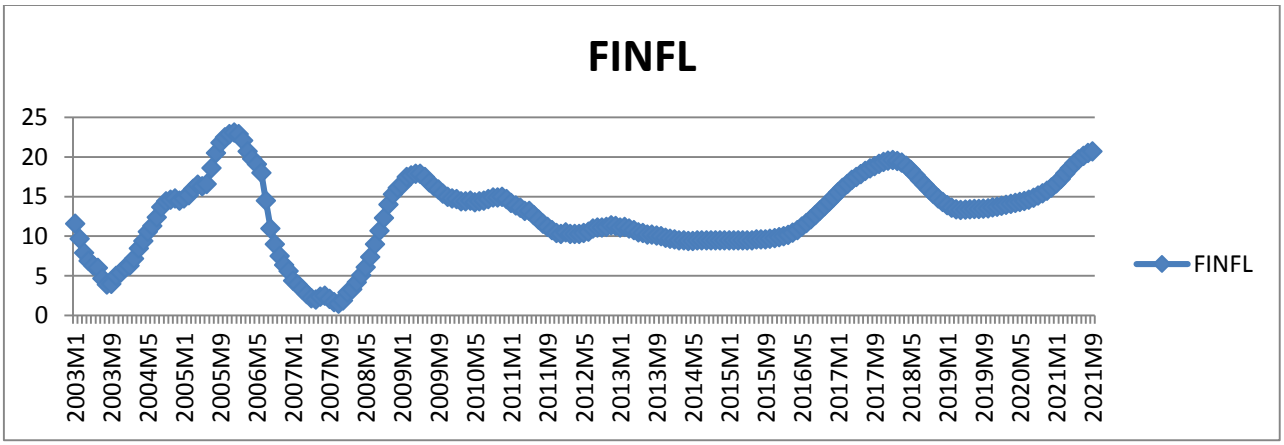


Fig. 4 Trend of Inflation in Nigeria
Note: FINFL = food inflation
Source: Authors' compilation

METHODOLOGY

The review paper covered the period from 2010 upward and the reason for the choice of the period was because of the aftermath of the world financial meltdown that occurred around 2008 which led to high inflation rate across many countries. The period of study also captured post COVID-19 pandemic period in which several countries adopted policies to reduce the effect of the pandemic. The review flowed chronologically and only papers that were peer-reviewed and published in journals that have international visibility and which focused on the determinants of food inflation were considered. In carrying out

the review on extant literature, this paper includes articles cited in papers indexed in the Web of Science, SCOPUS, Google Scholars and other indexing bodies with food inflation as the main keyword and which can be tracked through the digital object identifier.

REVIEW OF EXTANT LITERATURE ON THE DETERMINANTS OF FOOD INFLATION

Across different locations of the world, empirical researches have revealed several factors that influence food inflation. In Nigeria, Effiong and Eze (2010) used histogram and price index number to prove that the cause of food price inflation was continuous hike in the petroleum products prices in addition to poor agricultural sector performance. In Pakistan, Rehman and Khan (2015) revealed that while food exports and indirect taxes had positive and significant impact on food price inflation, the impact of GDP and government subsidy was negative. Other studies in Pakistan have equally identified taxes and food imports to fuel food inflation, while money supply reduced it. Agricultural value addition has also been identified to have significant and negative influence on food inflation. Another study for India by Sekhar *et al.* (2017) found that supply and demand for food items was the main drivers of food inflation volatility and that the level of inflation among the commodities differed. Furthermore, Egwuma, Ojeleye and Adeola (2017) revealed that food import, real GDP and crude oil price impacted on food price inflation positively in the long run in Nigeria. In Indonesia, Ismaya and Anugrah (2018) reveal that productivity in agriculture, food import, credit to the agricultural sector, output of the agricultural sector, seasonal events and demand level were the dominant determinants of food inflation. In Nigeria, Akinbode, *et al.* (2021) revealed that in the short-run exchange rate, crude oil prices, money supply and food production significantly impacted on food inflation, while in the long run only food production did not have significant impact on food inflation. This has been supported by other studies in the country which show that food import and real GDP impacted on food price inflation positively in the long run.

CONCLUSION

This paper set out to provide a review of literatures on the factors that lead to food inflation, reviewing papers that are published in peer reviewed journals. Food inflation has remained a phenomenon that needs urgent attention by the government and policy makers. Without tackling this menace, policies on poverty reduction will not have any effect on the people and achieving the sustainable development goals will not be possible. In this study, several factors have been revealed to be responsible for food inflation. Some of these factors include: exchange rate, crude oil prices, money supply and food production, food import, credit to the agricultural sector and seasonal events and demand level. Even though some of these determinants could be country-specific, there are still others that are very common such as productivity in agriculture and exchange rate for mainly food net importers. These findings definitely provide policy toolkits for countries that suffer food inflation to address the cankerworm. Specifically, a country like Nigeria which currently grapples with rising food prices is advised to handle exchange rate volatility with utmost care, especially in the short-run in order to encourage the importation of staple foods to augment the shortfall in local supply while the long-run plan should be to improve agricultural productivity using different strategies. These include incentivizing smallholder farmers and providing security in the agricultural communities.

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A REVIEW PAPER ON POLICIES TO COMBAT FOOD INSECURITY: WHAT ARE THE LESSONS FOR NIGERIA?

Nzeh, I. C[1*], Osuagwu, C. O[2].& Akalazu, E. C[3].

[1]Department of Cooperative and Rural Development, University of Agriculture and Environmental Sciences Umuagwo, Imo State, Nigeria.

[2]Department of Agricultural Economics, University of Agriculture and Environmental Sciences Umuagwo, Imo State, Nigeria.

[3]Department of Marketing, University of Agriculture and Environmental Sciences Umuagwo, Imo State, Nigeria

***Corresponding Author**: E-mail: nzechile@yahoo.com, innocent.nzeh@uaes.edu.ng ORCID ID: 0000-0002-3131-9036, Phone Number: +234-8034222084

ABSTRACT

The menace of food insecurity, especially in developing countries calls for policy interventions to curb its devastating effects on the wellbeing of the people. Policy actions in this direction are perhaps more relevant for a country like Nigeria where incessant rise in the prices of food items has of recent become hydra-headed. In this paper, effort was geared towards providing a review of extant literatures on the policies adopted to combat food insecurity. The review x-rayed different papers which address food insecurity using various policies. To ensure the review is robust, the paper provided conceptual definitions of the relevant terms that are associated with food security. In selecting the papers that are relevant to the study, the paper focused on the keywords such as food insecurity, food security, food availability, food affordability, food stability, food utilization, etc. Only peer-reviewed articles which are published in reputable indexed journals and which address food related issues were selected. The paper contended that Nigeria should consider the various policy options suggested in the papers reviewed in order to reduce the current rising menace of food insecurity in the country.

Keywords: Food affordability, food availability, food security

INTRODUCTION

The term food security was conceptualized by the Food and Agricultural Organization (FAO, 2006) as a condition, in which everyone at all times, both physically and economically, has access to sufficient, safe and nutritious food to meet their daily nutritional needs according to their preferences". The FAO noted four dimensions through food security can be viewed, namely: access, stability, utilization and availability. While the availability point of view looks at food security in terms of food supply, the access viewpoint considers food security from the angle of food price's affordability. On the opposite end, the FAO, the International Fund for Agricultural Development (IFAD) and the World Food Programme (WFP) have conceptualized food insecurity as a situation that exists when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life. In recent times also, the term nutrition security has gained traction as it lays emphasis on consistent access, affordability and availability of foods and beverages that enhance people's well-being (Mozaffarian, Fleischhacker & Andrés, 2021).

Nigeria and in fact the sub-Saharan African countries have been grappling with the scourge of poverty over the years which manifests in low income, food insecurity and malnutrition. As observed by the 2024 report by the Food and Agricultural Organization, by 2030, Africa's 1.67 billion inhabitants are expected to account for nearly 20 percent of the world's population. The report noted that the high inflation and the slow projected recovery in income levels suggest that population growth will remain the major driver of rising food consumption in the continent. There is therefore need for drastic efforts to ensure the ugly trends bedeviling the sub-Saharan African countries are put in check. In this study, the effort is to provide past literatures on policies to combat food security with the hope that countries bedeviled by food insecurity such as the current situation in Nigeria will take a cue from the suggested policy options from the reviewed papers.

Conceptual Issues

Food Insecurity: Food insecurity is the opposite of food security and it has been defined as the lack of access to sufficient quality and quantity of healthy nutrition food for an active and healthy life as well as the inability of households or individuals to meet the required consumption level in the face of fluctuating production, price and income (Maharjan & Chhetri, 2006). Food insecurity has been defined by the Expert Panel, 1990 cited in Peng and Berry (2019) as a situation that arises whenever the availability of nutritionally adequate and safe foods, or the ability to acquire acceptable foods in socially acceptable ways, is limited or uncertain**.** Food insecurity does not just affect the amount of food which is eaten but also influences food choice.

Food security: The FAO (1996) defined food security as a situation when all people at all time have physical and economic access to sufficient, safe and nutritious food for a healthy and active life. According to a currently accepted definition from the FAO, **f**ood security is achieved when it is ensured that all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life. According to Idrisa, Gwary and Shehu (2008), food security in a broad sense has to do with having at all times an adequate level of food and food products to meet increasing consumption demand to mitigate fluctuation in output and price. Seen from another angle, Oriola (2009) contended that food security entails producing food that will go round every citizen both in quality and quantity. Food is here defined as any substance that people eat and drink to maintain life and growth. As a result, safe and clean water is an essential part of food commodities. Food security can be seen through four dimensions. Four dimensions of food security have been identified according to the definition by FAO (2008) and they include: availability, access, utilization, and stability as can be seen in Figure 1 below.

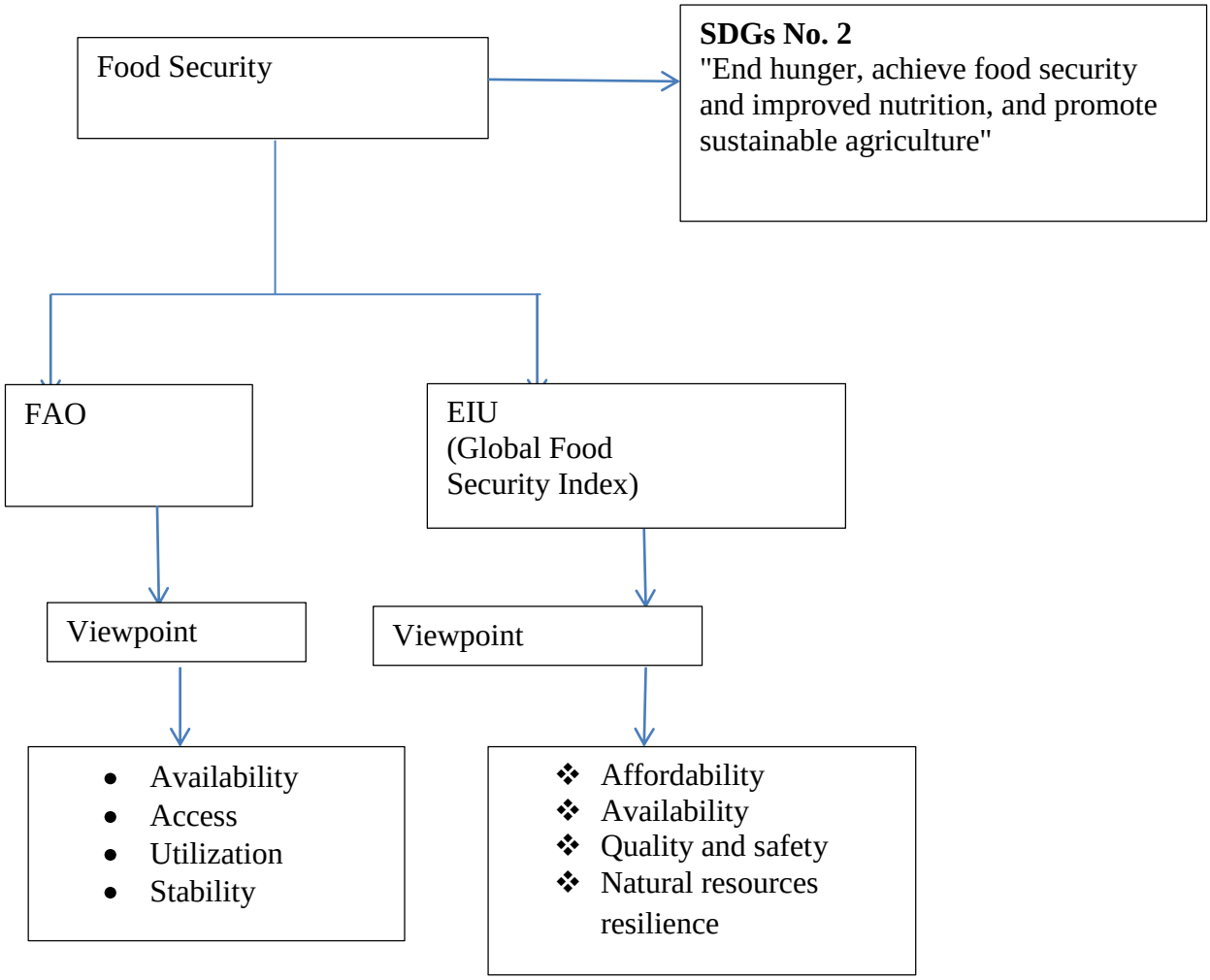

Figure 1 Food Security Concept from Food and Agriculture Organization (FAO) and Economist Intelligence Unit (EIU).
Source: Fernandes and Samputra (2022)

Food Access is ensured when all households and all individuals within those households have sufficient resources to obtain appropriate foods for a nutritious diet. It is dependent on the level of household resources such as capital, labor, and knowledge – and on prices.

Food Utilization refers to the socio-economic aspect of household food security. If sufficient and nutritious food is both available and accessible the household has to make decisions concerning what food is to be purchased, prepared and consumed (demanded) and how the food is allocated within the household.

Food Stability or sustainability refers to the temporal dimension of nutrition security i.e. the time frame over which food security is being considered. In much of the food security literature, a distinction is made between chronic food insecurity - the inability to meet food needs on an ongoing basis - and transitory food insecurity when the inability to meet food needs is of a temporary nature.

METHODOLOGY

The review of extant literature followed a chronological order, that is from earlier studies to later studies. This study only considered studies that were peer-reviewed and published in the English language. The study included only studies that contained the terms: food security, food affordability and food availability in any part of the study, such as the title, abstract, keywords or the main text. In carrying out the review on extant literature, this paper includes articles cited in papers indexed in SCOPUS, Google Scholars and other indexing bodies with food security as the main keyword. Also considered as a criterion for the choice of the papers included in the review is the citation counts of the articles reviewed obtained from the SCOPUS and Google Scholars data bases, thus ensuring that the papers reviewed have visibility.

REVIEW OF EXTANT LITERATURES ON FOOD SECURITY POLICIES

To achieve food security, some scholars have suggested diverse policy frameworks. Cheng (2007) was of the view that there is need for policies that will not lead to the likelihood of undernutrition and micronutrient deficiency as a result of measures that target obesity. For instance, a policy to increase the price of an "unhealthy" food (e.g. red meat) could reduce access to its healthy components (e.g. protein, calcium and iron). In another dimension, Haggblade, Hazell and Reardon (2010) suggested that measures to strengthen the rural non-farm economy should be implemented with a focus on strategies to address the effects of inequities in assets and capacities across households and communities. The study equally suggested for measures to strengthen technical and organizational capacities of farmer organizations, direct institutional demand for quality food (e.g. from school feeding programmes) towards smallholders, and provide coordination and linkage support to key supply chain service providers would be beneficial, ideally reinforced by improved incentives for financial institutions to expand rural footprints and lending to farmer organizations and rural. Moreover, it contended that to overcome constraints on entry and participation in high-volume, high-quality markets for foods and complementary goods and services, measures should be adopted to strengthen technical and organizational capacities of farmer organizations as well as direct institutional demand for quality food (e.g. from school feeding programmes) towards smallholders. Also, there is need to provide coordination and linkage support to key supply chain service providers through improved incentives for financial institutions to expand rural footprints and lending to farmer organizations and rural agrifood SMEs.

In Nigeria, the Anchor Borrower Programme was initiated in 2015 which aimed at diversifying the economy towards agricultural sector, driven by small scale farmers to enhance local production of maize, rice, cassava and wheat. A study by

Ayinde, Fatigun, Ogunbiyi, Ayinde and Ambali (2016) recommended that the governments must intervene with subsidized lending since most borrowers in rural areas are small farmers who are poor. The study was of the view that low cost credit responds to poverty alleviation considerations. In another respect, Adamu and Kalgo (2019) recommended that there is the need to assign professional supervisors that should first supervise the intended lands to be cultivated by the farmers so as to give the farmers professional advices on the type of crops to plant in order to avoid seeds failing problem. It further recommended that the Anchor Borrowers' Programme (ABP) should boost and encourage irrigational farming to ensure efficient and constant food production in Nigeria. To address gaps in access to key commercial technology and capital for farmers and rural agrifood SMEs, institutional innovations (including public-private partnerships) to share risk and de-risk lending to rural agrifood SMEs should be prioritized.

From another dimension, Wdrammeh, Hamid and Rohana (2019) contended that women's empowerment projects should be prioritized to enhance their economic status. The study was of the view that since women spend their income in the household, when women's situation improves, there will be a likely decline in poverty, an increase in food production and an improvement in nutrition. In a study carried out to evaluate cassava productivity in Nigeria, Agbaeze, Ohunyeye, Obamen and Ibe (2020) recommended that for cassava to play a major role in Nigeria's national development, government must ensure that there is a full exploration of all opportunities that have the potential to yield strong advantage. This could be achieved through a holistic assessment of the cassava process that is geared toward improving the quality of life and well-being of citizens based on Nigeria's comparative advantage in cassava production and processing. Avery (2021) suggested a host of policy choices to address the problem of food security. These include: subsidizing healthier foods, taxing foods and drinks providing empty calories, providing incentives for the production of traditional nutrition-rich staples, influencing healthier food choice through accessible nutrition labeling and nutrition education, and providing subsidized healthy meals at nurseries, schools, in the workplace, and at luncheon clubs might be some potential solutions.

CONCLUSION

In this study, extant literatures on the policies to address food insecurity are reviewed. The review has revealed diverse policy options available for countries battling with food insecurity. These policy measures are perhaps of more relevant to Nigeria as the country currently suffers acute food insecurity which manifests mainly in high food prices. It is hoped that by adopting the policies suggested in the papers reviewed, the menace of food insecurity could be reduced. In particular, rural development through the provision of key infrastructure holds the key for improved food productivity as it will stem the tide of rural-urban migration. Moreover, women empowerment is vital to improve food productivity, mainly at the subsistence level.

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AWARENESS AND PERCEPTION OF AGRO-TRAINEES ON CLIMATE CHANGE IN FEDERAL UNIVERSITY OF AGRICULTURE ABEOKUTA, OGUN STATE, NIGERIA

[1]Joshua, Y., [1]Fapojuwo, O. E., [1]Ayodeji A. O., [1]Alabi, O. S. & [2]Ogunjinmi, K.O.
[1]Department of Agricultural Administration, College of Agricultural Management and Rural Development, Federal University of Agriculture, PMB 2240, Abeokuta, Nigeria.
[2]Department of Agricultural Extension and Rural Development, College of Agricultural Management and Rural Development, Federal University of Agriculture, PMB 2240, Abeokuta, Nigeria
Corresponding Author: joshuay@funaab.edu.ng +2348039526718

ABSTRACT
The study examined the awareness and perception of agro-trainees to climate change in Federal University of Agriculture Abeokuta (FUNAAB)**,** Ogun State, Nigeria. Simple random sampling technique was used to select 50% (150) out of 300 agro-trainees for the study. A structured questionnaire was used to obtain data and analyzed using frequency counts, percentages, means, standard deviation and Pearson Product Moment Correlation (PPMC). The results show that 94.0% of the agro-trainees were aware of climate change. Respondents perceived that planting crops ($\bar{x}$=3.55), water management to prevent water logging and erosion ($\bar{x}$=3.55), and construction of drainage channels ($\bar{x}$=3.55) were effective climate change adaptation strategies. There was a significant relationship between the respondents' awareness and their perception on climate change ($r = 0.45$, $p<0.05$). This study concluded that most agro-trainees had favorable perception of climate change. Therefore, agro-trainees should learn more from university lecturers about the potential impacts of unmanaged climate change, as well as options for adaptation and mitigation, in order to enable a complete and robust understandi*g.*
Keywords: Awareness and Perception, Agro-Trainees, Climate Change.

INTRODUCTION
In the context of environmental policy especially in recent times, climate change has always been causing noticeable variation in environmental and atmospheric compositions, (The Inter-governmental panel on climate change (Adekunmi, 2022). Any appreciable alteration in the earth's climate that lasts for a long period of time is referred to as climate change. It is an increase in average global temperatures. Natural events and human activities are conceived to be associated with climate change. Climate change is one of the most severe problems facing farmers in this present day and seems to be too severe than the threat of terrorism, affecting not only the sustainable development of socio-economic and agricultural activities of any nation but also threatening the complete human existence. It is clearly evident that farm families are among the most threatened by climate change and surging populations in Nigeria because they rely solely on rain-fed agriculture; they often operate with scanty financial resources and have little or no access to credit facilities, Adekunmi (2022). In addition to existing challenges, the impacts of climate change are making farm households more vulnerable. It can impact millions of people in the country (Lübke, 2022). Unfortunately, most developing and under-developing countries are still in the denial stage of climate change grief (Jylhä *et al*, 2021). It becomes pertinent therefore, to investigate into the next generation knowledge of climate change impact as a measure for creating awareness of the problem. This is so because proper environmental education and awareness can help eliminate and overcome environmental problems in the future. Research conducted by Joshua and Christopher (2019) on awareness and Attitude Towards Climate Change of Selected Senior High Students in Philippines found out that students had low level of awareness and attitude towards climate change. Assessing students' awareness and perception on environmental issues will help to understand students' scientific literacy which is considered an important asset for developing responsible decision-makers that will promote sustainable development in the future. Therefore, the study investigated awareness and perception of agro-trainees on climate change in Federal University of Agriculture Abeokuta Ogun State, Nigeria. Specifically, the study: describe the personal

characteristics of the respondents; determine the respondents' level of awareness regarding climate change and determined the perception of the respondents on climate change.

H_{01}: There is no significant relationship between the agro-trainees' awareness and their perception on climate change.

RESEARCH METHODOLOGY

Survey research design was adopted for this study; the area of the study was Federal University of Agricultural Abeokuta, Ogun state, Nigeria. The research study, focused on three (3) major agricultural colleges in the institution, because they are agriculture (50%) random sampling technique was used to select 150 respondents for the study. A structured questionnaire was used for data collection and were analyzed using percentages, means, standard deviation and inferential statistics such as Pearson product monument correlation (PPMC).

RESULTS AND DISCUSSION

Personal characteristics: Table 1 presents the personal characteristics of the respondents. The results indicated that most (82.0%) of the agro-trainees were below 25 years, with a mean age of 23 years. This implied that this range of agro-trainees are young and expected to be energetic to carry out their farming duties effectively. Over half (52.0%) of the respondents were female. This implies that female gender is important in influencing and raising general climate change awareness in the family (Joshua and Christopher, 2019). Results also revealed that most (92.0%) of the respondents were single. This is expected because they are agricultural students still in tertiary institution, this implies that they don't have any family responsibility which gives them opportunity to learn more about climate change. Furthermore, 49.3% of the respondents had CGPA within 3.50-4.49 (second class upper) and 36.0% had between 2.50-3.49 (second class lower). CGPA may have effects on the awareness and perception of climate change as the brilliant ones could read wide on the topic.

Table 1: Frequency Distribution of Respondents' Personal Characteristics (n=150)

Variables	Frequency	Percentage (%)	Mean	Std. d.
Age			**23**	**2.36**
≤ 23	86	57.3		
24 – 25	37	24.7		
26 – 27	16	10.7		
28+	11	7.3		
Gender				
Male	72	48		
Female	78	52		
Marital status				
Single	138	92		
Married	12	8		
CGPA			**3.69**	**0.62**
≤ 2.49	2	1.3		
2.50 - 3.49	54	36		
3.50 - 4.49	74	49.3		
4.50 - 5.00	20	13.3		

Source: Field Survey, 2022

Respondents' Awareness Level on Climate Change

Table 2 presents the awareness of respondents on climate change. Respondents reported that climate change is dynamic over time ($\bar{x}$=3.54), Damage to the ozone layer causes climate change ($\bar{x}$=3.37), burning fossil fuels causes climate change ($\bar{x}$=3.28) and climate change can cause more floods and drought ($\bar{x}$=3.26). However, people can help stop climate change by using more renewable resources of energy ($\bar{x}$=3.32), and planting more trees ($\bar{x}$=3.13). This implies

that respondents are generally aware of climate change. Overall, 94.0% of the respondents have high level of awareness on climate change. The quality of climate change awareness is very important as this affects the behaviour, quality of response and reactions of people. Improving climate literacy and understanding of climate change are vital to promote public engagement, support for climate action and literacy (Lee *et al*., 2015). The role of educational institutions in promoting awareness on climate change is vital. The formative years of high school education is very important as students have the capacity to mold the society into being climate change literate. However, there are still students who do not have enough knowledge and awareness towards climate change.

Table 2: Awareness level of respondents on Climate Change

Statements	EA	MA	SA	NA	$\bar{x}$	STD.D
Climate is dynamic and is always changing through time	100(66.7)	34(22.7)	13(8.7)	3(2)	3.54	0.74
Climate does not mean the same thing as weather.	95(63.3)	30(20)	19(12.7)	6(4)	3.43	0.86
Damage to the ozone layer causes climate change.	81(54)	48(32)	16(10.7)	5(3.3)	3.37	0.81
People can help stop climate change by using more renewable resources of energy.	83(55.3)	40(26.7)	19(12.7)	8(5.3)	3.32	0.89
Climate in weather condition over an extended period is climate change.	80(53.3)	43(28.7)	18(12)	9(6)	3.29	0.9
Burning fossil fuels causes climate change.	83(55.3)	36(24)	21(14)	10(6.7)	3.28	0.94
Climate change can cause more floods and drought	84(56)	35(23.3)	17(11.3)	14(9.3)	3.26	0.99
People can help stop climate change by planting more trees	72(48)	41(27.3)	22(14.7)	15(10)	3.13	1.01
Cutting down trees causes climate change.	72(48)	37(24.7)	21(14)	20(13.3)	3.07	1.08
More garbage/waste causes climate change.	61(40.7)	50(33.3)	23(15.3)	16(10.7)	3.04	1
Acid rain causes climate change.	58(38.7)	51(34)	29(19.3)	12(8)	3.03	0.95
Climate changed for millions of years.	69(46)	31(20.7)	31(20.7)	19(12.7)	3.00	1.09
Climate change can cause polar ice caps and glaciers to melt.	51(34)	46(30.7)	38(25.3)	15(10)	2.89	0.99
Climate change comes with rise in sea level.	41(27.3)	39(26)	47(31.3)	23(15.3)	2.65	1.04
People can help stop climate change by using more electricity.	34(22.7)	38(25.3)	33(22)	45(30)	2.41	1.14

Source: Field Survey,2022. Extremely Aware (EA); Moderately Aware (MA); Slightly Aware (SA); and Not Aware (NA).

Figure 1: Level of awareness on climate change

Respondents' Perception on Climate Change

Table 3 shows the perception of respondents on climate change. Results revealed that respondents perceived that the climate is changing ($\bar{x}$=4.55) as there is observed changes in temperature ($\bar{x}$=4.25). Temperature is rising ($\bar{x}$=4.22) as there is shift in the months of rainy seasons ($\bar{x}$=4.19) and decrease in the volume of rainfall in the last few years ($\bar{x}$=4.04). This leads to change in planting dates ($\bar{x}$=4.06), increase in pest and disease outbreak ($\bar{x}$=3.89) and reduction in plant and animal species ($\bar{x}$=3.81). They perceived higher occurrence of floods ($\bar{x}$=3.89), and more severe than in the past ($\bar{x}$=3.73), due to rise in sea

level ($\bar{x}$=3.68). These findings align with those of Oruonye (2011) and Falaki *et al*., (2013) who reported that temperatures were rising in most parts of Nigeria.

Table 3: Perception on Climate Change

Statements	SA	A	U	D	SD	$\bar{x}$	Std.d.
I perceive that climate is changing	104(69.3)	31(20.7)	10(6.7)	3(2)	2(1.3)	4.55	0.82
There is observed changes in temperature	73(48.7)	52(34.7)	18(12)	4(2.7)	3(2)	4.25	0.91
Temperature is rising	74(49.3)	45(30)	23(15.3)	6(4)	2(1.3)	4.22	0.94
There is shift in rainy season's months	71(47.3)	50(33.3)	18(12)	8(5.3)	3(2)	4.19	0.98
There is change in planting dates due to climate change	62(41.3)	57(38)	16(10.7)	8(5.3)	7(4.7)	4.06	1.08
There is decrease in the volume of rainfall in the last few years	71(47.3)	39(26)	18(12)	19(12.7)	3(2)	4.04	1.13
There has been higher occurrence of floods	63(42)	40(26.7)	23(15.3)	15(10)	9(6)	3.89	1.23
There is increase in pest and disease outbreak	54(36)	49(32.7)	27(18)	16(10.7)	4(2.7)	3.89	1.1
There is reduction in plant and animal species	52(34.7)	52(34.7)	20(13.3)	18(12)	8(5.3)	3.81	1.19
Flood is more severe than in the past	52(34.7)	45(30)	27(18)	12(8)	14(9.3)	3.73	1.27
There is rise in sea level	54(36)	36(24)	28(18.7)	22(14.7)	10(6.7)	3.68	1.28

Source: Field Survey, 2022

Strongly Agree (SA); Agree (A); Undecided (U); Disagree (D); and Strongly Disagree (SD).

Test of Hypothesis

There is no significant relationship between the awareness of respondents on climate change and their perception on climate change. The hypothesis was tested using Pearson Product Moment Correlation (PPMC). Table 4 revealed a significant ($p<0.05$) relationship between the respondents' awareness and their perception on climate change (r =0.45). This implies that the more the agro-trainees are aware of climate change the favourable their perception towards climate change adaptation.

Table 4: Result of Test of relationship between agro-trainees' awareness on climate change and their perception

Variables	R	p-Value	Decision
Relationship between the awareness of respondents on climate change and their perception on climate change	0.45	0.00	S

Source: Field Survey, 2022 S = Significant

CONCLUSION

This study concludes that most of the respondents had favourable perception of climate change because they perceived climate to be changing as there is observed changes in temperature is rising due to shift in rainy season's months and the major causes of climate change perceived by the respondents were ozone depletion, bush burning and natural cause.

RECOMMENDATIONS

Societies should stop climate change by using more renewable resources of energy and planting more trees, they should also stop burning fossil fuels which is a cause of climate change, stop Cutting down trees causes climate change, use more of electricity and gas for cooking.

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PERCEIVED EFFECT OF CLIMATE VARIABILITY AND ADAPTATION STRATEGIES AMONG CASSAVA BASED FARMERS IN IDO LOCAL GOVERNMENT AREA OF OYO STATE

Ayodeji, O.O.[1]*, Oni, T. S[1]., Fadeyi, O. J. [2] and Ezekiel, E. O. [3]

[1]Agricultural Economics and Environmental Policy Programme, Centre of Excellence in Agricultural Development and Sustainable Environment, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

[2]Institute of Food Security, Environmental Resources and Agricultural Research, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

[3] Department of Agricultural Economics and Farm Management, Federal University of Agriculture Abeokuta, Ogun State, Nigeria.

*Corresponding authors' email: abiolaoo@funaab.edu.ng

ABSTRACT

This study explores the perceived effects of climate variability and adaptation strategies among cassava farmers in Ido Local Government Area of Oyo state. The research was conducted using primary data collected through questionnaires. A multi-stage sampling technique was employed to select a total of 135 cassava farmers from the study area. Descriptive statistics, adaptation index and ordered logit regression model were used to analyze the data. The findings of the study reveal that respondents face various challenges due to climate variability. The major challenges encountered in cassava production were outbreaks of diseases, increased pest attacks, soil erosion, nutrient loss, and crop failure. Various adaptation techniques were adopted by the farmers with the majority (84.4%) of them adopting soil erosion control as their major technique. The result of the ordered logit regression indicates that factors such as farm size ($p<0.05$), education ($p<0.05$), and income ($p<0.05$) significantly influenced the level of adoption of adaptation strategies. It is therefore recommended that the government should subsidize the cost of agricultural technologies for the poor farmers in order to afford them the opportunity to be able to increase their adoption of these technologies. Also, extension agents should provide training for the farmers through on farm demonstration of some of these technologies in order to enhance their knowledge and increase their level of adoption of adaptation strategies.

INTRODUCTION

Climate variability can be referred to as the difference from the statistical average of climate over a given period of time (Olatunde et al., 2013). It is one of the most serious challenges to Africa's agriculture sector and food security due to its sensitivity and vulnerability to temperature and rainfall changes (Mangaza *et al.*, 2021). Cassava (*Manihot esculenta*), the third-most significant source of calories in Africa's tropical and subtropical regions, has been under the threat of climate change-related events influencing agriculture (FAO, 2020). For instance, changes in extreme weather events, such as temperature increases, changes in precipitation patterns, changes in relative humidity, windstorms, etc., have been reported to reduce the yield of cassava production (Ajala and Ajetomobi, 2020). Also, reduced rainfall shrivels cassava tubers that are growing in the soil, causing deterioration and a decrease in size and market value. Furthermore, rainfall increases spawn a variety of pests and diseases that heavily consume cassava leaves, lowering the photosynthetic activity of cassava plants. Several studies have examined the effects of climate variability on cassava production in Nigeria. However, very few empirical studies have research into the specific challenges faced by cassava farmers in Oyo state. Thus, this study aims to contribute to existing knowledge by examining the effect of climate variability on cassava production as well as exploring the various adaptation strategies adopted by the cassava farmers in the study area.

MATERIAL AND METHODS

Study Area

The study was carried out in the Ido Local Government area of Oyo State

Sample size and sampling procedure

A multi-stage sampling procedure was employed in selecting 135 respondents. Stage 1 involved the purposive selection of three high cassava producing wards in Ido Local Government (Ward 3, Ward 4, Ward 10). The second stage involved the random selection of three villages from each of these wards to give a total of 9 villages while the final stage involved the purposive selection of fifteen (15) cassava farmers from each village to give us a total of 135 respondents.

Method of Data Collection

Primary data was used by means of well-structured questionnaires.

Methods of data analysis

Descriptive statistics, adaptation index and ordered logit regression model were employed to analyze the data collected. Following Farid et al. (2015), the adaptation index is specified as:

$$\text{Adaptation index} = \frac{number\ of\ practices\ adopted}{Total\ number\ of\ adopting} \times 100\%$$

Where respondents whose scores were ≤ 49 percent were classified as low adopters, between 50% - 80% were regarded as medium adopters and respondents whose scores were ≥ 80% were referred to as high adopters of the agricultural technologies.

Results and Discussion

Perceived effects of climate variability on cassava yield

Table 1 revealed that the major consequences of climate variability in cassava production were disease incidence (72.6%), soil erosion (68.1%), and increased incidence of pest attacks (66.7%), amongst others. These findings align with previous research conducted by (Iseyemi et al., 2023).

Table 1. Perceived effects of climate variability on cassava production

Perceived effects	Frequency	Yes
Decreased crop yield	78	57.8
Increased crop failure	84	62.2
Disease incidence	98	72.6
Nutrient loss	81	60.0
Soil erosion	92	68.1
Reduced biodiversity	89	65.9
Increased incidence of pests' attack	90	66.7
Increased water logging condition	73	54.1
Total	135	100.0

Field Survey, 2023

Adaptation Strategies of Climate Variability

The result of Table 2 revealed that the most adopted adaptation strategies employed by the cassava farmers were soil erosion control techniques (84.4%), planting of improved cassava varieties (81.5%), organic fertilizer application (79.3%), delayed harvesting (74.8%), and soil and water conservation techniques (73.3%).

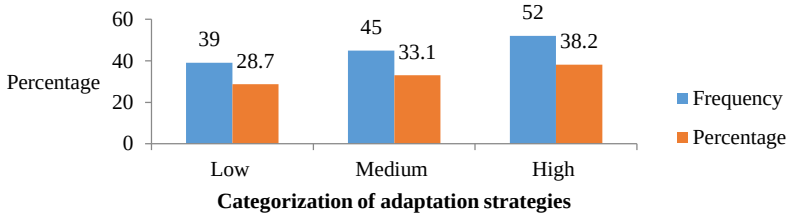
Table 2. Adaptation Strategies of Climate Variability

Adaptation Strategies	Frequency	Adopters (%)	Rank
Crop rotation and intercropping	88	65.2	8th
Improved cassava varieties	110	81.5	2nd
Integrated pest management	88	65.2	8th
Inorganic fertilizer application	81	60.0	9th
Organic fertilizer application	107	79.3	3rd
Soil and water conservation techniques	99	73.3	5th
Agroforestry	98	72.6	6th
Irrigation	88	65.2	8th
Soil erosion control	119	84.4	1st
Minimal tillage	98	72.6	6th
Delayed planting date	91	67.4	7th
Delayed harvesting date	101	74.8	4th
Total	135	100.0	

Field survey, 2023

Level of adoption of adaptation strategies employed by cassava farmers

Figure 1 shows that approximately 38.2% of the respondents are classified as high adopters of these strategies, with around 33.1% falling into the medium adopter category. In contrast, the remaining 28.7% are characterized as low adopters of adaptation strategies.



Field survey, 2023

Factors that influence the levels of adoption of adaptation strategies among cassava farmers

The coefficient values of farm size, education and income collectively explain factors affecting farmers' choices of adaptation strategies. From Table 3, it can be revealed that having a small farm size ($p<0.05$), low level of education ($p<0.1$), and low income ($p<0.05$) can increase the likelihood of the cassava farmers adopting few adaptation strategies. Also, being educated ($p<0.05$) and income ($p<0.05$) can significantly increase the likelihood of adopting a moderate to high number of adaptation strategies in the study area.

Table 3: The Marginal Effects of the Ordered Logit Regression

	Adopters categories					
Variables	Coef. (y = 0)	SE	Coef. (y=1)	SE	Coef. (y=2)	SE
Sex	0.0035	0.0750	0.0007	0.0157	0.0042	0.0907
Age	0.0269	0.0415	0.0057	0.0099	0.0327	0.0506
Marital status	0.0143	0.0590	0.0030	0.0128	0.0174	0.0717
Farm size	0.0741**	0.0302	0.0008	0.0065	0.0049	0.0367
Education	0.0508*	0.0269	0.0128 **	0.0055	0.0162	0.0293
Income	1.02e-06**	0.0000	2.20e-07**	0.0000	1.24e-06**	0.0000
Farming experience	0.0077	0.0070	0.0016	0.0018	0.0094	0.0085
Member in a cooperative society	0.0730	0.0888	0.0146	0.0198	0.0876	0.1054
Extension contact	0.0923	0.0847	0.0227	0.0276	0.1151	0.1086
Credit	0.0268	0.0839	0.0057	0.0180	0.0325	0.1015

Field survey, 2023. ***= significant at 1%, ** =significant at 5% and *= significant at 10% respectively where y = 0, 1 and 2 = low, medium, and high adopters respectively, y= categories of adopters

CONCLUSION AND RECOMMENDATIONS

Based on the findings of this study, it can be concluded that the incidence of pests and disease, soil erosion, reduced biodiversity and crop failure were the major perceived consequences of climate variability on cassava production. Also, soil erosion control, planting of improved cassava varieties and application of organic fertilizers were the most adopted adaptation strategies by the cassava farmers. Furthermore, farm size, educational level and income were the significant factors positively influencing the farmers' level of adoption of various adaptation strategies. Thus, it can be recommended extension agents should provide training for the farmers through on-farm demonstration of some of these technologies in order to enhance their knowledge and increase their level of adoption of these adaptation strategies. Furthermore, due to income constraints by small-scale cassava farmers, the government should subsidize the cost of agricultural technologies for the poor farmers in order to afford them the opportunity to be able to adopt these modern technologies.

