AGRICULTURAL ECONOMICS AND EXTENSION

Journal of Applied Agricultural Research 2022, 10(2): 2-14
ISSN 2006-750X.

ANALYSIS OF GENDER DIFFERENTIALS IN TECHNICAL EFFICIENCY OF HUNGRY RICE (*Acha*) FARMERS IN PLATEAU STATE, NIGERIA

[1]Amusa, T. A and [2]Esheya, S. E.
[1]Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike.
[2]Department of Agricultural Economics and Extension, National Open University of Nigeria, Kaduna Campus.
Author's Contact: amusa.taofeeq@mouau.edu.ng; hamfeeq@yahoo.com

ABSTRACT

Hungry rice (*Acha*) is an important staple in northern Nigeria that had not received commensurate research attention. Hence, this study analysed gender differentials in technical efficiency of a*cha* farmers using Plateau State as a case study. Multistage random sampling technique was used to select 160 *acha* farmers (80 males and 80 females). Data were collected with structured questionnaire and analysed using descriptive statistics, stochastic frontier production model and z-test statistics. The result of the study showed that there exist significant differences in level of education, access to credit, extension contacts, farm size and farm output of male and female *acha* farmers. The computed mean technical efficiency of male acha farmers was 0.77 higher than that of female farmers 0.61. The result of the production function (technical efficiency) was good as indicated by Sigma Square (δ^2) value of 0.89 for males and 0.67 for females, gamma statistics (variance ratio) value of 0.85 for males and 0.69 for females and Lambda (λ) estimate of 5.63 for males and 5.29 for females *acha* farmers. Farm size, planting materials, fertilizers and hired labour significantly influenced male farmers' output while family labour with farm size, planting materials and fertilizers influenced female farmers' output. On the inefficiency model, age, education, farming experience and credit access were significant variables influencing technical inefficiency of male and female farmers. However, in addition to these variables, extension contact also significantly influenced male farmers inefficiency. In conclusion, there is clear empirical evidence of gender disparity in technical efficiencies of the *acha* farmers. The study therefore recommend (i) timely and adequate provision of production inputs to help boost efficiency of the farmers, (ii) there should be specific effort by stakeholders in Nigerian agriculture to enhance women access to land and other farm resources that will help to alleviate the current gender disparity, and (iii) formulation of gender sensitive policies that will help strengthen women farmers and reverse their present institutional neglect.

Keywords: Gender, hungry rice, *acha*, technical efficiency, Plateau State.

INTRODUCTION.

Food self-sufficiency has continued to receive attention in roundtable discussions among African nations amidst the ravaging food crisis and volatility in global food markets. Despite the rising trend in food insecurity, the economic and food security potentials of notable grains such as Hungry Rice (*Acha*) has remained untapped. Hungry rice, that goes by

Nigerian local name "*Acha"* and botanical name (*Digitaria spp*) belongs to the family *Graminae* and genus *digitaria*. In Nigeria, *acha* is mostly grown in Plateau, Kaduna, Kebbi, Nassarawa, Gombe, Bauchi, Niger State and FCT Abuja. National Research Council [NRC] (1996) reported that Hungry Rice is grown across fifteen West African countries where it is known with such names as *fonio*, *iburu*, *findi*, *fundi*, *pom* and *kabug*. The English name "Hungry Rice" was coined by the Europeans who considered the tiny grains as hungry poor man's food. Hungry rice (*Acha)* is an annual cereal crop and an important staple across northern Nigeria where it is majorly produced. If properly harnessed, *acha* production and export has the capacity to significantly raise household income and reduce poverty while providing the much needed jobs for the jobless citizens of the producing states (Umaru and Hassan, 2018). The nutritional value and potential of *acha* grains is enormous. For instance, Ukim, *et al* (2021) noted that *acha* is the most nutritious cereals and a good source of cysteine and methionine, which are important to the health of humans and growth of poultry. In addition to methionine, the grains contain some essential minerals and trace elements such as calcium, magnesium, iron and copper than most cereals (Chukwu and Abdul-Kadir, 2008). As reported by Kuta, *et al.* (2005), *acha* grains has high protein content of more than 7% and is found to be very rich in leucine, valine and methionine with great taste among all grains.

Acha is a fast growing crop that can thrive on marginal fertile land. For instance, Dachi and Gana (2008) stated that *acha* can be cultivated up to two to three times within a year since its maturity period is within an average of 120 days. The annual *acha* production in West Africa is about 250,000 tonnes with estimated land area of about 380,000 hectare being put to its production. Among the West African countries where *acha* is grown, Nigeria remains one of the leading producers, followed by Guinea, Burkina Faso and Mali. Gyang and Wuyep (2005) affirmed that *acha* is produced in commercial quantity in some parts of Nigeria with Plateau State being the largest producer with an estimated production of 20,000 tonnes per annum. Despite the reported tonnage, Cruz (2004) noted that the average production of *acha* per hectare has remained relatively low ranging from 600-700kg/ha.

Despite the overwhelming food security potential of the crop, knowledge about its production efficiency, input and output relationship had remains very scanty most especially in the leading producing state of Plateau. Though, Dachi and Omueti (2000) reported that *acha* is a crop that is found to responds positively to both organic and inorganic fertilizer application. *Acha* production fits well into the low-input farming systems of the resource-poor farmers. Otitoju and Enete (2014) shared that technical efficiency is the ability of farmers to derive maximum output from the inputs used in a farm. Hence, more researches on efficiency, inputs and output relationship in *acha* production remain paramount.

Efforts to estimate efficiency of inputs use in agricultural production can only be effective with an understanding of gender differentiated perspective and access to farm resources. This is because, gender and access to farm resources are cross-cutting issues, but most frameworks in which the farm input-output relationships are being addressed often times neglects gender perspectives which are crucial for efficiency. Gender approach takes into consideration the fact that women and men participate in socioeconomic realities differently depending on their age, education and culture (Amusa, 2014). Hence, some empirical studies evident in Umaru and Hassan (2018) and Duniya, Damisa and Abdulsalam (2013) had estimated productivity and technical efficiency of *acha* production both in Kaduna State. It is imperative to state that no empirical study available to the researchers captured the gender differentials in technical efficiency of *acha* farmers in the leading producing state (Plateau). Against this background, this study was carried out to bridge the existing gap in knowledge. Specifically, the study cross-tabulated gender of the farmers against their farming characteristics, computed and compared the technical efficiencies of the *acha* farmers on gender basis, and estimated the determinants of technical efficiencies of the acha farmers on gender basis.

METHODOLOGY.

Study Area.

The study was conducted in Plateau State, north-central Nigeria. The State derives its name 'Plateau' from its high altitude geographical landscape. Plateau State created in 1976 lies between latitudes 8° N and 10°N, and longitude 7°E and 11°E of the prime meridian. The state is made up of 17 administrative local government areas (LGAs) broadly divided into three agricultural zones which are: north, central and south agricultural zones. The north agricultural zone is made up of Bassa, Barkin Ladi, Jos East, Jos North, Jos South and Riyom LGAs. The central agricultural zone is made up of Bokkos, Kanke, Mangu, Kanam and Pankshin LGAs while the south agricultural zone consist of Langtang North, Langtang South, Mikang, Qua'an Pan, Shendam and Wase LGAs. The population of Plateau State according to National Bureau of Statistics (2012) is 3,669,993.

Plateau State is bounded by Bauchi State to the northeast, by Kaduna State to the northwest, by Taraba State to the southeast and by Nasarawa State to the southwest. The state is predominately agrarian with farming being the major means of livelihood of vast majority of the people providing income and employment for more than 75% of the population. Major food crops grown in the state include *acha*, potatoes, maize, guinea corn, millet, yam, fruits and vegetables among others.

Sampling Techniques.

Multi stage random sampling technique was used to select 160 *acha* farmers for the study. The first stage involved random selection of two agricultural zones in the state (north and central agricultural zones). In the second stage, two LGAs Barkin Ladi and Riyom LGAs were randomly selected from north agricultural zone while Bokkos and Mangu LGAs were randomly selected from the central agricultural zone making a total of four (4) LGAs for the study. The third stage involved random selection of four (4) communities from each of the selected four (4) LGAs making a total of 16 communities. From the 16 selected communities, a sampling frame of 834 *acha* farmers was obtained through the help of extension agents and local facilitators. At the fourth stage, random sampling was employed to select 10 *acha* farmers (5 males and 5 females) from the sampling frame of *acha* farmers obtained in each of the 16 selected communities making a total of 160 *acha* farmers (80 male farmers and 80 female farmers) for the study.

Data Collection and Analysis.

Data for this study were obtained from primary source through the use of well-structured questionnaire. The data were collected in 2021 cropping season by the researchers and their research assistants. Data collected focused on socio-economic characteristics of the *acha* farmers, output and inputs used in the last cropping season. The data were analysed using descriptive statistics such as frequency, percentage, means, cross-tabulation, stochastic frontier production model and Z-test statistics.

Estimation Procedure.

Stochastic frontier production function (Technical efficiency)

Stochastic frontier production function was used in analyzing the data for the study. The stochastic production function with a multiplicative disturbance term is of the form:

$Y = f(X\beta)e^{\mu}$ ……………………………….. (1)

Where:

Y is the output of *acha* harvested in kg, X is a vector of input quantities used in the production, β is a vector of parameter estimates while e is a stochastic disturbance term consisting of two independent elements U and V, given by: $e=v-u$ …..................... (2)

The stochastic frontier production function used in this study is fitted into Cobb-Douglas production function as follows:

$In\ Y_i = \beta_o + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + \beta_5 InX_5 + \beta_6 InX_6 + v_i - u_i$ ....….. (3)

Where:

In = natural logarithm to base e,

Yi = Output of *acha* (in kg)

X_1 = Farm size (in hectare)

X_2 = Planting material (*acha* grains) in kg

X_3 = Agrochemicals (in litres)

X_4 = Fertilizer used (in kg)

X_5 = Family labour (in mandays)

X_6 = Hired labour (in mandays)

v_i = error in measurement and other factors (random stocks) beyond control of the farmers.

u_i = technical inefficiency effects which captures deviation from the frontier.

Technical inefficiency model

The stochastic frontier production (technical efficiency) in this study also incorporates a model of inefficiency effect. In the inefficiency model, certain socioeconomic factors are hypothesized to contribute to inability of the male and female farmers to operate on the frontier specified as follows:

$Ui = \partial_0 + \partial_1 InZ_1 + \partial_2 lnZ_2 + \partial_3 lnZ_3 + \partial_4 lnZ_4 + \partial_5 lnZ_5 + \partial_6 lnZ_6 + \partial_7 lnZ_7 + W$………… (4)

Where: Ui = technical inefficiency of the ith *acha* farmer

∂'s are scales of parameters to be estimated.

Z_1 = Age (number of years)

Z_2 = Education (number of years)

Z_3 = Household Size (number of persons)

Z_4 = Farming experience (number of years)

Z_5 = Membership of cooperative (1 if member, 0 if non-member)

Z_6 = Access to credit (amount received in ₦)

Z_7 = Extension contacts (number of visits)

W = random variable defined by the truncation of normal distribution with zero mean & variance

Hence, since the dependent variable of the efficiency function represents the mode of the inefficiency, a positively sign estimated parameter indicates that the variable has a negative effect on inefficiency and a negatively sign parameter indicates that the variable has a positive effect on inefficiency.

Z-test for Hypothesis Testing

$$Z_{cal} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S^2\bar{X}_1}{n_1} + \frac{S^2\bar{X}_2}{n_2}}} \text{ ………………… (5)}$$

Where;

$\bar{X}_1$ = Mean technical efficiency of male *acha* farmers.

$\bar{X}_2$ = Mean technical efficiency of female *acha* farmers.

$S^2\bar{X}_1$ = Variance of technical efficiency of male *acha* farmers.

$S^2\bar{X}_2$ = Variance of technical efficiency of female *acha* farmers.

n_1 = number of male *acha* farmers.

n_2 = number of female *acha* farmers.

$n_1+n_2 - 2$ degree of freedom.

RESULTS AND DISCUSSIONS.

Farming Characteristics of the *Acha* Farmers.

The result in Table 1 shows cross-tabulations of farming characteristics of the farmers against their gender.

The results in Table 1 is a cross tabulation of farm characteristics of the *acha* farmers in respect to their gender. The mean age of the male farmers was 49.47 while that of their female counterparts was 48.30 with a p-value of 0.613. The mean of years of education of the male *acha* farmers was 10.62 while that of females was 7.73 with a p-value of 0.034 which showed a significant difference in years of education of male and female farmers in favour of the males. The report of Gender Justice (2018) affirmed that gender based discrimination continues in multiple ways as women farmers are not well captured in farming policies thereby denying them of necessary institutional supports of financial institutions, insurance, cooperatives, and education. The average size of the male farmers' households was 11.50 persons while that of female farmers' households was 10.92 with a p-value of 0.388 indicating that household size was not a source of difference. The mean value of credit accessed by male farmers was ₦53,720.70 while that of female farmers was ₦31,567.31 and a p-value of 0.000 which indicate a significant difference in credit accessed by both gender in favour of the male farmers. Amusa (2014) in a study identified some of the challenges of women farmers to include gross lack of access to supporting facilities such as credit, loans, cooperative, adult education programme.

The mean of extension visit of male farmers was 2.93 and 1.35 for female famers. The p-value of 0.026 showed a significant difference in extension visits received by the male farmer and their female counterparts as the female farmers received less attention from extension agents. Extension visits to farmers increase their access to relevant farm information. Deressa, *et al* (2008) reported that lack of information is one of the greatest challenges facing farmers in climate change adaptation. The mean years of farming experience of both gender males (35.95) and females (35.03) with p-value of 0.452 was not significantly different. The mean farm size in hectare for male farmers was 1.39 while that of their female counterparts was 0.58 and a p-value of 0.003 which indicate a significant difference in farm size in favour of the male farmers. Quisumbing and Pandolfelli (2010) observed that only a minority of policy interventions are directed towards increasing female farmers' access to productive resources such as farmlands. The patriarchy African culture grossly denies women access to and control of farmlands (Amusa, 2014). The mean of *acha* output was 645.37kg for male while that of their female counterparts was 593.54kg and a p-value of 0.000 which indicate a significant difference in farm outputs of the farmers in favour of the male farmers.