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FACTORS INFLUENCING THE LEVEL OF ADOPTION OF LOW CARBON PRACTICES AMONG RICE FARMERS IN SOUTHWEST, NIGERIA

Oni T. S.*[a], Obayelu A. E.[b], Ashaolu[c], O. F. & Aydeji O. O. [d]

[a and d] Department of Agricultural Economics and Environmental Policy, Centre of Excellence in Agricultural Development and Sustainable Environment, Federal University of Agriculture Abeokuta, Nigeria.
[b and c] Department of Agricultural Economics and Farm Management, Federal University of Agriculture Abeokuta, Nigeria.
Corresponding Author: oni.temitopes@pg.funaab.edu.*ng*

ABSTRACT
This study examined the factors influencing the level of adoption of Low Carbon Practices (LCPs) in Southwest, Nigeria. A cross-sectional data were collected from 577 rice farmers. Descriptive statistics, Adoption quotient and ordered logit regression model were used for data analysis. Results indicated that most of the respondents were male (81.5%), married (92.0%), had between 7 to 12 years of formal schooling (47.0%). The average age of the respondents was 45 years, while the average size of household was of 6 persons. The most adopted LCPs are inorganic fertilizers, disease resistant varieties, green manure, early maturing varieties and zero tillage practice. The results of the ordered logit regression showed that gender, marital status, years of education, access to credit, main occupation, land tenure system, rice farming experience, membership of farmers' group and agro-ecological zones were significant determinants of level of adoption of LCPs. The study thus revealed that LCPs were being adopted at different levels with different factors influencing their level of adoption. It is therefore recommended that farmers should be well educated by extension services on the benefits of LCPs in rice production, with a view of reducing the negative impact of climate change on their rice farming operations.
Keywords: Adoption Quotient, Low Carbon Practices, Ordered Logit Regression,

INTRODUCTION
The global crisis and challenges as a result of climate change are massive and this generally reflected in agricultural production leading to low yield, increase in poverty and food insecurity (Ogunwale *et al.,* 2021). Specifically, in Nigeria, rice production is seriously affected with consequences of the changes associated with climate change for instance; increase in temperature adversely affects rice physiology, ultimately decreasing crop yields and grain quality (Osagie, 2015). Similarly, drought have the tendency of reducing stand establishment, tillering, plant height, spikelet fertility and also delay flowering (Manneh *et al.*,2007).

In contrast, emissions of greenhouse gases (GHGs) pose potential threats to the larger landscape over a long time. Moreover, agriculture is the major source of the GHGs that are driving those changes, contributing about 53% and 78% of the total anthropogenic emissions of methane (CH_4) and nitrous oxide (N_2O), respectively (FAO, 2019). With regard to CH_4, rice (Oryza sativa) production remains the largest emission source from a single sector and accounts for 18% of total agricultural CH_4 emissions (Chen *et al.,* 2021). Therefore, development strategies of adaptation and mitigation for rice production systems are an urgent issue currently (Chen and Chen, 2022). The study aimed to: i) understand the analysis of adoption of LCPs by the respondents, ii) classify respondents into different level of LCPs adopters and, iii) recognize the factors influencing level of adoption of LCPs in the study area.

MATERIALS AND METHODS
The study area was Southern States of Nigeria which made up of Ogun, Ondo and Ekiti States. The data were collected directly from the respondents through the use of well-structured questionnaire. A multi-stage sampling technique was used for selection of the respondents. The first stage involved a purposive selection of the two dominant agro-ecological zones (Savanna and Rainforest agro-ecological zones) in the Southwest, Nigeria. Ekiti and Oyo States belong mainly to Savanna dominated agro-ecological

zone. While Ondo, Ogun and Osun States mainly belong to Rainforest agro-ecological zone. The second stage involved purposive selection of Ekiti, Ondo and Ogun out of the States in Southwest Nigeria because of high rate of rice production in the three States (Arimi 2014; Evans *et al.* 2018). The sample size of rice farmers that was selected in Ekiti, Ogun and Ondo were 225, 180 and 172 respectively, making a total sample size of 577. The data were analysed using descriptive statistics, adoption quotient and ordered logit regression model. Model was implemented in STATA 13 econometrics package.

Model specification:

$$Adoption\ quotient = \frac{acreage\ of\ land\ where\ LC}{Total\ acreage\ used\ for\ r}$$

Ordered Logit Regression Model

The ordered logit model was expressed as:

$$Yí^* = X'\beta + \varepsilon í \quad \text{(Equation 2)}$$

Where Yí* is the unobserved discrete random variable, X' is the vector of independent variables, β is the vector of parameters of the regression estimated and ε i is the vector of error term. Thus, Yí, which is the observed ordinal variable (Greene, 2003), takes on the following values:

Yí = 0 if Yí* ≤ 0, Yí = 1 if 0 <Yí* ≤ μ1 and Yí = 2 if μ1 <Yí* ≤ μ2.

The dependent variable is Yí = levels of adopters of LCPs (0 = low adopter, 1 = medium adopter, 2 = high adopter).

RESULTS AND DISCUSSION

Analysis of Adoption of LCPs

Table 1 shows that the most adopted LCPs are inorganic fertilizers (55%), disease resistant varieties (52%), green manure (48%), early maturing varieties (46%) and zero tillage (43%) in descending order, while irrigation scheme practice (9%) is the least adopted LCPs in the study area. This is similar to the study of Jaja and Barber (2017) conducted in Nigeria.

Table 1. Statistics of Adoption of Low Carbon Practices (LCPs)

LCPs	*Percentage*	*Rankings*
Irrigation scheme	9.0%	12th
Mixed cropping system	25.0%	11th
Controlled flooding	26.0%	10th
Farm yard manure	27.0%	9th
Inorganic fertilizers	55.0%	1st
Diseases resistant varieties	52.0%	2nd
Green manure	48.0%	3rd
Early maturing varieties	46.0%	4th
Zero tillage	43.0%	5th
Retention (bush burning)	40.0%	6th
Integrated pest management	38.0%	7th
Agro forestry	31.0%	8th

Source: Field survey, 2023

Levels of Adoption of LCPs among Rice Farmers

The findings in Table 2 revealed that about 34.0% of the respondents were low adopters (these are farmers who score below 33.5 score (Mean (52.5) - S.D (19.0) with an average of 4 LCPs adopted, about 42.0% were medium adopters (farmers who score between 33.6 - 71.4 score) with an average of 6 LCPs adopted, while about 24.0% were high adopters (these are farmers who score above 71.5 score (Mean (52.5) + S.D (19.0) with an average of 9 LCPs adopted by the farmers. This is similar to the study conducted by Victor et al. (2020) in King Cetshwayo District Municipality, South Africa.

Table 2. Levels of Adoption of LCPs

Level of adoption quotient	Frequency	Percent
Low adoption (below 33.5 score)	198	34.3
Medium adoption (between 33.6-71.4 score)	241	41.8
High adoption (above 71.5 score)	138	23.9

Source: Field survey, 2023.

Mean = 52.5 Standard Deviation =19.0

Factors influencing the levels of Adoption of LCPs

The Log likelihood estimate of -516.45 with a p-value of 0.00 revealed that the model as a whole was statistically significant. The estimated cut-off points (μ) (Cut 1 = - 0.5947 – 0.7809 and Cut 2 = 1.4209 – 1.9824) showed that the categories were ranked in an ordered way of μ2>μ1>μ0. The dependent variables were low adopters (Y = 0), medium adopters (Y = 1) and high adopters (Y = 2). The findings in Table 3 revealed that the marginal effect estimates indicated that gender, marital status, years of education, access to credit, main occupation, land tenure system, rice farming experience, membership of farmers' group and agro-ecological zones were the significant explanatory variables that influenced the adoption of LCPs among various adopters' categories at the 1%, 5% and 10% levels of significance respectively.

Moreover, rice farming experience, membership of farmers' group and agro-ecological zones were the significant explanatory variables that influenced the adoption of LCPs among the low adopters, medium adopters and high adopters' categories in the study area at the 1%, 5% and 10% levels of significance respectively which were all negatively related. The negative sign implies that a decrease in the adoption all these variables will cause the rice farmers who are medium and high adopters of LCPs to decrease their level of adoption of LCPs. On the other hand, all other above stated significant explanatory variables were positively related. This positive sign implies that as these variables increase, there will be an improvement in the level of adoption of LCPs among the low and medium adopters' category in the study area.

Table 3: Results of the Marginal Effects on Probability of Rice Farmers

Variables	ME (Low adopters)	SE	ME (Medium adopters)	SE	ME (High adopters)	SE
Age of the farmer	0.0012	0.0025	0.0002	0.0005	0.0010	0.0020
Gender of the farmer	0.0439***	0.0092	-0.0019	0.0086	0.0353***	-0.0073
Marital status	0.1696***	0.0420	0.0376	0.0404	0.2072***	0.0788
Educational attainment	0.0061*	0.0036	0.0013	0.0009	0.0047*	0.0028
Farm size	0.0006	0.0047	-0.0001	0.0010	0.0005	0.0037
Household size	0.0014	0.0070	0.0003	0.0015	0.0011	0.0055
Extension service	0.0646	0.0535	0.0191	0.0200	0.0455	0.0340
Access to credit	0.0737 **	0.0365	0.0160	0.0097	0.0576**	0.0287
Farming experience	0.0004	0.0029	0.0001	0.0006	0.0003	0.0023
Rice farming experience	-0.0401***	0.0053	-0.0087***	0.0032	0.0313***	0.0045
Income of the rice farmer	0.0346	0.0260	0.0075	0.0062	0.0270	0.0204
Main occupation	0.0831**	0.0401	-0.0181	0.0110	0.0650**	0.0313
Distance from rice farm	0.0002	0.0017	0.0000	0.0003	0.0002	0.0013
Members in rice farmers' association	-0.1635***	0.0356	-0.0162***	0.0037	0.1598***	0.0442
Tenure system	0.0392***	0.0096	-0.0021	0.0089	0.0303***	-0.0074
Agro-ecological zones	-0.2280**	0.0859	-0.0676*	0.0346	0.1603**	0.0556

Source: Field Survey, 2023. *, **, *** represent 10%, 5% and 1% level of significance respectively. ME- Marginal effect; SE-Standard error

CONCLUSION

This study found that factors such as gender, marital status, years of education, access to credit, main occupation, land tenure system, rice farming experience, membership of farmers' group and agro-ecological zones were significant determinants of level of adoption of LCPs among the respondents. It is therefore recommended that farmers should be well educated and enlightened by extension services on the benefits of LCPs in rice production, which are the remedy for reducing the negative impact of climate change on their rice farming operations.

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ADAPTATION TO CLIMATE CHANGE BY COCOA FARMERS IN ONDO STATE NIGERIA

Agbeniyi S.O., *Oladokun Y.O.M., Agulanna F.T., Akinpelu A.O. and Oluyole K.A
Cocoa Research Institute of Nigeria, P.M.B 5244 Idi-Ayunre Ibadan.
***corresponding autho**r: yomoladokun@gmail.com; +2348067487930

ABSTRACT
Cocoa production in Africa is highly vulnerable to changes in climatic conditions such as droughts, higher temperatures and reduced precipitation levels, largely due to the rain-fed production system in the region. This study identified the sources of information on climate and adaptation strategies to climate change in Nigeria. The study was carried out among one hundred and sixty cocoa farmers in Ondo state. The mean age of the farmers was 47±15, the mean age of the farm was 34±16. Sixty-eight percent of cocoa farmers were male and mostly (63.1%) had a farm size of ≤ 5 hectares in Ondo state with a mean of 8.9±11.7 hectares. Eight percent of the farmers got their information on climate change from Cocoa Research Institute of Nigeria, while 3% got information from television. Farmers should be encouraged to continue to get information from the various channels they have access to and be engaged in the various adaptation strategies to help reduce the effect of climate change.
Keywords: Adaptation strategies, Cocoa production, Information channels, Ondo

INTRODUCTION
Climate is the state of the atmosphere created by weather events over a period of time (≥35years). Climate, compared to other natural resources is a predominant factor that influences agricultural production in the world. Climate has been changing over the years, giving rise to the concept of climate change. International Panel on Climate Change defines it as a statistically significant variation in the mean state of climate that persists for an extended period of time (IPCC, 2014). Climate change is as a result of the natural climate cycle and human activities. Climate change is experienced globally, but the most adverse effects are being felt in developing countries, especially those in Africa due to low level of coping capabilities. Agriculture is threatened by extreme climatic events such as droughts or floods induced by climate change (FAO, 2011). According to IPCC (2014), cocoa is very sensitive to climate change and it will increase existing stress on agricultural system, particularly those in Africa because majority of the cocoa production in Africa are mainly rain-fed and therefore highly vulnerable to changes in climatic conditions such as droughts, higher temperatures and reduced precipitation levels. Also, cocoa production in Africa is mostly extensive and practiced on relatively poor quality soils, with little use of modern inputs and farming methods to cope with climate change impacts (Ziervogel *et al*. 2006). Adaptation strategies are methods used by farming to better adjust to changing climates. Cocoa farmers need to use these strategies to improve the yield of farmers even in the face of changing climates. Farmers also need to assess information on the strategies to use. In view of this what are the sources of information available to the farmers to adapt to climate change? What are the adaptation strategies used by cocoa farmers in the study area ?
The objectives of the study were to:

1. Profile the socio economic characteristics of respondents
2. describe the sources of information on climate change by the respondents
3. ascertain adaptation strategies to climate change by the respondents

METHODOLOGY
The study was carried out in Ondo State. A multistage sampling technique was adopted for the study. The first stage involved the purposive selection of Ondo State in Nigeria because of her high level cocoa production. The second stage involved the use of simple random sampling technique to select five high producing Local Government Areas (LGAs) which are Akure South, Idanre, Ondo West, Ondo East and Odigbo. The third stage involved the random selection of one community each from each of the LGAs. The fourth stage involved selection of one hundred and eighty farmers (60% of registered farmers) proportionate to the sizes of the selected communities using a well-structured pretested interview schedule to get information from the respondents. With 11.1% attrition, a total of one hundred and sixty cocoa farmers' information was used for analysis.

Descriptive statistics such as percentage, mean, standard deviation and charts were used to analyse the data.

RESULTS AND DISCUSSION

Socioeconomic Characteristics of cocoa farmers

Table 1 below shows the socioeconomic characteristics of cocoa farmers in the study area. Mean farm age and farmers' mean age were 34±16 and 47±15 years, respectively. This reveals that majority of the cocoa farmers were still in their productive years, while most of the cocoa trees were old and needed replacement. Table 1 also revealed that 67.5% of the sampled cocoa farmers in Ondo State were males. This reinforces the general dominance of male in agricultural activities. Male dominance in agriculture is commonly attributed to the laborious nature of small scale farming due to high dependence on manual labour. Hence, agriculture is mainly considered as a male enterprise because of the drudgery associated with its activities. In addition, limited access of women to productive resources in Nigeria and in Africa at large has also made men the major actors. Cocoa farmers in Ondo State (80.6%) were married. This may enable the farmers to be engaged in adaptation strategies that will increase their productivity resulting in rise in their income. Also their wives and children could assist on the farm with the adaptation strategies. This is in line with Girei *et al* (2018), who opined that married farmers are likely to be committed to increasing the yield on their farms as it is critical to the sustenance of their family.

The farmers (44.4%) had secondary education in the study area. This shows that most of the farmers had one form of education or another; they are enlightened which tends to influence decisions on the farm and may also enable them to access information needed to adapt to climate change. Households with 6-10 persons had the highest percentage of 61.9%. Also, 66.3%, having 1-3 persons assisting with farm work on the cocoa farms in Ondo state. Most of the farmers, 63.1% had a farm size of ≤ 5 hectares in Ondo State with a mean of 8.9±11.7. Farming experience of 11-20 years was shown to be highest in Ondo state (38.8%) with a mean of 22 ±12. Table 1 also revealed membership of association among cocoa farmers. It indicates that 84.4% of the cocoa farmers in Ondo belonged to social groups. Information on the different social groups to which the respondents belonged is as presented in Table 1 below. The table shows that being members of cooperative societies (80.8%) was the most paramount to the farmers. Often, farmers form groups in order to forge a common front or to access benefits from government or credits from financial institutions. Obi (2015) stated that most rural dwellers participate in cooperative activities so as to improve their life styles and standard of living. For instance, when asked about the roles performed by the associations (Table 1), most of the farmers (79.3%) indicated that their association helped them in purchasing farm outputs. Farmers are attracted to joining a group if they are aware that their needs will be met by belonging to such group. All these benefits derivable from their association without any doubt would have informed their membership of their respective associations.

Table 1: Socio economic characteristics of Cocoa farmers

Variable	Percentage
Age of farmer (years)	
≤ 30	17.5
31-60	66.9
>60	15.6
Mean 46.5±14.5	
Age of farm (years)	
≤ 10	11.9
11-20	8.8
21-30	30.6
31-40	16.3
41-50	20.6
51-60	6.8
>60	5.0
Mean 33.7±15.7	
Gender of farmer	
Male	67.5

Female	32.5
Marital status	
Single	11.9
Married	80.6
Divorced	7.5
Educational Level	
No formal education	15.6
Primary	28.1
Secondary	41.3
Tertiary	15.0
Household size	
1-5	30.0
6-10	61.9
>10	8.1
Mean 7±3	
Household members assisting on cocoa farm (number of persons)	
1-3	66.3
4-6	28.1
7-9	3.2
10-12	1.2
>12	1.2
Mean 3±4	
Farm size	
≤ 5	63.1
6-10	17.5
11-15	6.3
≥ 16	13.1
Mean 8.9±11.7	
Farming experience (years)	
≤ 10	18.1
11-20	38.8
21-30	25.6
31-40	11.2
41-50	6.3
Mean 22.2±11.6	
N =160	
Membership of association	
Yes	84.4
No	15.6
Types of Association	
Cooperative	80.8
Savings and credit group	5.9
Town union	1.5
Cocoa Association of Nigeria	5.9
Cocoa Farmers Association of Nigeria	5.9
Roles performed by Association	
Purchase of farm outputs	79.3
Financial assistance	13.3
Supply of inputs	7.4

Source: Field survey, 2022 Number of Observation = 160; ± = Standard Deviation

Figure 1 presented the channels of information on climate change. Eight percent of cocoa farmers in Ondo state reported that they got their information from Cocoa Research Institute of Nigeria while 3% got information from television.

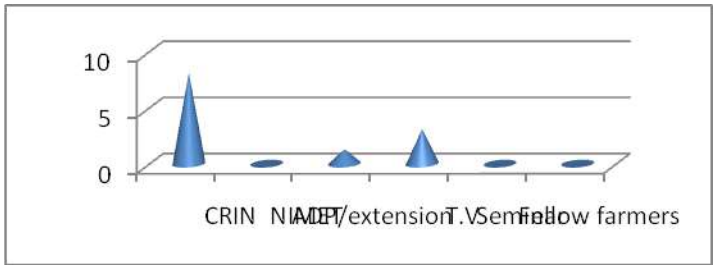

Figure 1: Sources of Information on Climate Change
Source: Field survey, 2022; Number of Observation = 160 (Multiple responses)

In Figure 2, the mean of the responses of cocoa farmers on the adaptation strategies used in coping with climate change effects was presented. Crop diversification ($\bar{X}$=1.6), timely application of pesticides against insects, diseases and weeds had the highest mean ($\bar{X}$=1.6), spraying of pesticides to control insect pest and diseases ($\bar{X}$=1.5), planting of shade crops ($\bar{X}$=1.4), use of improved cocoa variety ($\bar{X}$ =1.3), indigenous knowledge ($\bar{X}$=1.2), changes in cropping pattern ($\bar{X}$=1.1). Other adaptation strategies are rain harvesting, using early warning signal, composting and irrigation during dry season. Zhafran *et al*. 2022 affirmed the use of practises such as changes in cropping pattern, crop diversification as adaptation strategies.

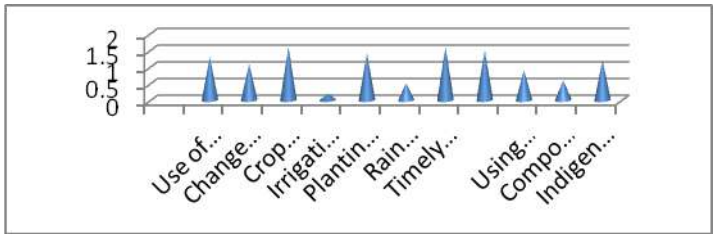

Figure 2: Adaptation strategies to climate change adopted by cocoa farmers in Ondo state
Source: Field survey, 2022 Number of Observation = 160 (Multiple Responses)

CONCLUSION AND RECOMMENDATION

Climate change has come to stay. This study has been able to come up with some adaptation strategies to avert the effect of climate change. Such adaptation strategies include crop diversification, timely application of pesticides against insects, diseases and weeds, spraying of pesticides to control insect pest and diseases, planting of shade crops, use of improved cocoa variety and changes in the cropping pattern. Others are rain harvesting, using early warning signal, composting and irrigation during dry season. It is hereby recommended that information about climate change should readily be made available to farmers especially from the Cocoa Research Institute of Nigeria. Farmers should also be encouraged to engage in the various aforementioned adaptation strategies to help reduce the effect of climate change.

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IMPACT OF FARMERS' ADOPTION OF CLIMATE CHANGE ADAPTATION STRATEGIES ON FOOD SECURITY IN NIGERIA: A PROPENSITY SCORE MATCHING APPROACH

Arowolo, A. O. & Emmanuel, A. E
Department of Agricultural Economics and Farm Management, Federal University of Agriculture Abeokuta, P. M. B 2240, Abeokuta, Ogun State, Nigeria
Corresponding Author's email: arowoloao@funaab.edu.ng

ABSTRACT
The food security status of agricultural households in Nigeria is threatened by the negative effects of climate change on the country's agriculture. However, the embracement of climate change adaptation (CCA) strategies by Nigerian agricultural households is still low. The study used the wave 4 (2018/2019) general household survey data of the World Bank Living Standard Measurement Survey (LSMS) to analyze the effects of CCA adoption on the food security status of crop farming households in Nigeria. Data were analysed using Descriptive Statistics, Multivariate Probit (MVP) model, and Propensity Score Matching (PSM). Agricultural households that adopted CCA strategies had 16% higher food security levels than those who did not adopt and the adoption of CCA practices was influenced by age, sex, household size, dependency ratio, education, farm size, location, tenancy status, and credit access. Adoption of CCA measures should be encouraged while underscoring the need for tailored approaches across different zones in Nigeria to ensure sustained food security.

INTRODUCTION
Nigerian agriculture has experienced significant setbacks as a result of the rapidly changing climate (Ogunnaike et al., 2021) evident through temperature rise, erratic rainfall patterns causing increased droughts in the North, increased floods and erosion in southern Nigeria, among others (Ogunpaimo et al., 2021). This has led to significant threats to the availability, affordability, and accessibility of food for the ever-growing population of the country. Nigerian agriculture is especially vulnerable to climate change as it is rain-fed and the majority of the population is highly dependent on agriculture and poor with low adaptive capacity to withstand or deal with the consequences of climate change. As a response or a pro-action to curb the negative consequences of climate change, farmers worldwide have used various strategies that have stemmed from both traditional practices and modern technologies (Diallo et al., 2020). These practices are called climate change adaptation (CCA) strategies. The adoption of CCA strategies enhances agricultural production by reducing the risk associated with climate change on the farmers and consequently influencing food availability and food security of the farming households (Ogunpaimo et al., 2021). However, the response of the smallholder farmers in Nigeria to the adoption of CCA is not encouraging (Ogunnaike et al., 2021). This study is carried out to substantiate or support the existing and very limited studies on the determinants of farmers' adoption of climate change adaptation strategies and the poorly investigated linkage between CCA strategies adoption and food security in Nigeria.

Data Description (Study Area and Data Source)
The study was conducted in Nigeria using the wave 4 (2018/2019) general household survey data of the World Bank Living Standard Measurement Survey (LSMS) collected by the National Bureau of Statistics (NBS) which includes about 5000 households from which 3442 crop farming households were used for the study.

Analytical Technique
Food consumption score was used to obtain the food security status of agricultural households following Kennedy et al. (2010). The number of times a household consumes a food group is multiplied by a nutrient weight assigned to the food group. This was then added together to obtain the food consumption score. The food groups and their weights are Cereals - 2, Tubers - 3, pulses and nuts - 3, vegetables - 1, meat, fish and animal products - 4, fruits - 1, milk and milk products - 4, oil and fats - 0.5, sugar and sugar products - 0.5, spices/condiments - 0.

$$FCS = \sum_{i=1}^{10} W_i FGF_i$$

…… ……..... (i)

Where FCS = Food Consumption Score, FGF = Food group frequency of consumption, W = weight assigned to each food group

Food insecure household: FCS = 0-42 Food secure Households: FCS = >42

Multivariate probit (MVP) was used to identify the factors influencing the adoption of CCA strategies in Nigeria which simultaneously models the influence of the independent variables on each CCA strategy while allowing the error terms to be freely correlated (Ogunnaike et al., 2021).

The model is specified as: $Y_{ij}^{*} = \beta_{ij} X_{ij} + \varepsilon_j$, $Y_{ij} = 1 \; if \; Y_{ij}^{*} > 0 \; and \; 0 \; if \; otherwise$…….. (ii)

Where Y_{ij}^{*}= is a latent variable capturing the observed and error preferences and is associated with j^{th} CCA strategy; Y_{ij} denotes the binary dependent variables representing the CCA strategies and users of each strategy take a value of 1, and 0 otherwise; j denotes the various CCA strategies used by agricultural households in the study area including intercropping, planting improved variety, use of irrigation, income diversification, and use of organic manure; X_{ij} is a vector of the independent variables and β_j is a vector of unknown parameters to be estimated.

Propensity score matching (PSM) was used following Gebre et al. (2023) to analyze the impact of CCA strategy adoption on the household's food security status.

$P(W) = Pr(D = I|W) = E(D|W)$ …… …… (iii)

Where D is the indication for the adoption of any CSA strategy and W is the vector of pre-adoption characteristics. The conditional distribution of W, given as $P(W)$ is similar between adopters and non-adopters. *(Note: The treated crop farming households in this study are the CCA adopters, and vice versa)*

RESULTS AND DISCUSSION

The result of the choice of CCA method adopted by the agricultural households (Table 1) showed that only close to half adopted income diversification (49.84%) and intercropping (47.75%) as adaptation measures to mitigate the negative effect of climate change while the use of organic manure (17.27%), planting of improved variety (8.14%) and use of irrigation (2.06%) were very low.

Table 1: Distribution of agricultural households by their choice of CCA strategy

CCA Strategies	Intercropping	Planting Improved Variety	Irrigation	Income Diversification	Organic manure
Adopters	1648 *(47.75)*	281*(8.14)*	71 *(2.06)*	1720 *(49.84)*	596 *(17.27)*

Source: LSMS data, 2018/2019; Percentages (%) in parenthesis

The results of the MVP model parameter estimates (Table 2) showed a significant ($Prob > \chi^2 = 0.0000$) Wald chi-square test statistic (Wald chi-square (75) = 1214.04), thus, the hypothesis that all regression coefficients in each equation are jointly equal to zero is rejected indicating the fitness of the model with the data, and the relevance of the chosen explanatory variables in explaining the model. Also, the null hypothesis, that all of the ρ (Rho) values were jointly equal to 0, is rejected supporting the use of the MVP model rather than the estimation of independent univariate probit models. The result showed that age had a significant and positive effect on the likelihood of adopting intercropping, but decreased the farmers chances of adopting income diversification measure of CCA. This shows that younger household heads will rather engage in multiple streams of income as a means of mitigating climate change effects, while older household heads will likely adopt intercropping. Households whose heads are female are more likely to adopt intercropping CCA strategy while male-headed households will likely use irrigation. Household size has a significant and positive effect on the probability of the farmers adopting diverse sources of income as a CCA strategy. The need to cater for large household sizes pushes the household to get more income thereby enhancing the availability of funds to curb the effects of

climate change and enhance food security. The dependency ratio has a significant and positive effect on the probability of adopting intercropping but a negative effect on the likelihood of adoption of improved seed variety. A higher dependency ratio means households have more members to cater for hence the need to select a less expensive CCA. Having at least primary education by the household head increased the chances of adopting intercropping, planting improved varieties, income diversification, and use of organic manure. This may be due to a higher level of awareness and exposure attached to being educated as they can interpret information better than their illiterate counterparts.

Households located in the North zones and the south-east are more likely to choose CCA strategies of irrigation, organic manure, and income diversification compared to those in South-west. Irrigation is essential for households who reside in the North zones because of poor rainfall and increased incidence of drought in the region. Households in the North-west are more likely and those in North-east and North-central are less likely to adopt the income diversification CCA strategy compared to those in the south-west. The CCA strategies of intercropping and planting improved variety are more likely be adopted by households in the South-east and South-south, respectively compared to those in the South-west. Access to credit had a significant and positive influence on the likelihood of adopting income diversification as a CCA measure. This implies that access to finance allows for engaging in multiple streams of income as an adaptation strategy to mitigate climate change effects. The size of a farm influences the adoption of irrigation negatively but positively influences the adoption of engagement in multiple income sources. Irrigation on a large farm is expensive and more stressful compared to a smaller farm size. The tenancy status of a household, an indication of land ownership, decreased the chances of the farmers adopting planting improved variety as a CCA measure but increased their chances of adoption of organic manure to mitigate climate change effects. The results obtained in this study aligned slightly with the that of Ogunpaimo et al. (2021) and Ogunnaike et al. (2021).

Table 2: MVP model result of factors influencing the choice of CCA strategies.

Variables	Intercropping	Planting improved variety	Irrigation	Income diversification	Organic manure
	Coeff. (std. error)	Coeff. (std. error)	Coeff. (std. error)	Coeff. (std. error)	Coeff. (std. error)
Age (Years)	0.0034**_(0.002)_	-0.0014_(0.003)_	-0.0043 (0.004)	-0.0040**(0.001)	0 .0016(0.002)
Sex (Male =1)	-0.0721***_(0.104)_	-0.2374_(0.152)_	0.4578**(0.228)	-0.0386(0.106)	0.026(0.150)
Household size	0.0022_(0.008)_	0.0094(0.012)	0.0134(0.018)	0.0477***(0.008)	-0.0068(0.009)
Credit (Access=1)	0. 085_(0.065)_	-0.2342(0.101)	-0.0401(0.155)	0.2342***(0.065)	0.1009(0.079)
Marital status	0.0481_(0.096)_	0.1383**(0.144)	-0.5205***(0.187)	0.3693***(0.098)	0.1995(0.134)
Dependency ratio	0.0006**_(0.000)_	-0.0008 **(0.000)	-0.0007(0.0007)	-0.0002(0.000)	-0.0001(0.000)
Education	0.0167***_(0.047)_	0.1530**(0.071)	0.0852(0.110)	0.1406***(0.047)	0.0984*(0.058)
[b]North-central	0.0092_(0.096)_	-0.0891(0.166)	0.5964***(0.373)	-0.3738**(0.099)	0.4479**(0.216)
[b]North-east	0.1413_(0.097)_	0.2467(0.158)	0.2482** (0.390)	-0.2481***(0.099)	1.3043***(0.206)
[b]North-west	0.0818_(0.098)_	0.1695(0.161)	1.0274***(0.367)	0.4412***(0.100)	1.7708***(0.205)
[b]South-south	-0.1411_(0.098)_	0.9657***(0.147)	0.0033(0.430)	0.1223(0.099)	0.3107(0.225)
[b]South-east	1.0241***_(0.101)_	0.0574(0.163)	0.6575*(0.376)	0.09413(0.099)	1.0302***(0.209)
Extension access	0.0450_(0.057)_	0.0616(0.086)	0.0255(0.130)	-0.0219(0.059)	0.0480(0.069)
Farm size (ha)	-0.0006_(0.001)_	-0.0060 (0.005)	-0.0021*(0.007)	0.0030*(0.002)	0.0015(0.001)
Tenancy status	-0.0032_(0.058)_	-0.2262***(0.080)	0.0548(0.151)	0.0384(0.058)	0.2045**(0.083)
Constant	-0.4850_(0.136)_	-1.3898(0.210)	-2.5472(0.439)	-0.4690(0.137)	-2.5498(0.245)

Log-likelihood = -6876.6478; Wald $chi^2(75)$ = 1214.04; Prob> chi^2 = 0.0000; Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0: $chi^2(10)$ = 183.946; Observations = 3442

Source: LSMS data, 2018/2019

, **, * significant at 10%, 5% and 1% respectively, [b]base category is South-west*

The result of the food security status of the agricultural households is presented in Table 3. The mean food consumption score is 59.94 and about three-quarters (76.38%) of the households have a food consumption score above 42 and are classified as being food secure.

Table 3: Distribution of agricultural households by food security status

Food security status	Frequency	Percentage
Food secure (FCS: >42)	2,636	76.38
Food insecure (FCS: 0-42)	815	23.62
Mean food consumption score		59.94

Source: LSMS data, 2018/2019

Table 4: PSM Showing the effect of CCA Adoption on Household Food Security.

Outcome variable	ATT	t-values	Mean bias	Median bias	% variation
Food security	0.1558***	2.69	4.3	3.8	25
Treated	809				
Untreated	2642				

Source: LSMS data, 2018/2019

***** significant at 1%, ATT- Average treatment effect on the treated**

PSM result (Table 4) showed that agricultural households who adopt at least one CCA measure have higher food security status (16%) than those who did not. This result aligns with the result of Ogunpaimo et al. (2021) who got 9% higher food security for adopters of CCA than their non-adopters counterparts. This implies that the adoption of CCA strategies fosters the food security status of agricultural households in Nigeria.

CONCLUSION

This study accessed the effect of CCA strategies adoption on the food security status of agricultural households in Nigeria. The result showed that households adopted income diversification and intercropping the most over other CCA. Several factors influenced the agricultural households' choice of adopted CCA such as age, education, farm size, tenancy status, and location among others. The study concluded that CCA adoption enhances the food security status of adopters. The study therefore recommends the continual adoption of CCA practices by farming households. At the same time, extension agents and the government should enhance their efforts towards encouraging the participation of youths in agriculture and create awareness among farmers about more CCA location-specific strategies, training, and capacity building to ensure sustained food security.

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ASSESSMENT OF ADAPTATION STRATEGIES TO CLIMATE CHANGE AMONG ARABLE CROP FARMERS IN OBAFEMI OWODE LOCAL GOVERNMENT AREA, OGUN STATE, NIGERIA

Soetan O, J.[1], Adubi, K. O.[2], Dada, O. E. [1], Inibhunu, O. [1], Alo, D. A.[3], Soetan, H. O.[4,] Abdulsalam-Saghir, P. B.[1], Ashimolowo, O. R.[1]

[1] Department of Agricultural Extension and Rural Development, Federal University of Agriculture, Abeokuta, Nigeria,

[2]Department of Home Science and Management, Federal University of Agriculture, Abeokuta, Nigeria,

[3]Lagos State Agricultural Development Authority, [4] Department of Economic, Tai-Solarin University of Education, Ijagun, Ogun State, Nigeria

corresponding author: soetanoj@funnab.edu.ng/+2348031114702

ABSTRACT

Climate change is perhaps the most serious environmental threat facing mankind worldwide. This study examined the adaptation strategies used in militating climate change risks among arable crop farmers in Obafemi Owode Local Government Area, Ogun State. Multistage sampling procedure was used to sample 160 arable crop farmers for the study. Data were obtained with the aid of an interview guide. Data were analysed using descriptive statistics (frequency counts, percentages, mean, standard deviation). Findings revealed that the highly utilized adaptation strategy among the arable crop farmers was changing from farming to non-farming activities ($\bar{X}$ =2.54, SD =1.5937). The study concluded that the arable crop farmers utilized most of the adaptation strategies less. The study therefore recommended among others that continuous awareness campaign on climate change adaptation strategies should be made through media houses and extension agents to the farmers

Keywords: Adaptation, strategies, mitigating, climate change, risks, arable crop farmers

INTRODUCTION

Climate change poses significant risks to agriculture worldwide, particularly to arable crop farming which is highly dependent on weather conditions. The increasing frequency and severity of extreme weather events such as droughts, floods, and heatwaves, alongside gradual changes in temperature and precipitation patterns, have profound impacts on crop productivity, food security, and farmers' livelihoods (IPCC, 2022).

Arable crop farmers are among the most vulnerable groups to climate change due to their direct reliance on environmental conditions for crop growth and yield. The Intergovernmental Panel on Climate Change (IPCC) has documented that climate change affects agricultural productivity through altered rainfall patterns, increased temperatures, and heightened incidence of pests and diseases (IPCC, 2022). These changes can lead to reduced crop yields, increased production costs, and, consequently, higher food prices and food insecurity (FAO, 2021).

Despite the progress in adaptation, several challenges remain. Limited access to resources, lack of technical knowledge, and insufficient institutional support are significant barriers to effective adaptation (Thornton *et al.*, 2018). Moreover, the socio-economic conditions and policy environments in many developing countries hinder the widespread adoption of adaptation measures. For example, smallholder farmers often lack the financial capacity to invest in new technologies or diversify their crops (Morton, 2007). The study is thereby guided by the objectives and hypothesis stated below:

i. describe the socio-economic characteristics of the arable crop farmers in the study area and
ii. determine the adaptation strategies to climate change among the respondents.

Ho1: There is no significant relationship between socio-economic characteristics of the respondents and their adaptation strategies to climate change.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Obafemi Owode Local Government Area, Ogun State. This study area was selected due to the activities of quarry

factories and its possible effect on the climatic condition of the environment (preliminary survey, 2024). Obafemi-Owode LGA typically experiences high temperatures throughout the year. The average annual temperature ranges from 24°C (75°F) to 30°C (86°F). The hottest months are usually March and April, with temperatures occasionally exceeding 35°C (95°F) (World Bank, 2021). The area has a bimodal rainfall pattern, characteristic of southwestern Nigeria. There are two main rainy seasons: the major rainy season from March to July and the minor rainy season from September to November. The annual rainfall ranges from 1200 mm to 1800 mm. The heaviest rainfall typically occurs in June and October (Ogun State Government, 2019). Humidity levels are generally high, averaging between 70% and 90% throughout the year. The relative humidity is highest during the rainy season, contributing to the lush vegetation and agricultural viability of the area (Nigerian Meteorological Agency, 2021).

Population of the Study

The population of the study were arable crop farmers Obafemi Owode Local Government Area, Ogun State.

Sampling Technique and Sampling Size

Multistage sampling procedure was used to select arable crop famers as follows:

Stage 1: Random selection of 5 political ward out of the 12 political ward; Ajebo, Ajura, Kajola, Obafemi and Owode. Stage 2**:** Random selection of 2 communities in Ajebo out of 13 communities, 4 communities in Ajura out of 20 communities, 2 communities in Kajola out of 12 communities, 3 communities in Obafemi out of 14 communities, and 5 communities in Owode out of 39 communities. Stage 3: Sixteen respondents were conveniently selected from each of the selected communities. Thus, a total of 160 arable crop farmers were used for the study.

Method of Data Collection

Data were collected with the aid of interview guide.

Measurement of Variables

Adaptation strategies: This was measured at interval level by adapting Adaptation Strategies Scale (ASS) on a 5 – point Likert-type format of very great extent, great extent, little extent, very little extent and not at all with score 5,4,3,2 and 1 respectively. Items with the mean scores of ≥2.00 were considered to be commonly used by the arable crop farmers and otherwise if the mean scores were <2.00.

Method of Data Analysis

The primary data was analyzed and presented by using both descriptive and inferential statistics. The descriptive statistics includes percentage, frequency, mean, and standard deviation while, Logistic Regression Model (LRM) is used to analyze the hypothesis.

Results and discussion

Result in Table 1 revealed that the mean age of the arable crop farmers was 52±11.751. Older farmers typically possess extensive experience and traditional knowledge, which they rely on to adapt to climate variability. This accumulated wisdom helps them understand historical climate patterns and develop locally suited practices. However, this reliance on traditional methods can sometimes hinder the adoption of innovative adaptation techniques that may be more effective in the face of unprecedented climate change (Asfaw *et al.*, 2019). Also, finding showed that most (71.3%) were male; majority (60.0%) had no formal education and most of the respondents did not have access to extension agents (76.2).

Table 1: Selected socio-economic characteristics of the arable crop farmers

Variables	F (%)	Mean (x□)	SD
Age			
≤ 30	9 (5.6)	52	11.751
31-40	16 (10)		
41-50	55 (34.6)		
51-60	50 (31)		
61-70	20 (12.6)		
≥ 70	10(6.2)		
Sex			
Male	114 (71.3)		
Female	46(28.7)		
Marital status			
Single	2(1.3)		
Married	146 (91.2)		
Widow	12(7.5)		
Education status			
No formal education	96(60.0)		
Adult education	8(5.0)		
Primary education	32(20.0)		
Secondary education	24(15.0)		
Access to extension agents			
No	122 (76.2)		
Yes	38 (23.8)		

Adaptation strategies of arable crop farmers

Findings in Table 2 revealed that the highly utilized adaptation strategies in militating climate change risks among the arable crop farmers were changing from farming to non-farming activities (X□ =2.54**)** and planting early maturing crops (X□ =2.01**)**. As more individuals leave farming, there could be a loss of traditional agricultural knowledge and skills, which are crucial for sustainable farming practices (Adger *et al.*, 2014).

Table 2: Climate Change Adaptation Strategies used by the Arable Crop Farmers

Sn	Variables	X□	SD
1.	Changing from farming to non-farming activities	2.54*	1.5937
2.	Planting of early maturing crops	2.01*	1.4177
3.	Arable crop farming and doing other businesses	1.09	1.0440
4.	Permanent migration	1.05	1.0247
5.	Changing from arable crop farming to off farming activities	1.04	1.0198
6.	Planting of drought resistant seedlings	1.04	1.0198

There is no significant relationship between socio-economic characteristics of the respondents and their adaptation strategies to climate change.

Result of the logistic regression shows that there is a significant relationship ($p \leq 0.05$) between age (β=73.219); education status (β=111.164); access to extension service (β=61.139) and adaptation strategies to climate change. The age of farmers plays a critical role in shaping their adaptation strategies to climate change. While older farmers bring valuable experience and knowledge, they also face unique challenges that necessitate tailored support and interventions. Likewise, the educational status of farmers has a profound impact on their ability to develop and implement adaptation strategies to climate change. Education influences farmers' access to information, their ability to comprehend and apply new techniques, and their overall capacity to innovate and manage risks.

There is no significant relationship between socio-economic characteristics of the respondents and their adaptation strategies to climate change.

Variables	β -value	S.E	Wald	D.f	P-value	Decision
Age	73.219	30155.014	0.000	1	0.050	S
Sex	6.090	26821.708	0.000	1	0.100	NS
Marital status	22.229	4667.627	0.000	1	0.996	NS
Educational status	111.164	10703.740	0.000	1	0.010	S
Access to extension agents	61.139	8701.713	0.000	1	0.009	S
Constant	162.652	8632.031	0.000	1	0.005	S

CONCLUSION AND RECOMMENDATIONS

The study concluded that the arable crop farmers utilized most of the adaptation strategies less. The study therefore recommended among others that continuous awareness campaign on climate change adaptation strategies should be made through media houses and extension agents to the farmers.

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ASSESSMENT OF CLIMATE VARIABLES FOR SUSTAINABLE AGRICULTURE

Agbor C. F, Onilude Q.A, Ogunwale O.R Yusuf I.O. & Ishola A.S

Forestry Research Institute of Nigeria, Jericho, Ibadan, Oyo State,
Corresponding Author: chukwuka_Friday@yahoo.com.

ABSTRACT.
This study is set to evaluate the spatial variability of some climate variables such as net solar radiation and land temperature in Ibarapa East Local Government Area of Oyo State. The evaluation was carried out using Landsat 8 image of 2023 and digital elevation model. The results revealed mean temperature of 32.7 ^{o}C while the mean net radiations was 221.2 $W\ m^{-2}$. The study revealed strong negative relationship of 84% between surface energy balance and temperature. An intriguing finding of this study is the fact that net radiation decreased with increase in temperature. This can have a cooling effect on the atmosphere, which could explain why there is a negative relationship between net radiation and air temperature. Thus, the need for farmers to select crop varieties that are more resilient to lower temperatures.
Keywords: Climate variables, Net solar radiation, Land surface temperature, and Landsat image

INTRODUCTION

Climate change is a pressing issue facing humanity in the 21st century, with profound implications for agriculture ecosystems (IPCC, 2014). Understanding the spatial and dynamics of climate variables such as net Solar radiation and temperature is crucial for accurately assessing the impacts of climate change and formulating effective adaptation and mitigation strategies (IPCC, 2014). In this context, the application of remote sensing has emerged as a powerful approach for analyzing climate variables at various spatial and temporal scales (Goodchild, 2015).

Satellites equipped with sensors capable of capturing data across multiple spectral bands enable the observation of various climate-related parameters, including land surface temperature, vegetation cover, precipitation, and atmospheric composition (Makinde *et al*, 2019). Remote sensing-derived datasets provide valuable input data for initializing and validating climate models, improving the accuracy of simulated climate projections (IPCC, 2014).The spatial analysis of climate variables using geoinformatic techniques represents a cutting-edge approach for understanding the dynamics of earth's climate system. Ibarapa East is known for its rich tradition of agriculture with limited resources to acquire expensive early warning devices such as agrometeorological stations. As climate change continues to exert profound impacts on agriculture, this study is set to use remote sensing to assess the spatial distribution of aforementioned climate variables in the area, and provide evidence-based decision-making for climate adaptation and mitigation strategies. By harnessing the effectiveness of these techniques, this study provides insights into the spatial patterns of climate variability in the study area. As climate change continues to exert profound impacts on our environment, and agriculture in particular, this study is set to use remote sensing to assess climate processes and provide evidence-based decision-making for climate adaptation and mitigation strategies.

The study area falls within latitudes $7^{0}.15'$ N and $7^{0}.55'$ N and longitudes 3^{0}E and $3^{0}.3'$ E, within Oyo State, Nigeria. The area is approximately 706 km² in geographical size, located in the western part of Oyo state and falls within the Forest-savanna Transition Zone. The predominant occupation of the people is farming. The region has a tropical climate with two distinct seasons, the rainy season and the dry season.

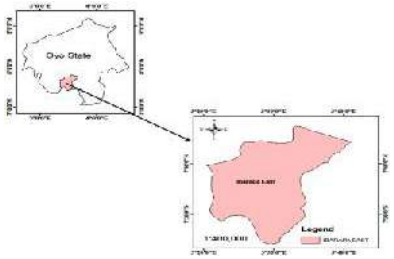


Fig. 1: The Study Area Map

2. Material and Method

2.1 Data collection and processing

The satellite images used have been summarized in table 1. The choice of Landsat data is based on its moderate spatial resolution and availability.

Table 1: Satellite Images

Satellite Sensor	Spatial resolution	Acquisition years	Path	Row
Landsat 7 & 8	30m x 30m	13/4/2023	191	55
Asterdem	30m interval	2000	191	55

2.2 Estimation of climate variables

Net Solar Radiation: This was determined using Mapping EvapoTranspiration at high Resolution with Internalized Calibration (METRIC) model for calculating surface energy balance (SEBAL) (Ryan *et al*, 2017). The METRIC model is being used in determining the net solar radiation because it accounts for the effect of surface reflectivity, which is a major contributing factor to surface temperature changes (IPCC, 2014). Net radiation (N_r) is computed by adding all incoming radiation and subtracting all outgoing radiation:

$$N_r = (1 - \alpha)d_s + d_l - u_l - (1 - e_o)d_l$$

Where α is the surface albedo, d_s, d_l and u_l are the incoming and outgoing radiations respectively, and e_o as the surface emissivity.

*Land surface temperature(LST)***:** The air surface temperature T_a was estimated in equations 8.

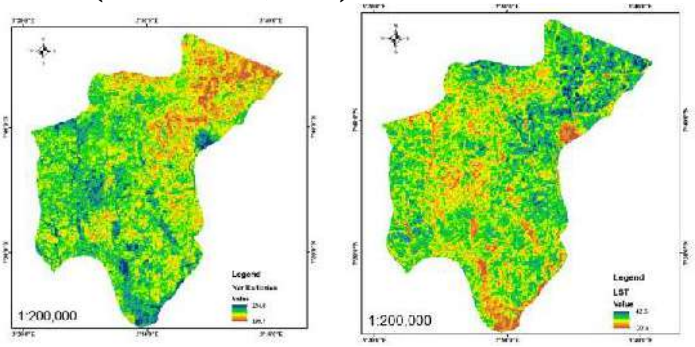
$$\boldsymbol{T_s} = \frac{T_a}{1 + \left(\frac{\lambda \mathbf{x} T_a}{\boldsymbol{\rho}}\right) \ln \boldsymbol{\varepsilon}} \quad \text{(xi)}$$

where: λ is the wavelength of emitted radiance (11.345 for TM/ETM and 11.5 μm for OLI), ρ is $h \times c/\lambda$ (1.438 $\times 10^{-2}$ m K), σ the Boltzman constant (1.38 $\times 10^{-23}$ J/K), h the Planck's constant (6.626$\times 10^{-34}$ J s), c is the speed of light (2.998 $\times 10^{8}$ m/s) and $\boldsymbol{\varepsilon}$ denotes emissivity (Lillesand *et al*, 2008 and Makinde et al, 2019)

RESULTS AND DISCUSSION

Figures 2 and 3 present the spatial pattern of net radiation and surface temperature and the interactions between the climate variables in 2023. For example, figure 3 explains a very strong negative relationship of 84% between temperature and net radiation. Figure2 shows that net solar radiation was higher in the southern part of the area with lower surface temperature. The mean temperature and net solar radiations were 32.7 ^{o}C and 221.2 $W\ m^{-2}$ respectively. Considering the relationship between the two variables, one would expect to see a positive correlation, since an increase in net radiation would generally lead to an increase in air temperature (David, 2017). One possibility could be the effect of vegetation cover. This can have a cooling effect on the atmosphere, which could explain why there is a negative relationship between net radiation and air temperature (Gabriela et al, 2010). Vegetation releases water vapor into the air through transpiration, which increases the humidity and leads to lower air temperatures (Julia et al, 2006). This is important to farmers because, the primary effects of climate change on agriculture arise from changes in temperature and intensity of extreme weather events (Lobell et al, 2011). As a result, farmers may need to select crop varieties that are more

resilient to low temperatures with increase in net radiation **(Hatfield et al, 2015).**



(a) (b)

Fig 2. (a) Net Radiation (b) Surface temperature

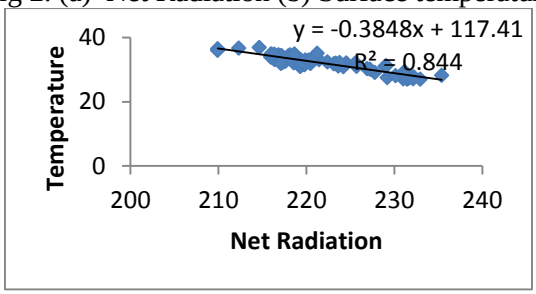


Fig 3 Relationship between N_r and LST

CONCLUSION

The assessment of spatial pattern of net solar radiation and surface temperature in Ibarapa East local government area offers invaluable insights into their impacts in agriculture ecosystem. Through the application of geospatial technologies, researchers can better understand the spatial patterns of these climatic variables among others. The results of this study revealed a negative response of temperature to increase in net solar radiation. It is quite intriguing and at the same time suggests the need to enhance our capacity to effectively win the global fight against climate change, ultimately contributing to a more sustainable food production for all.

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8th Annual Conference and 67th AGM-ABEOKUTA of The Association of Deans of Agriculture in Nigeria Universities (ADAN), Held at The FUNAAB Red Senate chamber, Abeokuta, Ogun State, Nigeria, from July 7th to 11th, 2024. Theme: Climate Change: Agricultural Innovations and Bio-entrepreneurship for Sustainable Development, Food Sufficiency and Economic Transformation. **Edited by:** A. E. Obayelu, O.M Olosunde, P. B. Abdulsalam-Saghir, O.S. Sowande, E.O. Fakoya and J.J. Atungwu

EFFECT OF ADOPTION OF SUSTAINABLE AGRICULTURAL PRACTICES (SAP) ON PROFIT EFFICIENCY AMONG CASSAVA FARMERS IN ABEOKUTA ZONE OF THE AGRICULTURAL DEVELOPMENT PROGRAMME, OGUN STATE, NIGERIA.

[14]Oke, F. O., [1]Tolorunju, E.T., [24]Kareem, I. A., [34]Sanni-Bamigbade, S. A. [4]Ayegbokiki, A.O.

[1]Department of Agricultural Economics and Farm Management, Federal University of Agriculture, Abeokuta, Nigeria

[2]Department of Forestry and Wildlife Management, Federal University of Agriculture, Abeokuta, Nigeria

[3]Department of Business Administration, Federal University of Agriculture, Abeokuta, Nigeria

[4]Agricultural Media Resources and Extension Centre, Federal University of Agriculture, Abeokuta, Nigeria

Correspondence to:

Oke, Folasade Olukemi; Phone: +234- 703-0625-030; E- mail: folasadeolukemioke@gmail.com

ABSTRACT

The study was conducted in Ogun state to examine the effect of adopting sustainable agricultural practices (SAP) on profit efficiency among cassava farmers. Primary data was collected from 120 farmers with a structured questionnaire. Data analysis was done using descriptive statistics and the Cobb-Douglas stochastic frontier profit function. The descriptive statistics showed that the cassava farmers were predominantly male (79.2%) with a mean age of 45 years. A large proportion (83.3%) had secondary education. The majority (95%) had more than ten years of farming experience and average farm size is 2 hectares. SAP adopted among the farmers include soil enrichment (65%), integrated pest management (63.3%), intercropping (59.3%), crop rotation (55.8%), mixed farming (54.2%), agroforestry (45.8%) and cover cropping (38.5%). Profit efficiency analysis revealed that the minimum and maximum profit efficiency were 0.13 and 0.95, respectively, with a mean profit efficiency of 0.64. Farm size ($\beta = 0.188$, $p<0.01$), cost of hired labour ($\beta = -0.120$, $p<0.05$) and cost of cassava stem ($\beta = -0.020$, $p<0.01$) were significant variables in the profit efficiency model. In addition, SAP variables influencing profit efficiency include mixed farming ($\beta = -1.436$, $p<0.05$) and integrated pest management ($\beta = -0.496$, $p<0.10$), as well as socioeconomic variables of age ($\beta = -0.506$, $p<0.10$), education ($\beta = -0.184$, $p<0.01$), farming experience ($\beta = -0.844$, $p<0.05$) and extension contact ($\beta = -0.994$, $p<0.01$). The study concluded that cassava farming in the study area is worthwhile and that adopting sustainable agricultural practices can boost its profit efficiency. The study recommends more access to extension agents for increased awareness and knowledge of sustainable agricultural practices.

Keywords: Agriculture, Cassava, Sustainability, Profit efficiency

INTRODUCTION

Agriculture is the most significant factor in economic growth, progress, and industrialization, especially in emerging nations like Nigeria (Pawlak and Kołodziejczak, 2020). Crop production continued to be the sector's key driver by accounting for 86.85% of the sector's total nominal value in the first quarter of 2023 (NBS, 2023). Root crops like cassava are cultivated throughout the world, but mainly in tropical climates due to its minimal labour requirements, capacity to withstand drought conditions, poor soil and reputation for high value (Ezeibe et al. 2015).

However, Ibekwe et al. (2012) reported that the primary reason for cassava's low productivity is that it is grown primarily by small-scale and low-resource farmers who find it difficult to pay for agricultural inputs. Unprofitable output is therefore unavoidable due to farmers' inefficiency in using a variety of farm resources and small farmers' inadequate allocation and utilization of farm inputs. In addition, Akerele et al. (2019) further reported that illiteracy among most of the farmers who grow cassava makes it difficult for them to absorb new ideas and techniques that can improve the profit efficiency of the crop. Therefore, for cassava to play a significant role in agricultural development, it will be necessary to establish sustainable strategies that go beyond maximizing agronomic efficiency to boost farm productivity. Sustainable cassava farming entails ensuring enough food for the current and future generations, enhancing the standard of living in

rural regions and providing enough money for the farmers. In addition, an essential component of sustainable cassava profit efficiency is maintaining the viability of farming operations Sustainable agricultural practices like crop rotation, use of cover crops, integrated pest management (IPM), agroforestry techniques, reduced tillage system improve the ability to adapt to climate change and variability, reduce the environmental effect of agriculture and allow for a more efficient use of natural resources (Reimer et al. 2012). Considering these factors, this study looked at how adopting sustainable agricultural practices affected the profit efficiency of cassava farmers in Ogun State, Nigeria. The specific objectives include: describing the socioeconomic characteristics of the study area's cassava farmers and identifying the sustainable agricultural practices and its impact on profit efficiency.

METHODOLOGY

The study was carried out in Abeokuta Agricultural Development Programme (ADP) Zone in Ogun State. The study area lies between latitude 7.1475° N and longitude 3.3619° E. It has a land area of about 879 km^2. The state's workforce is mainly employed in the civil service, agriculture, fishing, apparel, and adire fabric production.

A multistage sampling technique was used in selecting the cassava farmers in the study area. In stage one, 2 blocks were chosen randomly from the ADP zone. In stage two, 2 cells were chosen randomly from each block to give 4 cells. In stage three, proportionate sampling across the 4 cells was done to obtain 120 farmers.

Data on cassava farmers' socioeconomic characteristics, sustainable agricultural practices adopted, input use and cost, output were collected with a structured questionnaire. Collected data was analysed using descriptive statistics (frequency and percentage) and Cobb-Douglas stochastic frontier profit function specified below:

$$.l_nC = \beta_o + \beta_1 l_n X_1 + \beta_2 l_n X_2 + \beta_3 l_n X_3 + \beta_4 l_n X_4 + \beta_5 l_n X_5 + V_i - U_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

l_n = Logarithm to base ;
C= Profit of the cassava farmers (₦)
X_1 = Farm size (ha) ;
X_2 = Cost of hired labour (₦/ha)
X_3 = Cost of cassava stem cuttings (₦/ha) ;
X_4 = Cost of pesticide (₦/litre)
X_5 = Cost of fertilizer (₦/kg) ;
U_1= Error term
β_o = Constant term ;
$\beta_1 \ldots \beta_5$ = Regression coefficients
Ui= are random variables assumed to be independent and normally distributed with zero mean and constant variance V_i- N (0, δ^2). They are non–negative random variables and are crucial in understanding and addressing profit inefficiency in production.

The determinant of profit inefficiency is defined by :

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} + \delta_8 Z_{8i} + \delta_9 Z_{9i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (ii)$$

Where:
U_i = profit inefficiency ; Z_1 = Intercropping as SAP (adopted = 1 ; 0 otherwise)
Z_2 = Mixed farming as SAP (adopted = 1 ; 0 otherwise)
Z_3 = Crop rotation as SAP (adopted = 1 ; 0 otherwise)
Z_4 = Integrated pest management as SAP (adopted = 1 ; 0 otherwise)
Z_5 = Farmers' age (years) ;
Z_6 = Farmers' level of education (years)
Z_7 = Marital status (married = 1 ; 0 otherwise) ; Z_8 = Farming experience (years)
Z_9 = Extension contact (yes = 1 ; 0 otherwise) ; δ_0 -δ_9 = parameters.

RESULTS AND DISCUSSION

Socioeconomic characteristics of cassava farmers

Table 1 shows that 79.2% of the respondents were male, while 20.8% were female. This showed that men are more predominant in cassava farming in the study area. Age distribution of the farmers showed that very few (7.5%) were between 20-30 years of age, while a large number (43.3%) were between 41-50 years, with an average farmer being 45 years old. Also, 97.5% were married, while 2.5% were separated. It was found that 7.5% of the farmers had primary education, 83.3% had secondary education and 9.2% had tertiary education. According to farm size, more than half (54.2%) of the farmers had between 1.1 – 2.0 hectares of farmland, while 35.8% had

between 2.1 – 3.0 hectares. The average farm size was 2 hectares. Furthermore, majority (59.2%) of the farmers had between 11 and 20 years of farming experience, whereas only 5.0% had less than ten years of farming experience. 35.9% had farming experience above 20 years. The result also revealed that 91.7% of the respondents had access to extension services, while 8.3% had no access.

Sustainable agricultural practises among cassava farmers

Sustainable agricultural practices adopted among the cassava farmers in ranking order as shown in Table 2 revealed that soil enrichment is mostly (65.0%) adopted, followed by integrated pest management (63.3%), intercropping (59.3%), crop rotation (55.8%), mixed farming (54.2%), agroforestry (45.8%) and cover cropping (38.5%).

Profit efficiency among cassava farmers

The cassava farmers' profit efficiency is shown in Table 3. From the table, 4.1% of the farmers had a profit efficiency of 0.2 and below. 29.2% had 0.21-0.40. The majority (41.7%) had profit efficiency between 0.41-0.60, whereas 15.0% and 10.0% had profit efficiency of 0.61-0.80 and 0.81-1.00 respectively. The minimum and maximum profit efficiency were 0.13 and 0.95, respectively, with a mean profit efficiency of 0.64. The mean profit efficiency of 0.64 implies that the cassava farmers obtained 64% of their potential profit from a unit mix of inputs. In other words, about 36% of the profit is lost to the inefficiency of management practices. Thus, in the short run, there is a scope for increasing profit from cassava production by 36%. This result aligns with the findings of Ettah and Kuye (2017).

Determinants of Profit efficiency among cassava farmers

The parameter estimates of the determinants of profit efficiency among cassava farmers were presented in Table 4. The estimated gamma parameter (γ) is 0.813 and significant at a 1 per cent probability level. This implies that about 81.3% of the variation in actual profit from maximum profit among farmers mainly arose from differences in farmers' practices rather than random variability. The estimated parameter obtained for farm size had a positive relationship with profit. This implies that an increase in farm size cultivated will lead to an increased profit. This is in tandem with the earlier findings of Oyewole and Oyewole (2023). The cost of hired labour and cassava stem were also negatively significant at 5% and 1%, respectively. This implies that an increase in the price of these variables will reduce the cassava farmers' profit efficiency.

For the profit inefficiency model, the estimated coefficient for age was negative and significant at the 10% level. This implies that as farmers' age increases, the level of profit inefficiency tends to decrease, thereby increasing profit efficiency. This could be that the older the farmer gets, the more efficient he becomes, possibly due to the mastery and perfection of the technicalities involved in cassava production. This finding is in line with the work of Oke et al. (2022), where age positively contributed to profit efficiency. An inverse and significant relationship was found between education and profit inefficiency. This implies that an increase in education decreases profit inefficiency. This finding agrees with the work of Oke et al. (2021) that education increases profit efficiency in catfish farming. Farmers' educational status impact productivity as educated farmers find it easier to understand information on innovations on-farm practices and production technologies than their counterparts. The coefficient for farming experience was negative and significant at 5%, implying that an increase in farming experience tends to decrease the level of profit inefficiency (i.e., increase profit efficiency). This finding aligns with the findings of Abu and Abah (2012), who found that an increase in farming experience decreases the profit inefficiency of female smallholder farmers. Extension contacts also had a significant negative relationship with profit inefficiency. This means that contact with extension agents decreases profit inefficiency and increases profit efficiency. This is expected as this could afford them the opportunity to interact with them, thereby exchanging information on improved technology in farming. This result agrees with the findings of Oyewole and Oyewole (2023). The sustainable agricultural practices (SAP) variables influencing profit inefficiency were mixed farming and integrated pest management. These variables were found to reduce profit inefficiency among the farmers.

CONCLUSION AND RECOMMENDATION

The study concluded that SAP were adopted by the farmers, cassava farming is a profitable venture in the study area given the mean profit efficiency of 0.64 and SAP also positively impacted profit efficiency. The study recommended that farmers should be encouraged to invest in cassava production due to its profitability, inputs should be made available and reasonably priced and policy that supports extension are required to ensure that farmers receive training on sustainable agricultural practices to maximize profit efficiency.

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Table 1: Distribution of cassava farmers according to socioeconomic characteristics

Socioeconomic characteristics	Frequency	Percentage	Mean
Sex	95	79.2	
Male	25	20.8	
Female			
Age (years)			
20 – 30	9	7.5	
31 – 40	33	27.5	
41 – 50	52	43.3	
51 and above	26	21.7	45
Marital status			
Married	117	97.5	
Divorced	3	2.5	
Educational qualification			
Primary	9	7.5	
Secondary	100	83.3	
Tertiary	11	9.2	
Farm size (hectares)			
0.1 – 1.0	12	10.0	
1.1 – 2.0	65	54.2	
2.1 – 3.0	43	35.8	2
Farming experience (years)			
< 10	6	5.0	
10 – 20	71	59.2	
> 20	43	35.8	18
Access to extension services			
Yes	110	91.7	
No	10	8.3	

Table 2: Sustainable agricultural practices (SAP) among cassava farmers

Sustainable agricultural practices	Percentage**
Soil enrichment	65.0
Integrated pest management (IPM)	63.3
Intercropping	59.3
Crop rotation	55.8
Mixed farming	54.2
Agroforestry	45.8
Cover cropping	38.5

**Multiple responses

Table 3: Distribution of cassava farmers according to profit efficiency

Profit efficiency range	Frequency	Percentage
0.2 and below	5	4.1
0.21 – 0.40	35	29.2
0.41 – 0.60	50	41.7
0.61 – 0.80	18	15.0
0.81 – 1.00	12	10.0
Total	**120**	**100.0**
Minimum	0.13	
Maximum	0.95	
Mean	0.64	

Table 4: Determinants of Profit efficiency among cassava farmers

Variables	Co-efficient	Standard error	t-value
Constant	9.024***	2.160	4.18
Farm size	0.188***	0.030	6.27
Cost of hired labour	-0.120**	0.061	1.97
Cost of cassava stem	-0.020***	0.005	4.00
Cost of pesticide	0.003	0.060	0.05
Cost of fertilizer	-0.092	0.076	1.21
Inefficiency model			
Constant	2.753***	0.589	4.67
Intercropping	0.463	0.783	0.59
Mixed farming	-1.436**	0.656	2.19
Crop rotation	0.695	0.783	0.89
Integrated pest management	-0.496*	0.280	1.77
Farmers' age	-0.506*	0.300	1.69
Level of education	-0.184***	0.042	4.38
Marital status	0.097	0.242	0.40
Farming experience	-0.844**	0.415	2.03
Extension contact	-0.994***	0.151	6.58
Sigma squared (δ^2)	10.471***	2.385	4.39
Gamma (γ)	0.813***	0.215	3.78
Log likelihood function	-198.43		
Observations	120		

* Significant at 10% level, ** significant at 5% level, *** significant at 1% level.

Sub-Theme Four
Natural Resource Control, Agricultural Production and Extension

8th Annual Conference and 67th AGM-ABEOKUTA of The Association of Deans of Agriculture in Nigeria Universities (ADAN), Held at The FUNAAB Red Senate chamber, Abeokuta, Ogun State, Nigeria, from July 7th to 11th, 2024. Theme: Climate Change: Agricultural Innovations and Bio-entrepreneurship for Sustainable Development, Food Sufficiency and Economic Transformation. **Edited by:** A. E. Obayelu, O.M Olosunde, P. B. Abdulsalam-Saghir, O.S. Sowande, E.O. Fakoya and J.J. Atungwu

IMPACT OF HUMAN ACTIVITIES ON LAND USE CHANGE AND WILD ANIMAL SPECIES IN OLUSEGUN AGAGU UNIVERSITY OF SCIENCE AND TECHNOLOGY, OKITIPUPA, ONDO STATE

Ogunjobi, J. A
Department of Forestry, Wildlife and Environmental Management
Olusegun Agagu University of Science and Technology, Okitipupa, Ondo State
ja.ogunjobi@oaustech.edu.ng, ogunjonson02@gmail.com

ABSTRACT
Land use and land cover change is one of the major threats facing wild animal resources globally. In this study, effects of land use and land change on wild animal species were investigated from 2000 to 2020 to examine the land changes and affected wild animal species within Olusegun Agagu main campus along Okitipupa-Igbokoda road, Ondo State, Nigeria. This study employed satellite images and transect walk to examine land use changes as well as semi structured questionnaire was used obtain information on changes in wild animal resources over the years under study. Digital image-processing software ENVI 5.5 and GIS software Arc GIS 10.2 were used for processing, analysis and integration of spatial data. A decrease in the forest from 166.9 ha (93.41%) in 2000 to 0.36 ha (0.2%) in 2020 was recorded whereas cultivated land area increased from 11.41 ha **(**6.38%) in 2000 to 54.21 ha (30.35%) in 2020. The study concluded that increase in human activities particularly farming is a threat to wild animal species in the study area. The study recommended amongst other things wildlife conservation education and all-inclusive habitat management plan by the University management.

INTRODUCTION
Land is a vital natural resource for human survival and the base for all terrestrial ecosystems. A change in land is liable to interfere with various components of terrestrial ecosystem including wildlife resources. This study seeks to assess impact of land use on wildlife resources using an approach based on remote sensing to investigate the extent of land use or land cover changes in Olusegun Agagu University of Science and Technology main campus located along Okitipupa- Igbokoda road in Ondo State, Nigeria with a view to investigates land change from 2000 to 2020 and its impact on wildlife resources.

MATERIALS AND METHODS
This research work was carried out in Olusegun Agagu University of Science and Technology, Okitipupa, Ondo State, Nigeria. Olusegun Agagu University of Science and Technology (OAUSTECH), Okitipupa was established by the Ondo State government in 2008. The government changed the name to Olusegun Agagu University of Science and Technology (OAUSTECH) in 2019. The University is located within Ikale land with a land area of about 803 km². The area lies between Longitudes 40’ 3” and 6’ 00” East of Greenwich Meridian and latitudes 50’ 45” and 80’ 15” North of the Equator. To determine the Land-use/Land-cover of the area in 2000, 2010 and 2020 as well as to determine the extent of vegetation cover in the area in 2000, 2010 and 2020, each image set carried out from the recorded data were broadly classified into five different categories/polygons. After the classification was done, the area coverage (extent) of each land use/land-cover type of the four periods was ascertained by constructing the histogram of each classified image. To determine the land-use/land cover change of the study area between 2000-2020, the area coverage (km²) of each classified land-use/land-cover type for these time period was extracted from the images histograms prepared and the result was subsequently compared to calculate the area (km²) and percentage change of each land-use/land-cover type. The area change of vegetation was ascertained by subtracting the former area coverage of vegetation from the latter area coverage of vegetation. The “Line transects technique as described by Buckland *et al*., 2001 was employed. The trails were cut by an experienced hunter with minimal impact on the vegetation and swept clear of debris to minimize noise during walks for indirect and direct analysis

of wildlife species. Furthermore, two communities surrounding the study area were selected (Igodan and Ayeka communities) and interview was conducted with the villagers. The two villages were purposefully selected on the bases of a long history of agriculture and hunting and proximity of villages to the study area.

RESULTS AND DISCUSSION

The assessment of land use status in 2000 showed that forested area which include; mixed forest, Oil Palm Plantation and other tree plantings covered 166.95 ha (93.41%) of the total land surface of the study area. Light Vegetation includes; Derived Savannah, Grassland, Farmland and other green spaces was covered by 11.41 ha (6.38%) of the total land area. This was followed by Developed Area which includes; Buildings, Road and Bare Surfaces which covered 0.36 ha (0.2%) and as at 2010, the forested area has reduced to 88.89ha (49.77%) meaning a reduction by 43.64%. Developed Area which includes; Buildings, Road and Bare Surfaces saw an increment and covered 54.21 ha, representing 30.35% of land coverage. In 2020, forested area which include; mixed forest, Oil Palm Plantation and other tree plantings covered 39.9 ha (22.34%) of the total land surface. Developed Area which includes; Buildings, Road and Bare Surfaces increased to 48.02ha (26.89%). From 2000 to 2010, the forested area reduced from 166.9 ha (93.41%) to 88.89ha (49.77%) in 2010. This accounted for a magnitude change of -78.1 ha (43.64%) reduction of the forest with an annual deforestation rate of 4.36%. Within this time, Light Vegetation which includes; Derived Savannah, Grassland, Farmland and other green spaces, increased from 11.41 ha (6.38%) in 2000 to 35.5 ha (19.88%) in 2010. This gave a magnitude change of +24.09 ha. (13.5%) accounting for an annual increment rate of 1.35%. Developed Area which includes; Buildings, Road and Bare Surfaces increased from 39.9 ha (22.34%) in 2000 to 90.68 ha (50.77%) in 2010. Between 2010 and 2020, the magnitude of change was also very significant. Forested area reduced from 88.89 ha (49.77%) in 2010 to 0.36 ha (0.2%) in 2020. This gave a magnitude change of -88.53 ha (49.57%), giving an annual reduction rate of 4.96%. Farm land increased from 35.5 ha (19.88%) in 2010 to 54.21 ha (30.35%) in 2020. This gave a magnitude change of 18.71 ha (34.33%) with an annual rate of 3.43%. Developed area decreased from 90.68 ha (50.77%) in 2010 to 48.02 ha (26.89%). This gave a magnitude change of 42.66 ha (23.88%) giving an annual rate of 2.39%. The magnitude of change for the study period (2000-2020) showed an increment in the magnitude of land use and land cover. Forested area reduced from 166.9 ha (93.41%) in 2000 to 0.36ha (0.2%) in 2020. This accounted for -166.54 (-93.21%), giving an annual deforestation rate of 4.66%. Light vegetation increased from 11.41 ha (6.38%) in 2000 to 54.21 ha (30.35%) in 2020. This gave a magnitude change of 42.8 ha (23.97%) with an annual rate of 1.2%. Developed area increased from 39.9 ha **(**22.34%) in 2000 to 48.02 ha (26.89%) in 2020. This gave a magnitude rate of 8.12 ha (4.55%) giving an annual growth rate of 0.23%. This land cover change is caused by a number of factors which are grouped into expansion of farmlands, population increase, livestock grazing, environmental change, bush fire and illegal exploitation of the forest and migration of wildlife species. From our interview with the villagers, a high proportion of the respondent (20.9%) was of the fact that increasing farming activities in the park have remained the main cause of land use change. This was followed by (19.1%) for those who advocated population increase to be the main cause of land use change. The least (13.1%) were those who saw bush fire as leading cause of land cover change.

Table 1: Changes in wildlife resources in OAUSTECH for two decades

Common Name	Scientific Name	2000-2010	2010-2020	Trends
Africa rock python	*Python sebae*	***	***	Reducing
Antelope	*Bovidae*	****	**	Reducing
Baboon	*Papio anubis*	***	**	L.E(local extinct)
Bush buck	*Tragelaphus sylvaticus*	***	**	Reducing
Bush fowl	*Amaurornis olivacea*	****	**	Incraesing
Bush pig	*Potamochoerus larvatus*	**	*	L.E(local extinct)
Civet cat	*Civettictis civetta*	****	**	Reducing
Cobra	*Naja naja*	****	****	Increasing
Crocodile	*Crocodylus niloticus*	**	*	Reducing
Deer	*Cervidae sp.*	**	*	Extinct
Dove	*Columbidae sp.*	****	****	Increasing
Duiker	*Cephalophinae*	**	*	Reducing
Elephant	*Elephantidae sp.*	**	*	Extinct
Gabon viper	*Bitis gabonica*	****	**	Reducing
Grasscutter	*Thryonomys swinderianus*	****	***	Reducing
Guinea fowl	*Numididae sp.*	****	**	Reducing
Hippopotamus	*Hippopotamus amphibious*	**	*	Extinct
Kite	*Milvus migrans*	****	****	Reducing
Monitor lizard	*Varanus sp.*	****	****	Reducing
Monkey	*Cercopithecidae sp.*	**	*	Reducing
Owl	*Strigiformes sp.*	****	***	Reducing
Pigeon	*Columba livia*	***	**	Reducing
Porcupine	*Hystrix cristata*	****	**	Reducing
Squirrel	*Sciuridae sp.*	****	****	Increasing
Vulture	*Cathartidae sp.*	***	**	Increasing

****=very abundant ***= abundant, **= less abundant, * = not present

A high proportion of respondents (30.8%) were of the fact that rodents dominate the study area. This was followed by those who saw reptiles as most numerous (26.6%). The least was those for ungulates (19.4%). Five factors were discovered to have been the major impact of land use changes on the population of wildlife in the park. A high proportion of respondent (34.2%) identified migration of species as a major consequence of land use changes. This was followed by those who opined that decline in wildlife population is the major resultant effects of land use (30.4%). The least were those who thought that land use change is leading to increase in wildlife population in the study area (Table 1).

Land use change in OAUSTECH is really visible; through a reduction of forests stand by 43.64% (for example, expansion of farm land, illegal logging) for the past two decades and the increase in bare soils of 28.43% (increasing grazing) for same period while at moment deforestation stands at 4.36%. Thus, meaning an increase of 88.53ha in the past two decades. If land uses continue in the same paste, holding everything constant, we are expected to lose an additional 22.11km² by 2050. Extensive land uses occurs in all habitat types but remained the dominant threats to forest and grassland species (Aramde *et al*, 2014) as seen from deforestation rate and the rate of bare soils in the study area. This had significantly affected wildlife in Olusegun Agagu University of Science and Technology main campus through reduction in population and diversity. The major factors responsible for land use and land cover change were the expansion of farmlands (commercial and subsistence) and structures, population growth, increasing livestock grazing activities, environmental degradation, bush fire illegal logging and settlements. A high proportion (47.7%) of the people involved in farming both subsistence and cash crop production have between 3 and 5 farms while (32.7%) have less than 3 farms and (19.6%) have above 5 farms. Individual farm sizes differ. A great number of

the people (44.4%) of the people have farm sizes ranging from 0.5 ha to 3ha. This is followed by (39.3%) with farm sizes between 3.5ha to 5ha while (16.4%) have farm sizes that range above 5 ha.

CONCLUSION AND RECOMMENDATIONS

An important aspect is to look at the planning of developmental process to ensure natural areas are protected as much as possible due to their enormous advantages. This study shows that this spatial developmental change has resulted in the migration of wildlife resources outside the main campus of Olusegun Agagu University of Science and Technology (OAUSTECH). The most critical change on the campus was the conversion of forested area to developed areas and farmland making the wildlife resources seeking for safe heaven elsewhere. The increase in development area through building, road and other infrastructural construction was undoubtedly necessary due to the development and growth of the university. The findings of this study are useful to help the university authority and stakeholders understand the trend and pattern of landuse and land cover changes on OAUSTECH campus and its effects on wildlife resources. Sustainable land use practices in form of wildlife conservation education outreach was suggested by Ogunjobi and Surulere (2020). Serious plan to guide the preparation of a developmental framework that would consider a holistic environmental issues is timely. A sustainable land use practice in form of wildlife conservation education couple with all-inclusive habitat management plan by the University management was recommended.

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INFLUENCE OF BIOCHAR APPLICATION RATES ON SOIL PROPERTIES, GROWTH, AND YIELD OF TOMATO (SOLANUM LYCOPERSICUM) IN OKITIPUPA SOUTHWEST NIGERIA

Oladitan, T. O.

Department of Crop, Soil &Pest Management, Olusegun Agagu University of Science and Technology. Okitipupa. Ondo State Nigeria.

*ditanbimpe@gmail.com;to.oladitan@oaustech.edu.ng.Tel: 08060485319

ABSTRACT

Increasing pressure on land use and soil management practices is crucial in agricultural systems for crop production, Biochar offers a sustainable solution by sequestering carbon in soil and enhancing soil health. A study was conducted at T & RF, OAUSTECH, Okitipupa to investigate effects of biochar application rates on growth and yield of Tomato varieties (Beske and Ibadan local). The soil treated with four biochar application rates (0kg/ha, 5t/ha,7.5t/ha, and 10t/ha) and was laid in a randomized complete block design, replicated thrice. Measurements were taken on soil properties, phenology and yield parameters. Results: 7.5 t/ha-1 application rate ($P>0.05$), recorded the best improvement in soil properties. Bulk density decreased in biochar amended plots, while Total N, available P, organic carbon, pH and exchangeable bases (K+, Ca2+, Mg2+ and Na+) were significantly higher in biochar amended plots compare to the control. Biochar application at 10t/ha-1 significantly ($P<0.05$) increased phenology parameters and recorded the highest fruit yield (3446.5kg/ha^{-1}) while control was 1953.2kg/ha^{-1}. The study recommended 10 t ha^{-1} as a good biochar application rate in the study area. Results indicated that biochar application could be a possible way of improving soil properties and native soil carbon in degraded alfisol and intensive cropping systems.

Keywords: Degraded soil, Sustainable management, Tomato, carbon, Biochar.

INTRODUCTION

The decreasing soil fertility in many developing countries has brought forward the importance of technologies that are locally available, economically possible, and environmentally friendly (Poudel, 2015). Improving environmental quality by reducing soil nutrient leaching losses, reducing bioavailability of environmental contaminants, sequestering C, reducing GHGs', and enhancing crop productivity in highly weathered or degraded soils, has been the goal of agroecosystem researchers for years (Ippolito et al., 2016). Biochar is one of the promising tools employed in enhancing the soil physiochemical properties including the moisture retention and aggregation of soil particles (Ippolito et al., 2016). Numerous researchers have shown that biochar amendment can reduce the bioavailability of toxic metals (Khan et al., 2017) due to high pH and CEC and organic carbon (Mohamed et al., 2016).