Technical Efficiencies of the Male and Female *Acha* Farmers.

Table 2 compares technical efficiencies of male and female *acha* farmers in the study area. The computed technical efficiency of male *acha* farmers ranged from 0.42 to 0.95 and a mean of 0.77 while that of the females ranged from 0.30 to 0.89 with a mean technical efficiency of 0.61. This implies that male *acha* farmers are more technically efficient than their female counterpart. The findings of this study agreed with that of Oduntan (2019) who found that the mean of technical efficiency of male yam farmers was 0.76 while the mean technical efficiency of female yam farmers was 0.62. Also in a study carried out by Danso-Abbeam, Baiyegunhi and Ojo (2020) in Ghana, the authors found that female cocoa farmers are less technically efficient relative to their male counterpart. The result is also in agreement with that of Yisa, *et al* (2020) who found that male farmers had mean efficiency score of 0.82 higher than 0.78 for female farmers.

The result shows high variability in technical efficiencies of both male and female farmers; indicating that there is opportunity to improve the current level of technical efficiency by 23% for male *acha* farmers and 39% for females. Comparison in the levels of variations in technical efficiencies of male and female *acha* farmers was also depicted in figure 1.

Test of Significant Difference in Technical Efficiencies of Male and Female *Acha* Farmers.

The gender differential in the technical efficiency of *acha* farmers was subjected into an empirical test using z-test statistics (Table 3). The mean technical efficiencies of male and female *acha* farmers are 0.77 and 0.61 respectively. The p-value (sig.) was 0.001 and z-calculated (z-cal) value of 2.97 at 158 degree of freedom (DF). This implies that there is significant difference in the technical efficiencies of male and female *acha* farmers in Plateau State. Gebre, *et al* (2021) in a study found that the productivity of male-headed households was significantly higher than that of female-headed households.

Maximum Likelihood Estimates of Technical Efficiency of Male and Female *Acha* Farmers.

The result of the stochastic frontier maximum likelihood estimate of the production function (Technical efficiency) of male and female *acha* farmers is presented in Table 4. The analysis showed that the estimate of Sigma Squares (δ^2) are 0.8989432 and 0.6799803 for male and female farmers respectively. These are high and both statistically significant at 1%. The gamma statistics (variance ratios) of 0.8564956 and 0.6909554 implies that about 86% and 69% of the variation in the output of the male and female *acha* farmers respectively were as a result of differences in their technical efficiencies. The Lambda (λ) estimate of 5.63774 for male and 5.29048 for female *acha* farmers are both greater than 1, indicating good fits and the correctness of the specified distributional assumptions of the composite error terms in the equations.

Table 1: Cross-tabulation of farming characteristics of the farmers against gender.

Variables	Male (n = 80) $\bar{X}$	SD	Female (n = 80) $\bar{X}$	SD	z	DF	P (sig.)
Age of Farmers	49.47	10.32	48.30	9.36	-0.45	158	0.613
Education	10.62	4.34	7.73	3.08	1.99	158	0.034*
Household Size	11.50	5.73	10.92	5.34	0.53	158	0.388
Access to credit	53720.70	949.41	31567.31	778.65	22.94	158	0.000**
Ext. Contacts	2.93	0.82	1.35	0.89	2.30	158	0.026*
Experience	35.95	7.67	35.03	7.75	-0.34	158	0.452
Farm Size	1.39	0.23	0.58	0.14	2.26	158	0.003**
Farm output	645.37	84.60	593.54	63.26	3.77	158	0.000**

Note: $\bar{X}$ = Mean; SD = Standard Dev; **Sig. at p <0 .01; *Sig. at p <0 .05.
Source: Field Survey, 2021.

Table 2: Distribution of Technical Efficiency of the Male and Female Acha Farmers

	Male TE		**Female TE**	
Efficiency range	**Freq.**	**Perc. (%)**	**Freq.**	**Perc. (%)**
0.31 – 0.40	0	0.00	6	7.50
0.41 – 0.50	5	6.25	11	13.75
0.51 – 0.60	10	12.50	20	25.00
0.61 – 0.70	18	22.50	25	31.25
0.71 – 0.80	35	43.75	17	21.25
0.81 – 0.90	8	10.00	1	1.25
0.91 – 1.00	4	5.00	0	0.00
TOTAL	**80**	**100.0**	**80**	**100.0**
Minimum	0.42		0.30	
Maximum	0.95		0.89	
Mean ($\bar{x}$)	**0.77**		**0.61**	
Std. Deviation	0.15		0.17	

Source: Field Survey, 2021; TE = Technical Efficiency

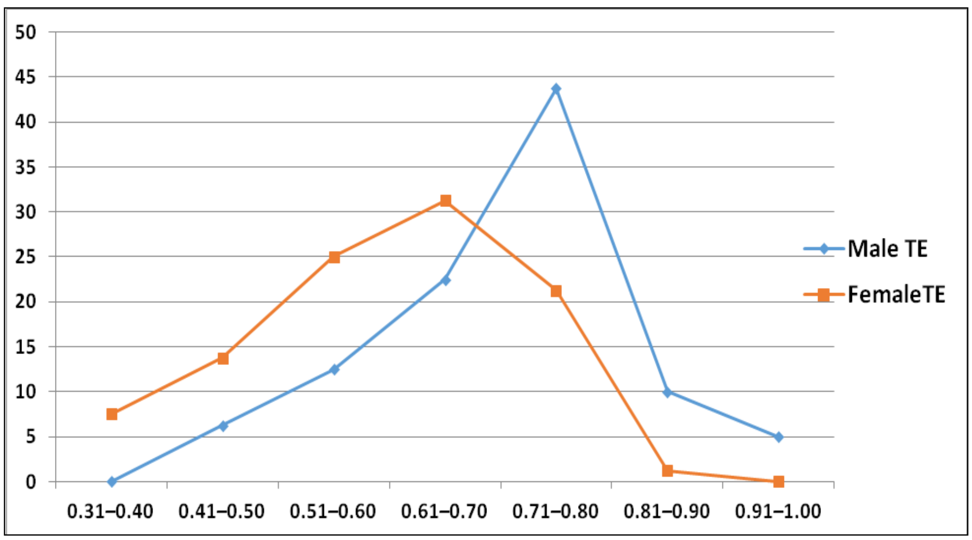

Figure 1: Line Graph of Technical Efficiencies of Male and Female *Acha* Farmers
Source: Field Survey, 2021.

Table 3: Z-test statistics of no significant difference in the Technical Efficiencies of Male and Female *Acha* Farmers.

Variables	**N**	**$\bar{X}$**	**SD**	**DF**	**Std. Error**	**p-value (sig.)**	**t-Cal.**	**Rmks**
Male Farmers	80	0.77	0.15					
				158	0.028	0.001	2.97	**S***
Female Farmers	80	0.61	0.17					

Note: S* = Significant at 0.01 (1%).
Source: Field Survey, 2021.

Table 4: Stochastic Frontier Maximum Likelihood Estimate of Technical Efficiency of male and Female *Acha* Farmers in Plateau State.

		Male farmers		**Female farmers**	
Regressors	**Parameters**	**Coefficients**	***Z*-ratios**	**Coefficients**	***Z*-ratios**
Efficiency model					
CONSTANT	β_0	3.805803	6.21***	-0.4553984	-5.43***
		(0.6129632)		(0.0838965)	
Farm Size	β_1	1.031941	3.61***	1.127253	2.53**
		(0.285550)		(0.4450182)	
Planting Materials	β_2	0.2252774	5.74***	0.1182612	3.99***
		(.0392643)		(0.0295739)	
Agrochemicals	β_3	0.0238197	1.20	-0.0325841	-1.42
		(0.0198651)		(0.0228733)	
Fertilizers	β_4	3.572713	4.59***	1.607982	3.38***
		(0.7776023)		(0.4753847)	
Family Labour	β_5	0.0769423	0.56	0.2851044	2.26**
		(0.1367031)		(0.1260486)	
Hired Labour	β_6	0.3993479	3.60***	0.0749595	0.34
		(0.1110194)		(0.2178615)	
Inefficiency model					
CONSTANT	∂_0	-6.670543	-7.81***	-2.795763	-6.29***
		(0.8543724)		(0.4442478)	
Age of Farmers	∂_1	0.7688135	3.63***	1.301925	3.83***
		(0.2120770)		(0.3398088)	
Education	∂_2	-0.4588408	-4.79***	-0.1949370	-2.96***
		(0.0957126)		(0.0656766)	
Household Size	∂_3	0.6308273	0.68	0.5503702	0.51
		(0.9332147)		(1.076488)	
Farming Experience	∂_4	-0.5074902	-2.16**	-0.1069136	-1.97*
		(0.3342896)		(0.0542389)	
Cooperative	∂_5	-0.6651894	-0.77	-0.4415280	-0.87
		(0.8657524)		(0.5056108)	
Credit Access	∂_6	-2.203267	-4.13***	-1.962808	-2.47**
		(0.5323513)		(0.7942693)	
Extension	∂_7	0.0893322	1.95*	-0.4211370	-0.79
		(0.0457234)		(0.5357354)	
Diagnostic statistics					
Sigma Square	δ^2	0.8989432	4.89***	0.6799803	4.13***
		(0.1837243)		(0.1644373)	
Gamma (variance ratio)	Υ	0.8564956	9.15***	0.6909554	7.68***
		(0.0935837)		(0.0899835)	
Lambda	λ	5.63774		5.29048	
Log likelihood function		-720.874		-680.943	
Likelihood-ratio test		45.49***		40.88***	
Observations		80		80	

Note: *** denotes sig. at 1%; ** denote sig at 5%; * denote sig at10%.
Figures in parentheses are standard errors.
Source: Field Survey, 2021.

Generalised likelihood ratio-tests of 45.49*** for male and 40.88*** for female farmers are highly significant at 1%. This indicates the relevance of the stochastic parametric production frontier and maximum likelihood estimator for this study. For the efficiency model, four out of the six specified variables which are: farm size, planting materials, fertilizers and hired labour significantly influenced output of male *acha* farmers. On the other hand, the variables that influenced output of female *acha* farmers were: farm size, planting materials, fertilizers and family labour.

The coefficients of farm size were positively signed and significant at 1% for male *acha* farmers output and at 5% for females. The results suggest that farm size is an essential factor in crop production as the result implies that, both male and female farmers with large farm sizes tend to produce higher output of *acha* in kg than their counterparts with smaller farm sizes. Otitoju and Enete (2014) equally found that farm size significantly and positively relates to output of crop farmers. Planting materials was highly significant at 1% and positively related with outputs of male and female *acha* farmers. The implication of the positive relationship is that the higher the quantity of *acha* seed planted in production process, the higher the output of *acha* harvested, gender of the farmers, notwithstanding. Duniya, *et al* (2013) in a study in Kaduna State affirmed that increase in planting materials result in higher output. Though, the result of this study contradicted that of Ebojei (2016) whose result showed negative relationship between seed input and output. The negative relationship between seed input and output in that study might have resulted from factors such as late planting, poor germination rate due to bad seeds and wrong spacing causing low yield.

The coefficients of fertilizer use were both highly significant at 1% and positively related with harvested *acha* output of male and female farmers. The result indicates that increase in fertilizer use by *acha* farmers boost output of the crop irrespective of gender of the farmers. Nwahia, *et al* (2020) found that as the amount of fertilizer used in rice production increases, output of rice farmers increase. The findings of this study corroborated that of Lawal (2008) who found that fertilizer use increase output of crop farmers in Niger State and therefore recommended improve use of fertilizer by farming household to improve their productivity. Hired labour was highly significant at 1% and positively signed with *acha* output of male farmers. The result implies that increase in the use of hired labour has an increasing effect on output of acha farmers. On the other hand, family was significant and positively related with female farmers *acha* output at 5%. Availability of labour or manpower serves as incentives for increase output of farmers. Hired labour was significant for male farmers possibly due to higher financial ability of the males while family labour was significant for female farmers as a result of their high dependence on family labour due to lack of financial resources. Umaru and Hassan (2018) found that positive and significant relationship exists between labour and output of *acha* in Kaduna State.

Inefficiency effects.

The influence of socioeconomic characteristics of the farmers on male and female *acha* farmers' inefficiency is also presented in Table 4. The negative signs of some of the coefficients for both gender agree with *a priori* expectations. This is because, negative relationship of a variable with production inefficiency implies that as the value of the variable decreases, level of technical inefficiency tends to decrease implying increase in technical efficiency. On the other hand, positive effect of a coefficient implies that as value of the variable increases, the level of technical inefficiency increase which indicate decrease in technical efficiency.

The coefficients of age of the male and female farmers were highly significant at 1% but positively signed with level of technical inefficiency of both gender This implies that as farmers get older, their level of technical inefficiency tend to increase, that is, their technical efficiency drops. The result of the study of Ashagidigbi (2017) affirmed that increase in age of farmers tends to enhance their level of inefficiency. Education was a significant (1%) factor which in this study negatively relates with level of inefficiency of the both male and female *acha* farmers. The negative coefficients of education suggest that as years of education of farmers increase, there is decrease in level of technical inefficiency and an increase in efficiency. This is expected as education is a factor that naturally increases farming knowledge and skills of farmers towards improved efficiency. Duniya, *et al* (2013) in their study found that level of formal education was significant and negatively related to technical inefficiency of acha farmers in Kaduna State. Though, Otitoju (2013) found that the coefficient of education was positive and significantly related with technical inefficiency of arable crop farmers in southwest Nigeria which contradict the result of the present study. The variation in the results of the two studies may be due to disparity or inequality in levels of education between north and southern Nigeria.

The coefficients of years of *acha* farming experience were negatively related with technical inefficiency and significant at 5% for males and 10% for female *acha* farmers. The implication of the negative signs is that as number of years a farmer put into farming increases, there is decrease in level of technical inefficiency, that is, increase in their technical efficiency. Experience is key in making informed decision and wise allocation of farm resources for improved productivity and efficiency. Ajibefun, *et al.* (2002) reported negative and significant relationship between farming experience and technical inefficiency. Amusa (2010) observed that farming involves a lot of risks and uncertainties, hence, years of farming experience improves farmers' skills and competencies in effective handling of day to day farming activities.