The benefit of producing vegetable crops for food and economic purposes to bridge the gap in coastal rainforest of south west Nigeria is eminent. This is as a result of highly degrading soil from continuous cultivation. The production of most economic fruit vegetables such as the *Solanaceae* (Tomato, eggplant) are limited by biotic and abiotic factors in management and agronomic practices. (Akinseye et al., 2018; Ayankojo and Morgan, 2020). Understanding the optimal biochar application rates for tomato can contribute to developing sustainable agricultural practices that mitigate soil degradation, reduce nutrient losses, and promote long-term soil productivity. Biochar application rates have been shown to affect the yield-related traits of tomato. The research studied by Chen et al. (2015) and Liu et al. (2000) indicated that appropriate biochar application rates increased fruit weight, number of fruits per plant, and total yield in various vegetable tomato. These findings suggest that biochar can positively impact the yield potential of tomato plants. However, there is little or no confirmation of the rate to be applied for tomato production. Therefore, the study aims to determine the proximate composition of the material used (biochar), and estimate the rate of application suitable for tomato production.

MATERIALS AND METHODS

The experiment was conducted to manage the soil fertility using biochar derived from the pyrolysis of oil palm solid waste to improve tomato production at the Teaching and Research farm of Olusegun Agagu University of Science and

Technology, Okitipupa (OAUSTECH), at a coordinate within latitude 06°25' N and 06°25' N and longitude 04°35' E and 04°50' E with elevation less than 300m above the sea level ,under rainfed conditions during 2021 and 2022 cropping seasons.

Procedure

Biochar materials and soil samples collected from 0-30 cm depth randomly from the experimental site, bulked for proximate laboratory analysis. Post-planting soil analysis were also carried out at the end of the cropping season to evaluate the effects of biochar on the growth and yield of the tomato and soil properties (IITA,2001). The treatments were four rates of biochar applications (Control at 0kg/ha, 5t/ha,7.5t/ha, and 10t/ha) incorporated into the soil 10 days before transplanting, and tomato varieties (Platino and Ibadan Local), nursed and transplanted after 28 days. The seedlings were laid in a Randomized Complete Block Design (RCBD) on 1.5 x 2 m^2 plots replicated thrice at a planting distance of 30cm by 90cm to give a planting population of 55,556 stands/ha. Growth and yield data were collected from the three tag plants (3 plants per plot) which were randomly selected from the net plot weekly. Collected data were subjected to analysis of variance (ANOVA) using the SAS statistical package at 5% Significant Difference.

RESULTS

Parameter	Unit	10t/h	7.5t/ha	5t/ha	control
Sand	%	67.95±0.08a	72.68±0.45d	70.06±0.08c	41.00±0.0a
Clay	%	12.16±0.18b	10.84±0.23a	14.68±0.46c	39.00±0.0d
Silt	%	19.93±0.10c	16.98±0.03b	15.77±0.33a	20.00±0.0c
$pH_{(Kcl)}$		6.09±0.13b	6.04±0.06b	6.06±0.08b	5.00±0.0a
N	($cmolckg^{-1}$)	0.58±0.60a	0.17±0.03a	0.57±0.62a	0.59±0.58a
P	($cmolckg^{-1}$)	7.95±0.08b	7.73±0.39b	8.05±0.07b	5.26±0.37a
Na	($cmolckg^{-1}$)	0.69±0.44a	0.72±0.40a	0.79±0.30a	0.61±0.55a
K	($cmolckg^{-1}$)	1.85±0.22b	1.74±0.37b	1.21±0.29b	0.16±0.04a
Ca	($cmolckg^{-1}$)	2.92±0.12b	2.78±0.32b	3.01±0.01b	1.20±0.28a
Mg	($cmolckg^{-1}$)	3.77±0.33b	3.69±0.44b	3.08±0.11b	0.80±0.28a
CEC	(meg/100)	7.98±0.04a	8.58±0.60a	8.12±0.17a	8.15±0.21a
Cu	mg/kg	1.90±0.14a	1.82±0.25a	1.79±0.30a	1.90±0.15a
Al	mg/kg	0.09±0.01a	0.08±0.04a	0.09±0.01a	2.90±0.14b
TOC	(%)	1.47±0.05b	1.13±0.18ab	1.04±0.06a	1.12±0.17ab
Texture		Sandy clay loam			sandy clay
Bulk Density	gm	1.31	1.34	1.42	1.51

Similar alphabet along the column in same treatment are not significantly different p< 0.05 (DMRT)

The nutrient status of surface soil, displayed in Table 1 shows that biochar application rates have a significant effect on both physical and chemical properties. The soil particle sizes and percentages were statistically and significantly different, there was an increase in the percentage of sand recording 70%, 72.5%, and 68% respectively for biochar at 5t/ha, 7.5t/ha, and 10t/ha and a decreased range between 10.8% -20.0% was recorded in the parentage quantity of clay and silt respectively. Other properties such as texture, structure, pore size distribution, and bulk density were altered. The findings are in line with the study of Mohammed et al. (2017) in the application of biochar to infertile soils decreases soil bulk density, increases total pore volume and water holding capacity, and Oguntunde et al. (2008), investigating the influence of biochar on bulk density in charcoal-site soil that was reduced by 9% compared to adjacent field soils.

Biochar exhibits the potential to improve the chemical properties of soils. The soil pH without biochar application was acidic (pH 5), and with treatment application, the pH increased significantly with biochar treatments at different rates from pH 5 to 6.09 for 10t/ha, and pH 6.06 for 5t/ha. The CEC was statistically different and increased with the volume of biochar treatments

in the soil, there was no significant difference among the treatments.

These results indicate that biochar treatment application can serve as a buffer in balancing the soil pH (Khan et al., 2017). This tallies with the researcher's report that biochar amendment can reduce the bioavailability of toxic metals due to high pH and CEC and organic carbon (Park et al., 2011; Khan et al., 2017). Significant differences were shown in the concentration of Phosphorus and Potassium among the treatments. At the application of 5t/ha, the available P increases by 8.05%, significantly different from the application of 10t/ha which increases by 7.95%. Available P content was higher in the treatment of biochar at 5 t ha^{-1} followed by biochar at 10 t ha^{-1}. The increase in available phosphorous could be due to the high adsorption and desorption potential of biochar. The total amount of potassium present in the initial analysis was (0.16cmol/kg), after the application of biochar at 10t/ha, it increased to (1.85cmol/kg), 7.5t/ha increased to (1.88cmol/kg), and the application of biochar at 5t/ha with increased it (1.21cmol/kg).

Table 2 Effects of biochar application treatment rates on the yield and yield component of tomato

Treatment	anthesis day	fruit wt.(g) (wet)	fruit no./m2	harvested wt.(kg/ha)	shoot dry wt.(g)	harvest index
10t/ha	21.61a	85.95a	635.8b	3446.5a	24.8625b	0.05042b
7.5t/ha	21.36b	78.72b	686.2a	3452.8b	25.3725a	0.07271a
5t/ha	21.53ab	76.42b	567.6c	2197.8c	18.6278d	0.04708b
Control 21.50ab		41.48c	426.5d	1953.2d	19.2398c	0.03583c
L.S.D	0.163	0.066	8.58	7.07	0.033	0.0026
varieties*fertilizer	**	*	**	*	*	*

Similar alphabet along the column in same treatment are not significantly different p< 0.05 (DMRT)

The biochar application rates on anthesis day were significantly different among the treatment effects, however, the range was statically similar (Table 2). The control plot attained the earliest anthesis day (approximately 21 days), and was statistically similar to other application rates, but were significantly different from each other application rate. It affirms the finding of Ayakojo and Morgan, (2020); Oladitan and Akinseye, (2014) that anthesis is genetically composition, but it could be influenced by environmental factors. The richness of N in biochar could also play a role in reaching days to anthesis. The highest mean fruit weight was recorded from 10t/ha (85.95g) followed closely by I7.5t/ha application rate recording 78.7g while the control plot recorded (41.48g) had the least fruit weight. it could be inferred that the number of fruits produced is a result of nutrient availability in the soil and environment interaction. (Oladitan et al., 2020). The total harvested weight (kg/ha) was significantly different among the treatment factors. 7.5t/ha application rate recorded the maximum harvested weight (3452.8kg) closely followed by 10t/ha application (3446.5kg) but was significantly different from the 5t/ha and control respectively, which were the lowest (2197.8kg and 1953.2kg).

CONCLUSION

Application of biochar at different rates enhanced crop growth and yield. Biochar may improve soil physicochemical properties, consequently increasing root growth. Biochar application at a higher rate was found efficient in increasing soil nutrient availability such as N, P, and K, thereby increasing tomato yield. Given the shortage of fertilizers for most subsistence farmers, the promotion of biochar-based organic fertilizers should be encouraged through research and extension by the concerned authorities for wider adoption by farmers in their farmland.

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TREE CROPS IMPLICATED FOR CLEAN-UP OF SOILS CONTAMINATED WITH ORGANIC POLLUTANTS

***Unaeze, C. H.[1], Ebi, D.[1], Madu L.[1], Oko, V[1]. & Madu J.[1]**
[1]National Biotechnology Development Agency

Corresponding Email: chyfor1@yahoo.com

ABSTRACT
Organic pollutants are highly toxic environmental pollutants and are known to accumulate in the environment due to their non-degradability. Phytoremediation is a biological technology which involves using plants to remove pollutants from the environment or to render them harmless. It is considered to be environmentally friendly and cost-effective using pollutant-accumulating plants for the cleaning of the polluted environmental compartment. Development of phytoremediation technique involves searching for species that can tolerate large accumulations of heavy metals in them. These accumulations happen in the root system of the plants, and are then translocated into the aerial part. To achieve this process, fast growing plants are suitable which will create a large biomass within a short period. This article looked at various studies on the use of tree crops in the phytoextraction of organic pollutants in contaminated soils. Findings from the reviewed work were collated, and it revealed the most promising species for these studies which include *Popullus, Salix, Pinus, Eucalyptus, Robiniapseudo, Acasia, Leucaena leucocephala, Melia azedarach, Dalbergia sissoo, Acer, Betula pendula, Tilia cordata,* and *Ulmus laevis.* These tree crops have shown promising abilities in decreasing the amount of organic pollutants and thereby increase the productive value of the contaminated soils. This paper presents a review of the literature on the use of tree crops in the phytoremediation of soils contaminated with heavy metals. Plant species with prospects for removal of organic pollutants have been identified in this article. Phytoremediation potentials of the identified tree crops have been documented, there is therefore sufficient grounds for further exploration.
Keywords: Phytoextraction, Contaminated Soils, Tree Crops, Pollutants

INTRODUCTION
Phytoremediation is a sustainable, cost-effective, and environmentally friendly technology for the recovery of contaminated soils, water, and air. It involves the use of plants to absorb, transform, or degrade contaminants in the environment. Trees are one of the most important components of the ecosystem and have been extensively studied for their potential use in phytoremediation due to their large biomass, deep roots, and ability to accumulate high levels of contaminants.

LITERATURE REVIEW
In this literature review, we will explore some of the researches conducted on tree crops used in phytoremediation.

Mleczek *et al.*, (2017), studied the phytoextraction abilities of six tree species namely; *Acer platanoides* L., *Acer pseudoplatanus* L., *Betula pendula* Roth, *Quercus robur* L., *Tilia cordata* Miller, and *Ulmus laevis* Pall., cultivated on sludge contaminated with pollutants. All six tree species were able to survive on such an unpromising substrate. However, *A. platanoides* and *T. cordata* seedlings grown on the polluted substrate showed significantly lower biomass than control plants. The pollutants predominantly accumulated in the roots of all the analyzed tree species with the following highest contents: 1616, 268, 2432, 547, and 856 mg kg^{-1}, respectively. *A. platanoides* was the most effective in pesticide phytoextaction, with a bioconcentration factor (BCF) of 8.99 and a translocation factor (TF) of 1.5. Furthermore, with the exception of *A. pseudoplatanus*, the analyzed tree species showed a BCF > 1 for Tl, with the highest value for *A. platanoides* (1.41). However, the TF was lower than 1 in all the analyzed tree species. *A. platanoides* showed the highest BCF and a low TF and could, therefore, be a promising species for Tl phytostabilization. In the case of the other analyzed tree species, their potential for effective phytoextraction was markedly lower.

A study by Ullah *et al.* (2017) showed that pine trees can remove up to 82% of pollutants from contaminated soil. Another study by Forni *et al.* (2019) found that pine trees can accumulate high

levels of pesticides in their needles. Furthermore, a study by Piotrowska-Długosz *et al.* (2017) demonstrated that pine trees can enhance the microbial diversity and activity in the rhizosphere, thereby promoting the biodegradation of organic pollutants and the immobilization of pollutants in contaminated soil.

METHODS OF PHYTOREMEDIATION

The methods of phytoremediation includes phytoextraction, phytostabilization, phytovolatilization, phytodegradation and risodegradation. This process leads to the absorption of pollutants from the soil through the roots of plants, translocation and their accumulation in the aboveground organs. Pollutants can also be degraded by plants with their enzymes to inorganic compounds that accumulate in the plant. Phytoremediation is very useful in removing pesticides with good mobility in the plant.

FINDINGS

The authors reviewed previous works on the use of tree crops in phytoremediation and identified various tree crops that has successfully removed or reduced organic pollutants from contaminated soils. The findings from the reviewed works were collated for proper documentation and for further studies.

Table 1 shows the tree crops that were identified to have successfully removed organic pollutants from contaminated soils.

Table 1: Tree Crops and the Pollutants Successfully Rmediated

Tree Crop	Pollutants remediated	Reference
Poplar *(Populus spp)*	Polychlorinated biphenyl	Rizwan *et al.* (2017), Liu *et al.* (2017), Niazi *et al*. (2019)
Willow Tree *(Salix spp)*	Trichloroethylene	Chen *et al.* (2017), Gai *et al.* (2019)
Pine Tree *(Pinus spp)*	1,1,2,2-Tetrachloroethane	Ullah *et al.* (2017), Forni *et al.* (2019), Piotrowska-Długosz *et al.* (2017)
Eucalyptus *(Eucalyptus spp)*	Carbon tetrachloride	Figueire, do *et al*. (2018), Kaur *et al.,* (2018)
Black locust tree *(Robinia oacacia)*	Organic pollutants	Zhang *et al.* (2019)
Acacia *(Acacia spp)*	Organic pollutants	Liu *et al*. (2021)
Tamarin *(Leucaena leucocephala)*	Organic pollutants	Kaur *et al.,* (2018)
Chinaberry *(Melia azedarach)*	Organic pollutants	Kaur *et al.,* (2018)
Rosewood *(Dalbergia sissoo)*	PCBs	Kaur *et al.,* (2018)
Maple *(Acer Spp)*	Organic pollutants	Mleczek *et al.,* (2017)
Silver Birch *(Betula pendula*)	Organic pollutants	Mleczek *et al.,* (2017)
Oak Tree *(Quercus robur)*	Organic pollutants	Mleczek *et al.,* (2017)
Linden *(Tilia cordata)*	Organic pollutants	Mleczek *et al.,* (2017)
Elm Tree *(Ulmus laevis*)	Organic pollutants	Mleczek *et al.,* (2017)

CONCLUSION

This review showed that the phytoremediative potential of the studied tree species is limited to the phytoextraction of selected elements only. For this reason, the proper selection of tree species is a factor that can strongly influence the efficiency of heavy metal phytoextraction. This is especially important when we decide to cultivate a great number of plants on a polluted area. Several authors have documented the phytoremediation potentials of these tree crops, there is therefore sufficient grounds for further exploration.

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ASSESSMENT OF OCCUPATIONAL HAZARDS IN SAWMILLING IN KWARA STATE, NIGERIA

Falola, A.[1], Mukaila, R.[2*], Faruwa, F. A.[3], Musa, M. O,[4], Abarike, C. A.[1]

[1]Department of Agricultural Economics and Farm Management, University of Ilorin, Ilorin, Nigeria
[2]Department of Agricultural Economics, University of Nigeria, Nsukka, Nigeria
[3]Department of Forestry and Wildlife Management, Federal University of Agriculture Abeokuta, Ogun State, Nigeria
[4]Department of Agricultural Extension and Rural Development, University of Ilorin, Ilorin, Nigeria
[*]**Corresponding Author's E-mail**: ridwan.mukaila@unn.edu.ng

ABSTRACT
Sawmill workers are exposed to occupational hazards. Yet, there exists a dearth of information in the literature on it. Therefore, this study assesses the occupational hazards in sawmilling in Kwara State, Nigeria. Data collected from randomly selected 120 sawmill workers were analysed with descriptive statistics. The study showed that repetitive motion injury often occurs, and there were severe injuries and environmental pollution in the sawmill industry affecting the workers. The preventive measures (safety gear) used by sawmill workers were safety boots and goggles. Furthermore, the sawmill workers employed environmental measures. Meanwhile, the majority of the workers did not use earplugs, had no sensitization meetings, and had no medical outreaches and checkup campaigns. It is recommended that government agencies and relevant stakeholders should sensitize and ensure that sawmill workers are properly trained and have access to necessary protective equipment or devices. Measures should also be put in place to encourage and if possible, enforce the usage of this equipment.
Keywords: Occupational hazards, safety equipment, saw millers, workers' safety

INTRODUCTION
Sawmilling is a process and complete system of turning logs into lumber. Sawmill workers perform several duties and are exposed to a variety of occupational health risks (Onowhakpor et al., 2017). Sawmill workers encounter dangers from saws, conveyors, and mobile plants (Nnaji & Udokpoh, 2023), and have poor knowledge of the hazards inherent in their jobs (Odibo et al., 2018). Most of the sawmill workers in a bid to minimize cost work at the expense of their health. However, this could lead to severe health challenges and a reduction in sawmill output. Since hazards affect the health of sawmill workers and in turn the level of productivity of wood products, it is important to assess the occupational hazard situations surrounding sawmilling with the aim of understanding and finding better ways of preventing or managing hazard occurrences.

Although there are studies on occupation hazards, there exists scanty information about occupation hazards in the sawmill industry as the available studies focus on its knowledge (Adeoye et al., 2015; Agbana et al., 2016). Therefore, this study aimed to examine the occupational hazard situations facing sawmill workers and identify the common hazard preventive measures used by sawmill workers. This would help point out ways occupational hazards in the sawmill industry could be properly managed or avoided. This information can inform policy and programme

interventions aimed at managing occupational health hazards in the sawmill industry in Nigeria.

METHODOLOGY

This study was conducted in Kwara State, Nigeria. A three-stage sampling procedure was employed. The first stage involved the purposive selection of three local government areas (LGAs) widely known for sawmilling activities. The second stage involved the purposive selection of two main sawmills from each LGA. The third stage involved random selection of 20 workers from each sawmill making a total of 120 workers. Data were collected using a structured questionnaire.

Descriptive analysis was employed to examine the occupational hazard situations facing sawmill workers and identify common hazard preventive measures employed by the sawmill workers in the study area.

RESULTS AND DISCUSSION

Occupational Hazards of Sawmill Workers

Table 1 shows the cases of hazards in the sawmill industry. The majority (65%) of the saw millers agreed that slip and fall cases occur just sometimes. This could be because, sometimes, sawmill floors in the study area are slippery because of the growth of mould and mildew, fungi, and algae. Most of the workers (73.33%) agreed that severe injury occurs sometimes. Only 8.3% of the respondents reported that electric shocks occur sometimes. Also, only 0.83% of the respondents reported that sometimes the collapse of improperly built structures occurs, while the majority reported that the collapse of structures rarely occurs in the industry. The majority reported that repetitive motion injury occurs often (75%). For collision cases, the majority (59.17%) agreed that collision cases occur sometimes. A larger proportion agreed that hazards due to improper use of tools cases occur rarely (39.17%) and sometimes (30.83%). The majority agreed that hazard due to lack of effective protective gear cases occurs sometimes (68.33%) and often (29.17%). Adeoye et al. (2015) reported a similar finding that a lack of personal protective equipment posed a serious threat to the health of sawmill workers. About 41.67% of the workers reported that hazards from faulty machinery occurred sometimes. A few of the workers (0.83%) agreed that a fire outbreak occurs often in the industry, while the majority (85%) agreed that it never occurs. Meanwhile, most (95%) of the respondents reported that environmental pollution leading to illnesses occurs always. These results imply that sawmill workers were exposed to several occupational risks and hazards capable of causing permanent damage to the workers and affecting the sawmill industry's productivity.

Table 1: Categorization of Hazards Facing Sawmill Workers in the Study Area

Variables	Always	Often	Sometimes	Rarely	Never	Mean
Slip and falls	0 (0)	2 (1.67)	78 (65.00)	25(20.83)	15 (12.50)	2.55
Severe Injury	0 (0)	1 (0.83)	88(73.33)	18 (15.00)	13 (10.83)	2.05
Electric Shocks Hazard	0 (0)	0 (0)	10 (8.33)	36(30.00)	74 (61.67)	1.47
Collapse of structure	0 (0)	0 (0)	1 (0.83)	16(13.33)	103(85.83)	1.15
Repetitive motion injury	2(1.67)	90(75)	26 (21.67)	1 (0.83)	1 (0.83)	3.75
Collision	0 (0)	1 (0.83)	71 (59.17)	44(36.67)	4 (3.33)	2.57
Improper use of tools	0 (0)	20(16.67)	37 (30.83)	47(39.17)	16 (13.33)	2.50
Lack of effective protective gear	0 (0)	3(29.17)	82 (68.33)	3 (2.5)	0 (0)	3.267
Hazard from faulty machinery	0 (0)	2 (1.67)	50 (41.67)	65(54.17)	3 (2.50)	2.42
Fire outbreak	0 (0)	1 (0.83)	1 (0.83)	16(13.33)	102(85.00)	1.17
Environmental pollution leading to illness	114 (95.00)	5 (4.17)	0 (0)	1 (0.83)	0 (0)	4.93

Source: Field Survey 2023

Occupational Hazards Preventive Measures of Sawmill Workers

Table 2 shows the preventive measures engaged by sawmill workers in the study area. About 52.5% of the saw millers reported that they use gloves while 47.50% did not make use of gloves in milling activities. However, they complained about the poor quality and nature of the gloves. Only 5.83% used dust masks and 25% used safety boots as preventive tools. 64% of the respondents used safety goggles as a preventive tool. Only 8.4% of the respondents attended sensitization meetings by the Sawmill Association or other stakeholders, which is quite low as many workers will only consider taking their occupational health seriously when proper sensitization is done regularly. Access to medical outreaches and campaigns in the sawmill industry was very low (6.67%). Almost all the workers agreed that environmental measures were in place in their sawmills. Only 35.83% of them agreed that a day was set for sawmill maintenance and social work as a preventive measure. It is worthy of note that none of the respondents agreed to the use of earplugs as safety devices. The respondents reported that they were not aware of this measure or found it very expensive.

These results imply a low level of protective and preventive measures employed by sawmill workers as well as low knowledge of occupational hazards by sawmill workers. This is detrimental to their health and can cause severe health challenges, which could consequently affect their output level. These results are in line with those of Agbana et al. (2016) and Onowhakpor et al. (2017), who reported poor safety procedures among sawmill workers, and the workers had poor knowledge of work-related health hazards.

Table 2: Protective and Preventive Measures Employed Against Hazard

Equipment	Yes	No
Glove	63 (52.50)	57(47.50)
Dust Mask	7 (5.83)	113(94.17)
Safety Boot	30 (25.00)	90(75.00)
Ear Plugs	0 (0)	120(100)
Goggle	65 (54.17)	55(45.83)
Are there meetings to sensitise on preventive measures?	10 (8.4)	109(91.60)
Availability of medical outreach to lecture and conduct check-ups	8(6.67)	112(93.33)
Are there environmental measures (inspection) in place?	119(99.17)	1 (0.83)
A day is set aside to care for the site and conduct social work	43 (35.83)	77(64.17)

Source: Field Survey, 2023

CONCLUSION AND RECOMMENDATIONS

The study highlights the hazards, and preventive measures among sawmill workers in Kwara State, Nigeria. This study concludes that sawmill workers face various occupational hazards. While some preventive measures are in place, there is room for improvement, particularly in promoting the use of safety gear and raising awareness about occupational hazards. Therefore, this study recommends the provision of safety training and education on the proper use of safety gear, and hazard awareness and prevention. Also, sawmill associations should promote safety measures and supply resources for their members to access safety gear. The government should enforce occupational safety regulations and support sawmill workers, including safety gear.

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ASSESSMENT OF UTILIZATION OF EXTENSION SERVICES ON OIL PALM PRODUCTION IN IJEBU NORTH LOCAL GOVERNMENT AREA OF OGUN STATE

[1]Oyebamiji, B. A., [1]Adeyeye, O.A. [1]Adetarami., O. [1]Adeoye, A. S., [1]Sodiya, C. I.
[1]Okunade, J. A. & [1] Fagbenro, Z.O.
1 Department of Agricultural Extension and Rural Development, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.
*Corresponding author: oyebamijiba@funaab.edu.ng, +2348061242039, 0000-0002-9052-083X

ABSTRACT
The study investigates the utilization of extension services for oil palm production in Ijebu North Local Government Are of Ogun State, Nigeria under the theme of Science, technology, and Innovation for Sustainable Agriculture Development. It employs descriptive statistics to analyze data collected from 118 oil palm producers. Findings indicate a predominantly male demographic with significant potential for productivity. However, utilization of extension services was notably low (74%). Although there was a modest increase in oil palm production (1.13 tonnes) post production levels. The study underscores the importance of enhancing farmers' access to extension services through training and capacity-building initiatives to improve production outcomes and address challenges in the sector.
Keywords: Extension services; Oil palm Farmers; Challenges; Oil palm Producers; Utilization; Livelihood activities

INTRODUCTION
Oil palm production has been significantly reduced due to factors such as lack of research institutions, contaminated seedlings, poor resources, ancient farming practices, high labor costs, poor transportation, and lack of technology equipment (Murphy *et al.,* 2021). Extension services are crucial for improving agricultural practices and overcoming economic challenges, but their effective utilization among oil palm farmers remains a significant issue (Sebaggala and Christian, 2020). There is a message gap and a need for regular training and capacity-building opportunities to improve knowledge and sustainable farming practices. The principal objectives of the Ogun State Agricultural Development Project (OGADEP) and the National Agricultural Extension and Research Liaison Services (NAERLS) in Ogun State are to enhance farmers' livelihoods through sustainable development initiatives and better agricultural practices, while also bridging the gap between farm research and agriculture. The study aims to describe socioeconomic characteristics, examine extension service utilization, identify factors influencing utilization, and assess oil palm production levels.

METHODOLOGY
This study was carried out in Ijebu North Local Government Area, which is one of the Local Government Areas in Ogun State, Nigeria. A simple random technique was used to select 118 out of 168 registered oil palm farmers from Oil Palm Growers' Association of Nigeria, Ijebu branch (OPGAN, 2023) using Taro Yamane formula @ 0.05 and an interview guide was used to collect data. The broad objective was to assess utilization of extension services on oil palm production in Ijebu North Local Government Area of Ogun State, while the specific objectives were to describe the socio-economic characteristics of the respondents, examine the utilization of extension services, and determine oil palm production (before and after). Factors Influencing the utilization of extension services was measured at interval level using a 3 point rating scale as major (3), minor (2) and not a factor (1), any mean score above g*rand* ($\bar{x}$):1.66 was categorized as high factors and vice-versa. Utilization of extension services was measured at interval level 21 items were measured with a 5 rating response, as always, often, sometimes, rarely, and never with scores 4, 3, 2, 1, and 0 respectively Scores less than 64 were categorized as low and score above 63 was categorized as high utilization. The oil palm production was measured at interval level as estimated production

before and after utilization were captured in tonnes. The data obtained from this study was subjected to both descriptive (frequency, percentages, and means) and inferential statistics (Pearson Product Moment Correlation) used to test the hypothesis. Both variables were measured at interval level.

RESULTS AND DISCUSSION

The result in Table 1 reveals that the majority (73.7%) of the respondents were male, with a mean age of 48.4 years, 90.7% were married with 71.2% had between 1 and 5 persons per household, and 61.0% had secondary. This result indicated that the majority of the oil palm farmers were male, and could read or write. This result agreed with the findings of Nainggolan *et al.* (2021), who reported that most of the active and productive oil palm farmers' average age was 48 years. Furthermore, the result implies that the respondents were productive, economically active, and had a deep sense of responsibility. The household size could promote productivity and enhance the efficiency of farming activities. In addition, Agrawal and Goyal (2018) revealed that oil palm farmers' age, marriage, and household size have significant positive contributions towards oil palm production

Table 1: Socio-economic Characteristics of the Respondent. (n=118).

Statements	Frequency	Percentage	Mean ($\bar{X}$)
Sex			
Male	87	73.7	
Female	31	26.3	
Age			
31 – 40	29	19.6	
41 – 50	60		48.36
51 – 60	20		
Above 60	9		
Marital status			
Single	3	2.5	
Married	107	90.7	
Widowed	8	6.8	
Separated	0	0.0	
Divorced	0	0.0	
Educational Level			
No formal education	1	0.8	
Primary education	13	11.0	
Secondary education	72	61.0	
Tertiary education	32	27.1	
Religion			
Christianity	74	62.7	
Islam	42	35.6	
Traditional	2	1.7	
Farming experience(years)			
1-10	53	44.9	
11-20	51	43.3	14.36
21-30	10	8.4	
31-40	4	4.4	
Average monthly Income (₦)			
50,000-99,000	31	26.3	
100,000-150,000	58	49.2	₦136,949.15
151,000-199,000	6	5.0	
200,000-250,000	22	18.6	
251,000 above	1	0.8	
Household size (person)			
1-5	84	71.2	4.92
6-10	34	28.8	
Farm size(hectares)			
0-3	95	81.0	2.49
4-6	23	19.0	
7-10	0	0.0	

Source: Field Survey, 2023.

The result in Table 2 shows that the factors influencing the utilization of extension services to oil palm farmers in the study area. Findings revealed that the major factors that influenced utilization of extension services in the study area were: resources availability ($\bar{x}$ =2.78), infrastructural facilities ($\bar{x}$ = 2.77), fund ($\bar{x}$ = 2.72)household size ($\bar{x}$ =2.25), personal motivation ($\bar{x}$ = 2.08), cost of service ($\bar{x}$ =1.91), peer influence (1.89), distance to farm ($\bar{x}$ =1.85), limited information on extension services ($\bar{x}$ =1.84), lack of technical know-how ($\bar{x}$ =1.77), language barrier $\bar{x}$ =1.69), time consumption (1.69), culture ($\bar{x}$ =1.68), availability of time ($\bar{x}$ =1.67). This implies that there are quite number of factors that could have contributed to the low use of extension services, including a lack of resources, a knowledge gap, poor communication between extension agents and farmers, farmers' distance from one another, and the high cost of the services in the study area . This results agreed with Jama and Pizarro (2021): Ayinde *et al.* (2022) and Khan *et al.* (2022) that the performance of agricultural extension services is heavily influenced by the availability of resources, more infrastructures, farmers, income, household size and cost of extension services resulting in better service delivery and higher farmer outcomes.

Table 2: Factors Influencing the Utilization of Extension Services.

Variables	**($\bar{x}$)**
Limited information on extension services	1.84
Distance to the farm	1.85
Cost of services	1.91
Lack of technical know-how	1.77
Availability of Time	1.67
Languages Barrier	1.69
Culture	1.68
Funds	2.72
Availability of resources	2.78
Infrastructural facilities	2.77
Personal motivation to improve skills or knowledge	2.08
Influence of peers or community members	1.81
Time consumption	1.89
Household size	1.69
Level of education	2.25
Climate variation	1.55
Membership in cooperative	1.51
Membership in oil palm association	1.48

Source: Field survey, 2023 ***Grand ($\bar{x}$):1.66***

Utilization of extension services for oil palm farmers in the study area.

Results in Table 3 reveal that the majority (74.6%) of the respondents had low utilization of the extension service, this indicated that the majority of the oil palm producers had low utilization of extension services towards their production and could be linked to geographical location, low ratio of extension agents to farmers, corruption, etc. This finding is line with Doe and Smith (2023), who report that implementing extension services could be difficult and complex due to farmers' low income, corruption and location of the target farmers'. These could have adverse effects on oil palm production and food insecurity. Extension services need to be readily reliable, utilized, and accessible by farmers for optimum production and services.

Table 3: Categorization level of utilization of extension services among the Oil palm farmers. (n=118)

Utilization	Frequency (F)	Percentages (%)
High Utilization (63-105)	30	25.4
Low Utilization (21-62)	88	74.6

Source: Field Survey, 2023.

Findings in Table 4 shows that oil palm production per hectare before and after extension service utilization by respondents in the study area, with 3.72 and 4.85 tonnes respectively. The utilization of extension services led to a 1.13 tonnes increase in oil palm production per hectare, indicating that respondents followed advisory services and implemented improved practices, potentially improving food security and livelihood income. This result agreed with the finding of Oke *et al.,* (2020) affirmed that adopting improved techniques and practices boosts oil palm production.

Table 4: Oil palm production level before and after utilization of extension services (n=118).

Oil palm production ($\bar{x}$) Before utilization of extension services (tonnes)	Oil palm production ($\bar{x}$) after utilization of extension services (tonnes)
3.72	4.85

Source: Field survey, 2023.

Test of the relationship between utilization of extension services and oil palm production.

Hypothesis 1: There is no significant relationship between the utilization of extension services and oil palm production in the study area was tested using Pearson Product-Moment Correlation (PPMC). The result in Table 4 reveals that there is no significant relationship ($p>0.05$) between the utilization of extension services and oil palm production. The study found no significant relationship between the utilization of extension services and oil palm production in the study area, this suggested that the utilization of extension services may not be the main determinant of oil palm production and that there is low utilization among the oil palm. This study is in line with Adetarami *et al.* (2022) affirmed that utilizing extension services, improved techniques, and practices boosts agricultural production.

Table 5: Relationship between utilization of extension services and oil palm production.

Variables	r- value	p-value	Decision
Utilization of extension services and oil palm production	0.110	0.234	Not significant

Source: Field Survey, 2022

CONCLUSION AND RECOMMENDATIONS

This study concluded that oil palm farmers had low utilization levels of extension services but utilized the extension services, the oil palm production was increased with less than 2 tonnes. This study therefore recommends that there should be adequate effective extension services to promote farmers' participation and boost oil palm production Government and stakeholders should establish strong devices to improve the utilization of extension services through identified factors.

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LAND USE SUITABILITY ASSESSMENT IN AGROFORESTRY SYSTEM OF PARKIA BIGLOBOSA, IN OYO STATE, NIGERIA

***Agbor C. F, Pelemo O.J, Onilude Q. A, Ogunwale O.R, Yusuf I. O, & Ishola A.S**
Forestry Research Institute of Nigeria, Jericho, Ibadan, Oyo State,
***Corresponding Author email:** chukwuka_friday@yahoo.com; +234 814 705 7828

ABSTRACT
To avoid conflicts resulting from pressure on forest and agricultural land for the production of food in Oyo State, there is a need to maximize the uses of agricultural land using different agroforestry practices. Therefore, this study developed a multi-criterion evaluation (MCE) of land use suitability for Taungya Farming system in Ibarapa area of the State dominated by *Parkia biglobosa*, using physical and ecological criteria in the study area. The selected criteria were assembled and the weights of their respective contributions to land suitability for agricultural uses were assessed using an analytic hierarchical process (AHP) in Idrisi. The result of this study found about 17% of the area was suitable for agro-forestry and about 83% unsuitable. While this study could be useful in assessing the agricultural land use potentials, it could also provide guidance for farmers to act in more structured and strategic ways for sustainable agricultural planning.
Keywords: Multi-criteria evaluation, Taungya Farming system, Analytic hierarchical process, and Sustainable agricultural planning.

INTRODUCTION
The major cause of pressure on world natural and agricultural resources today is the rapid increase in global population especially in the third world countries (Goma *et al.,* 2016). The resultant pressure on land resources is capable of causing land degradation (Aguiar *et al.,* 2007). To develop land use policies that will sustain the development of human society, reliable land use potential evaluation becomes inevitable to the decision-making processes. To achieve self-sufficiency in agricultural production in developing countries such as Nigeria, land assessment systems remain crucial in simulating land's suitability for different agricultural practices (Attual *et al.,* 2014). Multi-criteria evaluation processes have been used in some large-scale planning processes to estimate the potential of land for alternative land uses including agricultural land use (Malczewski ,1999). Ibarapa region is endowed with a large area of land and vegetations, but the use of this important resource has been abused, not sustainably used or managed. For the classification of land suitability in our study area, we adopted AHP to combine different types of input data, and the pairwise comparison method for comparing variables instantaneously. The application of the AHP process involves several steps in order to rank Criteria to the set of suitable criteria.

MATERIALS AND METHODS
Study Area
The Ibarapa area falls within latitudes 70.15' N and 70.55' N and longitudes 30E and 30.30' E. It is located approximately 95 km west of the Oyo state capital and neighboring city of Ibadan (Femi, 2011). The area is approximately 2,496 km² in geographical size, and consists mostly of rolling savannah with forests situated along the southern border and in isolated patches along with river courses such as the Ogun. The natural vegetation was originally rainforest but that has been mostly transformed into derived type savanna as a result of several centuries of slash & burn agricultural practices (Ogundele et al, 2012).

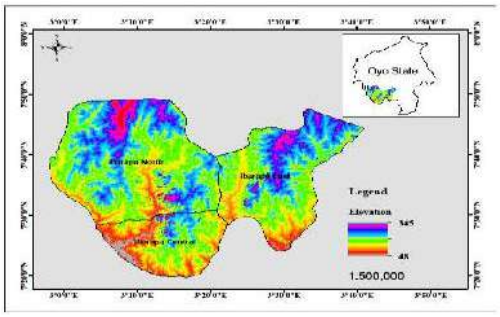

Figure 1. Ibarapa Area of Oyo State

Data collection and preparation using GIS

The satellite images and data utilized have been summarized in table 1

Table 1: Satellite Images used for the study

Satellite Sensor	Spatial resolution	Acquisition years	Path	Row
Landsat 8	30m x 30m	2020	190	55
Asterdem	30m interval	2000	190	55

For the Data Preparation, ecological (slope and soil), climatic (rainfall and temperature), and proximity (distance from water bodies) criteria that influence land suitability for agricultural uses were aggregated in this study (Malaysia, 2014). All these criteria constitute the maps; and, the maps were projected to the same scale, boundary extent, resolution of 30m^2 and spatial reference

Methods

The images were processed using maximum likelihood classier in ArcGIS software environment to group the pixels into four broad classes: built-up area, forest area, water body, and farm/grassland (Rawat *et al.,* 2015). The temperature variable was derived from Landsat image using equation 1 (Giannini *et al.,* 2015). This is satellite temperature in Kelvin.

$$BT = \frac{K_2}{\left(ln\left(\frac{k_1}{TOAr}+1\right)\right)} - 273.15 \quad 1$$

Where BT is temperature, $TOAr$ *is* Top of Atmosphere radiance, *K1* is calibration constant 1 (774.89 for OLI band 10) and K2 is calibration constant 2 (1321.08 for OLI band 10).Slope data were derived from the AsterDEM data using the Surface Analysis module in ArcGIS 10.5. soil moisture derived using equation 2 (Haas, 2010):

$$SMI = \frac{T_{max} - T_s}{T_{max} - T_{min}}$$

Where T_{max} is maximum temperature, T_{min} is minimum temperature and T_s the surface temperature.

Selection of the Criteria for Suitability Classification

Five criteria were selected for evaluating the agricultural and agroforestry land suitability in the study area (Table 2) (Malaysia, 2014).

Table 2 selected criteria for the study

No.	Criteria Weight
1	Precipitation
2	Water Bodies
3	Soil texture
4	Temperature
5	Slope
Total	-

The Scales for the pairwise AHP comparisons (Saaty, 1980) is given in table 3.

Table 3. Scales for the pairwise AHP comparisons (Saaty, 1980).

Intensity of importance	Description
9	Extreme importance
7	Very strong or demonstrated importance
5	Strong or essential importance
3	Moderate importance
1	Equal importance
2,4,6,8	Intermediate values
Reciprocals	Values for inverse comparison

Results

Overlaying criteria layers,

The weighted overlay is a technique for applying a common scale of values to diverse and dissimilar input data to create an integrated analysis. After weighting of the criteria, regarding their importance for the land suitability analysis, all the maps were overlaid using a suitability index produce suitability map of figure 2. Table 4 shows the weights of selected criteria for land classification. Land use suitability statistics are presented in table 5.