Access to credit was highly significant and negatively signed with technical inefficiency of male farmers at 1% and female farmers at 5%. The negative coefficients imply that access to credit has the effect of decreasing the level of technical inefficiency of the farmers, irrespective of gender; that is increasing their level of technical efficiency. The findings of this study conformed with that of Lawal (2008) who found that farmers' access to credit shows negative relationship with technical inefficiency of crop farmers. Though, the result of this study is at variance with that of Ebojei (2016) who found that the coefficient of access to credit had positive sign with technical inefficiency. The contradiction of the result with a priori expectation could be as a result of diversion of credit meant for farming into other non-farm activities. The coefficient of extension contacts was significant and negatively signed with technical inefficiency of male *acha* farmers but not significant with female farmers. Amusa (2014) identified lack of extension programmes directed to meet women farmers' need as major challenge of farm women in making informed decision. The negative relationship of extension contacts with male farmers' technical inefficiency suggests that the more extension visits to male farmers, the higher their technical efficiency.

CONCLUSION.

Hungry rice (a*cha*) is an important staple in Nigeria that had not received adequate research attention most especially evidence-based research on its production efficiency, input and output relationship. Hence, this study estimated gender differentials in technical efficiency of hungry rice (*Acha*) farmers using Plateau State, the highest producing state in Nigeria as case study. The result of the study showed that there exist significant differences in level of education, access to credit, extension contacts, farm size and farm output of male and female acha farmers. The computed mean technical efficiency of male *acha* farmers was 0.77 higher than that of female farmers 0.61. Empirical evidence from the results clearly showed gender disparity in technical efficiencies of the *acha* farmers. Based on the findings, the study recommended:

i. Timely and adequate provision of production inputs such as improved planting materials and fertilizer at subsidized rate to both male and female farmers to help boost their efficiency and consequently farm output.
ii. There should be specific effort by stakeholder in Nigerian agriculture to provide increased women access to land and other farm resources to alleviate the current gender disparity in access to and control over farm lands.
iii. There should be formulation of gender sensitive policies that will help to strengthen women farmers and reverse their present institutional neglect.

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Journal of Applied Agricultural Research 2022, 10(2): 15-21
ISSN 2006-750X.

ANALYSIS OF THE DETERMINANTS OF ADOPTION OF BIO-HERBICIDE TECHNOLOGY FOR SUSTAINABLE FOOD PRODUCTION IN THE NORTH-EASTERN REGION OF NIGERIA.

Adewuyi, A.K. and Gwandi, O.
Department of Agricultural Technology, Federal Polytechnic, Mubi, Nigeria.
Author's Contact: kolbetsy@yahoo.com; adewuyikola2015@gmail.com

ABSTRACT

There is a growing concern in many developing countries of sub-Saharan Africa on the harmful effects of synthetic herbicide usage on the agro-ecology as well as food crop production. Therefore, this study focused on analysing the factors that influence the adoption of Bio-herbicide Technology as an alternative to the chemical herbicides used by rural farmers in the North-Eastern region of Nigeria. Multi-stage random sampling technique was used to select 330 small-holder farmers in the study area using structured questionnaires. The data obtained were analysed using Probit Regression Model. The results of Probit Regression identified the farmers' age, educational status, farm-size, access to extension services, farming experience and membership in cooperative society as the factors which influenced adoption of the Bio-herbicide Technology by farmers in the study area. The study concludes that determinants of the adoption of Bio-Herbocide Technology age, educational status, farm size, access to Extension Service, farming experience and membership in cooperative socities. It was recommended that awareness campaign on the new Bio-herbicide Technology among farmers in the area should be intensified. The farmers' access to education and extension services should be improved to enhance adoption of Bio-herbicides technology which will impact significantly on the food production in the area. Also, farmers should be encouraged to be part of cooperative societies as a way to improve the adoption of Bio-herbicides for increased productivity.

Keywords: Adoption, Bio-herbicides, Sustainable, Food, Probit Model.

INTRODUCTION.

The need for sustainable food production and elimination of perennial hunger occasioned by the insurgency in the North-eastern states of Nigeria top the priority of Government programmes and policies. However, if activities that have the tendency of causing land degradation and environmental hazards are not properly addressed; many laudable efforts of the Government would not yield the expected results. Wrong use of synthetic herbicides is one of the major activities that have a potential threat on the environment and agricultural land. Shashidhara (2017) stressed the need for alternative methods in pest control which essentially include expanding biological agriculture and employing natural enemies to combat pests in order to lower the degree of toxicity accompanying the indiscriminate use of chemical pesticides by rural farmers. The multiplier effects of increasing use of chemical herbicides according to Saskia (2019) which include land degradation, depletion of essential soil-microbes, loss of nutrients, erosion and deposition of toxic elements in the soil etc. pose great danger to the efforts at improving food sufficiency in Nigeria, especially the North-Eastern States that have been severally ravaged by insurgent activities and communal crisis.

Many researchers have raised concern on the damaging impacts of chemical herbicides on the environment and human life (Matías et al., 2021; James et al., 2018; Sanzidur & Chidiebere, 2018; Melesse, 2018). The potential of chemical herbicide released into the environment causing harm is measured largely in terms of its toxicity and persistence. Shashidhara (2018) reported in his study of farmer's perception on ill effects of agro-chemicals in North-eastern part of Karnataka that environmental pollution affects farmlands and water supply which in turn makes them susceptible tocancer-related ailments commonly observed among most rural farmers due to excessive and indiscriminate use of chemical herbicides. Mercy et al (2016) also observed that environmental degradation factors such as climate change effects e.g. shrinking of Lake Chad, erosion, flooding, desert encroachment etc. are increasingly aiding the fast deterioration of the agriculture production resources. Joseph et al.(2018) opined that wrong handling of chemical pesticides by rural farmers in Nigeria have the tendency of damaging the natural nutrients regeneration capacity of soil as well as poor water retention efficiency of the farmlands. James et al. (2018) noted that weed management is essential for agricultural production and management of landscapes. They noted that proper weed management which involves mass production of microbes applied as bio-herbicides to suppress weeds is a promising alternative to chemical herbicide for the preservation of the environment.

The adoption of modern agricultural technologies by rural farmers has been shown to be influenced by some major factors. Melesse (2018) identified farm size as a factor that significantly affect the adoption of different agricultural innovations and technologies by rural farmers in developing countries. Thomas et al (2017) also reported in their study of the factors influencing the adoption of improved Rice Varieties (Nerica) in the Northern Region, Ghana, that farm size represented a very significant factor. Moreover, membership in farming association such as cooperative societies has been observed to play a major role in the adoption of modern agricultural technologies.(Dhraiefa et al., 2018; Ogochukwu & Okafor, 2017). The introduction of new farming technology is desirable for improved productivity and efficiency. Matías et al. (2021) noted that the utmost concern of farmers is usually the increase in the farm yields. However, many rural farmers are generally influenced by an array of certain important factors which critically determine their level of adopting new farming techniques. Therefore, this study is focused on analysing the factors that influence the adoption of Bio-herbicides by farmers, as alternatives to toxic chemical herbicides, to enhance sustainable food production in the North-east, Nigeria.

METHODOLOGY.

The Study Area.

The study was carried out in the North-Eastern Region of Nigeria which comprises of Adamawa, Borno, Yobe, Bauchi, Taraba and Gombe State. This research is focused only on three States from the region namely; Adamawa State, Borno State and Yobe States. These three States have high records of land degradation and desert encroachments coupled with negative impacts of insurgent activities especially by Boko-Haram and

Fulani-herders-men/Farmers clashes (Saskia, 2019). These three states are notably agrarian with farmers growing cereal crops such as maize, guinea corn, cowpea, groundnuts, millet etc. animal husbandry is also predominant in Adamawa State mostly among the Fulani dwellers. The Northern States, which are substantially rural and having less exposure to education, experience more poverty than other parts of the country. The inhabitants are predominantly peasant farmers, though few are cattle herdsmen. North-East occupies slightly less than one-third of Nigeria's total area and had a projected population for 2011 of 23,558,674 or 13.5% of the country's population. The inhabitants are mainly Fulani with only Borno State has Kanuri people as majority with more than 100 minority ethnic groups. Adamawa State is located at the northern part of Nigeria. It shares with Taraba State in the south and west with Gombe State in North-West and Borno Statee to the North. The State has an international boundary with Cameroun Republic along its eastern side.

Sampling Technique.

Primary data for this study were collected through the use of structured questionnaires. The questionnaires were distributed by enumerators using a multi-stage sampling survey for the study. The first stage involved random sampling of three Local Government Areas each from Adamawa State, Borno State and Yobe State within the North-Eastern region of Nigeria. Second stage involved the random sampling of four wards from each of the 9 Local Government Areas sampled in the three selected States. Thus, a sum of 36 Wards were randomly sampled and ten (10) farmers were selected from each of the Wards to give a total sample size of three hundred and sixty (360). At the end of the survey, three hundred and thirty (330) properly filled questionnaires were returned and used for the analysis.

Analytical Framework.

Probit Regression Model was used to evaluate the determinants of adoption of the Bio-herbicide technology among farmers in the area. The Probit Regression model has been widely employed by many researchers to evaluate the functional association among the probability of decision and its determining variables (Agnieszka et al., 2020). The probit model assumes variable Yi as binary with only two possible outcomes (1 for adoption and 0 for non-adoption). It also considers a vector of explanatory variables xi which explains Yi.

The empirical specification of the probit model for the study is given as follows:

$$Yi = \beta_0 + \sum_{n=1}^{0} \beta_n X_{ni} + u_i$$

Where

Xi represents a vector of explanatory variables, u_i is a random disturbance term, n is the total sample size, and β is a vector of unknown parameters to be estimated by the method of maximum likelihood.

Hence, Yi = Adoption of Bio-Herbicides = (1 if farmer adopted, 0 otherwise); X1 =Age; X2 = Marital status; (1 if farmer is married, 0 otherwise); Gender (1 for Male farmer, 0 otherwise); X3 = Household Size; X4 = Education; X5 = Farm Size; X6 = Farming Experience (Years); X7= Access to Extension Services (1 for Access to Extension Services, 0 otherwise); X8 = Access to credit; (1 if farmer had access to credit, 0 otherwise); X9 = Membership of Cooperative Society (1 if farmer belong to Cooperative Society, 0 otherwise).

RESULTS AND DISCUSSION.

Determinants of Adoption of Bio-herbicide Technology by Farmers in the Area.

The results of the Probit regression analysis revealed that the factors which influenced the adoption of Bio-herbicide technology among the farmers in the North-Eastern Region of Nigeria include the age of the farmers, educational status, farm size, their access to Extension Services, farming experience and their membership in Cooperative Societies. The findings showed that age of the farmers, educational status, farm size and their access to Extension Services were identified as having statistically significant influence on the adoption of the Bio-herbicide Technology by the farmers in the study area at 1% level of significance. In addition, at a 5% significance level, farming experience and their membership in Cooperative Society also influence the farmers' decision in adopting the new technology.

Age of the farmers was identified from the result of the study as an important determinant of adoption of the Bio-herbicide technology in the area. This result supports the similar report obtained by Thomas et al. (2018) that age of farmers is an important factor that influences the probability of adoption of new technologies because it is said to be a primary latent characteristic in adoption decisions. The study further showed that the level of farmer's education plays a major role in determining the attitude of the farmers towards adopting the Bio-herbicide technology. The result indicates a statistically significant relationship between the farmers' education and the adoption of Bio-herbicide technology. This report corroborates the findings of Melesse (2018) who identified the farmers' access to formal education as an important factor that influences the adoption of Agricultural new technologies by farmers in Ethiopia. Sanzidur and Chidiebere (2018) also observed that educational level of farmers is critical in decision making process in adopting new farming techniques. Farmers' access to education will enhance efficiency in receiving and interpreting major information on new agricultural practices.

Moreover, the size of the farmland used by the farmers was also shown to have a positive and significant influence on the adoption of the new technology. This implies that farmers with larger farm sizes were ready to adopt the technology more than those with smaller plots. Generally, commercial farmers have greater capacity to take risks than peasant and subsistent farmers. The result agrees with the report of Thomas et al. (2018) who observed that the farm size played a major role in the adoption of Improved Rice Varieties (Nerica) in the Northern Region, Ghana. Another factor identified in the study as influencing the adoption of Bio-herbicide technology in the area is the access to extension services by the farmers. Extension service is a crucial institutional factor that differentiates adoption status among farmers as equally noted by Melesse (2018). Extension services creates a platform for the acquisition of relevant information on the new agricultural technologies. The result revealed that there is a positive and significant relationship between the access to Extension Services by the farmers and the adoption of the Bio-herbicide technology. It implies that the more access the farmers have to Extension Services, the better the attitude towards adopting the Bio-herbicide technology in the study area. Moreover, the study showed farming experience of the farmers as another important factor that determined the adoption of Bio-herbicide Technology by the farmers in the area. The result showed that the more years of their experience in farming, the higher the probability of adoption of the new technology. Also, their membership of cooperative societies was identified as a significant factor which influenced the decision of the farmers towards adopting the Bio-herbicide

Technology. Consequently, the formation of cooperative societies provides an added advantage to the farmers in taking corporate decisions on issues that would improve their productivity. Similar result was obtained by Dhraiefa et al. (2018) who identified the farmers' membership in association as a critical factor which significantly influenced their adoption of new farming technologies. Ogochukwu & Okafor (2017) also reported that membership in cooperative societies is a significant variable to be considered in determining the decision of farmers to adopt new technologies.