Table 4: Weighting matrix for the selected criteria.

No.	Criteria Weight	Weight
1	Precipitation	0.46
2	Water Bodies	0.32
3	Soil texture	0.13
4	Temperature	0.06
5	Slope	0.02
Total	-	1

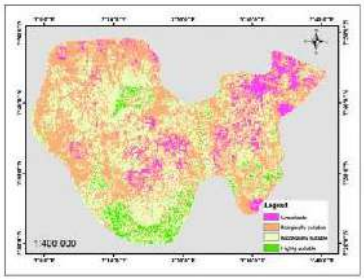

Figure 2. Land Use suitability model

Table 5: Taungya Land Use Suitability Statistics

LUSE	Area	%
Unsuitable for Agroforestry	2081.194	82.79883
Suitable for Agroforestry	432.3609	17.20117

DISCUSSIONS

The large extent of forest cover in the study area shows the potential of such a region being able to support agroforestry system. Considering the area extent of only 17.2% identified most suitable for food and wood production, there is an urgent need for a proper land use management system such as Taungya Farming, to avoid over exploitation of the land for agricultural purposes and the impending environmental implications of this practice. According to Pourkhabbaz (2014) and Attual *et al.*, (2014), agro-forestry practices have the potential of improving agricultural land use systems, providing lasting benefits and alleviating adverse environmental effects at local and global levels.

CONCLUSION

This study has revealed the potential agricultural land in the three local government areas, unfortunately, available evidence showed that most of these agricultural lands are being taken up by non-taungya uses and this has the potential of negatively affecting the state's green economy. For crop production to be matched with that of wood, physical and ecological variables such as climatic, edaphic and forest cover become eminent in identifying suitable areas for agroforestry.

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EFFECTS OF MUNICIPAL SOLID WASTE AND NPK 15-15-15 FERTILIZER ON SOME SOIL PROPERTIES AND FRUIT YIELD OF CUCUMBER (*Cucumis sativus L.*) IN OKITIPUPA SOUTHWEST, NIGERIA

Olojugba, M. R[*1] and Afolayan, R. O[2].

[1]Department of Crop, Soil and Pest Management, Olusegun Agagu University of Science and Technology, Okitipupa, Nigeria

[*]*Corresponding Author: mr.olojugba@oaustech.edu.ng*

ABSTRACT

Cucumber (*Cucumis sativus* L.) is an important exotic vegetable that is in high demand, but due to inadequate production and distance from areas of mass production, the supply is highly limited. Replicated field plots were employed in the experiments to determine the effect of municipal solid waste, supplemented with NPK 15:15:15, on cucumber, fruit yield and soil properties for a period of June to September, 2023. The treatments are: 10 t/ha of municipal solid waste, 300 kg/ha of NPK 15:15:15, 5 ton/ha of MSW + 150kg/ha of NPK 15:15:15 and control. In a Randomized Complete Block Design. Results of the analysis show that combined treatments treated plots significantly influenced plant height, plant diameter and leaf area than the plots that were treated with single nutrients and control. The best result of the fruit yield were obtained from plots treated with 5 t/ha of municipal solid waste supplemented with 150 kg/ha of NPK and 300 kg/ha NPK (1109.18 and 843.09 kg/ha) respectively. Soil analysis result show that treatments applied at various levels increased soil nitrogen, phosphorous and organic matter. The result of the study showed that the best crop yield of 1109.18 kg/ha was obtained with the treatment of 5t/ha municipal solid waste and 150 kg/ha NPK fertilizer.

Keywords: Municipal solid waste, NPK fertilizer, cucumber

INTRODUCTION

The production of waste, that is, unnecessary or undesirable by-products, is an unavoidable consequence of most processes. Globally, 7 – 9 billion tonnes of waste are produced yearly (Wilson and Velis, 2015). Municipal Solid Waste (MSW) is a specific category of waste stemming from households, and can include commercial and industrial wastes, depending on the reporting standard (Wilson and Velis, 2015). Municipal solid waste accounted for 2 billion tonnes of the total waste produced in 2016. However, it deserves special attention given its environmental impacts at local, regional and global scales (European Commission, 2015b; Kaza *et al* 2018). Organic manuring is becoming an increasingly significant part of environmentally healthy and long-term farming practices. Plant nutrients are replenished in agricultural soils primarily through inorganic, organic and bio-fertilizers. Inorganic fertilizers are used indefinitely, causing a decline in soil chemical, physical and biological qualities, as well as soil health (Singh, 2018).

Cucumber (*Cucumis sativus*) is an important vegetable crop cultivated worldwide due to its nutritional value, versatility in culinary applications, and economic significance in the agricultural industry (Rahman *et al*., 2019). It is highly valued for its high water content, dietary fiber, vitamins and minerals, making it a popular choice for salads, pickles and various cuisines (Thakur *et al*., 2018). However, the cultivation of cucumber faces numerous challenges, including nutrient management. (Kumar *et al*, 2023). Therefore, the objectives of the study were to assess the effect of municipal solid waste supplemented with NPK 15:15:15 fertilizer on cucumber production and soil properties.

MATERIALS AND METHODS

The experiment site

The experiment was conducted at the Teaching and Research Farm of the Olusegun Agagu University of Science and Technology, Okitipupa in longitude 6^0 25^1 and 6^0 25^1 and lattitude 4^0 35^1 and 4^0 50^1 within the tropical rainforest zone of Nigeria. The land has been subjected to

cultivation of arable crops like maize, cassava and vegetables.

Experimental design

The experiment was laid out as a Randomized Complete Block Design with four treatments and three replicates. An experimental field of 8 m × 11 m plot was demarcated on the teaching and research farm of Olusegun Agagu University of Science and Technology Okitipupa, Ondo State. Nigeria. The field was partitioned into three blocks of 2 m × 2 m separated by 1.0m buffer. Each 2m × 2m block was further partitioned into four 2m x 2m plots separated by buffer of 1.0m wide. The treatments were Control (no treatment application), NPK 15-15-15 at 300 kg/ha, MSW at 10 t/ha, and NPK 15-15-15 at 150kg/ha + MSW 5 t/ha. All treatments were allocated at random to the plots.

Treatments application

The municipal solid waste was incorporated into the appropriate experimental plots at the rates of 5 and 10 t/ha a week before sowing of seeds while NPK 15:15:15 inorganic fertilizer at 150 and 300kg/ha were applied to the appropriate plots at two weeks after seedling emergence.

RESULTS AND DISCUSSION

Soil properties of the experimental site

The physical and chemical properties of the soil of the experimental site before the treatment were applied showed that the soil is sandy loam with 69.52% sand, and it has a low organic matter of less than 2% according to Esu 1991 The pH shows that the soil was slightly acidic. pH (5.00), high total nitrogen but relatively adequate phosphorus content and low potassium content Worperesis et al., 2009; Esu, 1991

Table 1: Leaf area, Apex and Yield

Treatment	Leaf area (cm^2)	Leaf apex	Fruit yield (kg/ha)
NPK 15:15:15 (150 kg/ha) + MSW (5 t/ha)	68.93 ± 21.27^{b}	2.56 ± 0.78$^{b.}$	1109.18 ± 278.27^{b}
NPK 15:15:15 (300 kg/ha)	110.62 ± 21.00^{c}	4.11± 0.79$^{c.}$	843.90 ± 272.41^{ab}
MSW (10 t/ha)	145.01 ± 26.59^{d}	5.37± 0.99$^{d.}$	705.13 ± 179.40^{a}
Control	42.96 ± 20.47^{a}	1.62 ± 1.67$^{a.}$	540.10 ± 221.99^{a}

*Mean with same superscript along the columns are not significantly different at $p \geq 0.05$

Table 2: Soil chemical properties as affected by the application of organic and inorganic fertilizers after the experiment

Parameters	Control	MSW and NPK	300NPK	10T MSW
Sand	40.50±0.71 ^{a}	68.73±0.38 ^{c}	66.9±0.04 ^{b}	70.56±0.62 ^{d}
Clay	39.50±0.71 ^{d}	1.82±0.26 ^{a}	14.93±0.11 ^{c}	13.74±0.37 ^{b}
Silt	20.00±0.00 ^{b}	18.96±0.06 ^{c}	18.61±0.56 ^{c}	16.71±0.41 ^{a}
pH	5.00±0.00 ^{a}	5.02±0.02 ^{a}	4.77±0.33 ^{a}	5.74±0.37 ^{b}
Total N	0.59±0.58 ^{a}	0.58±0.59 ^{a}	0.59±0.59 ^{a}	0.56±0.63 ^{a}
Total P	5.76±0.34 ^{a}	11.97±0.42 ^{c}	9.98±0.04 ^{b}	9.77±0.33 ^{b}
Na	0.25±0.42 ^{a}	0.95±0.08 ^{b}	0.93±0.11 ^{b}	0.76±0.34 ^{b}
K	0.57±0.61 ^{a}	1.99±0.21 ^{b}	1.90±0.15 ^{b}	1.70±0.43 ^{b}
Ca^{2+}	1.20±0.28 ^{a}	3.89±0.15 ^{b}	3.63±0.53 ^{b}	4.00±0.03 ^{b}
Mg^{2+}	0.80±2.82 ^{a}	4.60±0.57 ^{c}	3.74±0.37 ^{bc}	2.75±0.36 ^{b}
CEC	6.40±1.14 ^{a}	9.60±0.60 ^{c}	8.00±0.01 ^{b}	8.00±0.30 ^{b}
CU	1.62±0.53 ^{a}	1.82±0.26 ^{a}	1.75±0.34 ^{a}	1.63±0.52 ^{a}
AL	0.06±0.06 ^{a}	0.70±0.04 ^{a}	0.06±0.06 ^{a}	0.07±0.05 ^{a}
TOC	0.90±0.14 ^{a}	0.96±0.04 ^{a}	1.10±0.14 ^{a}	1.00±0.06 ^{a}

*Mean with same superscript along the rows are not significantly different at p>0.05 $p \geq 0.05$

The comparisons between Leaf Area, index and Yield of the crop

Omotoso and Shittu 2007, reported that the fertilizer NPK significantly increase growth parameters (plant height, leaf area, root length, number of leaves), yield and yield components with fresh leaf, root and stem weight been higher in treatments that received 150 NPK kg/ha gives the highest yield, while application of Municipal solid waste at 10t/ha gave the highest number of leaves and stem girth

The texture of the study site was sandy loam. The site was slightly acidic (pH 5.00) in which alfisols of the southwest is known for (Awodun *et al* 2007). The soil of the experimental site was moderate in total nitrogen and also in organic carbon, although increased with the treatment that involves the combination of Municipal solid waste and NPK 15-15-15 fertilizer as shown in the Table 5. The organic carbon though a little moderate still needs improvement, hence organic fertilizer (Aubin *et al*., 2015). Again Awodun *et al* 2007 (198 reported an improvement of soil CEC for better nutrition retention following the addition organic fertilizer.

The initial chemical compositions of the soil used in this study are presented in Table 2. The organic matter, total nitrogen, exchangeable Ca, Mg and K were quite high except pH and available phosphorus contents of the soil when compared with the work of Ayeni (2010). The soil pH is slightly acidic with the value of 5.74. Similarly, the organic matter and organic carbon were quite high when compared with the work of Awodun *et al*. (2007)

CONCLUSIONS AND RECOMMENDATIONS

The results obtained from this study showed that various treatment combinations applied to cucumber significantly influenced leaf area, number of leaves, number of fruits/treatment and yield/ha. Furthermore, it was observed that plots that received the various treatments performed better when compared to the control plots in all parameters assessed. Consequently, it was recommended that cucumber farmers in this area should apply 150 kg/ha NPK + 10 tons/ha of municipal solid waste in the cultivation of cucumber production and to also maximize economic returns. Municipal solid waste should be recommended to reduce soil acidification present in the study area. More research needs to be carried out on the soil properties of the study area.

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Sub-Theme Five

Aquaculture, Feed Development, Agricultural Nutrition and Cross Cutting issues in Agricultural Development

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PROXIMATE AND MINERAL ANALYSIS OF ALOE VERA (*Aloe barbadensis miller*) LEAF MEAL

[1]Olayinka, O. I. and [2]Ibiwoye, K. O.
[1]Kabba College of Agriculture, Livestock Section, P.M. B 205, Kabba, Kogi State, Division of Agricultural Colleges, Ahmadu Bello University, Kaduna State. Nigeria.
[2]Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, P.M.B.810107, Zaria, Nigeria.
Corresponding Author: babawaleoluseyi@gmail.com, Phone Number: 07069387726

ABSTRACT
Aloe vera has a long history as medicinal plant with diverse therapeutic applications. An experiment was conducted to analyze quantitatively, the proximate and mineral analysis of aloe vera leaf meal. Result obtained from the proximate analysis of Aloe vera leaf meal was found to be rich in carbohydrate (50.40%), protein and lipid content were found to be relatively high (19.27 and 6.50 % respectively) while ash and crude fat were 10.83 and 1.50% respectively. The results obtained from the mineral analysis were; sodium and potassium content (12.00 and 60.20 mg/kg respectively) of the leaf meal. Aloe barbadensis leaf meal is also found to be rich in calcium and phosphorus (4.20 and 60.18 mg/kg), which is essential for bone formation. Potassium and magnesium (5.0 mg/kg). The overall data suggest that A. barbadensis leaf meal has some nutritional and medicinal properties.
Keywords: Aloe vera, leaf meal, proximate and mineral analysis.

INTRODUCTION
Aloe vera (*Aloe barbadensis miller*), belong to the family of the Liliaceae, it is a cactus-like plant and one of the oldest medicinal plant which is a perennial plant with turgid green leaves joined at the stem in a rosette pattern. The Aloe vera leaves are formed by a thick epidermis (skin) covered with cuticles surrounding the mesophyll, which can be differentiated into chlorenchyma cells and thinner walled cells forming the parenchyma, a short stemmed plant growing from 30-100 cm tall spreading by offsets. The parenchyma makes up the majority of the leaf by volume containing the aloe vera gel, synonymous with the inner leaf, inner leaf fillet, or aloe fillet (Guo and Mei, 2016). The plant is rich in many natural health promoting substances and raw pulp of aloe vera contains approximately 98.5% water, while the mucilage or gel consists of about 99.5% water, the remaining 0.5–1% solid material consists of a range of compounds including water soluble and fat-soluble vitamins, minerals, enzymes, mono and polysaccharides, sugar, lignin, phenolic compounds and organic acids. The medicinal qualities of aloe vera are much diversified and adoptogenic, and these include healing effect, reduces blood sugar in diabetes, sooths burn, eases intestinal problem, reduces arthritic swelling, ulcer curative object, stimulates immune response against cancer and it also provides antimicrobial, hypoglycemic effect, antioxidative, stimulates uterine contraction and anti-pruritic activities (Das, 2011). Therefore, the aim of this study is to investigate the proximate and mineral composition of aloe vera leaf meal.

MATERIALS AND METHODS
Collection and preparation of Samples.
Fresh leaves of aloe vera (*Aloe barbadensis miller*) was collected from the Horticultural section of Kabba College of Agriculture, Kabba, Kogi state. The samples were brought to the Biochemical Laboratory of Ahmadu Bello University, Zaria, Kaduna State. Kabba is located in the Southern Guinea Savannah Ecological Zone of Nigeria on the Latitude $7^0$53'N, Longitude $6^0$02'E with an average rainfall of about 1500 mm per annum and average temperature ranges from 18-32^{0}C. It is 427 m above sea level (Kabba College of Agriculture Meterological Station, 2024). The aloe vera was visually inspected. Defective tubers were removed and discarded. Hence, only matured healthy aloe vera leaves were selected. The fresh leaves were chopped and labelled.

Proximate Analysis
Samples were evaluated to determine moisture, crude protein, crude lipid, ash, crude fibre,

carbohydrate and mineral contents employing methods described by Association of Official Analytical Chemist (AOAC, 2005). The proximate values were reported in percentages. Determination of ash content was done by ashing at 550ºC for 3 hours. The Kjeldah method (AOAC, 2005) was used to determine the crude protein contents by multiplication of the nitrogen value with a conversion factor (6.25). The crude fibre content of the sample was determined by digestion method and the lipid content was determined by Soxhlet extraction method (AOAC, 2005). Total soluble carbohydrate was determined by the difference of the sum of all the proximate composition from 100%

Mineral Analysis

The mineral elements determined in this study were sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P), nitrogen (N), chromium (Cr), copper (Cu), selenium (Se) and zinc (Zn) are subjected to employing ethylene diamine tetra-acetic acid (EDTA) method (Harbone, 1973).

RESULTS AND DISCUSSION

The results of the proximate composition are shown in Table 1. Results obtained showed that carbohydrate content was high (50.40%) relative to others proximate values, followed by moisture (11.50%), ash (10.83%) crude protein (19.27%), crude fiber (6.50%) and lipid (1.50%) in descending order. These results indicate that aloe vera leaf meal contains some considerable levels of nutrients other than their phytogenic values. Higher carbohydrate content (50.40%) shows that aloe vera is a good source of energy for the body, this result is in agreement with the report of Adeyeye and Ayejuyo (2000). Carbohydrates provide readily accessible fuel for physical performance and regulate nerve tissue. The carbohydrate of Aloe vera juice have been reported to be glucose and a polyuronide composed of (a) a polyose (molecular weight up to about 2.75 x 105) containing glucose and mannose and (b) hexuronic acids such as glucuronic, mannuronic and galaturonic acids. A polysaccharide acemannan found in aloe vera acts as an immune stimulant against psoriasis vulgaris.The occurrence of carbohydrate as the highest parameter in this study is similar to that of Haque *et al.* (2011) and Mustapha (2006) who reported (56.27 and 56.64% respectively) carbohydrate content in Aloe vera leaf. Average moisture content (11.50 %) was the second highest parameter noted. It has been proven that too much moisture in any sample cause caking especially in flour and can also determine the Storage/Shelve life and the viability of microorganisms' growth (Adeyeye and Ayejuyo, 2000).

Ash content is very important in nutritional evaluation and is a reflection of the mineral preserved in the sample. It represents the total mineral content, which are essential for the proper functioning of tissues and act as second messengers in some biological cascade mechanisms. The value obtained in this result (10.83%) showed that aloe vera has high proportion of minerals which is in accordance with the report of Haque *et al.* (2011). Protein, was the fourth highest (19.27 %) parameter noted. Crude fibre content was the fifth highest (6.50 %). It could help in bowel movement. The lowest parameter noted was crude fat content (1.50 %).

The results of the minerals composition are shown in Table 2. Ten minerals were detected with K and P having the highest content (60.20 and 60.18 mg/kg respectively), followed by Se (20.13 mg/kg), Na (12.01 mg/kg), Cu (6.21 mg/kg), Mg (5.00 mg/kg), Ca (4.20 mg/kg), Cr (1.41 mg/kg), Zn (1.07 mg/kg) and the least is N (0.05 mg/kg). The mineral matter P was found to be (60.18 mg/g) of aloe vera powder. The main function of Ca and P is in the formation of bones and teeth, regulation of nerve and muscle function. It plays an important role in how the body uses carbohydrates and fats. Phosphorus also helps the body make ATP, a molecule the body uses to store energy. The concentration of micro minerals N, Cr, Cu, Se and Zn was found to be 0.05, 1.41, 6.21, 20.13 and 1.07 mg/kg respectively.

Table 1: Proximate composition of aloe vera leaf meal

Parameter	Composition (%)
Moisture content	11.50
Crude protein	19.27
Crude fibre	6.50
Ash	10.83
Crude fat	1.50
Carbohydrate	50.40

Table 2: Mineral composition of aloe vera leaf meal

Parameter	Composition (mg/kg)
Macro elements:	
Potassium (K)	60.20
Phosphorus (P)	60.18
Sodium (Na)	12.01
Magnesium (Mg)	5.00
Calcium (Ca)	4.20
Micro elements:	
Nitrogen (N)	0.05
Chromium (Cr)	1.41
Copper (Cu)	6.21
Selenium (Se)	20.13
Zinc (Zn)	1.07

CONCLUSION

Aloe vera leaves has been proved from the results obtained in this study to be a good source of protein, carbohydrate, fat and minerals. It could therefore, be concluded that Aloe vera is an important dietary source of nutrients in a feed based approach for combating micronutrient deficiency.

RECOMMENDATION

It can be recommended that aloe vera leaf contain both macro and micro minerals which are very essential in the livestock nutrition. Aloe vera leaf are good sources of crude proteins, crude fat, carbohydrate, ash, moisture and crude fibre which have the potentials of being combined in livestock nutrition as feed supplements/ additives or as alternative to antibiotic growth promoter

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MARKETING OF OCIMUM GRATISSIMUM (scent leaf) IN LAGOS STATE, NIGERIA

[1a]Kareem, I. A., [2a]Sanni-Bamigbade, S. A., [3]Adekola, O. A. & [1]Nwahiri, C. E.

[1]Department of Forestry and Wildlife Management
[2] Department of Business Administration
[3] Department of Agricultural Extension and Rural Development
[a] Agricultultural Media Resources and Extension Centre (AMREC)
Federal University of Agriculture, Abeokuta (FUNAAB), P.M.B 2240 Ogun State, Nigeria.
Corresponding Author: kareemia@funaab.edu.ng ORCID ID: 0000-0002-6194-1766

ABSTRACT
Ocimum gratissimum is a homegrown shrub, it is found in farms, and gardens, and is mainly used as a spice for cooking delicacies due to its aromatic taste. This study analyzed the marketing strategies for selling *Ocimum gratissimum* in Lagos State, Nigeria to determine its profitability and evaluate its economic and medicinal uses in the study area. A well-structured questionnaire was used to elicit data from 110 respondents. Results revealed that most (77.3%) of the sellers were females; 63.6% were married and had a mean age of 36 years old. The mean monthly income of the respondents is ₦39,500.16 ($25.77). The total revenue was ₦2,030.60 ($1.32) for an average quantity of 2.86g and its average total cost was ₦156.77 ($0.10). The net income was ₦1,335.30 ($0.87) with a gross profit of ₦1,492.07 ($0.97). The rate of return, return on investment, and marketing efficiency were 292.05%, 192.05%, and 2.92 respectively. This implies that *Ocimum gratissimum* is a profitable business. Also, *Ocimum gratissimum* can be used to stop vomiting, stomach pain, blood boosting, piles, infection, cough, diarrhoea, diabetes, blood cleansing, and constipation. In-availability during the dry season, drying easily, not selling fast, and preservation were the challenges encountered by the sellers. This study recommends enlightenment programs to educate the traders about specific areas of marketing such as processing and packaging that could make their *Ocimum gratissimum* more profitable and efficient.
Keywords: Profitability, Marketing efficiency, Medicinal benefits, Scent leaf.

INTRODUCTION
The aromatic and medicinal plants market is very flexible, and policymakers and researchers constantly push to add value to these plants to increase financial returns. Improved techniques for harvesting, storing, grading, and local value addition are just a few examples of straightforward interventions that can significantly increase returns. Cultivators can increase their profit margin by marketing semi-processed goods instead of raw crops (Mittal and Singh, 2007). *Ocimum gratissimum* belonging to the Lamiaceae family is known to have a variety of uses in cooking. The plant is native to South Asia, Africa, and several parts of South America, primarily found in tropical climates (Singh, 2012). Most plants are annuals, perennials, under-importance shrubs, or herbs. They have sessile glands or glandular hairs that secrete strongly scented volatile oils. Although flowers seem the same across the group, they are significant in taxonomy for identifying different species. Edible oils and a drying oil resembling linseed oil are present in the seeds (Makri and Kintzios, 2007). This study broadly aims to determine the marketing strategies involved in the sale of *Ocimum gratissimum* in Lagos State, Nigeria. Specifically, it aims to:

- examine the socio-economic characteristics of the *Ocimum gratissimum* sellers in the study area.
- estimate the profitability and marketing efficiency of *Ocimum gratissimum* in the study area.
-evaluate the economic and medicinal uses of *Ocimum gratissimum.*
- determine the challenges encountered in the marketing of *Ocimum gratissimum* in the study area.

Marketing Channels
Marketing channels are the paths through which a commodity moves or follows from production to consumption. It could be a single-stage channel or a multi-stage channel. The marketing channel is the link between the supply and consumption of a product. Marketing functions are specialized activities performed in the marketing process. The unique role of agricultural marketing is that it acts as a link between production and consumption points Usman *et al.* (2011). The marketing of *Ocimum gratissimum* supplies food supplements and herbs for medicinal purposes. The direction of the marketing occurs both in rural and urban areas because of its uses. The trade is characterized by the seller and buyer, *Ocimum gratissimum* is usually sold in the

open market by direct bargaining between the buyer and seller to ensure a high level of economic satisfaction Usman *et al.* (2011).

The main reason the production of *Ocimum gratissimum* in the agricultural sector is still thriving is because there is a market that serves as the channel for reaching out to final consumers. The place of market and marketing cannot be overemphasized as it is the medium for distribution. Interest was given to the study location which is Lagos state because it accounts for millions of inhabitants who would have several dietary needs amidst the hassle of activities they have to make do with daily. The supply, distribution, and marketing of *Ocimum gratissimum* would be made more tedious considering the remoteness of these supply routes until they reach their desired end consumers. It is against this background that this study examined the value chain and noted the lapses and profitability of the *Ocimum gratissimum* market.

METHODOLOGY

Study area

The state of Lagos, also known as just Lagos, is situated in Nigeria's southwest geopolitical region. With a population of over 15 million and the smallest land area among Nigeria's 36 states (Lagos State Government, 2014), Lagos State is undoubtedly the most economically significant state in the nation and the largest metropolitan area in the country. If it were a country, it would have the fifth-largest economy in Africa and be a significant financial hub Ekundayo (2013)

Data Collection

A survey research design was adopted. All parties involved in *Ocimum gratissimum* marketing in the Road 3 market, Ojo market, Iyana Iba, and Oshodi, all within the Lagos metropolis were randomly selected to form the population for the study. The sample for the study comprises 110 *Ocimum gratissimum* sellers from the four markets randomly selected using the Simple random sampling technique. A well-structured questionnaire as well as an oral interview was used to collect data.

Statistical Analysis

Descriptive Statistical analysis which includes the use of frequency counts and percentages was used to evaluate the socio-economic characteristics of the respondents, the economic and medicinal benefits of scent leaves, as well as the challenges encountered in *O. gratissimum* marketing.

Analysis of Cost and Returns

a. Variable Costs (VC) are made up of transportation costs, labour costs, cost of wares, and market tariffs.
b. Fixed cost (FC): These include the cost incurred on bags, stalls/shops.
c. Total Cost (TC) = TVC + TFC ------ Eqn. 1

Where: TVC = Total variable cost
TFC = Total fixed cost

d. Gross profit (GP) = TR – TVC ---------- Eqn. 2

Where: TR = Total Revenue

e. Net Profit (NP) = GP – TFC ---------- Eqn. 3

- Profitability ratio and Marketing efficiency were analyzed thus:

- Profitability Ratio:

a. Rate of Return (RoR%) = $\frac{TR}{TC} X \frac{100}{1}$ ----------Eqn. 4

b. Rate of Return on Investment (RoRI%) = $\frac{TR-TC}{TC} X \frac{100}{1}$ ---------- Eqn. 5

c. Marketing Efficiency (ME) = $\frac{\text{Total sales}}{\text{Total Marketing cost}}$ ---------- Eqn. 6

RESULTS AND DISCUSSION

Socio-economic Characteristics of *Ocimum* Sellers

Based on Table 1, most sellers (77.3%) were females and the remaining 22.7% were males. This aligns with a previous study by Usman *et al*. (2007) on the marketing analysis of miraculous berries (*Thaumatococcus danielli Benn*.) in Ibadan, which revealed that 99.2% of the vendors were women. More than half (63.6%) of the respondents were married, consistent with Usman *et al*. (2011) findings that also revealed that 63.3% of those working on *Ocimum gratissimum* performance and market structure were married. The mean age is 36 years, suggesting that the sellers are in their prime working years. Based on religion, 70.0% were Christians, 24.5% were Muslims and 5.5% were traditionalists. Of the respondents, 59.1% had completed their primary education, 29.1% had completed their secondary or high school education, and 11.8% had no formal education. This supports the findings of Usman *et al.* (2011) which also revealed that 51.7% of the participants had only completed elementary school. This indicates that there was education among the *Ocimum gratissimum* sellers in the research area. It follows that having reading and writing skills would make it easier for them to adopt innovations and expose them to market data, which would result in more effective marketing initiatives.

The household size survey revealed that the average number of people living in the respondents' homes was 3 persons. This suggests that marketing efforts increase with household size because of access to family labour. The results also showed that the Igbo tribe accounted for 55.5% of the respondents, followed by the Yoruba (28.2%), Hausa (5.5%), and other tribes (10.9%). The respondents' monthly average income is ₦39, 500.16 ($25.77).

Cost and return of *Ocimum gratissimum*

Scent leaf's profitability in the study area was ascertained through cost and return analysis (Table 2). With an average quantity of 2.86g, the resultant total revenue was N2,030.60, while the average total cost was computed to be N156.77. Additionally, N1,492.07 was the gross margin of N1,335.30 of net income. In addition, the marketing efficiency, rate of return, and rate of return on investment were 2.92, 192.05%, and 292.05%, respectively. This suggests that scent leaf marketing is a lucrative venture. Given that the value was greater than one, this demonstrated the effectiveness and profitability of *Ocimum gratissimum* marketing in the study area. The marketing efficiency is in good comparison to that of Usman *et al*. (2005), who discovered that Irvingia wombulu's marketing efficiency varies from 1.21 to 1.58 in various Ibadan marketing locations.

Medicinal uses of *Ocimum gratissimum*

The medicinal uses of *Ocimum gratissimum*, its method of preparation, and its procedure of usage as shown in Table 3 revealed that it can be used to stop vomiting, stomach pain, blood boosting, pile, infection, cough, diarrhoea, diabetes, blood cleansing, constipation. To stop vomiting, infection, blood cleansing, and stomach pain; squeeze and drink. For blood boosting, cook as soup; for a flat tummy; blend the leaves and drink at once, for cough; decoction and drink one cup morning and night. For head rashes; squeeze and apply on the affected part. For easy defecation; squeeze or chew as many as you can. For constipation; grind or squeeze the leaf, the seed can also be chewed raw. Plant materials have been used for medicinal, culinary, and spice purposes since the beginning of human history Nweze *et al.* (2004). In many nations around the world, the use of wild plants for medical purposes has become more acceptable recently.

Challenges encountered in the marketing of *Ocimum gratissimum*

The challenges encountered in the marketing of *Ocimum gratissimum* (Figure 1) showed that unavailability during the dry season, drying easily, not selling fast, and preservation were the challenges encountered by the sellers in the study area.

CONCLUSION AND RECOMMENDATIONS

From the findings of this study, it can be concluded there are more females than males involved in the marketing of *Ocimum gratissimum* in Lagos state and it is a profitable venture based on the values of the profitability ratios estimated. *Ocimum gratissimum* has been extensively used as a healing agent throughout human history in addition to its widespread usage as spice food.

Based on the findings of this research, it is recommended that *Ocimum gratissimum* traders be provided with adequate storage facilities, and adequate marketing information regarding prices, sources of supply, and availability of the buyers. These could be done through extension agents of both Federal and State Governments and private agencies.

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APPENDICES

Table 1: Socio-economic characteristics of *Ocimum gratissimum* sellers

Variable	Frequency	Percentage (%)	Mean/Mode
Gender			Female
Male	25	22.7	
Female	85	77.3	
Marital status			
Single	6	5.5	Married
Married	70	63.6	
Widowed	26	23.6	
Separated	8	7.3	
Age			
21-30	20	18.2	36 years
31-40	26	23.6	
41-50	22	20.0	
51-60	42	38.2	
Religion			
Christianity	77	70.0	Christianity
Islam	27	24.5	
Traditional	6	5.5	
Education			
No formal education	13	11.8	Primary school
Primary education	65	59.1	
Secondary/High School	32	29.1	
Tribe			
Yoruba	31	28.2	Igbo
Hausa	6	5.5	
Igbo	61	55.5	
Others	12	10.9	
Income			
≤ ₦30,000	25	22.7	
₦30,000-₦49,000	60	54.5	₦39,500.16
₦50,000-₦99,000	7	6.4	
₦100,000-₦149,000	18	16.4	
Nationality			
Nigerian	101	91.8	Nigeria
Non-Nigerian	9	8.2	
Minor occupation			
Trading	15	13.7	Farming
Farming	95	86.3	
Major occupation			
Farming	2	1.8	Trading
Trading	108	98.2	
Household size			
1-2	43	39.1	3 persons
3-4	62	56.3	
5-6	5	4.5	

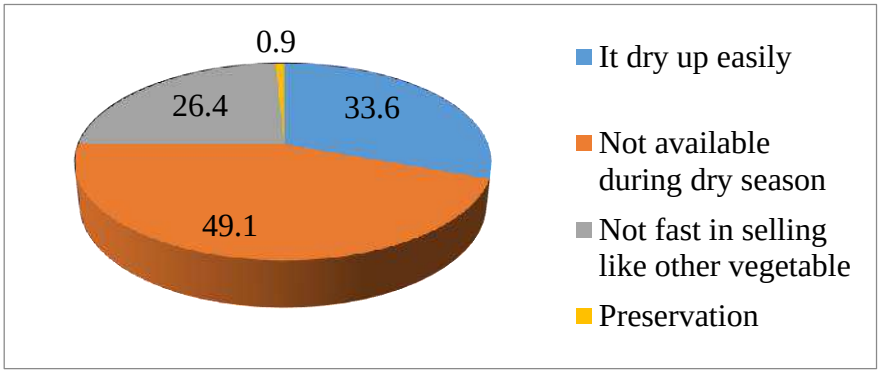
Table 2: Costs and Returns on *Ocimum gratissimum*

Variable	₦	%TC
Total revenue	2,030.60	
Average quantity	2.86g	
Average price/g	710.00	
Variable cost		
Market Tariff	306.12	44.03
Transportation cost	232.41	33.43
Total Variable Cost TVC	538.53	77.45
Gross Profit	1,492.07	
Fixed cost		
Knife	12.79	1.84
Sack	47.62	6.85
Rope	96.36	13.86
Total Fixed Cost TFC	156.77	22.55
Total Cost	695.30	100.00
Net income	1,335.30	
ROR (%)	292.05	
RORI (%)	192.05	
Marketing efficiency	2.92	

Table 3: Medicinal uses of *Ocimum gratissimum*

S/N	Medicinal Uses	Method of preparation	Procedure of usage
1	Stop vomiting	Squeeze	
2	Good for health	Cooked as soup	
3	Stomach pain	Squeeze	
4	Blood booster	Cooked as soup	
5	Pile	Squeeze and infusion	4 tablespoons morning and night
6	Diabetic	Squeeze and infusion	
7	Diarrhea	Infusion	
8	Antioxidant	Cooked as soup with another vegetable	Eat as desire
9	Blood cleansing	Squeezing	
10	Stop bleeding	Squeeze	used to rub the surface
11	Constipation	Grind or squeeze the leaves. The seed can also be chewed raw	if it is ground 2table spoon
12	Infections	Squeeze	used to rub the affected part
13	Cough	Decoction	Drink one glass cup morning and night
14	Flat tummy	Blend the leaves (₦ 200 worth of the leaves)	Pour in a glass cup and drink at once
15	Easy defecation	Squeeze or chew	as many as you can
16	Head rashes (lapalapa)	Squeeze	Used to rub the affected part

Figure 1: Challenges encountered in the marketing of *Ocimum gratissimum*



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INSIDIOUS IMPACT OF MICROPLASTICS CONTAMINATION ON FOOD SUPPLY CHAIN: A GROWING CONCERN

Alawode, R. A.[1], Oyedeji, M. B.[2], Adegbola, G.A.[3], & Oyediran, R.I.[1]

[1]Department of Biotechnology, Forestry Research Institute of Nigeria, Ibadan, Nigeria

[2]Department of Statictics, Federal College of Forestry, Ibadan, Oyo State, Nigeria

[3]Southern Guinea Research Station-Forestry Research Institute of Nigeria, Mokwa, Niger State, Nigeria

ABSTRACT

Microplastics are tiny plastic particles less than 5mm in diameter increasingly seeking attention due to their persistence in the environment and their adverse effect on man. The susceptibility of food chain to microplastics contamination has called for concerns because of its ultimate impact human health and the environment. This review is put together from the existing literature to examine the effect of microplastics on food supply chain from the point of agricultural production/factory to human consumption. Microplastics have been found in various food products ranging from seafood, honey, drinking water and even salt, having potential effect on human health by causing physical harm, chemical contamination and bioaccumulation. Also, microplastics are capable of altering soil fertility and structure which invariably affect plant growth and yield. The use of plastic mulch and synthetic fertilizers in agriculture exacerbates microplastics contamination. To mitigate these risks, sustainable practices such as reducing plastic use, increasing recycling, and implementing effective waste management strategies are essential. This review highlights the urgent need for interdisciplinary research efforts to thoroughly assess the risks posed by microplastics contamination to the integrity of food supply chain to formulate and recommend possible mitigation strategies for safer and more resilient food system for human.

Keywords: Microplastics, food supply chain, environmental pollution, human health, sustainability.

INTRODUCTION

Plastics are manufactured annually in millions of tons to ease human activities. The production of plastics was estimated in 2016 to be 335 million tons globally, with an average growth rate of 8.6% date back 1950s (this means an increase of about 1.7 million tons per annum) (Guo *et al*., 2020). The use of plastic materials in continuously on the rise due to it cost, accessibility and wide rage of use by human. It was reported that plastic waste has increased tremendously since corona virus pandemic (Meysam, 2024). The amount of plastic waste being deposited annually is on the increase due to poor disposal mechanism, low recovery rate and increased population. According to reports, it was revealed that degradation cycle of plastic waste poses serious environmental hazard as they are disposed on the surface of the earth, broken down by weathering conditions and mechanisms such as UV light and hydrolysis. This degradation continues while the plastics continuously break down to a tiny particle called microplastics (Guo *et al*., 2020).

Microplastics are tiny plastic particles of less than 5mm in size. They include plastic granules, fibers and fragments (Lebreton, 2016; Guo *et al*., 2020). The microplastics are emerging contaminants of concern. Studies revealed they are found in a wide range of products, including salt, honey, seafoods and drinking water. Also, it was estimated that 93-236 thousand tons of microplastics are floating in the ocean, amounting to about 51 trillion particles in the last decade.

Microplastics have being reported to be associated a wide range of deleterious health hazard to human and soil. High concentration of microplastics was found in soil which could be ingested by soil microorganisms leading to reduction in their population. This issue has recently called for concern as a result of the wide spread use of plastics and the need to understand their negative impact on human health and the environment (Guo *et al*., 2020). Therefore, this review is put together to create awareness on the risk microplastics could pose to human health through the food supply chain and highlight the possible means of eradicating its menace from the ecosystem.

Microplastics

Microplastics can have their origin from the breakdown of larger plastic materials or intentionally manufactured at small scales. They are divided into primary and secondary microplastics based on their source. Primary microplastics are those produced intentionally in microscopic sizes, which include microbeads used in personal care products. Industries formerly make use of ground almonds, oatmeal, or pumice in their products before the plastic evolution. Due to their known effect on human, it is often stated on their label that such product contains 'microbeads' or 'microexfoliant' (Meysam, 2024; Guo *et al*., 2020; Cverencarova *et al*., 2021).

The secondary microplastics are formed from degradation or breaking down of larger plastic items like bottles and bags released into the environment.

These particles are more available and widely spread in the ecosystem. These microplastics are formed through three means, either through natural degeneration of plastics (weathering or microbial activities); decomposition of plastics (direct activity of an organism) or resuspension of accumulated microplastics contamination in soil (Guo *et al*., 2020; Cverencarova *et al*., 2021).

Effect of microplastics on human health

The effect of microplastics on human health is not entirely known, but quite a number of possible health implications has been identified (Lebreton, 2017; Guo *et al*., 2020). Microplastics were reported to penetrate human through contaminated foods, inhalation and body contacts. However, contamination through food remains a thing of great concern (Cverencarova *et al*., 2021). Report says human can ingest microplastics through food and water waste accumulating in the gastrointestinal tract leading to inflammation, oxidative stress, and alterations in gut microbiota composition, potentially affecting digestive health. Also, they can act as carriers for other harmful substances, such as persistent organic pollutants (POPs) and heavy metals, which can adsorb onto their surfaces. When ingested, these contaminants leaches into the body, posing additional health risks like endocrine disruption and carcinogenic effects (Meysam, 2024).

Effect on aquatics and the environment

Microplastics pose significant threats to aquatic ecosystems and the environment. As persistent pollutants, they accumulate in marine and freshwater habitats, causing a range of adverse effects on aquatic organisms and ecosystem dynamics. For instance, small organisms such as plankton and filter feeders can mistake microplastics for food, leading to blockages in their digestive systems, reduced feeding efficiency, and impaired growth and reproduction. This can have cascading effects throughout the food web, affecting higher trophic levels including fish, seabirds, and marine mammals to human (Guo *et al*., 2020; Meysam, 2024).

Microplastics contaminant on food chain

Microplastics can contaminate foods at various stages of the supply chain, from production to consumption. One concern is the potential migration of microplastics from packaging materials into the food itself. Packaging materials, particularly plastics, can shed microplastics particle due to mechanical abrasion, degradation, or exposure to environmental stressors like heat and light. These particles may then leach into the packaged food, leading to unintended human ingestion. Moreover, they can act as pathogens for other contaminants, such as additives, dyes, and plasticizers, which may be present in packaging materials. These chemicals can migrate along with microplastics into the food, raising additional health concerns (Guo *et al*., 2020; Cverencarova *et al*., 2021).

Effect of microplastics on agriculture and soil

Microplastics pollution can have several detrimental effects on agriculture, including soil quality degradation, negative impacts on crop growth, and potential harm to organisms living in the soil. Microplastics, through various pathways such as irrigation with contaminated water, mulching with plastic films, or application of sewage sludge, can accumulate in agricultural soils, leading to soil contamination (Guo *et al*., 2020; Meysam, 2024). This contamination can alter soil physical, chemical, and biological properties. Microplastics in soil can affect soil health by reducing water infiltration, increasing soil compaction, and altering nutrient cycling processes. They can also adhere to the surfaces of crops or be taken up by plants, leading to crop contamination. Organisms like earthworm living in the soil can ingest microplastics, affecting their behavior and health (Meysam, 2024).

Control methods

To address these issues, there is the need to minimize the use of plastics in everyday life. This can be achieved by avoiding single use of plastics, choosing products with minimal plastic packaging and choosing suitable materials like biodegradable polymer which are derived from renewable resources like starch, cellulose and chitosan; paper-based packaging like cardboard and paper; edible films and coatings made from proteins, polysaccharides and lipids; polylactic acid (PLA) derived from starch and sugarcane and glass containers (Guo *et al*., 2020).

Regulatory agencies should involve individuals and public in proper waste disposal management controls, like proper disposal, recycling, and waste to energy technologies can help prevent plastics entering into the environment and degrading into microplastics (Lebreton *et al*., (2017). For instance, installing filtration systems in wastewater treatment plants can help capture microplastics before they are discharged into water bodies.

Also, adopting sustainable agricultural practices, such as organic farming and agroecology, can reduce reliance on plastic-based inputs like mulch films and fertilizers, thereby minimizing the introduction of microplastics into agricultural soils (Guo *et al*., 2020).

CONCLUSION

Plastics are produce in millions of ton annually to facilitate human activities. Therefore, its production increases annually with increase in human population. However, plastics used are improperly disposed become pollutants by breaking down to microplastics through weathering or biological factors. These pollutants cause detrimental effect on food chain ranging from the soil, water to human.

RECOMMENDATION

This review identified few measures such as reduced usage of plastics, implementation of proper waste disposal management and use of biodegradable materials to reduce microplastics pollution on agricultural systems, human and ecosystem's health underscoring the importance of mitigating microplastics contamination to ensure food security and environmental sustainability.

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SOME CHEMICAL COMPOSITION OF AGRO WASTE (PLANTAIN PEELS AND PALM OIL MILL EFFLUENT) OBTAINED FROM A PART OF SOUTHERN NIGERIA: AN ALTERNATIVE IN ANIMAL FEEDING

***Ekhorutomwen, V.E[1] and Nwokoro, S.O.**

Monogastric Animal Production Division, Department of Animal Science, Faculty of Agriculture, P.M.B. 1154, University of Benin, Edo State, Nigeria.

Corresponding author email: victoria.eguavoen@uniben.edu.

ABSTRACT

This study was initiated to investigate the proximate and some mineral compositions of ripe plantain peels collected from Auchi, Ekpoma, Benin City and palm oil mill slurry obtained from Okomu, Presco, Udo and Benin City, Edo State, Nigeria. Ripe plantain peels collected from Auchi, Ekpoma and Benin gave crude protein (CP) of 10.50, 11.08 and 10.50 % respectively; Ether Extract (EE) of 24.03, 25.02 and 23.84% respectively, Ash of 11.93, 12.47 and 11.00 % and 30.73, 34.87 and 37.15 % for NFE respectively. Crude fibre (CF) and Nitrogen Free Extract (NFE) were significantly ($P<0.05$) different with regard to Locations as the highest value 10.66 % were obtained from Benin City, which significantly ($P<0.05$) differ from Ekpoma (7.99 %) and close to the value 9.59 % recorded for Auchi. Palm oil mill slurry (POMS) from Okomu, Presco, Udo and Benin City revealed crude protein (CP) values of 2.62, 2.04, 3.79 and 3.21 % respectively, EE of 15.76, 17.59, 12.50 and 17.62 % respectively. The results of this study have shown the high nutritional content of plantain peels and palm oil mill slurry as such combination of this feed can effectively serve as animal feed.

Key words: Ripe Plantain Peels, Palm Oil Mill Slurry, Chemical Analysis

INTRODUCTION

Plantain peel is abandoned as garbage once the interior fleshy portion has been eaten, posing a threat to the environment, especially in areas where it is commonly consumed. (Auta and Kumurya, 2015). In every oil extraction process, palm oil slurry is a major waste product usually more than palm oil, which is the primary product (Heuzé *et al*., 2015). The plantain and palm oil processing industries generate a significant amount of waste in the form of plantain peels and palm oil mill slurry. These by-products accumulate and constitute a menace to the environment when improperly disposed of. At the same time, the rising cost of grains and concentrates used in producing animal and livestock feeds necessitates the exploration of alternative, cost-effective, and sustainable feed sources.

MATERIALS AND METHODS

Sources of plantain peel and experimental location

In the study, samples of ripe plantain peels were collected from plantain processing Centers, from Edo North, Edo Central, and Edo South Senatorial District, Edo State, Nigeria. Palm oil mill slurry was collected from Industrial (OKOMU and PRESCO) and Local processor in UDO Community and Benin Sapele Road, Edo South, Nigeria.

Collection and Preparation of Plantain Peels

Fresh ripe plantain peels collected from Benin City, Edo South, Nigeria were properly sun dried (30-35^{o}C), well ground and analyzed for proximate and mineral composition.

Chemical Analysis

Samples of the dried and milled plantain peels and freshly collected palm oil mill slurry (POMS) were used for the determination of dry matter, crude protein, crude fibre, ash, ether extract, nitrogen free extract, Calcium and Phosphorus.

Statistical Analysis

Palm oil Mill Slurry comparison was done based on the processing technology (Industrial vs Local Processor). In the ripe plantain peels, means were separated based on agro-ecological zones of Edo State (South vs Central vs North). Data collected were subjected to one way Analysis of Variance, using GENSTAT (2009) (12th Edition) package.

RESULTS AND DISCUSSION

The plantain peels collected from Auchi, Ekpoma and Benin (Table 1) were not significantly ($P >0.05$) different in crude protein, crude fat and ash. The crude protein was 10.50, 11.08 and 10.50 % respectively; EE of 24.03, 25.02 and 23.84 respectively, Ash of 11.93, 12.47 and 11.00 % and NFE values of 30.73, 34.87 and 37.15 % respectively. As NFE, the CF was significantly ($P<0.05$) different with location as the highest value was obtained from Benin City (10.66 %) which significantly ($P<0.05$) differ from Ekpoma (7.99 %) and statistically similar to Auchi (9.59 %). It was also observed that ripe plantain peels gave Potassium values of 202.86, 183.22 and 179.46 and

mg/kg respectively, Calcium values of 86.12, 72.67, and 62.15 mg/kg and Phosphorus values of 22.65, 24.39 and 32.69 mg/kg respectively. Crude protein values obtained for Auchi (10.50 %) and Ekpoma (11.08 %) were slightly higher than 9.19 % report by Akinmutimi *et al*. (2006). The crude fibre value was 9.59, 7.99 and 10.66 respectively. Akinmutimi *et al*. (2006) CF value (6.43 %). The EE values of 24.03, 25.02 and 23.84% respectively where significantly higher when compared to the value as reported by Akinmutimi *et al*. (2006). The observed disparity may be attributed to the species (or ecotype) and soil properties of the location. The ripening stage may also have influenced the composition of the ingredient.

Table 1: Chemical Composition of Ripe Plantain Peels Collected from Three Locations in Edo State

COMPOSITION	LOCATION			±SEM
	AUCHI	EKPOMA	BENIN	
Dry matter (%)	86.78^{c}	93.14^{a}	93.41^{b}	0.27
Crude protein (%)	10.50	11.08	10.50	0.67
Crude fat (%)	24.03	25.02	23.84	0.40
Crude fibre (%)	9.59^{ab}	7.99^{b}	10.66^{a}	0.51
Ash (%)	11.93	12.47	11.00	0.31
NFE (%)	30.73^{b}	34.87^{ab}	37.15^{a}	1.30
Ca (mg/kg)	86.12^{a}	72.67^{b}	62.15^{c}	0.67
Mg (mg/kg)	16.24^{a}	12.84^{b}	9.39^{c}	0.37
Na (mg/kg)	8.73^{b}	10.15^{a}	7.92^{a}	0.28
K (mg/kg)	202.86^{a}	183.22^{b}	179.46^{c}	0.97
P (mg/kg)	22.65^{b}	24.39^{b}	32.69^{a}	0.63
Pb (mg/kg)	0.34	0.35	0.42	0.03
Fe (mg/kg)	23.14^{a}	24.36^{a}	19.98^{b}	0.60

^{abc}means with different superscripts in the same row differ significantly (P<0.05).
SEM - Standard Error of Means

The chemical composition of the palm oil mill slurry from OKOMU, Presco, Udo and Benin City (Table 2) revealed crude protein values of 2.62, 2.04, 3.79 and 3.21 % respectively, EE of 15.76, 17.59, 12.50 and 17.62 % respectively. Samples from Udo gave the highest crude protein (3.21 %) and lowest crude Fat (12.50 %). These results are in line with previous study in Edo State (Abiola-Olagunji *et al*., 2014).

Table 2: Chemical Composition of Palm Oil Mill Slurry (POMS) Collected from Different locations in Edo state, Nigeria.

COMPOSITION	LOCATION				±SEM
	OKOMU (I)	PRESCO (I)	UDO (L)	BENIN (L)	
Moisture Content (%)	74.23^{ab}	72.79^{bc}	75.11^{a}	71.96^{c}	0.519
Crude Protein (%)	2.62^{bc}	2.04^{c}	3.79 ^{a}	3.21^{ab}	0.25
Crude Fat (%)	15.76^{b}	17.59^{b}	12.5^{c}	17.62^{a}	0.34
Ash (%)	4.91^{ab}	4.16 ^{b}	5.16 ^{a}	4.66^{ab}	0.36
NFE (%)	2.48^{a}	3.42 ^{a}	2.92 ^{a}	2.56 ^{a}	0.71
Ca (mg/kg)	315.77^{a}	188.58^{c}	306.67^{b}	176.04^{d}	0.90
Mg (mg/kg)	281.93^{a}	175.52^{c}	241.76^{b}	156.16^{d}	1.04
Na (mg/kg)	11.65^{c}	14.94^{b}	15.06^{b}	21.39^{a}	0.41
K (mg/kg)	476.98^{a}	365.33^{c}	408.09^{b}	363.57^{c}	1.28
P (mg/kg)	27.54^{a}	9.95^{b}	10.53^{b}	9.86^{b}	0.26
Pb (mg/kg)	0.17^{c}	0.78^{a}	0.37^{b}	0.36 ^{b}	0.03
Fe (mg/kg)	10.97^{d}	18.02^{c}	21.26^{b}	29.93^{a}	0.43

^{abc}means with different superscripts in the same row differ significantly (P<0.05).SEM - Standard Error of Means, I - Industrial processor, L - Local processor

CONCLUSION

The results from this study showed that the plantain peels collected from Auchi, Ekpoma and Benin were not significantly (P >0.05) different in crude protein, crude fat and ash. The Crude Fat (CF) was significantly (P<0.05) different with location. The locally processed palm oil mill slurry gave higher crude protein content of 3.50 % compared with 2.33 % from industrially processed slurry and the locally processed slurry had higher crude fat content. This may be accounted for by the efficiency of industrial facilities and processing methods.

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ANALYSIS OF AGRICULTURAL COMMERCIALIZATION AND POVERTY STATUS AMONG FARM HOUSEHOLDS IN ABEOKUTA NORTH LOCAL GOVERNMENT AREA, OGUN STATE, NIGERIA

Oladeji S.O., Oluwalana E.O.A. Olufemi .O and Jamiu A.G.
Department of Agricultural Economics and Farm Management,
Federal University of Agriculture Abeokuta, Ogun State Nigeria
Corresponding author's email: oladejiso@funaab.edu.ng 08056283951

ABSTRACT

The study examined the effect of commercialization and other socioeconomic characteristics on the poverty status in Abeokuta North Local Government Area in Ogun state using descriptive statistics, Household Commercialization Index (HCI), Foster Greer Thorbecke (FGT) Indices and Logit Regression Model. The data used were generated from a survey involving 120 farming households randomly selected using multistage technique. Results of analysis revealed that majority of the farm households were married with a very large household size, majority of the farm households had neither access to credit nor extension contact, 75% of the farmers utilized below 5 hectares of land, they also participated more in local marketing. The study shows that the degree of commercialization in the study area is high and significant at ($p<0.05$). The total crops harvested was 183452.7, the mean of the total value of crops sold was 151411.5 and the mean of the commercialization index was 0.984. The mean per capita expenditure among the farm households was ₦7,737.40. The FGT poverty incidence, depth and severity were 0.41, 0.07 and 0.09. The logit result of the regression indicates that age ($p<0.01$), farm size ($p<0.01$), household size ($p<0.05$), education ($p<0.01$) and access to credit ($p<0.1$) are the main significant variables in this study that influence the probability of the household being poor or non-poor. It is therefore recommended that government should empower the various government credit agencies so as to make credit available to farmers, strengthen the adult literacy education programmes and encourage farmers to expand their land for increased production.

INTRODUCTION

Commercialization of agricultural production simply means the creation of agricultural crops for sale in the market, rather than for family consumption. It is the process in which new products or production methods are introduced into the market. It is also the level to which a farm household is linked to the market. Commercialization brings about economic growth, and urbanization from the agricultural sector and positive changes in welfare at household and aggregate levels. Therefore, agricultural commercialization plays a crucial role in the structural transformation which is said to be the transition of an economy from low productivity and labour intensive economic activities to higher productivity and skills intensive activities. This means that the majorities of the people living in rural areas who depend directly or indirectly on semi-subsistence agriculture for their livelihood now live in urban areas and depend on employment in manufacturing or service industries as a source of livelihood. Agricultural commercialization comes into play when the agricultural sector as a whole depends entirely on the market to sell their produce and for the procurement or purchase of inputs used in production. Frequently, commercialization is perceived as being large scale and neglects those small scale farmers (Nwafor, 2012). Agricultural commercialized surpasses marketing of agricultural outputs, it includes the inputs and used product choice and it is based on profit maximization of the farm households for comparative advantage. The dimensions of agricultural commercialization are in two different forms.

First, smallholder farm household changes from producing food for own consumption and sales (semi-subsistence agriculture) to production mainly for sales. Hence, relying less on own produced inputs (manure) and depend more on the market to purchase farm inputs (inorganic fertilizer, improved seeds) and services (labour). According to (Ferris *et al.*, 2014) land ownership is

a major element that determines commercialization, unavailability of market can also hinder commercialization (Chirwa & Matita, 2012). When there is inadequate access to market, the benefit of higher product prices and lower input offered by commercialization will not be available to smallholder farms (Omiti *et al.,* 2009). The benefits of successful commercialization for farm household members are: increased income, nutrition, welfare and employment of other rural people. (Ogutu & Qaim, 2019) through the use of control function found that commercialization substantially reduces both income poverty and multidimensional poverty in Kenya. Farm commercialization which is a change from subsistence to a market-oriented farming helps in improving welfare of farm households and lead to high productivity, increased income, increase in employment rate and poverty reduction (Bellemare & Novak, 2017; Carletto, Corral, & Guelfi, 2017). The current study will therefore analyze agricultural commercialization and poverty status among farm households in Abeokuta North Local Government Area, Ogun State. Specifically, the study will:

Describe the socioeconomic characteristics of the respondents, Analyze level of commercialization among farming households in the study area, measure poverty status of farm households in the study area and Identify the effects of agricultural commercialization and other socioeconomic characteristics on poverty status of the respondents.

METHODOLOGY

Primary data were collected through a well-structured questionnaire administered to the respondents in order to draw out responses from the farm households in relation to the objectives. A multistage sampling technique was adopted to collect data from adult members of the selected households. The first stage involved simple random selection of 4 political wards (Olorunda, Imala, Isaga-Ilewo, and Gbagura) out of the 16 wards in the local government. Stage two entails purposive selection of 3 communities each from the 4 selected wards based on the concentration of small scale farmers in the communities. The final stage involves random selection of 10 farming households from the selected communities. In all, a total of 120 respondents were used for this study.

Analytical Techniques

The analytical tools that were used in analyzing the data collected are descriptive statistics, Household Commercialization Index (HCI), Foster Greer Thorbecke (FGT) Indices and Logit Regression Model respectively.

Household Commercialization Index (HCI)

The Household Commercialization Index (HCI) was computed to estimate the household level of commercialization among small holder farmers. It is a ratio of the gross value of crop sales by household in a given year to the gross value of all crops produced by the same household (I) in the same year (j) and expressed as percentage. This method is identical to that used in other commercialization studies by (Rao *et al.,* 2009).

$$\text{Level of Commercialization (HCI)} = \frac{\text{Total value of crop sold}}{\text{Total value of crop produced}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

A zero value for HCI means total subsistence while a HCI value approaching 100 is an indication of higher degrees of commercialization which implies a greater percentage of crops sold.

Foster Greer Thorbecke Index

The Foster Greer Thorbecke (FGT) Index was used to measure the poverty level of the respondents. The FGT is generally expressed using the formula:

$$\text{FGT}\ \alpha = \frac{1}{N}\left(\frac{Z-Yi}{Z}\right)^{\alpha} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

N = total number of respondents i.e. farm household sampled

Z = the poverty line defined as $\frac{2}{3}$ of the Mean Per Capital Household Expenditure (MPCHHE)

Y_i = per capita household expenditure of the i^{th} respondent (N/Household/Monthly)

Logit Regression Model

The Logit model was adopted for examining the effects of agricultural commercialization and other socio-economic characteristics on the poverty status of the respondents.

Using the logit distribution, it is specified as:

$$Zi\ p = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \ldots. + \beta_nX_n + \varepsilon i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where, Zi is the log odds of the i^{th} household, α is constant, β_1, β_2, β_3, and βn are coefficients of independent variables X_1, X_2, X_3, and Xn, and εi is an error term for the i^{th} household.

P = poverty status, (1 for poor and 0 if non-poor).

The independent variables specified in the model are:

X_1 = Age (years)
X_2 = Sex (male = 0, female = 1)
X_3 = Marital status (married 1, otherwise 0)
X_4 = Household size (number)
X_5 = Years of schooling (years)
X_6 = Farming experience (years)
X_7 = Farm size (ha)
X_8 = Access to credit (yes or no)
X_9 = Access to extension service (yes or no)
X_{10} = Level of commercialization
εi = error term

RESULTS AND DISCUSSION

The living conditions of the respondents. On the respondent's access to power supply, 35.8% uses IBEDC, 17.5% uses generator. Sadly, 46.7% of the respondents stated that they do not have access to the power supply.

Findings revealed that 77.5% of respondents stated in rented house, 10% stayed in owned houses, 10.8% of respondents stayed in inherited house while 1.7% purchased the houses they live in. Findings also showed that 39.2% of the road were tarred, 45.8% of the road were not tarred while 15% of the road were not motorable. According to the type of water used, the table shows that 1.6% of respondents drank tap water, 64.2% drank well water while 34.2% drank borehole water. The means of cooking of respondents indicated that 38.3% used gas, 15.8% used firewood while 45.9% used kerosene. 37.5% had latrine while 62.5% of the respondents had water closet. The table also shows that 15.8% of respondents had access to clinic while 84.2% had no access to clinic.

Level of Household Agricultural Commercialization index in the Study Area

From the research, the study shows that 95.6% of the respondents were into maize production and a mean Tonne of 0.362 was produced while a mean Tonne of 0.361 was sold and the mean price per Tonne in Naira was 84560.880. Also, it was shown that 97.8% of the total respondents were into cassava production and a mean Tonne of 3.562 was produced while a mean tonne of 3.123 was sold and the mean price per Tonne was 11660.345

Commercialization indices between 0-1

Table 5: Explain that 68.3 % of the respondents have a commercialization index that ranges from 0.81 to 1, 29.2% has a commercialization index of 0.51 to 0.80 and 2.5% has a commercialization index of less or equal to 0.5.

Distribution of Households According to Poverty Status

The household was classified into poor and non-poor based on the total expenditure on food and non-food items. The per capita household expenditure is ₦76,663.40 while the mean per capita household expenditure is ₦7,737.40 and the poverty line was analyzed to be ₦280. The result obtained from the FGT model showing from the FGT table below reveals that the poverty line was constructed and estimated using $\frac{2}{3}$ of the mean per capita expenditure which is estimated to be ₦280.

Effects of Agricultural Commercialization and other Socioeconomic Characteristics on Poverty Status

The result of the Logit regression analysis is presented in Table 8. The value of Chi^2 (10) is 22.37 and the value of Pseudo R^2 = 0.0803. This shows that the data fitted the model. Nearly all the determinants of poverty examined have the expected signs and are statistically significant at the stated probability levels. The Logit regression analysis revealed that agricultural commercialization, age, farm size, education, household size and access to credit have coefficients that are statistically significant. It therefore follows that those variables are the major determinants of poverty in the study area.

Agricultural commercialization is statistically significant at 5% and negatively correlated with poverty. This implies that as the adoption of agricultural commercialization increases, poverty status of the farm households diminishes.

The age of the sampled household heads was found to be a positive driver of poverty status, at a significance level of 1%. The direct relationship indicates that as the household heads gets older, the likelihood of being poor increases. This connotes that poverty rises with old age as the productivity of the individual declines.

The result also reveals that farm size was also significant and negative at 5%. This implies that an increase in farm size will lead to poverty reduction. Farm households with larger farm size have the tendency of not being poor. This is due to the expectation that households with larger farm size should generate more income which would

enhance consumption and thereafter reduce poverty status of the households.

A unit rise in the level of education of the farm household decreases the susceptibility of household to poverty. An improvement in the level of education of the household head was found to lower the probability of household being categorized as poor. The relationship between the level of education and poverty status was negative and statistically significant at 1%.

Household size was significant and positive at 5%. This suggests that larger households are more likely to be categorized as poor than smaller households. The larger the household size, the higher the probability of being poor because more of the household members will likely be children on whom a large part of the household income is spent in terms of expenses like medical bills, clothing and school fees.

Access to credit by the farm households has a 10% significant negative correlation to poverty. The household access to credit will facilitate the purchase of farm inputs such as herbicide, fertilizer, and increase productivity. Hence, an increase in credit access will decrease the poverty status of the households.

CONCLUSION AND RECOMMENDATION

Based on this study, the Household Commercialization Index (HCI) in the study area is high. The level of commercialization was also significant and is found to reduce the level of poverty among the respondents. The result reveals that poverty is still a serious problem in the study area with about 41% of the respondents below the poverty line. The poverty depth which was 7% implies that the consumption expenditure of household must be raised by 7% to move out of poverty and poverty severity of 9% shows that poverty is less severe among the respondents in the study area. The followings are recommended:

1. Facilitation by government agencies in improving market infrastructures including storage facilities, rural roads, and telecommunications which will create access to market opportunities, reduce transaction cost, support long distance marketing and promote easier transportation of farm produce to market centers which will increase the level of commercialization.
2. Efforts by governmental and non-governmental agencies in areas of infrastructural development (provision of electricity supply, access to clean drinking water, affordable housing, clinic access and so on) would help to improve the living condition of the people in the study area.

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SOME CHEMICAL COMPOSITION OF AGRO WASTE (PLANTAIN PEELS AND PALM OIL MILL EFFLUENT) OBTAINED FROM A PART OF SOUTHERN NIGERIA: AN ALTERNATIVE IN ANIMAL FEEDING

***Ekhorutomwen, V. E[1] and Nwokoro, S.O**.
Monogastric Animal Production Division, Department of Animal Science, Faculty of Agriculture, P.M.B. 1154, University of Benin, Edo State, Nigeria.
***Corresponding author email**: victoria.eguavoen@uniben.edu.

ABSTRACT
This study was initiated to investigate the proximate and some mineral compositions of ripe plantain peels collected from Auchi, Ekpoma, Benin City and palm oil mill slurry obtained from Okomu, Presco, Udo and Benin City, Edo State, Nigeria. Ripe plantain peels collected from Auchi, Ekpoma and Benin gave crude protein (CP) of 10.50, 11.08 and 10.50 % respectively; Ether Extract (EE) of 24.03, 25.02 and 23.84% respectively, Ash of 11.93, 12.47 and 11.00 % and 30.73, 34.87 and 37.15 % for NFE respectively. Crude fibre (CF) and Nitrogen Free Extract (NFE) were significantly (P<0.05) different with regard to Locations as the highest value 10.66 % were obtained from Benin City, which significantly (P<0.05) differ from Ekpoma (7.99 %) and close to the value 9.59 % recorded for Auchi. Palm oil mill slurry (POMS) from Okomu, Presco, Udo and Benin City revealed crude protein (CP) values of 2.62, 2.04, 3.79 and 3.21 % respectively, EE of 15.76, 17.59, 12.50 and 17.62 % respectively. The results of this study have shown the high nutritional content of plantain peels and palm oil mill slurry as such combination of this feed can effectively serve as animal feed.
Key words: Ripe Plantain Peels, Palm Oil Mill Slurry, Chemical Analysis

INTRODUCTION
Plantain peel is abandoned as garbage once the interior fleshy portion has been eaten, posing a threat to the environment, especially in areas where it is commonly consumed. (Auta and Kumurya, 2015). In every oil extraction process, palm oil slurry is a major waste product usually more than palm oil, which is the primary product (Heuzé *et al*., 2015). The plantain and palm oil processing industries generate a significant amount of waste in the form of plantain peels and palm oil mill slurry. These by-products accumulate and constitute a menace to the environment when improperly disposed of. At the same time, the rising cost of grains and concentrates used in producing animal and livestock feeds necessitates the exploration of alternative, cost-effective, and sustainable feed sources.

MATERIALS AND METHODS
Sources of plantain peel and experimental location
In the study, samples of ripe plantain peels were collected from plantain processing Centers, from Edo North, Edo Central, and Edo South Senatorial District, Edo State, Nigeria. Palm oil mill slurry was collected from Industrial (OKOMU and PRESCO) and Local processor in UDO Community and Benin Sapele Road, Edo South, Nigeria.

Collection and Preparation of Plantain Peels
Fresh ripe plantain peels collected from Benin City, Edo South, Nigeria were properly sun dried (30-35^{o}C), well ground and analyzed for proximate and mineral composition.

Chemical Analysis
Samples of the dried and milled plantain peels and freshly collected palm oil mill slurry (POMS) were used for the determination of dry matter, crude protein, crude fibre, ash, ether extract, nitrogen free extract, Calcium and Phosphorus.

Statistical Analysis
Palm oil Mill Slurry comparison was done based on the processing technology (Industrial vs Local Processor). In the ripe plantain peels, means were separated based on agro-ecological zones of Edo State (South vs Central vs North). Data collected were subjected to one way Analysis of Variance, using GENSTAT (2009) (12th Edition) package.

RESULTS AND DISCUSSION
The plantain peels collected from Auchi, Ekpoma and Benin (Table 1) were not significantly (P >0.05) different in crude protein, crude fat and ash. The crude protein was 10.50, 11.08 and 10.50 % respectively; EE of 24.03, 25.02 and 23.84 respectively, Ash of 11.93, 12.47 and 11.00 % and NFE values of 30.73, 34.87 and 37.15 % respectively. As NFE, the CF was significantly (P<0.05) different with location as the highest value was obtained from Benin City (10.66 %) which significantly (P<0.05) differ from Ekpoma (7.99 %) and statistically similar to Auchi (9.59 %). It was also observed that ripe plantain peels gave

Potassium values of 202.86, 183.22 and 179.46 and mg/kg respectively, Calcium values of 86.12, 72.67, and 62.15 mg/kg and Phosphorus values of 22.65, 24.39 and 32.69 mg/kg respectively. Crude protein values obtained for Auchi (10.50 %) and Ekpoma (11.08 %) were slightly higher than 9.19 % report by Akinmutimi *et al*. (2006). The crude fibre value was 9.59, 7.99 and 10.66 respectively. Akinmutimi *et al*. (2006) CF value (6.43 %). The EE values of 24.03, 25.02 and 23.84% respectively where significantly higher when compared to the value as reported by Akinmutimi *et al*. (2006). The observed disparity may be attributed to the species (or ecotype) and soil properties of the location. The ripening stage may also have influenced the composition of the ingredient.

Table 1: Chemical Composition of Ripe Plantain Peels Collected from Three Locations in Edo State

COMPOSITION	LOCATION			±SEM
	AUCHI	EKPOMA	BENIN	
Dry matter (%)	86.78^{c}	93.14^{a}	93.41^{b}	0.27
Crude protein (%)	10.50	11.08	10.50	0.67
Crude fat (%)	24.03	25.02	23.84	0.40
Crude fibre (%)	9.59^{ab}	7.99^{b}	10.66^{a}	0.51
Ash (%)	11.93	12.47	11.00	0.31
NFE (%)	30.73^{b}	34.87^{ab}	37.15^{a}	1.30
Ca (mg/kg)	86.12^{a}	72.67^{b}	62.15^{c}	0.67
Mg (mg/kg)	16.24^{a}	12.84^{b}	9.39^{c}	0.37
Na (mg/kg)	8.73^{b}	10.15^{a}	7.92^{a}	0.28
K (mg/kg)	202.86^{a}	183.22^{b}	179.46^{c}	0.97
P (mg/kg)	22.65^{b}	24.39^{b}	32.69^{a}	0.63
Pb (mg/kg)	0.34	0.35	0.42	0.03
Fe (mg/kg)	23.14^{a}	24.36^{a}	19.98^{b}	0.60

^{abc}means with different superscripts in the same row differ significantly (P<0.05).
SEM - Standard Error of Means

The chemical composition of the palm oil mill slurry from OKOMU, Presco, Udo and Benin City (Table 2) revealed crude protein values of 2.62, 2.04, 3.79 and 3.21 % respectively, EE of 15.76, 17.59, 12.50 and 17.62 % respectively. Samples from Udo gave the highest crude protein (3.21 %) and lowest crude Fat (12.50 %). These results are in line with previous study in Edo State (Abiola-Olagunji *et al*., 2014).

Table 2: Chemical Composition of Palm Oil Mill Slurry (POMS) Collected from Different locations in Edo state, Nigeria.

Ccomposition	Location				±SEM
	OKOMU (I)	PRESCO (I)	UDO (L)	BENIN (L)	
Moisture Content (%)	74.23^{ab}	72.79^{bc}	75.11^{a}	71.96^{c}	0.519
Crude Protein (%)	2.62^{bc}	2.04^{c}	3.79 ^{a}	3.21^{ab}	0.25
Crude Fat (%)	15.76^{b}	17.59^{b}	12.5^{c}	17.62^{a}	0.34
Ash (%)	4.91^{ab}	4.16 ^{b}	5.16 ^{a}	4.66^{ab}	0.36
NFE (%)	2.48^{a}	3.42 ^{a}	2.92 ^{a}	2.56 ^{a}	0.71
Ca (mg/kg)	315.77^{a}	188.58^{c}	306.67^{b}	176.04^{d}	0.90
Mg (mg/kg)	281.93^{a}	175.52^{c}	241.76^{b}	156.16^{d}	1.04
Na (mg/kg)	11.65^{c}	14.94^{b}	15.06^{b}	21.39^{a}	0.41
K (mg/kg)	476.98^{a}	365.33^{c}	408.09^{b}	363.57^{c}	1.28
P (mg/kg)	27.54^{a}	9.95^{b}	10.53^{b}	9.86^{b}	0.26
Pb (mg/kg)	0.17^{c}	0.78^{a}	0.37^{b}	0.36 ^{b}	0.03
Fe (mg/kg)	10.97^{d}	18.02^{c}	21.26^{b}	29.93^{a}	0.43

^{abc}means with different superscripts in the same row differ significantly (P<0.05).SEM - Standard Error of Means, I - Industrial processor, L - Local processor

CONCLUSION

The results from this study showed that the plantain peels collected from Auchi, Ekpoma and Benin were not significantly (P >0.05) different in crude protein, crude fat and ash. The Crude Fat (CF) was significantly (P<0.05) different with location. The locally processed palm oil mill slurry gave higher crude protein content of 3.50 % compared with 2.33 % from industrially processed slurry and the locally processed slurry had higher crude fat content. This may be accounted for by the efficiency of industrial facilities and processing methods.

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EFFECT OF *Euphorbia heterophylla* AQUEOUS LEAF EXTRACT ON PERFORMANCE AND CARCASS CHARACTERISTICS OF BROILER CHICKENS

***[1]Opowoye I.O., [1]Adewole, F.A., [2]Adeleye, O.O., [3]Adetoboye, O.O., [4]Salako, A.O., [2]Olayioye, A.A., [2]Akinjobi, V.O. and [2]Sogunle, O.M.**

[1]Institute of Food Security, Environmental Resources and Agricultural Research, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.
[2]Department of Animal Production and Health, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.
[3]Food Technology Department, Federal Institute of Industrial Research, Oshodi, Lagos State, Nigeria.
[4]Department of Animal Production, Faculty of Agriculture, University of Ilorin, Kwara State, Nigeria.
***Corresponding author**: opowoyeio@funaab.edu.ng

ABSTRACT
This study was conducted to determine effect of *Euphorbia heterophylla* aqueous leaf extract on performance and carcass traits of broilers. One hundred and ninety two day-old Arbor Acre chicks were randomly divided into six treatment groups with 4 replicates of 8 birds each. The 6 week experiment was laid out in a 2x3 factorial combination of two concentrations (40ml; 50ml/litre of water) of *Euphorbia heterophylla* aqueous leaf extract (EHLE) at frequency of administration: 0 days, 4 days and 5 days / week. Treatment 1: 40ml (EHLE) 0 times/week; Treatment 2: 40ml (EHLE) 4 times/week; Treatment 3: 40ml (EHLE) 5 times/week; Treatment 4: 50ml (EHLE) 0 times/week; Treatment 5: 50ml (EHLE) 4 times/week; Treatment 6: 50ml (EHLE) 5 times/week. Data was collected on growth performance and carcass traits. Results showed no significant ($P<0.05$) differences for main and interactive effects of EHLE on broiler performance. For main effect of EHLE on carcass traits, drumstick and liver weights were significantly ($P>0.05$) higher in birds on 40ml concentration. As frequency of administration increased from 0 to 5 days, dressing percent and drumstick weight were significantly ($P>0.05$) decreased. Interactive effect of EHLE on carcass traits showed no significant ($P<0.05$) influence.

INTRODUCTION
Euphorbia heterophylla (milk weed or spurge weed) belongs to the family Euphorbiaceae and either as weed or ornamental plant, it is a widely distributed medicinal shrub in the tropical and temperate regions of the world. The leaves have varied ethnomedicinal functions in different cultures; in the treatment of constipation, epilepsy, respiratory diseases, gonorrhea, diabetes mellitus and malaria. *Euphorbia heterophylla* is rich in phytochemicals such as flavanoids, alkaloids, tannins and sterols that are responsible for its pharmacological activities which include anti-inflammatory, anti-bacterial, antioxidant, anti-diabetic, anti-sickling and uterine contractile activity (Olajumoke *et al*., 2016). Reports are however limited on the effect of *Euphorbia heterophylla* leaves in livestock animals especially broilers thus, this study aims to investigate the effect of *Euphorbia heterophylla* aqueous leaf extract on performance and carcass traits of broiler chickens.

MATERIALS AND METHODS
The 6 week experiment was conducted at Federal University of Agriculture Abeokuta, Directorate of University Farm (DUFARM) poultry unit, situated in latitude 7º 13N and longitude 3º 26E. *Euphorbia heterophylla* leaves were harvested, dried, crushed and 50g was measured into 1 liter of freshly boiled water then left for 5 hours. After filtering with a muslin cloth, the filtrate was collected as *Euphorbia heterophylla* aqueous leaf extract (EHLE). One hundred and ninety two (192) day-old Arbor Acre broiler chicks purchased from a reputable hatchery in Oyo State, Nigeria were randomly divided into six (6) treatment groups with 4 replicates of 8 birds each. The experiment was laid out in a 2x3 factorial combination of two concentrations (40ml and

50ml/litre of water) of *Euphorbia heterophylla* aqueous leaf extract (EHLE) at a frequency of three separate administrations (0 days, 4 days and 5 days in a week). The treatments administered were as follows:

Treatment 1: 40ml (EHLE) 0 times/week;
Treatment 2: 40ml (EHLE) 4 times/week;
Treatment 3: 40ml (EHLE) 5 times/week;
Treatment 4: 50ml (EHLE) 0 times/week;
Treatment 5: 50ml (EHLE) 4 times/week;
Treatment 6: 50ml (EHLE) 5 times/week

Commercial starter and finisher diets were fed to the birds *ad libitum* and all vaccination /medication schedules according to farm guidelines were strictly adhered to. Data was collected on growth performance and carcass traits. The data was subjected to two way Analysis of Variance (ANOVA) using the General Linear Model of the Minitab statistical package. Significant differences among means were separated using the same package.

RESULTS AND DISCUSSION

The main and interactive effects of EHLE on performance of broiler chickens are shown in tables 1 and 2 and there were no significant differences observed in broiler performance. Table 3 presents the main effect of EHLE on carcass traits of broiler chickens. Drumstick (10.15%) and liver (1.98%) weights were higher in birds on 40ml concentration of EHLE. The same trend was observed for all other carcass traits (except proventiculus) with higher numerical values at 40ml concentration and they were not significantly ($P>0.05$) influenced. According to Prihambodo *et al*. (2021), liver weight increase may be attributed to presence of flavonoids and is seemingly due to detoxification process in the liver. This implies that flavonoid addition should not exceed an appropriate level so as to avoid detrimental effect on broiler metabolism and production. However, liver weight in this study falls within normal weight range of 1.72% to 3.88% of total carcass weight. The frequency of administering EHLE significantly ($P<0.05$) affected dressing percent and drumstick weight and as frequency of administration increased from 0 to 5 days, the values were significantly ($P>0.05$) decreased. The dressing percent of birds administered EHLE either at 0 day or for 4 - 5 days were found to be within the range 60.30 to 74.65% recommended for broiler chickens (Essien and Udoh, 2021). Interactive effect of EHLE on carcass traits of broiler chickens (Table 4) shows there were no significant ($P<0.05$) effects of treatments on all traits considered.