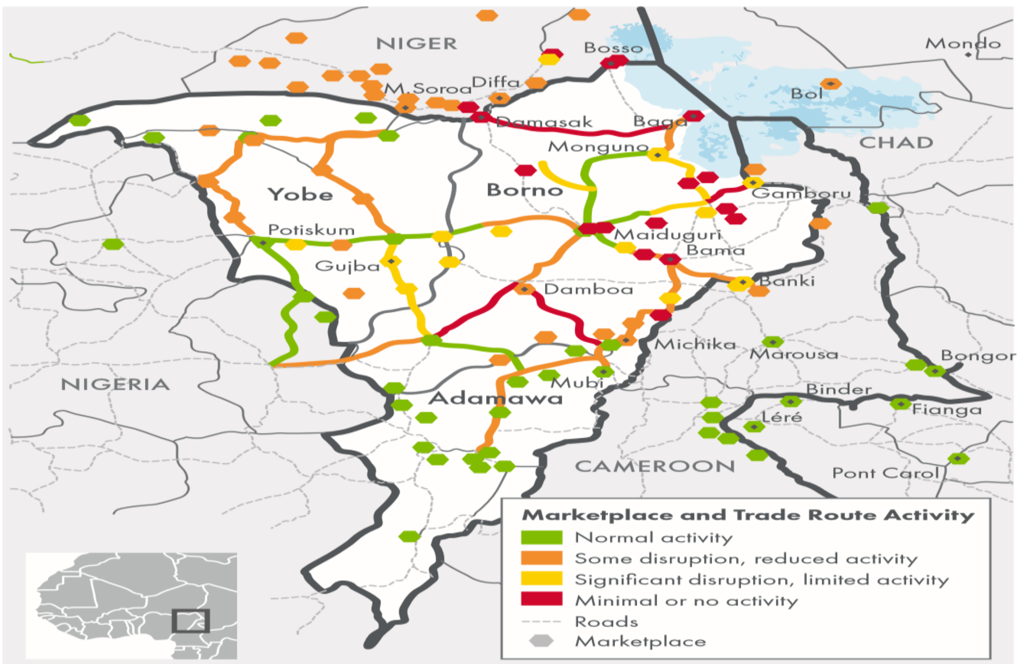

Figure 1: Map showing the Study Area.

Table 1: Determinants of the Adoption of Bio-Herbicides by Farmers in the Study Area.

Variable	Coefficient	Standard Error	Z-Statistic	P-Value
Age	-0.201857	0.042283	-4.773945	0.0000 *
Marital Status	-0.166895	0.109739	-1.520831	0.1283
Household Size	-0.007683	0.083502	-0.092008	0.9267
Education Level	2.366165	0.840941	2.813712	0.0049 *
Farm Size	2.998871	0.960444	3.122379	0.0018 *
Farming Experience	0.760099	0.358506	2.120184	0.0340 **
Extension Service	2.858395	0.607396	4.705984	0.0000 *
Access to Credit	0.131725	0.243569	0.540812	0.5886
Membership of Cooperatives	1.376817	0.633800	2.172322	0.0298 **
McFadden R-squared	0.743352			
Sum squared residue	16.59865			
Log likelihood	-57.47980			

Source: Field Survey, 2021.
* Significant at 1%; ** Significant at 5%;

CONCLUSION AND RECOMMENDATIONS.

The study has shown the various factors that have significant effects on the readiness of the farmers in the study area to adopt the Bio-herbicide technology as alternative method for weed control instead of using the mostly harmful synthetic chemical herbicides. The study concludes that the determinants of the farmers' adoption of the new technology according to the results of the study include age of the farmers, educational status, farm size, their access to Extension Services, farming experience and their membership in Cooperative Societies.

Therefore, it is recommended that an awareness campaign on the new Bio-herbicide Technology among farmers in the area should be intensified. Furthermore, the farmers' access to formal education should be improved, especially through adult literacy programmes as this will positively influence their adoption of new technology thereby enhancing their productivity. Moreover, the need to raise the farmers' access to Extension Services should also be stressed as it has been shown as a critical factor which influences the rate of the adoption of new technology by the farmers. Also, the need for the farmers to be part of cooperative societies in their farming communities should be emphasized. This will encourage useful all-inclusive decisions with concerted efforts towards increased food production in the area.

ACKNOWLEDGEMENT.

This research was sponsored by The Tertiary Education Trust Fund (TETFUND). Their support and contributions towards the successful execution of this research is thereby recognized.

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Journal of Applied Agricultural Research 2022, 10(2): 22-27
ISSN 2006-750X.

ANALYSIS OF THE RELATIONSHIP BETWEEN CASSAVA PRODUCTIVITY AND ADOPTION OF INTEGRATED SOIL MANAGEMENT PRACTICES IN OSUN STATE

L.K Olatinwo AND [2]M.J Wahab
[1]Department of Agricultural Economics and Extension, Kwara state university, Nigeria.
[2]Department of Agricultural Economics and Extension, Bayero University, Kano, State, Nigeria
Author's Contact: latifat.olatinwo@kwasu.edu.ng

ABSTRACT.

The study analysed the relationship between cassava productivity and adoption of integrated soil management in Osun, State, Nigeria. Primary data were used for the study and was collected with the aid of structured questionnaire. Multi-stage random sampling procedure was employed to select 120 cassava farmers for this study. The data collected were analyzed using descriptive and inferential statistics. The result of the study revealed that majority (81%) of the cassava farmers were males, 38% of the cassava farmers have secondary school education while 43% of the cassava farmers adopted the use of inorganic fertilizer and other methods which were either of shifting cultivation, crop rotation or bush fallowing, while (4%) of the respondents adopted all the soil management practices in the study area. There was a negative relationship between integrated soil management practices and output from cassava production. The study recommended that incentives be given specifically for women to participate more in cassava production in the study area.

Keywords: Integrated, soil management, cassava, and production.

INTRODUCTION.

Every nation attempts to address prevalent issue of food security. Agriculture provides food for the teeming population in Nigeria and contributes about 33% to the gross domestic product (GDP) of the nation (Bureau of African Affairs, 2010). The sector employs about one third of the total labor force and provide a livelihood for the bulk of the rural populace (FMARD, 2006). Land use in Africa nation predominantly Nigeria has been characterized by significant amount of land degradation which is caused by human activities through various soil management practices. Many poor African pastoralists and farming households responds to declining land productivity by abandoning existing pasture and crop land, and moving to a new land for grazing and crop production. Most farmers in developing countries, who are low income earners cannot afford to buy land, hence manage their soils and cropping systems to obtain better crop yields through proper use of soil conservation practices.

Cassava (*Manihotesculenta*) is cultivated mainly in the tropic and sub-tropic regions of the world, over a wide range of environmental and soil conditions. It is very tolerant of drought and heat stress and produces well on marginal soils. Nigeria was the largest producer of the crop with 45,721,000, 43,410,000, and 44,582,000 million in 2006, 2007 and 2008 respectively. About 90% of this is however, consumed as food (Awoyinka, 2009). Nigeria is yet to fully harness the socio-economic potentials of Cassava that would translate to higher ranking of Cassava next to petroleum as major contributor to the Gross Domestic Product (GDP). For this to be achieve Cassava farmers production efficiency and profit margins needs to be established in Nigeria. Cassava crop is one of the most important carbohydrate sources (Awoyinka, 2009). The large population of Nigeria depended on Cassava daily as their main dish such as *gari* and *fufu*, the leaves are consumed as vegetable, and it serves as raw material to industries as well as been a means of alleviating poverty (James *et al*, 2011).

The two important aspect of soil management are soil conservation and soil fertility management, thus soil conservation entails anything to prevent the soil from damages, which can be through erosion, soil acidification, and distortion of bio diversity (FAO, 2009). Soil fertility management involves the ability of the farmers to supply nutrients for optimum crop growth. Based on the poverty among rural farmers, these had led to the unimpressive performance of agricultural sector, thus resources must be used more efficiently, thereby eliminating waste, also leading to increase in farmers income Simonyan *et al*. (2010). One of the most severe threats to the sustainability of agricultural crops production in Nigeria is declining productivity as a result of the loss of soil fertility. Simonyan *et al*. (2010) stated that Nigerians are poor and hungry despite efforts made by various governments in improving agricultural productivity and efficiency of the rural farmers who are the major stakeholders of agricultural production. The performance of small holder farmers in Nigeria is observed to be unsatisfactory. The agricultural sector of Nigeria has failed to keep pace with the demand of households and industries for farm produce as food or raw materials (Nwaiwu *et al*., 2010). Despite the involvement of many rural farmers in the agricultural production, several odds however still work against their efforts to produce abundant food for the nation and live a better life. One of the odds is attributed to the fluctuation in market prices as a result of the demand factors (Mohammed and Achem, 2010), thereby, resulting to food insecurity. It was revealed that 80% of Nigerians in the rural areas eat a cassava meal at least once a day; hence it plays a major role in the country's food security. It is therefore important to study the small holder farmers who contribute to high bulk of production of this staple crop. The main objective of this study was to analyse the relationship between cassava productivity and the adoption of integrated soil management practices in Osun State. The specific objectives are to describe socio-economic characteristic cassava farmers in the study area, identify soil management practices among cassava farmers in the study area, and determine the relationship between soil management practices and output of cassava farmers in the study area.

MATERIAL AND METHODS.

Study Area.

The study was conducted in Osun state. The state is located in southwest Nigeria, it lies between latitudes 7.05^{o} N and 8.10^{o} N and longitudes 4.05^{o} E and 5.15^{o} E. It covers a total area of approximately 14,875km^2 while the land area is about 9,251km^2. Agricultural sector forms the overall thrust within the state with human population of about 3,416,959(NPC, 2006). The people in the state are mostly farmers producing food crops such as yam, maize, cassava, cowpea, cocoyam, okra, pepper, garden egg, groundnut and a number of cash crops such as cocoa, coffee, kola, cashew, and oil palm (NPAFS, 2009). There are two distinct climate seasons which are rainy season which exists from March to October and dry season from November to early march. Annual rainfall average is 1570mm while temperature ranges from to $27.5^{0}C$. Rainfall ranges between 900 and 1600mm annually and humidity between 85 and 95% (Mathew et al, 2015).Data used in this study were obtained from primary sources. Information was collected with the aid of structured interview schedule.

Sampling Procedure.

The sampling technique used for this study was multi-stage sampling procedure. The first stage involves purposive selection of three (3) Agricultural Development Programme (ADP) zones of the state, due to Administrative block arrangement. The second stage involves purposive selection of three (3) wards from each of the ADP zones due to high concentration of cassava farmers. The third stage involved random selection of (15) cassava farmers each from the selected wards, finally to make a total of 135 respondents, out of the 135 respondents, 15 were invalid making a total of sample size of 120 for this study. The ADP zones are Iwo, Osogbo, and Ife-Ijesha. The selected wards were Iwo,Masifa and Ejigbo from Iwo ADP zones, Obokun, Otan-ile, and Imesi-ile, were selected from Osogbo ADP zones, while Oyan, Igbaye and Okuku were selected in Ife-ijesha zone of the state.

Analytical Techniques.

Data for this study were analysed using descriptive and inferential statistics. Descriptive statistics were used to analyse socio-economic characteristics and integrated soil management practice in the study area, while Person's moment correlation analysis was used to analyse the relationship between output and integrated soil management practices in the study area.

RESULTS AND DISCUSSIONS.

Socio-economic Characteristics of Cassava Farmers.

Table 1 shows that majority of the cassava farmers in study area (80.83%) were male, while (19.17%) of the cassava farmers were female, this shows that most males were into cassava production than their female counterparts. Majority of the cassava farmers (31.67%) are within the age bracket of 47-57 years. About (25.0%) of the cassava farmers are within the range of 25-35years.About (20.83%) of cassava farmers are within the range of 36-46years.About (12.50%) of the cassava farmers are within 58-68 years and (10.0%) of cassava farmers are between the ranges of 68-78years. The mean age is 41years. Table 1 shows that majority of the cassava farmers (76.67%) are married. About (8.33%) of cassava farmers are single. About (15.0%) of cassava farmers are either separated or divorced. Table 1 below shows that majority of cassava farmers (51.67%) are involved in trading. About (29.17%) of cassava farmers are farmers .About (15.83%) of cassava farmers are artisans. About (8.33%) of cassava farmers are farmers. About (3.33%) of cassava farmers have no secondary occupation. Table 1 shows that majority of the cassava farmers in the study area (37.50%) have secondary education. About (28.33%) of the cassava farmers have primary education. About (25.0%) have tertiary education. About (9.17%) of the cassava farmers have no formal education. Table 1 also shows that majority of cassava farmers (54.17%) belong to cooperative society or farmers association, while (45.83%) of the cassava farmers did not belong to cooperative or farmers association. Table 1 shows that majority of the cassava farmers (32.50%) have farming experience between 11-20years.About (26.67%) of cassava farmers have farming experience between 21-30years.About (25.00%) of the cassava farmers have farming experience between 1-10years. About (15.83%) of cassava farmers have farming experience between 31-40years.The mean farming experience is 19 years, which implies most of the farmers have enough farming experience in the study area. Table 1 shows that majority of cassava farmers (55.83%) have a household size between 6-10.About (40%) of cassava farmers have a household size between 1-5.About (4.17%) of cassava farmers have a house hold size between 11-15.thus the mean household size is 6 persons, which implies cassava farmers with large household size can make use of family labour to reduce the cost spent on labour during production in the study area.The findings from this study agrees with Awoyinka (2009) and James *et al*. (2011) that cassava production was mostly dominated by male farmers, with mean age above 40years.

Soil Management of Cassava Farmers in the Study Area.

The results in table 2 shows the integrated soil management practices adopted by cassava farmer in the study area. Majority (42.5%) of the respondents adopted the use of inorganic fertilizer and other methods such as shifting cultivation, crop rotation, and bush fallowing. About (15.83%) adopted the use of organic and inorganic fertilizer, about (9.17%) adopted the use of organic manure and cover cropping. About (5.83%) adopted the use of inorganic, organic and intercropping with legumes such as soybean and cowpea. About (6.67%) adopted the use of inorganic and cover cropping system. About (5.0%) adopted the use of organic and intercropping with legumes. About (4.17%) adopted the use of all the soil management practices. About (2.5%) adopted the use of inorganic fertilizer and intercropping with legumes. The result from this study disagrees with Nwaiwu *et al*. (2010) that discovered that the use of inorganic was the common soil management practice by cassava farmers in Imo state.

Relationship between Soil Management and Output from Cassava Production.

Table 3 shows that there is a negative relationship between soil management practices and the output of cassava, thus it implies that the soil management practices adopted do not determine the output of cassava in the study area. The result from this study is similar to that of James *et al.* (2011), who discovered that the output from cassava production does not really depends on the type of production practice adopted by farmers in the study area.

CONCLUSIONS AND RECOMMENDATIONS.

Majority of the cassava farmers are males, there was a negative relationship between soil management practices and output from cassava production in the study area, and it implies the type of soil management practice adopted does not determine the level of output from cassava production. Majority of the respondents adopted the use of inorganic fertilizer and other methods such as shifting cultivation, crop rotation than any other soil management practices in the study area. Government should set better land policies to promote a domestic cassava production policy that favours farmers on land utilization and management. Extension agents should try to educate the women and young individuals on the potentials of the use of integrated soil management in cassava production, because it can be observed in the study that females are less involve in cassava production under integrated soil management practices.

Funding: This study received not specific funding.

Competing interests: The Authors declare that they have no competing interest.

Acknowledgement: All authors contributed to the conception and design of the study.

Table 1: Socio-economic Characteristics of Cassava Farmers in the study area.

Variables	Frequency	Percentage	Mean
Sex			
Male	97	80.83	
Female	23	19.17	
Age			
25-35	30	25.00	41.00
36-46	25	20.83	
47-57	38	31.67	
58-68	15	12.50	
69-79	12	10.00	
Marital status			
Single	10	8.33	
Married	92	76.67	
Others	18	15.00	
Level of Education			
None	11	9.17	
Primary	34	28.33	
Secondary	45	37.50	
Tertiary	30	25.00	
Farming Experience			
1-10	20	16.67	
11-20	14	11.67	19.00
21-30	28	23.33	
31-40	58	48.33	
Household size			
1-5	48	40.00	
6-10	67	55.83	6.00
11-15	5	4.17	
Total	**120**	**100**	

Source: ***Field survey, 2016***

Table 2: Distribution of respondents according to their integrated soil management practices.

Soil management practices.	Frequency.	Percentage (%)
Inorganic ,organic	19	15.83
Organic, inorganic, cover cropping	10	8.33
Inorganic,organic,intercropping	7	5.83
Inorganic fertilizer, others	51	42.5
Inorganic, cover cropping	8	6.67
Organic, cover cropping	11	9.17
Organic, intercropping	6	5.0
Inorganic ,intercropping	3	2.5
Inorganic,organic,intercropping,cover cropping, others	5	4.17
Total	120	100

Source: ***Field survey, 2016***

Table 3: Results of Pearson moment correlation analysis.

Variable	Coefficient	p-value
Output of cassava	-0.1165	0.2052

Source: ***Field survey, 2016***

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Journal of Applied Agricultural Research 2022, 10(2): 28-36
ISSN 2006-750X.

DETERMINANTS OF ADOPTION OF SOIL AND WATER CONSERVATION PRACTICES AMONG ARABLE CROP FARMERS IN OYO STATE, NIGERIA.

Adebanjo, O. A[1], Ladapo, H.L.[2], Hassan, T.I.[3], Mohammed H.[4], Saibu O.F.[5], and Iyiola, T.O[6],
[1,3,4,5,6] Department of Agricultural Technology, School of Technology, Yaba College of Technology, Lagos State, Nigeria.
[2] Department of Agricultural and Bio-Environmental Engineering, School of Engineering, Yaba College of Technology, Lagos State, Nigeria.
Author's Contact: olabisi508@gmail.com, Tel no: 07064989905

ABSTRACT.

Protecting soil and water resources against degradation is necessary for life, vital for continued food productivity, regenerative ecosystem services, and maintenance of biodiversity. This paper examined the determinants of adoption of soil and water conservation practices (SWCPs) among arable crop farmers in Oyo State, Nigeria. Data were collected from 80 respondents with the aid of a well-structured questionnaire using multi-stage sampling procedure. Data were analysed using descriptive statistics and logit regression model. The mean age of the respondents was 44years, with mean household size of 7persons, majority (53.8%) of the farmers were male. Few (35%) of the farmers had primary education, many (43.8%) cultivated on leased/rented farmland with mean farm size of 3.2hectares and 12years of farming experiences. Furthermore, majority (71.3%) of the farmers were aware of SWCPs, while (66.3%) adopted them, (70%) had contact with extension agents. Crop rotation (63.8%) and minimum tillage were the common SCWPs used in the study area. The logit regression revealed that farm size ($p<0.05$), farming experience ($P<0.05$), mode of land acquisition ($p<0.05$) Contact with extension agent ($p<0.05$) and access to credit facilities ($p<0.01$) were the significant determinants of adoption of SWCPs in the study area. Based on the findings of the study. It was concluded that farming experience, farm size, mode of land acquisition, contact with extension agent and access to credit facilities were the major determinants of SWCPs 'adoption in the study area. The study therefore recommended that, the continuous use of SWCPs should be encouraged among arable crop farmers, in order to protect the state of the soil (availability of beneficial soil organisms) thereby increasing their productivity a yield/profit of farmers production.

Keyword: determinant, adoption, water conservation, arable crop farmers

INTRODUCTION.

Land degradation due to biophysical factors requires that priority action is given to land reclamation and soil conservation and to activities intended to increase agricultural production. Flood, drought, climate change and the hazardous soil erosion threatens agrarian societies with a loss in productivity and by undermining long-term land management strategies and livelihoods. Erosion reduces soil health and arable land, producing a multiplicity of negative consequences for farmer communities worldwide (Ananda and Herath 2003). In Africa, soil erosion is the leading cause of land degradation, contributing to loss of crop production, a decrease in biodiversity, food and livelihood insecurity, siltation of waterways, shortage of fodder, and reduction of livestock. productivity (Haileslassie et al., 2005; Mengistu 2006; USAID 2008; Juying 2009; Yisehak et al., 2013). Soil erosion and water runoff are natural events, clearly observed on unleveled ground and areas where vegetation is scarce or absent. In the last 40years, nearly one-third of the world arable land was lost by soil erosion and continues to be lost at the rate of more than10 million hectares per year (Assefa, 2009; Penning DeVries etal., 2008). Water erosion commonly occurs in the form of rain, entrainment and channeling, and flooding. Fortunately, the rate at which erosion and water loss occur can be reduced significantly with appropriate adoption and application of SWCPs technologies (Wolka, 2014). Department of Soil Conservation and Watershed Management (DSCWM, 2004) defined Soil and water control technologies as a reasonable use of land resources, implementation of erosion control systems and practice of suitable cropping patterns to increase soil fertility and reduce land degradation and thereby ameliorate livelihoods of the local communities. Thus, adoption of soil conservation technology reduces soil erosion and soil loss, and also results in increasing quality and quantity of agricultural products thereby increasing household food security. The adoption of agricultural innovation is very important in development of the farmer, the communities and the country as a whole, as agriculture is seen as a way out of poverty, so is the rate of adoption of agricultural innovation. Bandiera and Rasul (2005) discovered that agricultural innovations are often adopted slowly and several aspects of adoption remain poorly understood. The poor level of adoption of soil and water conservation practices is common in the developing countries .Several studies have identified various factors that contributed to the low level of adoption of an innovation, among which are in adequate information on the technical know-how of the innovation, in-adequate extension services, poor linkages with research teams, illiteracy, poor transportation and communication networks. All these are considered as potential explanations for the determinant of adoption. This therefore gave the impetus to this study. Specifically, this study sought to identify the various SWCPs used in the study area, factors influencing choice of methods adopted, socio-economic determinant of adoption of SCWPs and the limitations to adoption of SWCP sin the study area.

MATERIALS AND METHODS.

The study was carried out in Oyo State. Oyo is an inland state in south-western Nigeria, with its capital at Ibadan. It is bounded in the North by Kwara State, in the East by Osun State, in the South by Ogun State and in the West partly by Ogun State and partly by the Republic of Benin. Oyo State covers approximately an area of 28,454 square kilometers and is ranked 14th by size. It has a total population of 5,580,892 (Census, 2006). The Climate is equatorial, notably with dry and wet seasons with relatively high humidity. Average daily temperature ranges between 25 °C (77.0 °F) and 35 °C (95.0 °F), almost throughout the year. Agriculture is the major occupation of the people of Oyo State. The climate of the state favours the cultivation of crops such as maize, yam, cassava, millet, rice, plantain, cocoa, palm produce, cashew etc. Multi-stage sampling technique was adopted in this study. First stage involved the Purposive selection of two (2) local government areas from the study area, second stage, involved random selection of 20% of the wards from each of the local government areas selected, which gives ten (10) wards. Stage three entailed convenience selection of eight (8) respondents from each ward which formed a total of 80 (eighty) respondents which constitute the sample size of the study .Data collected were subjected to descriptive statistics and Logit regression model. Specifically, logit regression was employed for the determination of the socioeconomic factors influencing the adoption of organic farming. The following equation shows the logit regression model for this study.

$Z=1n\ p/1\text{-}P = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8$

Where

Z = Probability of adoption

B_0= Coefficient of explanatory variable which increase or decrease

X1= Age (in years)

X2= Sex (male or female)

X3= Educational level (years spent in school)

X4=Marital status

X5= Household size (No of people)

X6= Farming experience

X7= Farm size

X8= labour type

X9= mode of land acquisition

X10= monthly income (₦)

X11= Extension contact

X12= access to credit

E = Error term

RESULTS AND DISCUSSION.

Socio-economic characteristics of the respondents.

The socio-economic characteristics of the respondents as illustrated on table 1 reveals that majority of the farmers were male (53.8%), This implies that, male gender were more likely to uptake farming as an occupation than female in the study area. Most (40%) of the respondents fell between the age range of 41-50years, the average age of the respondents was 40yearst. This implies that the population was made up of middle age farmers who are still agile and active for agricultural practices. Majority (73.8%) of the sampled respondents were married with a mean household size of 7 people. The result further revealed that 21.3% of the respondents had no formal education while most (35.0%) had primary education and few (8.7%) with tertiary education. This implies that the educational level of the respondents is low and could affect their rate of adoption of new technology or poor understanding/acceptance of an innovations. This is in consonance with Adeniyi and Akande, (2015) who opined that education is considered highly necessary in the adoption of new technology and the various technical operations involved in the use of mechanized farming systems. Contrary to this, Eleni (2008); elaborated that illiterate farmers are better to be involved in the use of SWCP than educated farmers who are usually engaged in other off-farm activity. Many (36.3%) of the farmers had a farm size ranging from 2.1-3 hectares, the average farm sizes of the respondents were 3.2hactares. The farm size may be as a result of the farmers age and other off- farm activities which were expected to influence the adoption of SWCP. This is corroborated with the findings of Fikru (2009); and Eleni (2008), who affirmed that farm size is associated positively and significantly with the adoption of introduced soil and water conservation practices. Furthermore, the results on table 1 reveals that the average Farming experience of the farmers was 12years and the methods of land acquisition were through rent (43.8%) and inheritance (38.8%). It is expected that the numbers of years an individual has been farming will influence their decision making in adoption of an innovation vis-à-vis method of land acquisition. Also, majority (55.0%) of the respondents used hired labour. The average monthly income of the farmers was ₦88,735.52. The average monthly income negates the assertion of Ekong, (2003) that farming was apart time activity, it indicates that most of the respondent's practices agriculture on large scale (commercial) rather than for sustenance. Table 1 also indicates that extension visits/services was adequate and regular in the study area, about (70.0%) at fortnight intervals (58.8%). This implies that the function of the extension service in the study area will facilitates the identification, integration and diffusion of relevant knowledge thereby bring about emergence of sustainable practice.

Awareness and Adoption of SWCPS.

Results on Table 2 revealed the extent of awareness and adoption of SWCPs. Majority, (71.3%) of the farmers were aware of SWCPs and 66.2 percent adopted the practices, while 56.3 percent were still using them but 23.8 percent discontinued the use of SWCPs. Rogers. (2003) have shown that an individual may decide to adopt an innovation based on the attribute of such innovation and also based on the needs of such individual. However, discontinuance tends to occur depending on the support for adoption of the innovation and the attitude of the individual. The discontinuance may be a replacement discontinuance whereby an individual rejects the innovation to adopt a better innovation or disenchantment discontinuance whereby the individual rejects the innovation because he or she is not satisfied with its performance. Another reason for this type of discontinuance decision may be that the innovation does not meet the needs of the individual or too complex to use by the individual.

Among the various methods of SWCPs Crop rotation, minimum tillage, mulching, organic matter and cover cropping were the major SWCPs adopted in the study area with 63.8%, 58.8%, 53.8 52.5% and 51.3% respectively. This is an indication that the farmers are adequately informed on SWCPs. Crop rotation among others is known to break the cycle of pest breeding and concentration. The practice also acts to improve soil fertility and crop productivity (Overstreet and Hughues 2009, Zinati 2002).

Factors influencing choice of SWCP Adopted by the farmers.

Result on Table 3 revealed the factors influencing choice of SWCP Adopted. Among the variables listed years of farming experience ($\bar{x}$=2.65) farm size ($\bar{x}$=2.60) and crop type ($\bar{x}$=2.58) were the prominent factors influencing the respondent's choice of SWCP adopted in the study area. This could be as a result of the mode of land acquisition as listed on Table 1 that many of farmers (43.8%) cultivated on a Leased land therefore, the finding negates the findings of (Moses, 2016) who stated that size of land does not influence adoption. Those with big land sizes may adopt to increase on their production by adopting techniques such as 5/9 seed holes, mixed cropping and biodiversity.

Determinants of Adoption of SWCPs in the study area.