Table 1: Main effect of *Euphorbia heterophylla* aqueous leaf extract on performance of broiler chickens

	Concentration				Frequency of administration				
Parameters	40ml/l	50ml/l	SEM	p-value	0 days	4 days	5 days	SEM	P-value
IW (g/bird)	37.23	37.44	0.28	0.62	37.30	37.38	37.33	0.35	0.98
FW (g/bird)	1314.40	1310.20	32.10	0.93	1301.10	1302.30	1333.50	39.3	0.81
TWG (g)	1277.20	1272.80	32.1	0.92	1263.8	1265.00	1296.20	39.6	0.80
DWG(g/bird)	30.41	30.30	0.76	0.92	30.09	30.11	30.86	0.93	0.80
DFI(g/day)	69.03	68.19	1.41	0.67	67.79	67.54	70.51	1.73	0.42
DWI(ml/day)	197.92	196.08	2.37	0.59	201.94	195.39	193.68	2.91	0.13
FCR	2.27	2.26	0.05	0.85	2.26	2.25	2.28	0.06	0.90

IW=Initial weight, FW=Final weight, TWG=Total weight gain, DWG=Daily weight gain, DFI=Daily feed intake, DWI=Daily water intake, FCR=Feed conversion ratio

Table 2: Interactive effect of *Euphorbia heterophylla* aqueous leaf extract on performance of broiler chickens

	Treatments							
	1	2	3	4	5	6		
Concentration	40ml/l	40ml/l	40ml/l	50ml/l	50ml/l	50ml/l		
Frequency of administration	0 days	4 days	5 days	0 days	4 days	5 days	SEM	P-value
IW (g/bird)	37.06	37.74	36.91	37.55	37.02	37.74	0.49	0.28
FW (g/bird)	1302.20	1314.10	1327.10	1300.00	1290.60	1340.00	55.45	0.94
TWG (g)	1265.10	1276.30	1290.20	1262.50	1253.60	1302.30	37.12	0.95
DWG(g/bird)	30.12	30.39	30.72	30.06	29.85	31.01	1.32	0.95
DFI(g/day)	68.42	66.81	71.88	67.16	68.27	69.14	2.43	0.69
DWI(ml/day)	8582.00	8242.00	8114.00	8381.00	8171.00	8155.00	172.33	0.78
FCR	2.28	2.20	2.33	2.24	2.29	2.24	0.09	0.61

IW=Initial weight, FW=Final weight, TWG=Total weight gain, DWG=Daily weight gain, DFI=Daily feed intake, DWI=Daily water intake, FCR=Feed conversion ratio

Table 3: Main effect of *Euphorbia heterophylla* aqueous leaf extract on carcass traits of broiler chickens

	Concentration				Frequency of administration				
Parameters	40ml/l	50ml/l	SEM	p-value	0 days	4 days	5 days	SEM	P-value
Live weight (g/bird)	1591.80	1648.00	33.80	0.24	1639.70	1576.80	1643.30	41.40	0.45
Dressed weight (g/bird)	1086.50	1101.70	26.5	0.68	1144.00	1051.30	1086.90	32.5	0.13
Dressing (%)	68.21	66.76	0.09	0.59	69.71[a]	66.70[b]	66.03[b]	0.72	0.00
Neck (%)	3.49	3.39	0.06	0.28	3.32	3.52	3.49	0.08	0.19
Breast (%)	24.11	23.33	0.40	0.18	24.32	23.68	23.16	0.50	0.27
Back (%)	12.75	13.04	0.33	0.53	13.35	12.71	12.63	0.40	0.39
Thigh (%)	11.44	11.26	0.18	0.51	11.49	11.14	11.42	0.22	0.53
Drumstick (%)	10.15[a]	9.66[b]	0.13	0.01	10.49[a]	9.63[b]	9.59[b]	0.16	0.00
Heart (%)	0.42	0.40	0.01	0.38	0.40	0.42	0.41	0.01	0.49
Liver (%)	1.98[a]	1.72[b]	0.05	0.01	1.73	1.93	1.90	0.06	0.07
Gizzard (%)	1.85	1.87	0.03	0.77	1.86	1.93	1.79	0.04	0.13
Proventiculus(%)	0.45	0.49	0.01	0.22	0.46	0.51	0.44	0.02	0.09

[a,b,c] Means in the same rows by factor with different superscripts differ significantly (P<0.05)

Table 4: Interactive effect of *Euphorbia heterophylla* aqueous leaf extract on carcass traits of broiler chickens

	Treatments							
	1	2	3	4	5	6		
Concentration	40ml/l	40ml/l	40ml/l	50ml/l	50ml/l	50ml/l		
Frequency of administration	0 days	4 days	5 days	0 days	4 days	5 days	SEM	P-value
Liveweight (g/bird)	1601.40	1643.80	1623.40	1530.30	1678.00	1642.80	58.60	0.69
Dressed weight (g/bird)	1127.40	1106.00	1076.50	1026.10	1160.60	1067.90	45.90	0.59
Dressing (%)	70.26	67.19	66.24	67.17	69.16	64.87	1.02	0.76
Neck (%)	3.34	3.62	3.51	3.52	3.28	3.36	0.12	0.55
Breast (%)	24.81	23.34	23.19	24.18	23.84	22.98	0.70	0.88
Back (%)	12.71	13.04	12.91	12.50	13.99	12.23	0.57	0.20
Thigh (%)	11.53	11.69	11.19	11.09	11.44	11.15	0.32	0.61
Drumstick (%)	10.54	10.02	9.38	9.88	10.45	9.16	0.23	0.26
Heart (%)	0.38	0.44	0.42	0.43	0.41	0.38	0.02	0.14
Liver (%)	1.88	2.07	1.86	2.00	1.57	1.73	0.09	0.55
Gizzard (%)	1.78	1.89	1.97	1.89	1.95	1.69	0.06	0.30
Proventiculus (%)	0.45	0.42	0.53	0.48	0.48	0.45	0.03	0.90

[a,b,c] Means in the same rows with different superscripts differ significantly (P<0.05)

CONCLUSION

This study showed that *Euphorbia heterophylla* aqueous leaf extract had no adverse effect on performance and carcass traits of broiler chickens but its administration in their drinking water should probably not exceed 40ml/litre of water so as to avoid likely detrimental effect on broiler carcass traits.

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RESPONSE OF GROWER-FINISHER PIGS TO CASSAVA PLANT MEAL-BASED DIETS

[*1]Adeyemi, M. A. and [2]Akinfala, E. O.

[1]Department of Animal Production & Health, Olusegun Agagu University of Science & Technology, Okitipupa

[2]Department of Animal Sciences, Obafemi Awolowo University, Ile-Ife

[*]Corresponding email address: ade_maxwell@yahoo.com

ABSTRACT

The research evaluated the growth response of finishing pigs to diets containing cassava plant meal (CPM). Twenty-seven growing crossbred (Large White x Hampshire) pigs with initial average weight of 44.80 ± 0.38 kg and of different sexes were randomly allotted to three experimental diets containing 0, 50 and 100 % CPM given as T1, T2 and T3, respectively. The study lasted for eight weeks. Results showed that there was no significant difference ($p \geq 0.05$) across dietary treatments for final weight and average daily weight gain. However, the average daily feed intake and feed conversion ratio of pigs in T3 (100 % replacement) was highest compared to other dietary treatments. Significant differences ($p \leq 0.05$) exist for average daily feed intake across dietary treatments. Feed conversion ratio, feed intake and weight gain values of pigs fed diet T3 were superior to those fed diets T1 and T2. It can be concluded that cassava plant meal could completely replace maize in the diets of grow-finish pigs without a significant decrease in their growth performance.

Keywords: Cassava plant meal; maize; pigs; feed intake; weight gain

INTRODUCTION

The importance of pig production as a cheap source of animal protein particularly in the humid tropic of Nigeria is constrained by the escalating cost of feed ingredients. The need to reduce the high cost of feeding, which usually makes up 70 – 80 % of the total cost of production (Longe, 2006) led to a continuous search for least-cost alternative feedstuffs as suitable replacements for conventional feed ingredients. Cassava and its products have received attention from swine nutritionist (Adeyemi and Akinfala, 2019). However, cassava root meal is deficient in essential amino acid such as methionine, cysteine and tryptophan (Montagnac *et al.*, 2009; Omede *et al.*, 2018)**.** The need to improve the nutritional profile of cassava meal as a replacement for maize informed the development of composite cassava plant meal (unpeeled roots + leaves + tender cassava stem) as livestock feedstuff for all classes of pigs (Akinfala and Tewe, 2001). This was in an attempt to balance the high crude protein, bulk, minerals and vitamins of leaves and tender stem with the energy-rich component of the roots. Previous studies have confirmed the suitability of cassava plant meal (CPM) as good substitute for maize (Akinfala and Tewe, 2004; Akinfala *et al.*, 2013; Akinfala *et al.*, 2019; Adeyemi and Akinfala, 2019) in the diets of pigs. However, most of the studies focused on weaner pigs and did not provide adequate information on the variety of cassava used, age and the length at harvest of the cassava stems. This research was carried out to evaluate the growth performance of grow-finish pigs to diets containing standardized cassava plant meal.

MATERIALS AND METHODS

The experiment was carried out at the Swine Unit of the Teaching and Research Farm as well as the Poultry Meat Laboratory of the Department of Animal Sciences, Obafemi Awolowo University, Ile – Ife. The cassava roots (TMS 30572) aged 2 years were purchased from a commercial farm in Supare Akoko, Ondo State. The cassava stems were gently lifted, soil was shaken off the tuberous roots, while the cassava leaves were harvested from the plant stem and the tender stems were harvested at 5 cm, usually 6 to 7 nodes from the top of the plant. All the cassava components were harvested between July and September 2020. The fresh roots (unpeeled cassava root) were washed and chopped into small pieces, sun-dried on a concrete floor for an average of 3 – 4 days depending on the intensity of the sunlight, milled and packed into sacks. Also, the fresh cassava leaves and tender stems were sun-dried for about 4 – 5 days after harvesting, milled and packed into separate sacks. The composite cassava plant parts were mixed in line with the procedure of Akinfala and Tewe (2001) at a ratio of 2.5:1 so as to have a comparable minimum crude protein content of 10 % as maize. The pigs were randomly allotted to three dietary treatments of 0, 50 and 100 % replacement of maize with cassava plant meal given as T1, T2 and T3 respectively. Each treatment consists of nine pigs and replicated three times with each replicate comprising of three pigs of same sex in a Completely Randomised Design. The percentage composition of experimental diet is shown in Table 1. Water and feed were offered *ad libitum* throughout the experimental duration. The pigs were weighed at the beginning of the experiment. Data were

collected on daily feed intake, weight gain and feed to gain ratio was evaluated. Data were subjected to One-way Analysis of Variance using SAS 9.1® and means were separated using Duncan's new multiple range test at 5% level of significance. The experiment was conducted between October and December, 2020 and lasted for eight (8) weeks.

Table 1: Composition of experimental diets

Ingredients (%)	T1	T2	T3
Maize	50.00	25.00	-
Cassava plant meal	-	25.00	50.00
Groundnut Cake	10.00	10.00	10.00
Soybean meal	8.00	8.00	8.00
Palm Kernel Cake	25.00	25.00	25.00
Fish meal	2.00	2.00	2.00
Bone meal	1.50	1.50	1.50
Oyster shell	3.00	3.00	3.00
*Premix (Vitamin-Mineral)	0.25	0.25	0.25
Salt	0.25	0.25	0.25
Total	100.00	100.00	100.00

**Grower Premix supplied kg/diet: vitamin A 10,000,000 IU; vitamin D 32,000,000 IU; vitamin E 8,000 IU; vitamin K 2,000 mg; vitamin B1 2,000 mg; vitamin B2 5,500 mg; vitamin B6 1,200 mg; vitamin B12 12 mg; biotin 30 mg; folic acid 600 mg; niacin 10,000 Mg; pantothenic acid 7,000 mg; choline chloride 500,000mg; vitamin C 10,000 mg; iron 60,000 mg; Mn 80,000 mg; Cu 800 mg; Zn 50,000 mg; iodine 2,000 mg; cobalt 450 mg; selenium 100 mg; Mg 100,000 mg; anti-oxidant 6,000 mg.*

RESULTS AND DISCUSSION

Table 2 shows the proximate composition of the experimental diets fed to growing pigs. The crude protein values ranged from 14.84 to 15.59 % and increases with increased inclusion level of cassava plant meal in the diets. The crude protein value falls within the range recommended by Aduku (2012) and Olomu (2011) for grow-finish pigs in the tropic but lower than the recommended value by NRC (2012). Also, the crude fibre content of the diets ranged from 6.28 to 6.87 % and increased with increasing inclusion level of cassava plant meal in the diets. The crude fibre values were within the value reported by Akinfala and Tewe (2001; 2004) who fed whole cassava-based diets to growing pigs. The values obtained for metabolizable energy fell within the range recommended by Olomu (2011) but lower than the value recommended by NRC (2012) for growing pigs in the tropics. The variations obtained in the study may be due to an increase in the proportion of low energy components (cassava leaves and tender cassava stem) with increase inclusion level of CPM to replace maize in the diets. Growth performance of grow-finish pigs fed diets containing cassava plant meal is shown in Table 3. There was no significant difference ($p>0.05$) in the final weight and average daily weight gain across dietary treatments. The average daily feed intake differed significantly ($p<0.05$) across dietary treatments with pigs on diet T1 consuming the least diet while pigs fed diet T3 consumed the highest feed. The data obtained on average daily weight gain indicated that pigs fed diet T1 (100 % maize) had the highest daily gain while those fed diet T3 had the least. The result obtained on feed conversion ratio showed significant difference ($p>0.05$) among treatment groups with pigs fed diet T1 (100 % maize) having the better value of 3.57 while those fed diet T3 had the poorest.

Table 2: Proximate composition and metabolizable energy of experimental diets

Parameters (%)	T1	T2	T3	SEM	*p*
Dry Matter	88.08	87.25	87.59	0.20	0.22
Crude Protein	14.84	15.22	15.59	0.24	0.59
Crude Fibre	6.28	6.62	6.87	0.31	0.31
Ash	5.60	5.73	5.90	0.17	0.43
Ether Extract	4.26	4.00	3.88	0.26	0.12
NFE	69.06	68.53	67.66	0.32	0.40
ME (kcal/kg)	2785.42	2755.18	2694.89	22.84	0.25

T1: Control (maize-based) diet; T2: 50% replacement of maize in T1 with Cassava plant meal; T3: 100% replacement of maize in T1 with cassava plant meal; NFE: Neutral Detergent Fibre; ME: Metabolisable Energy

Table 3: Growth performance of growing pigs fed experimental diets

Parameters (kg/pig)	T1	T2	T3	SEM	*p*
Initial weight	46.33	43.86	43.40	0.40	0.10
Final weight	76.29	73.26	72.30	0.18	0.09
Average daily weight gain	0.535	0.525	0.516	0.16	0.43
Average daily Feed Intake	1.89^{b}	1.94^{b}	2.02^{a}	0.02	0.007
Feed to gain ratio	3.57^{c}	3.69^{b}	3.91^{a}	0.03	<0.0001

a,b,c, means in the same row having different superscripts differ at p <0.05; SEM: Standard Error of Means; T1: Control (maize-based) diet; T2: 50% replacement of maize in T1 with Cassava plant meal; T3: 100% replacement of maize in T1 with cassava plant meal

CONCLUSION AND RECOMMENDATION

Findings from this study showed that cassava plant meal could completely replace maize in the diets of grow-finish pigs and there was no deleterious effect on their growth performance. Cassava is therefore recommended in diets of growing pigs.

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REVIEW ON BIOFLOC TECHNOLOGY AS A SUSTAINABLE AQUACULTURE SYSTEM

Babatunde, T. A.* & Zakari, H.
Department of Biology, Umaru Musa Ya'radua University,
P.M.B. 2218, Katsina State, Nigeria
*Corresponding author: E-mail: attaofeeq@gmail.com Tel: +23408037851688

ABSTRACT
Increasing demand for food, water scarcity for aquaculture are major constraints on a global scale. Intensive aquaculture is a promising alternative to meeting the growing demand for fish protein. However, conventional fish farming which necessitates water exchange for waste control is unsustainable. Biofloc technology is a new approach to aquaculture that can overcome the challenges of ammonia waste water in fish culture. Biofloc systems use a combination of bacteria, algae, and other microorganisms to convert nitrogenous waste into a natural food source for fish. In this system, carbon sources such as glucose, molasses, and tapioca starch are added to the waste water to promote the growth of beneficial bacteria. These bacteria convert the nitrogenous waste into biomass, which forms flocs that settle at the bottom of the tank. Biofloc technology has potential benefits that include: reduced water consumption, lower feed requirements, improved fish health and reduced environmental impact. The potential of biofloc paste as a feed ingredient for fish has also been identified. as a starter feed for post-hatch fish larvae, and it has the potential to be a more sustainable and affordable alternative to traditional fish feed. With further research and development, biofloc technology could play a significant role in the future of sustainable aquaculture production.
Keywords: Biofloc technology, aquaculture, production, sustainability,

INTRODUCTION
Aquaculture wastewaters pose a threat to the environment and hinder the growth of conventional fish farming, where regular water exchange is needed (Tidwell, 2012). Aquaponics is a system in which the fish waste is absorbed by plants and then reintroduced into fish holding units (Mahanand and Pandey, 2022), and biofloc technology (BFT), in which the waste products of fish metabolism are flocculated by the addition of carbon (Dauda *et al*., 2017), are among the new production techniques that are being introduced to overcome this challenge. By adding carbon sources as fertilizers to the fish rearing system, the conversion of nitrogenous waste produced by the fish into bacteria and plankton biomass as well as organic debris is achieved (Crab *et al*., 2012). Additionally, for aquaculture sustainability, efforts are focused on fishmeal replacement (Gatlin *et al*., 2007). In Nigeria, many local food producers focus on grow-out feed for fish production. While the focus on local starter feed for aquaculture production in Nigeria is less. Artemia dormant cysts, which are mostly imported in Nigeria under various brand name are not of reliable supply and affordable (Bwala *et al*., 2018). The biofloc paste has potential use as a starter feed in hatchery.

Principle of biofloc technology
The concept of BFT is based on the maintenance of microbial floc in a fish culture system using aeration and the addition of carbohydrates to allow aerobic decomposition of fish waste products, thereby permitting the continued use of water (Ahmad *et al*., 2017). The nature of the carbon sources plays a significant role in the success of the bioloc system. The system is based on the use of a microbial community, known as biofloc, to improve water quality and provide a food source for the fish (El-Sayed *et al*., 2021). The biofloc is a complex mixture of bacteria, algae, protozoa, and other microorganisms. The microbial diversity in biofloc systems is influenced by a number of factors including; the type of fish being cultured; the water quality; the feed; and the management practices (Wasave *et al*., 2020). In general, biofloc systems are characterized by a high diversity of microorganisms. This diversity is thought to be important for the provision of stable and resilient system, breakdown of organic matter, and as a nutritious food source for the culture fish.

Microbial communities in biofloc system
A study of the microbial community in a biofloc-based tilapia (*Oreochromis niloticus*) production system in China found that the dominant bacteria were *Acinetobacter*, *Pseudomonas*, and *Bacillus* species. The study also found that the biofloc contained a variety of other microorganisms, including algae, fungi, and protozoa (Yun *et al*., 2022). A study of the microbial community in a biofloc-based shrimp (*Litopenaeus vannamei*) production system found that the dominant bacteria were *Cytophaga*, *Flavobacterium*, and *Sphingomonas* species. The study also found that the biofloc

contained a variety of other microorganisms, including algae, fungi, and protozoa. (Panigrahi *et al*., 2018). Cardona *et al*. (2016) reported bacteria taxa of Proteobacteria, Bacteroidetes, and Cyanobacteria have the highest relative abundance in shrimp biofloc system. All these studies also found that the biofloc contained a variety of other microorganisms, including algae, fungi, and protozoa. These studies show that the microbial composition of biofloc systems can vary depending on the species of fish being cultured, the location of the system, and other factors. However, all of the studies found that biofloc systems contain a diverse community of microorganisms, which play an important role in the nutrient cycling and health of the system.

Nutritional quality of flocs

One of the benefits of biofloc systems is that the flocs themselves can provide a natural food source for fish. The nutritional quality of flocs produced in biofloc systems varies depending on a number of factors, including the type of bacteria and algae present in the flocs, the carbon source used to promote floc formation, and the water quality parameters (Ahmad *et al*., 2017). In general, flocs from biofloc systems have been shown to contain high levels of protein, carbohydrates, and lipids. The carbohydrate content of flocs can range from 20% to 60%, and the lipid content of flocs can range from 5% to 20% (Neupane *et al*., 2020). In addition, flocs also contain a number of other nutrients, including vitamins, minerals, and essential amino acids (Ekasari *et al*. 2014). The nutrient content of flocs can vary depending on the type of fish being cultured, the water quality parameters, and the feeding regime.

Studies have shown that flocs can be a valuable source of nutrients for fish. Nguyen *et al*., (2021) found that the growth performance of tilapia was significantly improved when they were fed a diet that included flocs from a biofloc system. The nutritional quality of flocs from biofloc systems is still being investigated. However, the available evidence suggests that flocs can be a valuable source of nutrients for fish. As research in this area continues, it is likely that the nutritional quality of flocs from biofloc systems will be further improved. Some of the factors that can affect the nutritional quality of flocs from biofloc systems include:

i. the type of bacteria and algae present in the flocs: The type of bacteria and algae present in the flocs can have a significant impact on their nutritional quality. For example, flocs that contain a high proportion of heterotrophic bacteria tend to be higher in protein than flocs that contain a high proportion of autotrophic bacteria (De Schryve *et al*., 2008).
ii. the carbon source used to promote floc formation: The carbon source used to promote floc formation can also affect the nutritional quality of the flocs. For example, flocs that are formed using molasses tend to be higher in protein than flocs that are formed using glucose (Ogello *et al*., 2021).
iii. the water quality parameters: The water quality parameters, such as the pH, temperature, and dissolved oxygen levels, can also affect the nutritional quality of the flocs. For example, flocs that are formed in water with a high pH tend to be lower in protein than flocs that are formed in water with a low pH (Azim and Little, 2008).

Overall, the nutritional quality of flocs from biofloc systems is a complex issue that is affected by a number of factors. As research in this area continues, it is likely that the nutritional quality of flocs from biofloc systems will be further improved.

These flocs are heterogeneous aggregates of suspended particles and a variety of microorganisms such as bacteria, algae, fungi, invertebrates, detritus, etc. held together in a loose matrix of mucus that is secreted by bacteria and bound by filamentous microorganisms or electrostatic attraction (Moreno-Arias *et al*., 2018). Therefore, biofloc meal can be a sustainable ingredient in aquafeed (Shao *et al*., 2017). This could replace the live feed produced for feeding newly hatching fish larvae. Therefore, the development of feed from biofloc particles could replace the expensive fish meal in fish feed production as the price of fishmeal is on the rise (Emerenciano *et al*., 2011; Moreno-Arias *et al*., 2018) and the richness of biofloc particle in live organism could make it a potential starter feed for aquaculture.

Importance of biofloc system

Nutrient recycling: Biofloc systems use a combination of bacteria, algae, and other microorganisms to convert nitrogenous waste into a natural food source for fish. This reduces the need for external feed, which can save water and reduce pollution (Padeniya *et al*., 2022).

Floc formation: The bacteria and other microorganisms in biofloc systems form flocs, which are aggregates of cells and organic matter. These flocs provide a natural food source for fish and improve water quality by absorbing ammonia and other pollutants (Ahmad *et al*., 2017).

Water quality management: Biofloc systems require careful management of water quality. The pH, temperature, and dissolved oxygen levels must be maintained within optimal ranges, and the concentration of ammonia and other pollutants must be kept below toxic levels (Robles-Porchas *et al*., 2020).

Reduced water consumption: Biofloc systems can reduce water consumption by up to 80%, compared to traditional aquaculture systems. This is because the bioflocs themselves provide a food source for the fish, which reduces the amount of external feed that is needed (Bossier and Ekasari, 2017).

Lower feed requirements: Biofloc systems can reduce feed requirements by up to 30%, compared to traditional aquaculture systems. This is because the bioflocs themselves provide a significant amount of the nutrients that the fish need (Ogello *et al*., 2018).

Improved fish health: Biofloc systems can help to improve fish health by providing a natural food source and by helping to control disease. The bioflocs contain a variety of beneficial bacteria that can help to protect the fish from pathogens (Ahmad *et al*., 2017).

Reduced environmental impact: Biofloc systems can reduce the environmental impact of aquaculture by reducing water pollution and by minimizing the use of chemicals. The bioflocs help to filter the water and remove pollutants, and they do not require the use of antibiotics or other chemicals (Robles-Porchas *et al*., 2020).

CONCLUSION

Biofloc is an eco-friendly and sustainable aquaculture alternative. The biofloc paste has the potential to be a more affordable alternative to traditional fish feed. It can be used as a starter feed for post-hatch fish larvae, and it has the potential to address the challenges of water scarcity, limited land, and environmental pollution. Biofloc technology is a promising new aquaculture production method that could play a significant role in the future of sustainable aquaculture.

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GROWTH PERFORMANCE OF *Clarias gariepinus* JUVENILES FED PEPPERMINT LEAVES (*Mentha piperita)*

***Ayebidun, O. V; Olusola, S.E & Aderinto, D. T**

Department of Fisheries and Aquaculture Technology, Olusegun Agagu University of Science and Technology, Okitipupa

Corresponding author email address: ov.ayebidun@oaustech.edu.ng

ABSTRACT

Two hundred and fifty *C*larias *gariepinus* fingerlings (mean weight = 2.56±0.00g) randomly grouped into six dietary groups with 20 experimental fish per bowl and replicated twice were used to evaluate the effects of inclusion of peppermint leaves on growth performance. The peppermint leaf meal was included at (T1) 0%, (T2) 4.5%, (T3) 9.0%, (T4) 18%, (T5) 27% and (T6) 36% in practical diets balanced with other ingredients in a 56-day feeding trial. Performance data taken on the fish include, weight gain, specific growth rate, percentage growth, production performance index and survival rate, while feed conversion ratio was evaluated. Routine and occasional management practices were carried out on treatment basis. Results showed that peppermint leaf meal significantly ($p<0.05$) influence weight gain, feed conversion ratio and survival rate of the experimental fish. Meanwhile the experimental fish fed diet T6 had the better feed conversion efficiency among the treatment groups. The study concluded that, inclusion of peppermint leaves in diets of *Clarias gariepinus* fish could be beneficial for improving growth since 36% resulted in the least amount of feed to produce flesh.

Keywords: Peppermint leaf; Clarias *gariepinus*; Growth

INTRODUCTION

Aquaculture is one of the fastest growing food production sectors in the world, with global inland aquaculture production increasing from 29.9 million tonnes in 2007 to 41.9 million tonnes in 2012 (Food and Agriculture Organization - FAO, 2014). Recently, the application of medicinal plants from different families in the management of aquaculture ponds is gaining momentum because they are safe, effective, widely available and inexpensive. Also, to produce fish free from any chemicals of public health hazards. Use of natural feed additives is becoming more important for fish feeding rather than chemical feed additives due to the cumulative effects of the chemical components on animal and human health.

Therefore, use of herbal medicines seems to be an attractive alternative to control fish diseases and enhance the growth (Keifer *et al.*, 2007). Peppermint (*Mentha piperita*) is a perennial herb belonging to the Lamiaceae family and it isamong the oldest herbs used for both culinary and medicinal products. Indigenous to Europe and the Middle East, the plant is now widely spread and cultivated in many regions of the world and recognized as plant source of menthol and menthone (Uritu *et al.*, 2018). Peppermint leaves have a long history of being used for medicinal purposes, dating back to ancient times. Variety of medicinal uses for peppermint include treating upset stomach, indigestion, and irritable bowel syndrome, relieving headaches and migraines, reducing anxiety and stress, curing bad breath, treating cold symptoms, such as coughs and sore throats, relieving muscle and joint pain, improving mental focus and alertness.

Natural immunostimulants and growth-promoting functions of medicinal plants in aquaculture have been on a steady rise (Ganapathi *et al.*, 2018). Peppermint (*Mentha piperita*) is a very popular herb and its numerous effects have been described in mammals but its effects on fish has not received much attention (Milad *et al.*, 2015). This study investigated the dietary effect of *Mentha piperita* on growth performance of *Clarias gariepinus* juveniles.

MATERIALS AND METHODS

The study was carried out in the Research Laboratory of the Department of Fisheries and Aquaculture Technology, Olusegun Agagu University of Science and Technology, Okitipupa. The fresh leaves of *Mentha piperita* were collected, washed and air dried for 2 weeks under shed and blend into powder.

Collection, Acclimatization of Experimental Fish and Design

Two hundred and fifty (250) healthy and active fingerlings of *Clarias gariepinus* of mean weight 2.56±0.0g were obtained from Speedy Grace Farm, Ibadan. The fish were acclimatised for one week and thereafter fed the experimental diet. There were five dietary treatments with inclusion levels of 4.5%, 9%, 18%, 27% and 36 % in practical meal balanced with other ingredients (Table 1). The fish were randomly allocated to the diets in 12 experimental tanks with 20 fish per bowl and the experiment lasted for 8 weeks.

Table 1: Composition of experimental diet (g/100g) fed to *C. gariepinus* Juveniles)

Ingredients	T1	T2	T3	T4	T5	T6
Groundnut cake	26.66	26.66	26.66	26.66	26.66	26.66
Fishmeal	13.33	13.33	13.33	13.33	13.33	13.33
Soybean	26.66	26.66	26.66	26.66	26.66	26.66
Yellow Maize	8.45	8.45	8.45	8.45	8.45	8.45
Wheat offal	8.45	8.45	8.45	8.45	8.45	8.45
Rice bran	8.45	8.45	8.45	8.45	8.45	8.45
Starch	1.00	1.00	1.00	1.00	1.00	1.00
DCP	2.00	2.00	2.00	2.00	2.00	2.00
Vit-min Premix	2.00	2.00	2.00	2.00	2.00	2.00
Salt	1.00	1.00	1.00	1.00	1.00	1.00
Veg. oil	2.00	2.00	2.00	2.00	2.00	2.00
M. piperita	0.00	4.50	9.00	18.00	27.00	36.00

T1: Control diet; T2: 4.5% inclusion of *Mentha piperita*.; T3: 9% inclusion of *Mentha piperita*.; T4: 18% inclusion of *Mentha piperita*.; T5: 27% inclusion of *Mentha piperita*.; T6: 36% inclusion of *Mentha piperita*; Vit- min premix for vitamin and minerals premix

Measurement of growth parameters

The weight of the *Clarias gariepinus* fingerlings in treated and untreated (control) test media were recorded on treatment basis with the aid of a battery operated weighing scale. Parameters such as specific growth rate, weigh gain, feed conversion ratio and survival rate were evaluated.

RESULTS AND DISCUSSION

Table 2 showed the growth performance and nutrient utilization of *Clarias gariepinus* fed different inclusion of *Mentha piperita*. There was general decrease in the value of the final body weight, weight gain, percentage weight gain, specific growth rate and production performance index of the experimental fish but there are no significant differences (P>0.05). The final weight gain was highest in Treatment 3 (4.95g) while the lowest was recorded in Treatment 2 (4.10g). The highest value for percentage weight gain was recorded in Treatment 6 (3.64g) while the lowest was recorded in Treatment 2 (1.54g). Similar findings have been reported on *C. gariepinus*, *O. niloticus* and *Heterobranchus bidorsalis* fingerlings fed with differently processed flamboyant seed meal-supplemented diets (Oyegbile *et al*., 2017). Fish in Treatment 3 had the best growth and feed utilization indices which evidently indicated optimal diet utilization that nevertheless was not achievable at higher substitution levels as growth steadily declined with increasing substitution levels. The observed percentage fish survival (62.5 – 92.5%) in the current study closely matched 54.03 – 97.33% already documented for *C. gariepinus* fingerlings (Milad *et al*., 2015) while it signified better survival when juxtaposed with 48.0 - 86.0% attained by *C. gariepinus* fingerlings. Moreover, it reflected sufficient acceptability of the experimental diets by fish which could be attributed to proper handling, adequate water quality management, appropriate feed processing, suitability as well as non-toxicity of peppermint inclusion in *C. gariepinus* diet

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Table 2: Growth Performance and Nutrient Utilization of *Clarias gariepinus* fed with different inclusion level of *Mentha piperita* leaf meal for 56 days

Parameters	T1	T2	T3	T4	T5	T6
IBW	2.56±0.01[a]	2.56±0.00[a]	2.56±0.01[a]	2.56±0.02[a]	2.56±0.02[a]	2.56±0.01[a]
FBW	7.15±3.15[a]	4.10±0.00[a]	4.95±0.55[a]	4.70±0.90[a]	4.47±0.67[a]	4.92±0.38[a]
WG	4.59±3.15[a]	1.54±0.00[a]	2.39±0.85[a]	2.14±0.90[a]	3.19±1.95[a]	3.64±0.90[a]
PWG	179.28±123.03[a]	60.20±0.00[a]	93.60±33.40[a]	83.70±35.30[a]	124.55±76.15[a]	142.15±35.15[a]
SGR	0.71±0.37[a]	0.37±0.00[a]	0.50±0.13[a]	0.46±0.15[a]	0.58±0.27[a]	0.68±0.11[a]
SR	45.00±15.00[a]	57.50±2.50[a]	40.00±10.00[a]	42.50±7.50[a]	37.50±22.50[a]	50.00±10.00[a]
FCR	0.30±0.21[a]	0.55±0.00[a]	0.33±0.12[a]	0.41±0.71[a]	0.44±0.27[a]	0.27±0.07[a]
PPI	2.85±1.31[a]	1.58±0.07[a]	1.56±0.19[a]	1.51±0.40[a]	1.36±0.03[a]	3.09±0.60[a]

IBW= Initial body weight, FBW = Final body weight, WG = Weight gain, PWG = Percentage weight gain, SGR = Specific growth rate, FCR = Feed conversion rate, SR = Survival rate, PPI = Production performance index, mean followed by the same letter is not significantly different (p>0.05)

CONCLUSION AND RECOMMENDATION

The inclusion of peppermint leaves in diets of *Clarias gariepinus* fish could be beneficial for improving growth since 36% inclusion resulted in the least amount of feed needed to produce flesh. Optimizing inclusion of peppermint leaf meal is recommended for researchers to clearly evaluate its effects in other growth stages as it led to appreciable improvement in growth and feed utilization.

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CARCASS DRESSING AND PROXIMATE COMPOSITION OF FARM-RAISED ATLANTIC TARPON (*Megalop atlanticus*) - A CANDIDATE SPECIES FOR COASTAL AQUACULTURE IN NIGERIA

Diyaolu D. O[1*] and Morakinyo O. S[2]

[1]Department of Fisheries and Aquaculture Technology, Olusegun Agagu University of Science and Technology, P.M.B. 353, Okitipupa, Nigeria

[2]Department of Fisheries and Aquaculture Technology, Federal University of Technology, P.M.B. 704, Akure, Nigeria

Corresponding Author's email: do.diyaolu@oaustech.edu.ng

ABSTRACT

Information on muscle composition of fish is very crucial, since it has a lot of influence on how the fish is perceived by the processors and consumers in terms of its taste, flavour, and general acceptability. The present study evaluated carcass dressing and proximate analysis of tarpon (*Megalop atlanticus*) collected from a grow-out farm in Ilaje Local Government of Ondo State. The fish were collected in three weight categories (to ensure that different sizes of fish being sold by the farmers were examined), designated as sample A (1000 – 1050 g), sample B (750 – 800 g) and sample C (500 – 550 g). Carcass dressing and proximate analysis of the fish samples were done in the laboratory following standard procedures. The results indicated that carcass dressings percentage weight of farmed tarpon without head and with head ranged from 67.13 – 68.26% and 91.32 – 92.25% respectively. Moisture and dry matter of the sampled fish were within the range recorded for other tropical fishes. In all the samples, protein was found to be highest, followed by lipids and ash. The results of this study reveale that *M. atlanticus* has high edible portions and can be reliable sources of nutrients if included in human diet.

Keywords: tarpon, carcass dressing, coastal waters, food fish

INTRODUCTION

In Nigeria, like many coastal developing countries, fish is an important source of food for the population, which is currently estimated at over 200 million people. Consumption of fish is associated with several benefits. Because of their high protein content, polyunsaturated fats, vitamins, and minerals, fish can play a major role in alleviating malnutrition particularly in young children, pregnant women, and the elderly. Fish consumption prevents cardiovascular diseases risk factors such as blood pressure, some types of cancer, Alzheimer's disease, and brain damage and decrease obesity. Despite the benefits of fish consumption, the *per capita* fish consumption in Nigeria—measured at 13.3 kg/capita/year—is low compared with the world's average of 20.3 kg/capita/year (FAO 2018).

Aquaculture is seen as a mechanism through which Nigeria can close its existing fish supply-demand gap, particularly as the supply from capture fisheries cannot meet the national fish demand. Of the finfish available for culture, Clarid catfishes are the most dominant cultured fish species, accounting for about 90% (by weight) of the fish produced from aquaculture, followed by tilapia. However, cultivation of these fishes is limited to freshwater areas, while there is no fish species available for commercial propagation in the vast coastal waters of Nigeria. Prioritizing tilapia and catfish monoculture has left unexplored the potentials of other fish species in contributing to the Nigerian aquaculture growth. According to Bradley *et al* (2020), culturing more fish species would widen food availability and nutrient diversity to feed the growing population.

The Atlantic Tarpon (*Megalop atlanticus*) (Plate 1) occurs in the tropical and sub-tropical Atlantic Ocean. Tarpon is a famous game fish supporting recreational fisheries in the Western Atlantic, Gulf of Mexico and Caribbean, highly appreciated by anglers and fetched millions of USA dollars annually. In Nigeria and other West African coastal nations, this species plays a major role in the commercial artisanal fisheries along the coastline areas, where it serves as food fish. Traditional capture-based aquaculture of tarpon (which involves capturing of fingerlings/juveniles from the wild and are growing (fattening) them to table-size fish in ponds or pens) has since been in practice in the coastal communities of Ondo State. This fish is a highly-priced food fish among the llajes, Ijaws and other coastal community dwellers (Anyanwu, 2004). Tarpon holds great potential as candidate species for coastal aquaculture in Nigeria but relevant information that could aid its general acceptability as food fish is lacking.

Muscle composition of fish flesh has a lot of influence on how the fish is generally perceived by the consumer in terms of its taste, flavour, and overall acceptability. Muscle composition could also vary depending on the

size of the fish. The present research therefore investigated the carcass quality and proximate composition of the pond-raised *M. atlanticus* to provide information concerning fish nutritional parameters relevant to both processors and consumers.

Plate 1 *Megalops atlanticus* raised in a pond

MATERIALS AND METHODS

Tarpon fish used in this study were collected from a grow-out farm in Olotu Kuwo (Lat. 5°45′ - 6°15′ N Long. 4°30′ - 5°00′ E) in Ilaje Local Government Areas of Ondo State. The farmer stocked wild-caught Tarpon juveniles in dug-out earthen ponds. Only tarpon fish were stocked in the ponds and were fed with trash fish/shrimps while the rearing water in the ponds was exchanged occasionally throughout the culture period. Fish samples were first classified into three weight groups, designated as sample A (1000 – 1050 g), sample B (750 – 800 g) and sample C (500 – 550 g), which represented the different sizes of the fish being sold by the farmers. Five specimens of each weight groups were then collected from grow-out ponds and used for the carcass and proximate analyses. In the laboratory, each fish sample was taken out of water, laid on the table and body wiped dry. After weighing, each fish was slaughtered and dressed by removing the scales and fins. The stomach was slit opened while the visceral organ was removed. The head was cut off from the skeleton by a circular cut in front of the pectoral fin girdle, after which the remaining body part was weighed. The dressing percentage (with head/without head) was determined.

The proximate analysis of the experimental fish carcass was carried out using the procedures described by the Official Methods of Association of Analytical Chemist. Briefly, moisture was determined by oven drying the fish at 105 ºC for 24 hours. Crude protein was determined by the Kjeldahl method after digestion with concentrated H_2SO_4. The lipid content was determined by subjecting the sample to a continuous extraction with petroleum ether using Soxhlet apparatus. Ash Content was determined by subjecting the already dried samples with known weight to ignition in a muffle furnace at 550°C for 8 hours. The nitrogen free extract was estimated by difference between the heated and unheated ash

The data obtained were subjected to one-way analysis of variance (ANOVA) to determine whether significant differences occurred among their means, and where significant differences existed, they were separated using Duncan Multiple Range test. All analyses were performed using SPSS version 20.

RESULTS

The results of the carcass analysis of *M. atlanticus* (Table 1) showed that carcass dressings without head and with head ranged from 67.13 – 68.26% and 91.32 – 92.25% respectively. The values were observed to be insignificant ($p<0.05$) among the different weight groups examined. In terms of the proximate composition of the samples, highest moisture content was observed in sample C (500 – 550 g) although the values were not significantly different from the other samples. The protein content was however significantly higher in sample A (1000 – 1050 g) than in other samples examined. Highest but non-significant values were also recorded for ash, fat and NFE contents in Sample A.

Table 1: Carcass and proximate analyses of pond raised *M. atlanticus*

Parameter	Sample A (1000 – 1050 g)	Sample B (750 – 800 g)	Sample C (500 – 550 g)
Carcass assessment			
Mean fish weight (g)	1021.54[c]	758.43[b]	515.75[a]
% Dressing (with head)	92.25	91.84	91.32
% Dressing (without head)	68.26	67.51	67.13
Proximate composition			
Moisture (%)	70.03	71.26	71.82
Ash (%)	3.61	3.31	2.96
Protein (%)	18.55[b]	17.38[a]	17.31[a]
Fat (%)	7.18	7.02	6.91
Nitrogen free extract (%)	1.63	1.03	1.02

The values were recorded as means of five samples. Values with different superscripts on a row are significantly different ($P<0.05$)

DISCUSSION

A higher dressing percentage from the fish is desirable since it leads to a higher yield of edible portions and subsequent reduction in the quantity of processing waste (Vandeputte *et al* 2017). Percentage carcass dressing in this study showed very high proportion of edible flesh to waste even when head was included. Similarly, high values were also observed among different weight categories examined. Although viscera is believed to be a major variable in determining the dressing percentage of any farmed fish, the proportion of viscera in *M. atlanticus* in the present study did not have significant impact on overall weight of the fish. This observation might be related to the carnivorous feeding nature of *M. atlanticus* at different weight groups examined in this study.

Moisture and dry matter contents of the sampled fish were within the range recorded for other tropical fishes. In terms of major constituents of the dry matter, protein was found to be highest, followed by lipids and ash. Protein content for all the fish sampled was within the range that is classified as high, since it is greater than 15%. When compared among the different fish sizes, the values for protein were significantly higher in fish weighing 1000g and above, but values for lipid and ash contents were observed to be insignificant. Similar values in the analyzed constituents in fish of different sizes observed in this study might be due to the same food materials given to the fish. Information from the farmers revealed that *M. atlanticus* were fed with fish and shrimp by-catches. However, this result was not in agreement with available literatures that showed marked variations in lipids, protein and ash among fish species of different sizes. According to Mahboob *et al*. (2004) young fish showed progressive reduction in fat reserves, yet before reaching a critical low level, proteins began to be utilized for energy purpose, and ultimately resulted in a reduction of their protein contents with increased water contents.

CONCLUSION

This study evaluated the carcass dressing and proximate composition of farm-raised Tarpon (*M. atlanticus*). When taking into account the macronutrient composition of farmed-raised tarpon for human nutrition, the results of this study show that this fish can be reliable sources of nutrients if included in the diet. The fish also has high edible portions with reduced quantity of processing waste. Further study is warranted to ascertain the micronutrient composition and provide other relevant information that will aid commercial propagation of this fish species in the coastal waters of Nigeria.

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DIGESTIBILITY OF KERATINASE ENZYME TREATED PIG HOOF MEAL DIET BY *Clarias gariepinus* JUVENILE.

Sule, S.O.[1*], Abdullahi, U.U.[2], Ashley-Dejo, S. S.[1] &Ajibade, A.O.[3]

[1.]Department of Forestry, Wildlife and Fisheries, Olabisi Onabanjo University, Ayetoro Campus, Ogun State, Nigeria.
[2.]Department of Agricultural Technology, Niger State College of Agriculture, Mokwa, Niger State, Nigeria.
[3.]Department of Fisheries Technology, Oyo State College of Agriculture and Technology, Igboora, Oyo State, Nigeria.
***Correspnding Author:** sule.okanlawon@oouagoiwoye.edu.ng okanlawon.sule@yahoo.com

ABSTRACT
This study investigated the digestibility of pig hoof by *Clarias gariepinus* juveniles. A total of 180 *C. gariepinus* juveniles (30/fish/tank/replicate) with average weight 10.51±1.20g were stocked in rectangular plastic tank of 65litre (0.6m X 0.3m X 0.3m) with a static water change method every two days. Protease enzyme of *Bacillus licheniformis* (Cibenza^{TM} IND900) was added to the pig hoof with diet formulated to contain 40% crude protein at 70%:30% ratio of fishmeal: pig hoof with inert chromic oxide biomarker and fed at 5% body weight of fish for 14 days and faecal collection was daily for the period/tank/replicate. Result of the experiment revealed protein, fat, fibre, ash, moisture content, dry matter, nitrogen free extract and energy, were significantly different ($P<0.05$) for fishmeal over pig hoof meal test diet, except for fat which was not significantly different ($P>0.05$). However, evaluation of nutrient coefficient revealed higher values of digestibility for protein 72%, fat 98%, fibre 87% and energy 71%. While moisture content, dry matter and nitrogen free extract were above average and ash was the least digested nutrient. Inclusion of pig hoof in diet of *C. gariepinus* juveniles is hereby reported to be favourably digested with respect to nutrient requirement of catfish.

Keywords: *Bacillus licheniformis,* Enzyme, Fishmeal, Keratin, Pig hoof, Protease,

INTRODUCTION
Fish farmers and consumers are willing to purchase feed and fish produced with pig hoof as ingredient, as this will reduce the cost of production. There is paucity of information on the use of pig hoof slaughter waste leading to discard. The valorization of this keratin rich product through biotechnology will afford the economical use of the nutrient rich waste. Utilization of keratin should be in minimal quantity in feed due to variability in quality of nutrient (Kawauchi *et al.,* 2014). Use of rendered slaughter waste as cheap protein source have been documented. Digestibility of rendered animal protein has been reported to be high as it has led to improve growth in fish. Digestibility studies provide valuable information about the energy and nutrient of ingredients with a view to achieving the nutrient requirement of fish Bureau *et al.,* (1999); Hussain *et al.,* (2011); Kawauchi *et al.,* (2014); Falaye and Sule, (2020). The nutritional content of cattle, pig and goat hoofs have been documented in literature to be high in nutrients. Korniłłowicz-Kowalska and Justyna (2011) noted that biotransformation of keratin is achievable through biotechnology which makes the nutrient available for growth of animal. Gachango *et al.,* (2017) reported that keratin production from slaughter house is on the increase with high cost of disposal and consumers are willing to purchase fish fed with pig hoof. The enormous value of hoof generated at slaughter house necessitated the use of protease enzyme *Bacillus licheniformis* to investigate the digestibility of pig hoof by African catfish juvenile.

MATERIALS AND METHODS
A total of 180 *C. gariepinus* juveniles (30/fish/tank/replicate) with average weight 10.51±1.20g were stocked in rectangular plastic tank of 65litre (0.6m X 0.3m X 0.3m) with a static water change method every two days. The pig hoof was processed with protease enzyme *Bacillus licheniformis* (Cibenza^{TM} IND900). Diet was formulated to contain 40% crude protein (Table 1) at 70%:30% ratio of fishmeal (reference diet) : pig hoof (test diet) and fed at 5% body weight of fish. The experiment lasted 14 days and collection of faecal samples of fish was carried out daily for the period from each replicate. The proximate analysis of diets, amino acid profile of diets, mineral analysis of diets and analysis of faecal samples from experimental fish was conducted

according to standard methods of analysis. The results of the analysis were used in calculating the Apparent digestibility coefficients (ADC) of dry matter = 100 x [1 – (% dietary chromic oxide / % faeces chromic oxide)], ADC =100 x [1- (% faeces nutrient / % dietary nutrient) x (% dietary chromic oxide/% faeces chromic oxide)], ADC of nutrient= $100/30(ADC_{test\ diet} - 70/100ADC_{ref\ diet})$. Statistical analysis was carried out by the use of independent t test and level of difference determined at 5% with SPSS version 20.

Table 1: Nutritional, mineral, faecal and amino acid analysis of test and reference diets.

Ingredient formulation %	FM diet	PH diet	Mineral analysis	FM diet	PH diet
Maize	26.53	18.57	P%	1.21	1.32
Soybean meal	23.49	16.44	Ca%	0.34	0.40
Groundnut cake meal	23.49	16.44	Mg%	0.97	1.07
Fish meal	23.49	16.44	K%	1.38	1.68
Dicalcium phosphate	1.00	0.70	Na%	2.10	2.18
Table salt	1.00	0.70	Mn mg/kg	27.50	48.00
Premix	1.00	0.70	Fe mg/kg	1030.00	2800.00
Cr_2O_3	1.00	1.00	Cu mg/kg	9.20	11.85
Test ingredient	--------	29.01	Zn mg/kg	57.90	48.75
Proximate analysis: Feed %			Faeces %	FM diet	PH diet
Crude protein	39.50	42.50		41.62	38.55
Crude fat	9.55	7.90		2.63	2.91
Ash	9.30	9.42		15.4	15.2
Crude fibre	4.20	3.99		2.45	1.89
Moisture content	8.45	8.62		10.11	9.84
Nitrogen free extract	27.41	27.57		27.79	33.30
Energy kcal/kg	3257.69	3184.37		2727.72	2691.65
Chromic oxide	1	1		0.89	0.55
Amino acid (g/100g)					
Leucine	8.00	8.53			
Lysine	3.98	4.03			
Isoleucine	4.12	4.52			
Phenylalanine	4.08	3.72			
Tryptophan	0.68	0.73			
Valine	3.98	3.80			
Methionine	2.30	2.30			
Proline	3.45	3.45			
Arginine	5.59	5.68			
Tyrosine	3.61	3.44			
Histidine	3.19	2.30			
Cystine	0.97	1.03			
Alanine	4.32	4.55			
Glutamic acid	11.66	12.27			
Glycine	3.99	3.94			
Threonine	3.72	4.00			
Serine	3.56	3.62			
Aspartic acid	8.62	8.99			

RESULTS AND DISCUSSIONS

The feasibility of replacing fishmeal with keratin has been documented in aquaculture with the use of feather meal, hair meal, hoof and horns at varying inclusion levels. These studies further revealed the implication of diet containing keratin on the haematology and

histology of fish. The apparent digestibility (Table 2) showed that FM diet was highly digestible over the PH diet with significant difference (P<0.05). According to Kawauchi *et al.*, (2014) the crude protein digestibility when dog was fed diet containing meat and bone meal 73-79%, poultry meal 80-89% was high and similar to the result obtained in this study. However, our findings was higher than values obtained by Bureau *et al.*, (1999) who reported protein digestibility (81%) and energy digestibility (76-87%) of four feather meals which are lower to the enzyme treated pig hoof. Lower protein, fat and energy compared to this study for fishmeal, bloodmeal and meat meal was reported by Hussain *et al.*, (2011). The use of cattle hoof in diet of catfish was digested with varied digestibility, while the ADC of nutrient of fermented cattle hoof was similar to the result obtained in this study (Falaye and Sule, 2020). The reason for high digestibility corroborates assertion of Korniłłowicz-Kowalska and Justyna (2011) who reported that fermentation is the major method by which bacteria convert keratin to beneficial use.

Table 2: Apparent and nutrient coefficient digestibility of Catfish fed pig hoof diet.

Apparent digestibility	FM diet %	PH diet %	Nutrient coefficient of PH diet %
Protein	88.16±0.21[a]	83.51±0.05[b]	72.65±0.04
Fat	96.91±0.11[a]	97.19±0.09[a]	97.86±0.62
Fibre	93.45±0.36[a]	91.39±0.10[b]	86.59±0.17
Ash	81.39±0.42[a]	70.66±0.14[b]	45.62±0.06
Moisture content	86.56±0.07[a]	79.19±0.11[b]	62.02±0.20
Dry matter	88.76±0.24[a]	81.82±0.06[b]	65.61±0.24
Nitrogen free extract	89.23±0.21[a]	78.06±0.09[b]	51.97±0.14
Energy	90.59±0.71[a]	84.63±0.63[b]	70.72±0.29

Row means values (±SE) with different superscripts are different significantly (P<0.05)

CONCLUSION

Digestibility of pig hoof indicated efficient utilisation of the nutrient in the diet suggesting the need for the inclusion of protease treated pig hoof in aquaculture diet.

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EFFECT OF PELLETING ON THE TOTAL AFLATOXIN CONCENTRATION IN FISH FEED

Ilesanmi, A. I[1]*., Bubu-Davies, O. A.[2]., Osemwegie, O.O.[3]., Abu, O. M. G[2]., Dan-Ologe, I. A[4]. & Ayegba, E. O[1].

[1]Department of Fisheries and Aquaculture, University of Agriculture and Environmental Sciences, Umuagwo, Imo State, Nigeria.

[2]Department of Fisheries and Aquatic Environment, Rivers State University, Port Harcourt, Nigeria.

[3]Department of Food Science and Microbiology, Landmark University, Omu-aran, Kwara State, Nigeria.

[4]Department of Biology, Federal College of Education, Abeokuta, Ogun State, Nigeria

***Corresponding author** - isaac.ilesanmi@uaes.edu.ng

ABSTRACT

The presence of mycotoxins in feed and food is a major issue due to the health effects it has caused worldwide, especially with the emerging effects of climate change on the environment. The effects of pelleting on the total aflatoxin in mould feed was studied in formulated fish feeds. The fish feeds were contaminated with the *Aspergillus flavus* organism in order to have some level of total aflatoxin secretion. The concentration level of the secreted total aflatoxin in the fish feed was determined using Thin Layer Chromatography (TLC). There are four (4) treatment (A, B, C and D) and three (3) replicates including the control (A – uncontaminated feed) of the experimental feed. The first analysis done was before the contamination and after the contamination of the feed with *Aspergillus flavus*. The second analysis was after the feed passed through the process of pelleting and drying. The results revealed the reducing effect of the pelleting process on the concentration of total aflatoxins in fish feed.

Keywords: Aspergillus flavus, Drying, Fish feed, Total aflatoxin

INTRODUCTION

Mycotoxins are naturally occurring harmful substance created as secondary metabolites by contagious moulds or living organism of the fungal (Sani *et al.*, 2013). It is known that filamentous organisms belonging to *Aspergillus, Alternaria, Penicillium* and *Fusarium* manufacture mycotoxins in a manner that is specific to each strain (Egbuta *et al.*, 2017). Mycotoxin contamination of food and feed is a serious global health hazard that is poisonous to living organisms and humans. Most of the crops cultivated globally are contaminated by these mycotoxins.

There are several methods that have been developed in order to decontaminate and detoxify mycotoxin contaminated food and feed. These include:

Pre-harvest – This includes reduction in plant stress and insect damage, Avoidance of environmental conditions that favour infection in the field (e.g. Drought, insect infestation, and delayed harvesting), good cultural practices, breeding of cultivars resistant to fungal infection, and development of transgenic plants resistant to fungal infection.

Harvest – This includes keeping mechanical damage of seeds to a minimum, timely harvest of field crops so as to reduce moisture level to a point where mycotoxin formation will not occur and immediate transportation of crops.

Post-harvest strategies – This involves the removal of damaged grain and drying of grain to the minimal moisture level, control of insect and rodent activities and maintenance of appropriate moisture levels and temperature, appropriate packaging, frequent cleaning of food/feed delivery systems, and short term storage.

Neme and Mohammed (2017) reported that the concentration of mycotoxins can be reduced with processing methods, although may not be completely removed. The level of mycotoxin contamination can be reduced by softening, because the fungi accumulate on the surface of the granules. The objective of this study is to determine the effect of the processing techniques on the mould fish feed.

MATERIAL AND METHODS

The experiment was conducted at the Departmental Laboratory of Fisheries and Aquatic Environment, Faculty of Agriculture, Rivers State University, Port Harcourt Nigeria. The feed ingredients were bought from Agro-Allied Company at Mamy market, Bori Camp Rumuokoro Port Harcourt, Rivers State. There are Four (4) treatments (A, B, C and D) and three (3) replicates of the experimental fish feed. The experimental feeds were collected for the total aflatoxin analysis before the inclusion of fungi organism and the mean values were recorded.

The formulated feed (Table 1) was then mixed with a little quantity of distilled water and together with a strain of *Aspergillus flavus* collected from the Microbiology Department of Rivers State University,

Port Harcourt. A plastic sac was used to cover the mixed feed to encourage the growth of the mould for 24hours. The feed was pelletized with a pelleting machine and dried immediately with an electric dryer at 60^{o}C for 12hours. Thereafter, the feeds were properly packaged and the final total aflatoxin analysis of the A, B, C and D was done to determine the level of total aflatoxin concentration at this stage.

Table 1: The dietary composition of the experiment

Ingredient	Feed (Kg)
Maize	22.5
Groundnutcake	30.50
Fishmeal	15.50
Soya-beanmeal	30.50
Mineral premix*	0.50
Methionine	0.25
Lysine	0.25
Total	**100**

***Contains VitA 4000000IU; Vit D. 800000IU; Vit. E 40000mg; Vit. K3 800mg; Vit. B1 1000mg; Vit. B2 6000mg; Vit. B6 5000m; Vit. B12 25mg; Niacin 6000mg; Patothenic acid 20000mg; Folic acid 200mg; Folic acid 200mg; Biotin 8mg; Manganese 300000mg; Iron 80000mg; Zinc 20000mg; Cobalt 80mg; Iodine 400mg; Selenium 40mg; Choline 800000mg

The mycotoxin analysis of each feed treatment was done at Aniete Laboratory with thin-layer-chromatography (TLC) (AOAC, 2000).

RESULTS AND DISCUSSION

The analysis of the total aflatoxin present in the feed at the initial stage are ranged from 7.15±0.55 to 238.23±0.08) as stated in the Table 2. The total aflatoxin observed after the pelleting and drying ranged from 3.00±0.13 to 11.00±0.22. The aflatoxin content of the experimental diet is higher than the standard limit level set by European Commission (2003) for complete and compound animal feeds are 10 µg/kg and 20 µg/kg for feed ingredients. It was observed from this study that the pelleting had reducing effect on the concentration of the toxin. This is in support of the report by Neme and Mohammed (2017) stating that the concentration of mycotoxin can be reduced by processing techniquesAlso, that the extrusion technique reduces aflatoxins depending on the processing temperature and granule moisture content reduction.

Table 2: Total Aflatoxin Analysis in the feed

Samples	Initial Total Aflatoxin concentrations (µg/kg)	Total Aflatoxin concentrations (µg/kg)
A	7.15±0.55	3.00±0.13
B	223.85±0.13	11.00±0.22
C	225.17±0.42	10.80±0.15
D	238.23±0.08	11.00±0.08

The concentration of aflatoxin found in the experimental feed purchased directly at feed mill used for this experiment is an indication that there is possibility of the presence of mycotoxins in the fed mill and farm across the nation. This result is in support of the global investigation of the occurrence of mycotoxin in animal feed by Biomin survey (2017) which revealed that about 74% of the ingredients used in compounding aquaculture feed are contaminated with mycotoxins which can have a substantial negative economic impact on the aquaculture industry.

Also, the concentration of aflatoxin in the experimental feed may be affected by the heat treatment during the drying period of the pelleted feed. This is supported by Kabak's (2006) report, which states that heat efficiency in decontaminating mycotoxins in feed depends on the chemical structure and concentration of mycotoxins, temperature, time, moisture content, pH, and ionic concentration during thermal treatment (Kabak, 2006).

In contrast to the results of this experiment, Ryu *et al*. (2003) reported that aflatoxin B1, deoxynivalenol,

zearalenone, and fumonisins B1 are compounds that cannot be affected by heat at decomposition temperatures greater than 237, 175, 220, and 150 °C, respectively, making them difficult to eliminate by conventional thermal processing. Nonetheless, thermal treatments consume an excessive amount of energy; also, high temperature-induced Maillard reactions diminish the nutritional content of feed items. This restricted the use of heat treatments in the feed sector (Pankaj *et al*., 2018).

CONCLUSION AND RECOMMENDATION

This study has revealed that mycotoxin level in fish feed can be reduced by pelleting process. It can be recommended from this study that every feed should pass through a proper processing method of pelleting because it can be concluded that pelleting has a way of reducing the concentration of mycotoxins.

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PHYSICO-CHEMICAL MEAT QUALITY OF RABBITS FED DIETS CONTAINING DRIED WATERMELON RINDS

[1]Ayo-Ajasa O. Y., [1]Olawale, C. A., [1]Adegoke, A. V., [1]Adeyemo, A. A.,[1]Ayoola A. A., [1] Egbeyale L. T., [2]Abiona J. A., [3]Fafiolu A. O. & [1]Sogunle O. M.

[1] Department of Animal Production and Health, Federal University of Agriculture, Abeokuta, Nigeria
[2] Department of Animal physiology, Federal University of Agriculture, Abeokuta, Nigeria
[3] Department of Animal Nutrition, Federal University of Agriculture, Abeokuta, Nigeria
***Corresponding Author:** olapejuyemisi@yahoo.com; ayo-ajasaoy@funaab.edu.ng

ABSTRACT
The competition between humans and livestock for maize has brought about the recent research on the use of unconventional feed ingredients, such as dried watermelon rinds (DWMR), in livestock feed. This study was therefore conducted to assess the effect of diets containing DWMR on rabbit meat quality. 80 crossbreed, unsexed weaner rabbits with mean weight of 630 g were used for this study. They were allocated on weight equalisation basis into 4 treatments (0%, 5%, 10% and 15% of DWMR inclusion levels, representing T1, T2, T3 and T4, respectively) and further divided into 5 replicates of 4 rabbits. Data generated were subjected to one-way analysis of variance. The results showed that inclusion of DWMR had no significant ($p>0.05$) effect on rabbit meat quality. The highest colour intensities (L*, a* and b*) were recorded in samples from rabbits fed diets containing DWMR. The mean scores for refrigeration and cooking loss decreased numerically with increasing level of inclusion of DWMR while the highest and least water absorptive power was noticed from rabbits fed diets containing 0% and 5% DWMR inclusion level, respectively. It was concluded that inclusion of DWMR in rabbits' diets had no negative effect on the quality of their meat.
Keywords: Rabbit, watermelon rinds, water absorptive power, cooking loss, refrigeration loss, meat colour

INTRODUCTION
Non-conventional feed ingredients like crop residues and agro industrial by-products, such as watermelon rind, that are not consumed by humans could be used as alternatives in rabbits' diets because they are efficient converter of fibrous feed ingredients and agro-industrial by-products to meat than other livestock species (Ajagbe *et al.,* 2022). Rabbits (*Oryctolagus cuniculus*) are described as sensitive micro-livestock species that has been researched to be the most affordable and viable means of producing animal protein in a developing country like Nigeria. Rabbit meat offers excellent returns on investment, premium meat products, a high protein content of approximately 20.8%, low levels of fat, cholesterol, and sodium, and it compares favorably to the local bush meat. However, the quality of rabbit meat is affected by a lot of factors which include nutrition, housing and climate. In order to reduce the rising cost of animal feed, it is necessary to find affordable, readily available, and ready-to-use alternative feedstuffs for rabbits (Ewa *et al.,* 2019). A very perfect alternative is watermelon rinds. Rinds from watermelons are abundant in Nigeria wherein they contain micronutrients that include carotene, vitamin K, ascorbic acid, riboflavin, iron, iodine, and other mineral components in high concentrations. The rinds of watermelon can be fed to animals such as rabbits and grasscutter for rapid growth due to their capacity to transform agricultural waste and tropical forages into meat for human consumption. Osman and Moustafa (2019) reported that the supplementation of 10% watermelon rinds in the diet of weaner rabbits resulted in a greater carcass weight and dressing percentage, but there was no information on its meat qualities. Hence, this research assessed the cooking loss, refrigeration loss and meat colour of rabbits fed diets containing dried watermelon rinds.

MATERIALS AND METHODS
The rearing aspect of the experiment was carried out at the Rabbitry unit of the Directorate of University Farms (DUFARMS) while the meat quality assessment was carried out at the Animal Products and Processing Laboratory, Department of Animal Production and Health, College of Animal Science and

Livestock Production, Federal University of Agriculture, Abeokuta, Ogun state, Nigeria.

Fresh watermelon rinds were collected from fruit vendors around Alabata axis, Odeda Local Government Area, Abeokuta, Ogun State, Nigeria. The rinds were rinsed thoroughly and scrapped to remove sand particles and watermelon remains that might cause decaying instead of drying. The rinds were then sliced into smaller sizes and sundried for about 3 weeks. After which the sundried rinds were milled with hammer mill into smaller sizes of 2 mm and incorporated into the diets of the experimental animals (80 crossbreed, unsexed weaner rabbits of an average weight of 630 g at 0, 5, 10 and 15% levels as shown in Table 1). The experimental animals were weighed and allocated based on weight equalization into four (4) dietary treatments *i.e.;*(0%, 5%, 10% and 15% of dried watermelon rinds inclusion levels, and this represents T1, T2, T3 and T4, respectively). Each treatment group, containing 20 rabbits, was further replicated five (5) times with each replicates containing 4 rabbits. The rabbits were kept in hutches equipped with concrete feeders and drinkers used to feed and provide water for the animals *ad-libitum*. Maintenance of strict hygiene like daily sweeping of the pens, washing and refilling of drinkers with fresh clean water, cleaning of feeders and provision of feed was thoroughly ensured throughout the 14-week period of the experiment. At the end of the experiment, six rabbits per treatment group were slaughtered for meat quality analysis. The colour of the meat samples was determined by measuring the L^*(lightness), a^* (redness), b^* (yellowness) as described by Yam and Papadakis (2004). Two repeated measurements were taken according to the guidelines for meat color evaluation procedure (Hunt *et al.*, 1991). The cooking loss, refrigeration loss and water absorptive power were determined by calculations. Data obtained were subjected to a One-Way Analysis of Variance using the generalized linear model procedure of Statistical Package for Social Sciences version 21 (SPSS, 2012). The significant differences among the treatment means were separated using Duncan's Multiple Range Test as contained in the same statistical package.

Table 1: Percentage Composition of Experimental Diets

	T1	T2	T3	T4
	Level of Inclusion of DWMR (%w/w)			
Ingredients	0	5	10	15
Maize	45.00	40.00	35.00	30.00
PKC	10.00	10.00	10.00	10.00
Soya bean meal	10.00	10.00	10.00	10.00
DWMR	0.00	5.00	10.00	15.00
Wheat offal	30.00	30.00	30.00	30.00
Bone meal	3.00	3.00	3.00	3.00
Oyster shell	1.50	1.50	1.50	1.50
Salt	0.25	0.25	0.25	0.25
Vit. Prix	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated Analysis				
ME (MJ/kg)	2611.40	2439.80	2268.20	2096.60
Crude protein (%)	15.39	15.55	15.72	15.89
Crude fibre (%)	5.52	6.16	6.80	7.44

DWMR: Dry Water Melon Rind

RESULTS AND DISCUSSION

Physico-chemical meat qualities of rabbits fed diets containing graded level of dried watermelon rinds is depicted in Table 2. Dried watermelon rinds had no significant ($p > 0.05$) effect on the cooking loss, refrigeration loss, colour and water absorptive power of rabbit meat. Samples of meat from rabbits fed diets containing 15% dried watermelon rinds had the lowest mean values for refrigeration (0.67 %) and cooking losses (13.43 %). The highest mean value (19.11 %) for water absorptive power was observed in the treatment group that contained meat samples from rabbits fed 0% inclusion of dried watermelon rinds in their diets while the least mean score (15.19 %) was noticed from the experimental animals fed 5% diets inclusion of dried watermelon rinds. This result is in

line with the report of Okanlawon *et al.,* (2024) who stated that the inclusion of phytobiotic blend (turmeric, garlic, ginger and clove) in the diets of rabbits had no significant influence on the final cook loss, water absorptive power and chilling loss. The inclusion of dried watermelon rinds in the diets of rabbits showed no significant ($p > 0.05$) effect on the colour intensities (L*, a* and b*) of the meat. The intensities of colour found in this experiment is similar to that of Mijangos-Santos *et al.* (2022) who reported that intensities L*, a* except b* of meat (Longissimus dorsi muscle) of rabbits were not affected by the different diets and a biological activator.

Table 2: Cooking loss, refrigeration loss, water absorptive power and colour of meat from rabbits fed diets containing dried watermelon rinds

	Inclusion Levels of DWMR (%)				
Parameters	0	5	10	15	SEM
Water absorptive power (%)	19.11	15.19	17.89	17.08	0.77
Cooking loss (%)	13.53	13.94	14.04	13.43	0.62
Refrigeration loss (%)	0.79	1.41	3.70	0.35	0.70
L*	34.38	37.06	34.78	35.70	0.52
a*	9.37	9.46	10.17	9.56	0.25
b*	4.36	5.06	4.41	4.36	0.27

[abcd] *Means along the row with different superscripts are significantly ($p<0.05$) different.*
DWMR - Dried Watermelon Rinds L* - Lightness intensity
SEM – Standard Error of Mean a* - redness intensity b* - yellowness intensity

CONCLUSION AND RECOMMENDATION

Based on the results of this study, the inclusion of dried watermelon rinds in rabbits' diets had no significant effect on the cooking loss, refrigeration loss, water absorptive power and colour of their meat. Hence, it can be effectively used as an unconventional feed ingredient without significant loss in physico-chemical qualities of rabbit meat.

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MICRO-MINERAL CONTENTS OF GLIRICIDIA-MEGATHYRSUS MIXTURES

Dele, P. A. Enwete, F.E., Akinyemi, B.T. Akinlolu, A.O., Badejo, E.D., Odunewu O.T. & Bello, E. O.
Department of Pasture and Range Management, Federal University of Agriculture, P. M. B. 2240, Abeokuta, Nigeria
Corresponding author's email: delepa@funaab.edu.ng

ABSTRACT
This study evaluated the micro-mineral elements of *Gliricidia sepium* and *Megathyrsus maximus* and their mixtures. The experiment was a completely randomized design with five (5) proportions as treatments; 100% *G. sepium* (100G); 75% *G. sepium* + 25% *M. maximus* (75G:25M); 50% *G. sepium* + 50% *M. maximus* (50G:50M); 25% *G. sepium* + 75% *M. maximus* (25G:75M) and 100% *M. maximus* (100M). The effect of proportion was significant (P<0.05) on the micro mineral contents. The 100M had the highest (119.78 mg/kg DM) concentration of Mn while the 25G:75M recorded the least value of Mn. The Fe concentration (1383.40 > 933.11 > 731.29 > 407.11 > 227.89 mg/kg DM) ranking for the mixtures were 100G > 75G:25M > 50G:50M > 25G:75M > 100M, respectively. The Cu concentration ranged from 7.52 mg/kg DM to 13.56 mg/kg DM, the Zn concentration of 100M was the highest (44.18 mg/kg DM) value. The forages and the mixtures had sufficient amounts of micro elements that could meet requirements of different classes of ruminants.

INTRODUCTION
Maintaining livestock's development, reproduction, and health requires making sure they receive an adequate supply of mineral nutrients, especially the micro-minerals whose roles are usually underestimated in livestock production in the tropics (Upadhaya and Kim 2020). Minerals from pasture-based livestock systems are largely derived from pasture herbage. Mineral supplementation is frequently supplied at a constant amount in these systems during the growing season (McDowell and Valle, 2000).

Gliricidia sepium is one of the major Pantropical forage trees which is rich in protein with high nutritive value (Heuze and Tran, 2015) with varying content of micro-minerals and commonly found around homes and stall as live-fencing and as well as fodder sources for ruminants along the region of West Africa.

Megathyrsus maximus, commonly called Guinea grass, is widespread throughout the tropics (Heuze and Tran, 2020). It is a quick-growing, green grass with significant nutritional content that is appealing to animals.

It is therefore necessary to identify ways to increase the mineral contents of the forages that are made available to animals since the quality of feed consumed has a significant impact on ruminant production. The aim of this study is to investigate concentrations of micro-mineral elements in Gliricidia-Megathyrsus mixtures as it relates to ruminant production.

MATERIALS AND METHODS
Experimental sites
The study was carried out at the Pasture Unit of the Directorate of University Farms and the laboratory of the Department of Pasture and Range Management, College of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta (FUNAAB) Nigeria. The region lies within Southwest Nigeria agro-ecological zone (Latitude 7° 13'49.46''N, Longitude 3° 26'11.98°E),

Sourcing of Forage materials and experimental design
Megathyrsus maximus was harvested from a pasture plot that was established in October 2015 on a land area measuring 589m^2 (31m x 19m). At the onset of the rainy season in March 2019, the plot was uniformly cut back to 20-cm height above ground level in order to stimulate re-growth. The plot was top-dressed with 30kg/ha of NPK 15:15:15 fertilizer while the grass was allowed 6 weeks' period of re-growth before harvesting. The *G. sepium* leaves were harvested from an already established intensive feed garden at the Directorate of University Farms, FUNAAB. The harvested forage materials were air-dried to constant weight and the two forages were combined into five (5) proportions (treatments) on dry matter basis in a completely randomized design with five (5) replicates: Sole *G. sepium* (100G), 75% *G. sepium* + 25% *M. maximus* (75G:25M), 50% *G. sepium* + 50% *M. maximus* (50G:50M), 25% *G. sepium* + 75% *M. maximus* (25G:75M) and sole *M. maximus* (100M).

Laboratory analysis
Samples of the proportions were oven-dried at 65°C until constant weight, and ground in a Wiley mill to pass through 1.0 mm sieve screen. The micro minerals

(Cu, Zn, Mn and Fe) were determined according to AOAC (1995).

Statistical analysis

The data obtained were subjected to one-way analysis of variance (ANOVA), while the treatment means were separated with Tukey HSD test. The box plots were built in SAS statistical software version 9.4.

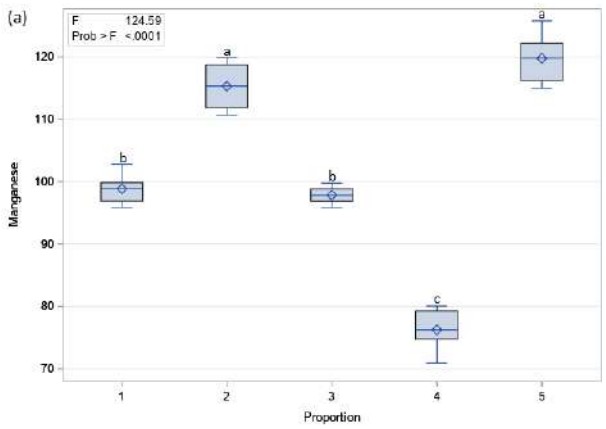
RESULTS AND DISCUSSION

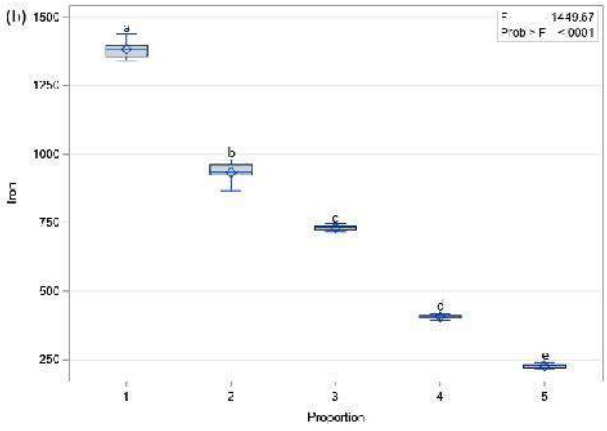
The manganese content was significantly ($P<0.05$) affected by the proportions, the highest (119.78 mg/kg DM) content was observed in sole *M. maximus* while the least (76.24 mg/kg DM) recorded for the mixture with the least *G. sepium* (25G:75M) (Figure 1a). The higher Mn content of *M. maximus* as against that of *G. sepium* aligned with the report of MacPherson (2000) that grasses have considerably higher Mn content than legumes. The antagonistic relationship between Fe and Mn in this study is obvious as they tend to be inversely related with *G. sepium* having higher Fe (1382.40 mg/kg DM) content and lower Mn (98.85 mg/kg DM) content while *M. maximus* having higher Fe (227.89 mg/kg DM) content and lower Mn (119.78 mg/kg DM) content.

The iron (Fe) content significantly ($P<0.05$) increased with increase in the proportion of *G. sepium*, making the sole *G. sepium* to have the highest concentration of Fe while the sole *M. maximus* had the least concentration of Fe (Figure 1b). The Fe content of the sole *G. sepium* was above 1000 mg/kg DM, a concentration with potential toxicity to animals (NRC, 2000) and could limit intake of other mineral elements. According to Juknevicius and Sabiene (2007), sole feeding of forages could cumulate into high demerit as against mixing them. The lower concentration of Fe in *M. maximus* as against that of *G. sepium* is in line with the report of Juknevicius and Sabiene (2007) that legumes accumulate Fe than grasses. Both *G. sepium* and *M. maximus* as well as their mixtures in this study contained enough Fe above the 30 – 50 mg/kg DM recommended to meet Fe requirement of ruminants for optimal performance (MacPherson, 2000).

The Cu concentration ranged from 7.52 mg/kg to 13.56 mg/kg (Figure 1c). The Cu content recorded in this study ranged from 7.5 – 13.5 mg/kg DM, which according to McDowell (1997) is sufficient to meet the Cu requirement of all classes of ruminants. The Cu content of the sole *G. sepium* was above the recommendation of McDowell (1997) but fell within the range of 4 – 22 mg/kg DM) reported for *G. sepium* by Heuze and Tran (2015). The Cu content of mixtures with *G. sepium* ≤50% was slightly higher than the range (6 – 7 mg/kg DM) categorized as Cu marginally deficient for dairy cattle, which could cause blood neutrophil depression (Torre *et al.*, 1996).

The Zn concentration of 100M was the highest (44.18 mg/kg) while the 75G:25M mixture recorded the least Zn value (Figure 1d), The Zn content of the forages and the mixture (25G:75M) were within the range (30-50 mg/kg DM) as recommended by (Khan *et al.*, 2009) and above 30 mg/kg DM (McDowell, 1997) for ruminants but the mixtures with 50% and above *G. sepium* fell below the critical levels recommended, the implication is that these mixtures will require Zn supplementation when fed to animals. According to MacPherson (2000), the forages and their mixtures in this study are categorized as been marginal in threshold (20 – 40 mg/kg DM) Zn concentration for cattle except for *M. maximus* which was above the marginal threshold.





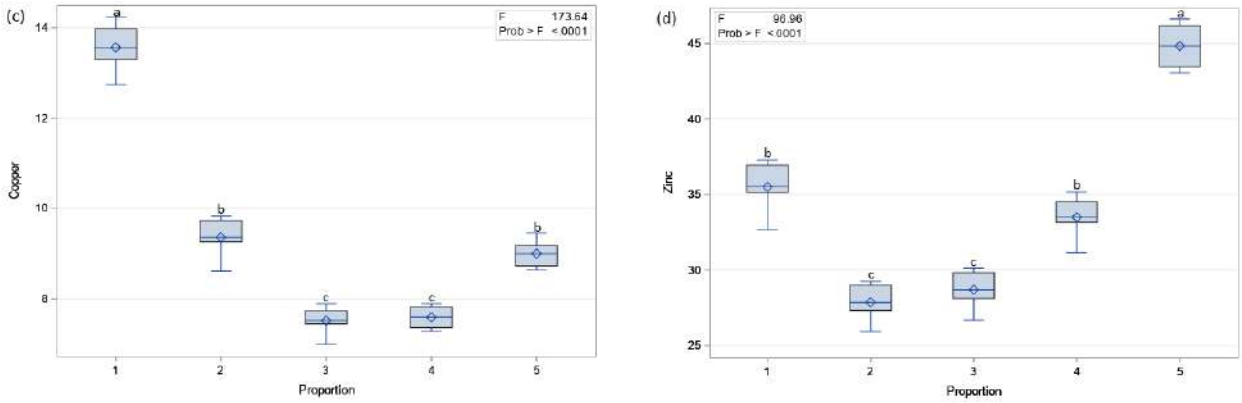


Figure 1: Box and whisker plots of micro-mineral concentrations (mg/kg DM) of Gliricidia-Megathyrsus mixtures as influenced by mixture proportion. **a** Manganese; **b** Iron; **c** Copper and **d** Zinc. Different lower-case letters depict significant differences among the five proportion of mixtures ($p < 0.05$). Proportions include: **1**: Sole Gliricidia (100G), **2**: 75% Gliricidia + 25% M. maximus (75G:25M), **3**: 50% Gliricidia + 50% Megathyrsus (50G:50M), **4**: 25% Gliricidia + 75% M. maximus (25G:75M) and **5**: sole M. maximus (100M).

CONCLUSIONS AND RECOMMENDATION

The study showed that forage mixtures are good for ruminant animals for adequate mineral nutrition and optimum productivity. For a balance of mineral supply for body functions a mixture of Gliricidia and Megathrsus at 50:50 and 75:25 is recommended as potential source of minerals as the mixtures will help in lowering the content of the micro-minerals which might tend toward toxicity if fed as sole.

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