Table 5 shows the result of the Test of association between of Socio-economic Characteristics and adoption of SWCP. Logit regression analysis was used to determine the effect of a number of socio-economic variables on the adoption of SWCP. The variables include: age, religion, household size, income, farm size, farming experience etc. A likelihood ratio test of overall significance of the logit regression model gave calculated Chi-Square of 68.02(p<0.0 5). The coefficients of multiple determinations ($R^{2)}$ – value of 0.643, which indicates that the factors in the model account for only 64.3% of the variation. Among the explanatory variable in the model, mode of land acquisition, farming experience, farm size, contact with extension agents and access to credit had significant effect on adoption of SWCP (p<0.05) in the study area. The mode of land acquisition and farm size were strong determinants in the adoption of any agricultural technology. The availability of land may spur the adoption of agricultural technology. Conversely, farmers whose mode of acquisition is by purchase have high probability of getting to continue an adoption, compared to farmers who are cultivating on leased land. On the other hand, ownership of a large expanse of land can facilitates experimentation with new agricultural technologies and also determines the pace of adoption as large land owners are more likely to be early adopters. Considering the respondents farm size on Table 1, it shows that respondents practices commercial farming thus adopting SWCPs is essential and necessary for ensuring high level of productivity and profitability. This research finding is in line with Fikru (2009); Eleni (2008); Million and Kassa (2004); Abera (2003) they affirmed that farm size is associated positively and significantly with the adoption of introduced soil and water conservation practices. The finding however, negates the findings of Habtamu (2006) and Budry et., al (2006) who asserted a negative and significant relationship between farmland size and the decision to retain soil and water conservation practices. Because most farmers who cultivate large farm sizes are old aged farmers (in this study farmers average age was 40years and not old).

Farming experience was also found to be positively significant ((p<0.05)) with the adoption of SWCP. This implies that older farmers were more acquainted in crop production, and it enhances their ability to make accurate and meaningful decisions in order to increase productivity as well as manage production/market risk. This is corroborated by the findings of Mejeha and Nnana (2010) who stated that experience offers farmers with opportunities to be acquainted with information on technology, input sources and markets outlets.

Furthermore, contacts with extension service agents was also positively significant, this is in line with the apriori expectation, that extension service providers identify problems faced by farmers and immediately help or try to proffer solution. This is in line with the finding of Adebanjo et.al (2020) who attested that extension agent has intensified their effort in the mobilization, integration and diffusion of relevant knowledge (modern agriculture) to local farmers so that new sustainable practice or innovation are fully adopted.

Access to credit facilities was also statistically significant (p<0.01). farmers access to credit facilities was expected to positively influence SWCPs adoption in the study area. This implies that a unit change in access to credit facilities by farmers will likely decrease the probability of farmers' adopting SWCP. Most of the farmers in the study area used credit for other purposes other than crop production. Furthermore, the high-interest rate might intimidate farmers from taking a loan, as stated by Njuguna and Nyairo (2010).

Constraints of SWCPs Adoption in the study area.

Results on Table 4 explain the constraints militating against the adoption of SWCP in the study area. A 4-pointLikert scale was used. Value of the discriminating index was calculated :(4+3+2+1)/ 4= 2.5. Thus, the value greater than or equals to 2.5 indicate that

Table 1: Socio-economic characteristics of the respondents.

Characteristics	Frequency (n=80)	Percentage (%)	Mean
Gender			
Female	37	46.3	
Male	43	53.8	
Age range (years)			
≤ 30	11	13.8	
31- 40	28	35.0	
41-50	32	40.0	
51 Above	9	11.2	**40years**
Marital status			
Single	7	8.8	
Married	59	73.8	
Divorced	7	8.8	
Separated	3	3.8	
Educational status			
No formal	17	21.3	
Primary	28	35.0	
Secondary	18	22.5	
Tertiary	7	8.7	
Adult/vocational	10	12.5	
Religion			
Christianity	35	43.8	
Islam	30	37.5	
Traditional	15	18.8	
Household size			
≤ 5	30	37.5	
6-10	32	40.0	
11-15	17	21.3	
≥ 15	1	1.3	**7persons**
Farm Size (hectare)			
≤ 1	9	11.2	
1.1-2	18	22.5	
2.1-3	29	36.3	
≥ 3	24	30.0	**3.2ha**
Labour type			
Family labour	14	17.5	
Hired labour	22	55.0	
Both	44	27.5	
Farming experience (years)			
≤ 5	13	16.3	
6-10	26	32.5	
11-15	25	31.3	
≤ 15	16	20.0	**12 years**
Mode of land acquisition			
Lease/lent	35	43.8	
Inheritance	31	38.8	
Purchase	10	12.5	
Gift	4	5.0	
Extension contacts			
No	24	30.0	
Yes	56	70.0	
Frequency of extension visit			
Once a week	15	18.7	
Fortnightly	47	58.8	
Monthly	14	17.5	
Once a year	4	5.0	
Monthly Income (₦/month)			
≤ 50,000	27	33.7	
51,000- 100,000	33	41.3	
101,000-150,000	8	10.0	
≤ 150,000	12	15.0	**₦88,735.52**

Table 2: Awareness and adoption of Soil and Water Conservation Practices

Awareness and Adoption of SWCP	Frequency	Percentage (%)
Are you aware of SWCP?		
Yes	57	71.3
No	23	28.7
Do you adopt any?		
Yes	53	66.2
No	27	33.8
Adopted and still using	45	56.3
Adopted and later discontinued	19	23.8
If yes which do you adopt?		
Crop rotation	51	63.8
Cover cropping	41	51.3
Intercropping	34	42.5
Mulching	43	53.8
Burn crop residue	12	15.0
Minimum tillage	47	58.8
Terraces	9	11.3
Organic matter	42	52.5
Trees and shrubs planting	13	16.3
Zero grazing	13	16.3
Vegetative ditches	20	25.5
Inlet irrigation	17	21.5
Fertilization	31	38.7
Soil test every 3 years	17	21.3
Making of mounds and contours	13	16.3

*Source: Field survey data, 2021*Multiple response items.

Table 3: Factors influencing choice of SWCP Adopted.

Variable	Major factor F (%)	Minor factor F (%)	Not a factor F (%)	Mean	rank
Land Plan/soil type	65(81.3)	11(13.8)	27(33.8)	2.51	4TH
Crop type	57(46.3)	17(21.3)	26(32.5)	2.58	3RD
Number of crops cultivated	42(40.0)	16(20.0)	12(15.0)	2.23	6TH
Farm size	58(35.0)	11(13.8)	41(51.3)	2.60	2ND
Farming Experience	72(40.0)	11(13.8)	37(46.3)	2.65	1ST
Participation in SWCP training	24(30.0)	8(10.0)	48(60.0)	2.26	5TH

Source: Field survey data, 2021

Table 5: Determinants of adoption of SWCP

Items	Coefficient	Std.Err	P-value	Decision
Constant	-4.672	2.460	0.103	NS
Age	-4.091	2.360	0.007	NS
Sex	0.36	0.23	0.019	NS
Educational status	9.670	1.99	0.046	NS
Marital status	1.961	0.44	0.038	NS
Household size	-0.290	1.93	0.319	NS
Farming Experience	**0.445**	**2.3**	**0.003**	**S**
Farm Size (acre per plot)	**0.064**	**0.23**	**0.005**	**S**
Types of labour	-1.02m 8	0.27	0.042	NS
Mode of land Acquisition	**I.163**	**0.24**	**0.003**	**S**
Income	-0.068	1.99	-0.058	NS
Contact with extension agent	**0.046**	**2.30**	**0.005**	**S**
Access to credit	**0.737**	**0.859**	**0.009**	**S**
Log likelihood ratio = 28.47706				
Chi-square statistics = 68.03				

; Nagelkerke R^2 = 0.563; Significant at 5% level, S= significant; NS= not significant

Source: Computed from Field Survey Data, 2021

Table 4: Summary of constraints militating against adoption of SWCP in the study area

Limitations	χ	Mode	Rank	Remarks
Level of education	2.50	0.60	5th	A
Farm income	2.58	0.52	3rd	A
Cost of inputs and implementation	2.52	0.61	4th	A
Lack of technical know-how	1.94	0.76	8th	DA
Mode of land acquisition	3.58	0.80	1st	A
Labour type	2.72	0.60	2nd	A
Farm size	2.29	0.65	7th	DA
Number of crops planted	2.33	0.84	6th	DA
Inadequate of T&V	1.84	0.70	9th	DA

Source: Field Survey, 2021 *A stands for Agreement; D stands for Disagreement.*

the respondents agreed to the variable as a constraint and any mean less than 2.5 means the respondents disagree. Level of education ($\bar{x}$=2.50), farm income ($\bar{x}$=2.58), cost of input and implementation ($\bar{x}$=2.52), mode of land acquisition ($\bar{x}$=3.58), labour type ($\bar{x}$=2.72) were the major constraints identified by the respondents in the study area. This is an indication that education either formal or informal has an allocative effect on acceptance and adoption of an innovation, whereby a farmer is able to acquire information about the cost of input and implantation of an innovation therefore checkmate if the farm income will commensurate the cost of adopting an innovation (i.e. the relative advantage and compatibility).

CONCLUSION AND RECOMMENDATION.

The study investigated determinants of adoption of soil and water conservation practices among arable crop farmers in Oyo state, Nigeria. The study found out that larger percentage of the farmers adopted one or more methods SWCPs in their farm enterprise. The study also found farming experience, farm size mode of land acquisition, contact with extension agent and access to credit facilities were the major determinant of SWCPs adoption in the study area. The results of this study shows that the farm income and access to credit facilities has a significant impact on the respondents decision making towards the adoption of SWCPs in the study area thus the study conclude that, extension agents/ service provider to address SWCPs problems in the study area should invest on improving the farm income of the farmers a priority in order to encouraged the adoption of Soil and Water Conservation Practices bringing about increase their productivity and prevent produce loss to harsh climatic factor. The study therefore recommended the encouragement and continuous use of soil and water conservation practices whereby protecting the state of the environment/soil which help in the availability of beneficial soil organisms as well as increasing the quality/profit of arable crop production.

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Journal of Applied Agricultural Research 2022, 10(2): 37-51
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DETERMINANTS OF RICE EXPENDITURE SHARE AND PREFERENCES AMONG EMPLOYEES IN PUBLIC UNIVERSITIES IN NIGERIA: A CASE STUDY OF NON-TEACHING STAFF AT THE FEDERAL UNIVERSITY OF AGRICULTURE, ABEOKUTA, OGUN STATE

Abiodun Elijah Obayelu[1] and Oluwatoba Israel Adeoye
[1]Department of Agricultural Economic and Farm management
Federal University of Agriculture, Abeokuta.
Author's Contact: obayelu@yahoo.com

ABSTRACT

Rice is an important food commodity frequently consumed by both the middle and high income earners' in Nigeria. Consumers appear to display a distinct preference for rice over other food leading to a market price premium for this food. The main objective of the study is to examine the drivers of expenditure share and preferences on rice among employees in public universities in Nigeria with a case study of the Non-Teaching Staff (NTS) in the Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State. A cross-sectional survey was carried out through a two-stage sampling procedure to select a total of 318 NTS. Descriptive statistics, logit and Ordinary Least Square multiple regression were used to analyze the data. Results revealed that about 61% respondents consumed rice nearly every day with an expenditure share of 23.24% on rice of the total households' expenditure on food. The sampled respondents earned an average monthly income of ₦80,289.01k (SD = ₦50,592.73), 63.9% were holders of first university degree or its equivalent, 64.8% were married with an average household size of 4 members. The significant factors influencing rice expenditure share include price of local rice, household size, frequency of rice consumption, and total monthly households' income, while different rice attributes were found as factors that explained respondents' purchasing decision between the Nigerian local rice and imported rice. Price of local rice, household size, frequency of rice consumption and households' monthly income significantly influenced rice expenditure share, while price of local rice, households' monthly income, household size, sex and marital status on the other hands had significant influence on rice preference. For the success of improving preference for local rice, it is necessary that the attributes of the rice that are link with its preference are understood. Rice researchers, processors and policy makers can also learn from various attributes observed by the respondents that influence their preferences for imported rice to improve the local rice.

Keywords: Rice consumption, utility, food budget shares, local rice brands, imported rice brands, consumers' preference for rice attributes

INTRODUCTION.

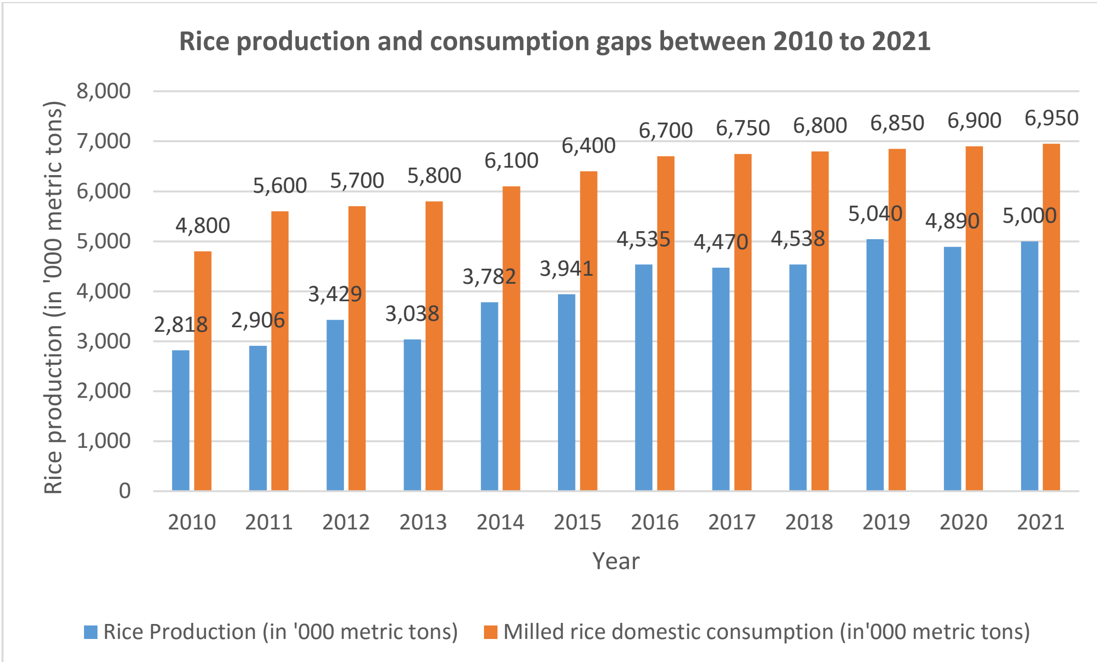
Household food consumption expenditure is a critical issue in most developing countries (Obayelu et al., 2009). Patterns of food consumption normally contribute greatly to the social and economic policy of the country. Rice (Oryza sativa) is one of the most important food crops consumed by more than half of the world's population (Khush, 2005) and one of the banned imported food items in Nigeria since 2015 by the government (CBN, 2015). It provides almost 20% and 17% of energy and protein needs to more than half of the world population respectively (Oko et al., 2012). Rice is the second most important staple food in Nigeria accounting for 10.5 percent of the average caloric intake (FAO, 2019) and 6 percent of household expenses (Johnson et al., 2013). This crop is grown in Nigeria mainly by small-scale farmers (80 percent of which farm less than a hectare) under rain-fed conditions, which leads to a relatively low yield productivity (Takeshima and Bakare, 2016). It ranks number one as everyone consumes it, both the young and old regardless of class, educational, financial background or tribes (Godwin, 2012). The only difference is the type of rice eating and the way it is prepared. Rice consumption in Nigeria is growing at a much faster annual rate than production (Kuku-Shittu and Pradesha, 2013). It has been estimated that Nigerians consume more than five million metric tons of rice each year (USDA, 2016) while quantity supplied was 2.7 million MT, with a demand–supply gap of about 2.3 million MT. A lot of consumers preferred rice as their meal probably due the relative ease of storage and preparation when compared to other foods.

The status of rice as a necessity food in the households' food basket of most Nigerians is a pointer to the growing consumer preference for rice (Oyinbo et al., 2015). Rice is consumed in every part of the country either prepared as coconut rice, jollof rice, fried rice or processed into the traditional dish (combination of rice with ground dry corn, spinach, tomatoes, onion, peppers, garden eggs, locust beans, groundnuts). Nigeria is African leading consumer of rice with about 85% of households consuming rice, and one of the largest producers of rice in Africa (United States Department of Agriculture, 2019, FAO, 2015), and interestingly second to China as the largest importer of rice globally (Takeshima, 2016, Cadoni and Angelucci, 2013). Most of the rice consumed in Nigeria is generally processed milled rice imported from Thailand, Brazil, India, United States, and the United Arab Emirates. Rice consumption is of interest to the Nigerian economy because of the huge amount of foreign exchange being spent on its importation (Adeyeye et al., 2010) in order to fill the gap between production and consumption (Obih and Baiyegunhi, 2018).

Nigeria government had therefore been intervening in terms of provision of farm inputs like agrochemicals, organic fertilizers, knapsack sprayers, planting and harvesting equipment such as reapers, mini combine harvesters, threshers to increase production of rice locally and reduce the import bills on this commodity. The interventions had to some extent being able to bridged demand- supply gap with marginal increase in the Nigeria's rice production (Figure 1). It rose from 4.89 million metric tonnes in 2020 to 5.0 million metric tonnes in 2021 (USDA, 2022).

Study of rice consumption is also of interest because despite reports that regular intake of white rice is associated with many adverse effects on human health, particularly risk of cardiovascular diseases and diabetes (Khosravi-Boroujeni et al., 2013) and increase in price of rice, its consumption is on increase. Most rice intakes are presently taking place in some households in Nigeria every day, reversing the trend from weekends consumption in the past or consumption during celebrations, and parties by most Nigerians. Also, there tend to be a reversal in the prevalent of consumption of locally grown rice (Akarolo-Anthony, et al. 2013).

To encourage consumption of locally produced rice and curtailed importation, it is necessary to identify the attributes of rice consumers want. This study assesses the frequency of rice consumption among Non-Teaching Staff at the University, identifies consumers purchasing criteria for types of rice, the budget share of rice in the food basket expenditure and factors influencing consumer preference for imported rice.



Source: Data from USDA (2022)

Figure 1: Rice Production and Demand Gaps in Nigeria between 2010-2021

Motivating Factors for the Study.

Rice is not just one of the most consumed cereal in Nigeria but it's also one of the most consumed staples. Rice expenditure survey is therefore particularly useful because it can provide information on specific sub-population of households that are more likely to be affected by changes in commodity prices or household incomes. Many studies on consumer preference for rice indicate that consumers prefer imported rice to locally produced rice due to the inferior grain quality of the latter. Complementing these reports, this study is undertaken to provide valuable information to researchers and policy makers on the determinants of rice expenditure share and preferences for rice types and highlights consumers' criteria for selecting alternative types of rice among the Universities employees in Nigeria using the non-teaching staff at the Federal University of Agriculture, Abeokuta in Ogun State as a case study. Findings will provide insight into how the non-teaching staff in Nigeria universities spend their income on rice, which could be a useful guide for real sector investors/entrepreneurs and for government policymaking.

Selected Literature Review.

Economic theory assumes that consumers are rational and would always like to maximise utility. The choice behaviour of consumers towards food products is based on the theoretical framework of Millock et al. (2002). According to this framework, a consumer's purchase food product based on the relationship between the consumer's willingness to pay premium price and the market price of the product. That is, consumers prefer imported rice if the expected utility from this rice is higher than that of local rice. Several attributes have been identified in the literature (such as: Fofana, 2011, Demont, 2013, Demont et al., 2013) to influence consumers' decision to purchase local or imported rice. These attributes include rice characteristics that are either intrinsic (such as taste, texture, swelling and ease of preparation) or extrinsic (such as color, packaging, brand, label, or price). Nigerians' demand for foreign rice is strong despite the restrictions placed on the importation of rice to control the outflow of hard currency while promoting domestic production (GAIN, 2019). Studies revealed that most Nigerians prefer to consume imported rice brands as compared to local rice varieties because Nigerian rice processors lack adequate technology of rice processing to meet international standard (Ebuehi and Oyewole, 2007) and local rice is more expensive than foreign rice.

Hagan and Awunyo-Vitor (2020) in their study on factors influencing consumers' preference for

imported rice in Kumasi Metropolis, Ghana observed that while education, gender and income of the consumers influenced consumption of imported rice positively, household size, age and price had a negative influence on consumption of imported rice.

Laizer et al., (2018) examined consumers' preference for and expenditure on rice in the Kilimanjaro region, Tanzania. Their results revealed that price of rice, income, frequency of consumption, and household size had significant effects on expenditure on rice, while household size had significant effects on preference.

Fiamohe et al., (2014) assessed the effect of consumer purchasing criteria for types of rice in Togo and their results show that imported rice is largely preferred to local rice, especially in urban areas. Cleanness and whiteness of imported rice were also found to be the most preferred attributes.

Oyinbo et al., (2015) examined consumption preferences between imported rice and domestically produced rice in Kaduna State, Nigeria. The results revealed that 75% of households preferred imported rice to domestic rice. The factors that influenced consumption preferences for rice included quality, ease of preparation, the price of rice, the frequency of consumption, household size, and income. The findings revealed that the quality of rice had a significant effect on consumption preference for the household.

Ismail *et al.*, (2012) assessed factors affecting consumer preferences of international brands over domestic brands of rice in Karachi, Pakistan. They found that consumers evaluated products based on intrinsic and extrinsic factors. The most important factors that influenced consumers' final decisions were the price and quality of the product. They also found that consumers had the notion that high-priced products have high quality and low-priced products have low quality.

Anang *et al.*, (2011) investigated influential factors on consumer preferences for various rice brands in the city of Tamale, Ghana. The sample contained 100 randomly selected respondents. The authors found that the quality attributes that were of most importance to the respondents were aroma, taste, cooking quality, the source of rice, impurities (presence of foreign matter), cooking time, and price. Hence, consumers were willing to pay premium prices for desirable qualities, especially aroma, taste, and source of rice.

MATERIALS AND METHODS.

Description of the Study Area:

This study was carried out in the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria which was established as a specialized University on January 1, 1988 by the Federal Government of Nigeria and is located in the south west zone of the country with a total land mass of 16,402.26 square kilometers. The land area of FUNAAB cover about 10,000 hectares in the North Eastern end of Abeokuta, the capital of Ogun State. FUNAAB is made up of 10 Colleges and 46 Departments. It has a population of teaching and non-teaching staff of about 529 and 1,541 respectively amounting to a total of 2,070 staff. The non-teaching staff are further divided into Senior non-teaching staff and Junior non-teaching staff with a population of about 1043 and 498 respectively with students' population of 15,095 undergraduates and 1,640 post-graduates making a total of 16,735 students (FUNAAB, 2021).

Study Population: The population is the non-teaching staff (both Junior and Senior staff) in the FUNAAB.

Sample size and Sampling Procedure*:*

The sample size for this study is 318 (both the Senior and Junior staff) determined using the sample size determination formula from Yamane (1967) (see Equation 1). A two-stage sampling procedure was used in the study. The first stage involved collection of the list of the Junior and Senior Staff from the Junior and Senior Staff Establishment, FUNAAB respectively. The second stage involved the random selection of staff from the existing units of these categories of staff existing in the university based on the sample size computed on the various unit with the distribution presented as in Table 1.

n= $N/(1+N(e^2)$ ------------------------------1

Where

n = Sample size,

N = Population size of the non-teaching staff = 1,541

e = Sample error/ level of precision (5%).

To select sample from each existing unit, we used the formula developed by Kothan (2004)

$n_{ui} = n \times Nu_i$ --------------------------------2

Where:

n_{ui} = sample size of each unit

n = Total sample size

$$Nu_i = \frac{Population\ of\ the\ unit\ i}{Total\ population}$$

$$n_{ui} = \frac{Total\ sample\ size\ \times Population\ of\ the\ unit\ i}{Total\ population}$$

Methods of Data Collection:

Primary data on food consumption and expenditure patterns were used in this study. The primary data were elicited using a structured questionnaire from the selected non-teaching staff in FUNAAB. The data were collected during the months between March and April 2021. Data were collected on the demographic characteristics of the respondents such as sex, age and educational level, household size and household income. Data collected on the rice consumption include among others: the type, frequency, quantity, price and expenditure on rice consumed by the households using memory recall in the past three months' period. The procedures were conducted according to an ethical protocol established in the university.

Data Analysis*:*

This paper explores the statistical properties of household consumption-expenditure budget share distributions. The data were analyzed using both qualitative and quantitative methods. While descriptive statistics such as frequency distribution tables, percentages and means were used to analyze the socioeconomic characteristics and consumption-expenditure share distribution of the respondents, the quantitative approach such as the Ordinary Least Square multiple regression (Equation 3) and logit model (Equation 5) were respectively used to determine the factors that influence expenditure share on rice and preference for consumption. The own price, income, price of a substitute, income, frequency of consumption in the classical theory of consumer behavior were operationalized as factors influencing rice expenditure share (Equations 3 and 6) of the selected staff.

$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_{8+} \beta_9X_9 + Ui$ -----------------3

Where:

Y= Rice expenditure share (₦)

X_1 - Price of imported rice

X_2 – Price of local rice

X_3 - Sex of respondents (male =1 and otherwise = 0)

X_4 - Age of respondents (years)

X_5 - Educational qualification of respondents (years)

X_6 - Household size (total number of family members)

X_7 - Consumption rate of Household/ frequency of consumption (number of times eating rice per week)

X_8 - Marital status of respondents (1 = married, 0 = otherwise)

X_9 - Total monthly income (₦)

U_i - Error term

Rice expenditure share per week = $\frac{\text{Weekly expenditure on rice (₦)}}{\text{Total weekly food expenditure(₦)}}$ --------------4

Per capita household rice expenditure share per week = $\frac{\text{Total weekly rice expenditure (₦)}}{\text{Total weekly food expenditure (N)x Household size}}$ --5

$$\text{Log}\frac{P_i}{1-P_i} = T = \beta_0 + \beta_1 PR + \beta_2 PC + \beta_3 IC + \beta_4 MS + \beta_5 ED + \beta_6 FC + \beta_7 Sex + \beta_8 HS + \beta_9 Age + \beta_{10} ZB + \beta_{11} Brd + \beta_{12} QR + \mathcal{E} \text{-------6}$$

Where:

$\frac{P_i}{1-P_i}$ = is the odd ratio where $p_i =$ the probability of interested outcome by respondent i

T = preference for rice, a dichotomous variable (1= prefer imported rice, and 0 = otherwise)

PR = Price of imported rice per kg

PC = Price of substitute (local rice) per kg

IC = Total monthly income (₦)

MS = Marital status (1 = married, 0 = otherwise)

ED = Educational level of the respondents (years of schooling)

FC = Frequency of consumption (number of times eating rice per week)

Sex = Sex of the respondents, a dummy variable (1 = male, 0 = otherwise)

HS = Household size (total number of those living under the same roof)

Age = Age of the respondent (years)

ZB = The label of the product, a dummy (1 = informative, 0 = otherwise)

Brd = Preference for brand name (1 = most preferred, 0 = otherwise)

QR = Quality of rice (total number of attributes considered when buying)

Ɛ = Error term

$\beta_0 \ldots \beta_{12}$ = unknown parameters

RESULTS AND DISCUSSION.

Socioeconomic characteristics and preference for rice types by the respondents.

Most (51.6%) of the respondents were females (Table 2). This is not surprising considering the objective of the study, where, expectedly, women would provide more reliable information on consumption than males. Over half (61.6%) of the respondents are having ages greater than 39. Household size was also moderate among the respondents as majority of the respondents (91.5%) have household size below 6 and mean of 4. Education was found to be high among the respondents. While 63.9% had at least first degree or its equivalent, only 21.7% had postgraduate education (MSc and PhD). The household income distribution shows that the largest proportion (75.24%) have incomes that are below ₦200, 000 (US$487.80 at official rate of ₦ 410/USD) per month. and only 1.3% had income above ₦200, 000.00. The mean households' monthly income was ₦80, 289.01 (SD = ₦50, 592.73).

Food consumption and rice expenditure share among the respondents.

Results of our findings presented in Table 3 revealed that about 25.47% of every member of the household of the sampled staff spent over ₦5000 (12.20USD) per week on food. While the mean weekly per capita household food expenditure was ₦7, 563.25 (18.45USD), the average weekly expenditure per person on rice of total weekly food expenditure was ₦1, 758.00 (4.29 USD). This implied that every household member in the study area spent 23.24% (₦1, 758.00/₦7, 563.25) on rice of the total food expenditure per week. This may probably not be unconnected with the frequency of its consumption. This result is higher than 14% monthly household rice expenditure share of the total food expenditure reported in a study on households' demand structure for rice consumption in Kaduna State, Nigeria in 2014 (Oyinbo, 2014).

Perceived attributes that influence decision to purchase imported rice rather than local rice.

Rice is a bundle of characteristics which gives rise to its utility. Consumer preferences are expressed based on these characteristics. Although this study and other previous studies in Nigeria, have shown that consumers consume more (59.3%) imported rice than the domestic rice (Gyimah-Brempong et al., 2016), and buy their rice mainly (70%) in open markets (Basorun, 2012), several perceived attributes in imported rice were identified to influence consumers' decision to purchase imported rice. These attributes according to literature include rice characteristics that are either intrinsic (such as taste, texture, swelling, easiness of preparation), or extrinsic (such as color, packaging, brand, label or price) (Rutsaert et al., 2011; USAID, 2009; Lançon et al., 2004).

Results presented in Table 4 revealed that the most important attribute that consumers considered in their choice for imported rice include relative price of imported rice to other types of rice (69.8%), taste of imported rice (61.0%), ease of cooking imported rice (53.5%), the aroma (51.6%) and cleanliness of imported rice (50.9%).

Factors Influencing Consumers Rice Expenditure Share.

Table 5 presents results from the OLS analysis on the effects of socioeconomic factors influencing rice expenditure share. The coefficient of determination (R-squared) of 0.55 indicates that 55% of the variability of staff households budget share on rice was explained by the explanatory variables included in the model.

Prices paid by consumers vary depending on the quality of the rice grade. The price of local rice had a negative relationship with the rice budget share and was significant ($P<0.1$). This implies that a unit increase in the price of local rice will decrease the households proportion of expenditure on rice by 0.00008. This finding agreed with Omonona et al. (2009) who posited that the price of rice is negatively related to households' expenditure on rice.

The coefficient of household size was found to be positive and significant ($P<0.1$). This means that as the household size increases, monthly expenditure on rice increases. A unit increase in household size would increase the households rice budget share by a unit of 0.05. An increase in the size of the household would result in additional costs, and the expenditure on rice will increase. Similar results were found by Oyinbo et al. (2013), Onu et al., (2018) who found that household size significantly and negatively affected the demand and consumption of rice.

The frequency of rice consumption has a significant effect ($p<0.01$) on rice expenditure share. The positive value of the coefficient of this variable as shown in Table 6 indicates that a unit increase in frequency of consumption of rice will lead to an increase in the expenditure share of rice by 0.23. The frequency of consumption of rice by most households in Nigeria and among the middle and high income earners even though it is starchy food may not be unconnected with the ease of its preparation. The coefficient of monthly income contrary to a priori expectation was negative and significantly ($P<0.01$) related to share of rice expenditure. This implies that as the monthly household income decreases, the share of expenditure of rice in the households' food basket increases thereby limiting the ability to buy and choose other commodities for consumption. Although this finding is contrary to the Engel's law that states that the share of household expenditure on food typically falls as income increase but the finding is in tandem with Bennet's law which states that, the share of expenditure on starchy staples (such as rice) in the food basket decreases as incomes rise and vice versa.

Factors Influencing Consumers' Preference for Imported Rice.

Table 6 presents the results of the maximum likelihood of the estimated coefficient of the logit regression showing variables that were important for determining consumers' preference for important rice in the study area. The result from our estimation clearly show the goodness of fit of the model since the calculated LR-Chi^2 is significant at 5 percent.

The coefficient of price of local rice is significant at 5% level and has a positive relationship with the consumer preference for imported rice. This suggests that the as price levels of local rice which is a close substitute increases there is the likelihood that a consumer will increase his or her preference for imported rice. A marginal effect of 0.000028 indicates that, as the price level of local rice increases by 1 unit, the preference for imported rice increases by 0.00003%. The finding is in agreement with Onu (2018) who also observed that the price of local rice has a positive and significance influence of preference for foreign rice among selected rural households in Imo State, Nigeria. The coefficient of marital status was significant at 1% and positively related preference for foreign rice. The positive sign of the coefficient is in consonance with the a priori expectation, implying that a shift in status of the respondent from single to married would increase the probability of their preference for foreign rice.

The coefficient for sex is significant at 5% level and has a negative influence on consumer preference for imported rice. This implies that females are more likely to consume imported rice than males and the likelihood of a male consuming imported rice decreases by 0.02%.

The coefficient of income is significant at 5% and has a positive influence on a consumer's preference for imported rice. This suggests that, as a consumer's income increases, there is a likelihood of that consumer will prefer imported rice. A marginal effect of 0.1802 indicates that, as consumer's income increases by one unit (₦1), there is a probability that consumption of imported rice increases by 0.18%. The finding is in line with Ogundele (2014) that revealed that the higher the income of consumers, the higher their preference for rice.

The household size variable is significant at 5% level and has its expected negative sign. Thus household size influences consumers' preference for imported rice negatively. The marginal value of -0.353 implies that a unit increase in the size of the households would decrease the probability of households' preference for foreign rice consumption by 0.35%. This suggests that the larger the consumer's household size, the lower the likelihood of the consumer to prefer imported rice. This further explains that consumers with larger household size prefer larger quantities of rice to be able to feed their large families. This finding is found to be in agreement with Hagan and Awunyo-Vitor (2020) who conducted a similar study on factors influencing consumers' preference for imported rice in Ghana.

Table 1: Sampling frame for the study.

S/N	Units	Senior Staff	
		Population Size	**Sample Size** based on Equation 2
1	Registry	382	79
2	Bursary	113	23
3	Library	24	5
4	Academic Planning	7	1
5	Works & Services	128	26
6	INHURD	2	1
7	DITTECS	163	34
8	Health Services	79	16
9	Sport	7	1
10	ICTREC	56	12
11	DUFARMS	64	13
12	COBFAS	10	2
13	IFSERAR	8	2
	Total (A)	**1043**	**215**
S/N	**Units**	**Junior Non-Teaching staff**	
1	Registry	49	10
2	Bursary	21	4
3	Library	19	4
4	Works & Services	99	20
5	INHURD	5	1
6	IFSERAR	2	0
7	DITTECS	3	1
8	Health Services	5	1
9	Staff School	4	1
10	FUCONS	14	3
11	DUFARMS	22	5
12	COBFAS	6	1
13	Environmental Unit	157	32
14	Student Affairs Division	50	10
15	COLAMRUD	3	1
16	COLANIM	5	1
17	COLBIOS	2	0
18	COLPHYS	4	1
19	COPLANT	6	1
20	COLVET	11	2
21	COLFHEC	3	1
22	COLENG	4	1
23	COLMAS	2	1
24	COLERM	2	1
Total (B)	**Total (B)**	**498**	**103**
Grand Total (A+B)		**1,541**	**318**

Source: Data from the Senior and Junior Non-Teaching Staff Establishment (SSE), FUNAAB, 2021

Table 2: Socioeconomic characteristics of the respondents.

Variables	Frequency (318)	Percentage (%)
Sex		
Male	154	48.4
Female	164	51.6
Age		
≤30	38	11.9
31- 40	126	39.6
41- 50	83	26.1
>50	71	22.3
Mean ($\overline{x}$) = 42 (Standard deviation [SD] = 9.107)		
Household size		
≤ 3	132	41.5
4 – 6	159	50.0
>6	27	8.5
Mean ($\overline{x}$) = 4		
Educational Level		
Completed primary school	4	1.3
Completed Secondary school	16	5.0
Higher National Diploma or National Certificate of Education	26	8.2
First degree or its equivalent	203	63.9
Master degree (MSc)	65	20.4
Ph.D. holders	4	1.3
Monthly Income (₦)		
≤100,000	239	75.2
100,001 - 200,000	75	23.6
<200,000	4	1.3
Mean ($\overline{x}$) = ₦80,289.01 (SD = ₦50,592.73		
Membership of cooperative society	302	94.97
Frequency of rice consumption		
Rarely	22	6.9
Between 2-4 times per week	62	19.5
More than 5 times per week	40	12.6
Nearly every day of the week	194	61.0
Preference on types of rice		
Local rice only	56	17.6
Imported rice only	189	59.4
Both local and imported	73	23.0
Type of imported rice consumed	Frequency (n =262)	Percentage (%)
Short grained parboiled rice	77	29.6
Long grained parboiled rice	134	51.3
Organic brown rice	12	4.4
Basmati rice	18	6.9
Medium gained parboiled rice	21	7.9

Source: Data from field survey, 2021

Table 3: Per capita weekly expenditure on food and rice expenditure share.

Weekly per capita household food expenditure (₦/week)	**Frequency**	**Percentage (%)**
≤ 1,000	24	7.55
1,001- 2,000	78	24.53
2,001- 3,000	63	19.81
3,001- 4,000	53	16.67
4,001- 5,001	19	5.97
> 5,000	81	25.47
Mean (x̄) = ₦7,563.25 (SD = ₦4,368.97)		
Per capita household rice expenditure share (₦ per week)	**Frequency**	**Percentage (%)**
≤ 500	34	10.69
510 – 1000	110	34.59
1,001- 1,500	104	32.70
1,510 - 2,000	37	11.64
2,001- 2,500	13	4.09
> 2,500	20	6.29
Mean (x̄) = ₦1,758.00 (SD = ₦1,365.00)		

Table 4: Perceived attributes by consumers for their choice for imported rice.

Attributes	Responses	
	Frequency	Percentage (%)
Price	222	69.8
Absence of foreign materials such as stone	150	47.2
Cleanliness	162	50.9
Whiteness	154	48.4
Number of broken kernels	15	4.7
Shape of kernels	21	6.6
Ease of cooking	170	53.5
Cohesion of kernels after cooking (very sticky)	23	7.2
Cohesion of kernels after cooking (non-sticky)	67	21.1
Taste	194	61.0
Aroma(perfume)	164	51.6
Swelling capacity	151	47.5
Hard texture	25	7.9
Soft texture	135	42.5

Source: Field Survey, 2021

Table 5: Ordinary Least Squares Regression analysis showing the factors that Influence rice expenditure share.

Expenditure share	**Coefficient (β)**	**Standard Error**	**P>|t|**
Price of imported rice	0.0000265	0.0000446	0.555
Price of local rice	-0.0000888*	0.0000528	0.096
Sex	0.0502	0.1377	0.716
Age	0.0112	0.009432	0.239
Educational qualification	-0.3961	0.5072	0.437
Household size	0.0538*	0.0501	0.085
Frequency of consumption	0.2318***	0.0844	0.007
Marital status	0.2670	0.1849	0.152
Monthly income (₦)	-6.79e-06***	1.52e-06	0.000
Constant	-.5117767	0.4257	0.232
Number of observations: 301,	Prob > F = 0.0643,	R^2= 0.5484	

* Significant at 10% ***Significant at 1%, Source: Field Survey, 2021

Table 6: Logit Regression analysis showing the marginal effect on the preference of rice.

Variable	**Coefficient (β)**	**Standard Error**	**P>|z|**	**Marginal effect (dy/dx)**
Price of local rice (₦)	0.0001198**	0.0005906	0.039	0.0000281
Price of imported rice (₦)	-0.0002386	0.0005485	0.664	-0.0000141
Monthly income (₦)	0.0000552**	0.0000255	0.050	0.1802
Marital status	3.5711*	2.1140	0.091	0.0818
Education qualification	0.2932	0.9071	0.747	-1.485
Frequency of consumption	0.5079	0.8516	0.551	0.0268
Sex	-0.6941**	1.3553	0.032	-0.01963
Household size	-1.4206**	0.8261	0.046	-0.3532
Age	-0.1666	0.1442	0.248	-0.1673
Label of the product	-1.5301	1.9390	0.430	0.05983
Preference for brand name	-2.9985	2.7014	0.267	0.0000418
Quality	0.2276	1.1827	0.847	0.4207
Constant	7.3930	9.7170	0.447	-
Pseudo R^2 = 0.5210 Prob> chi^2 = 0.0407 LR $chi^2(12)$ =18.91				

* Significant at 10%, **Significant at 5%.

CONCLUSION AND RECOMMENDATIONS.

This study assessed the respondents perceived attributes for the preferences for imported rice as well as the local rice among the public Nigerian Universities employees using the case of non-teaching staff in FUNAAB. The results indicate that consumption of foreign rice is influenced by socioeconomic factors and other attributes of rice. Most respondents preferred imported rice to local rice due to some attributes observed in foreign rice.

Rice consumers among the universities employees spent an average of 23.24% of the food expenditure on rice with an average weekly expenditure per person on rice of about ₦1, 758.00 (4.29 USD). Households size and frequency of rice consumption have a direct and significant effect on rice expenditure share, while price of local rice and total monthly household income have an inverse effect on the rice expenditure share. The key factors that positively influence consumers' preference for imported rice are prices of local rice, household income and marital status, while sex and household size negatively influence consumers' preference. In order to increase preference for domestic rice, it is necessary that the attributes of the rice that have link with consumers' preference are understood by the producers and marketers. Price and non-market attributes differentials can be integrated into the theoretical models of consumer behavior for rice and other food products. While creating new rice varieties, the researchers should take into account the preferred intrinsic (for instance, aroma and swelling capacity) and extrinsic (cleanness and whiteness) attributes of rice highlighted by the respondents in this study.

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Journal of Applied Agricultural Research 2022, 10(2):52-63
ISSN 2006-750X.

ENSURING FOOD SECURITY IN NORTH EAST NIGERIA: ASSESSMENT OF POST-HARVEST FISH LOSSES AMONG SMALL-SCALE FISHERMEN IN HADEJIA-JAMA'ARE KOMADUGU-YOBE BASIN YOBE STATE, NORTHEAST NIGERIA.

[1*]Ashley-Dejo, S. S., [2]Idi-Ogede A. M. [3]Musa A. M, [3]Sabo M. and [3] Usman J
[1]Department of Forestry, Wildlife and Fisheries, Olabisi Onabanjo University Ogun State
[2]Department of Aquaculture and Fisheries, University of Ilorin, Nigeria,
[3]Department of Fisheries and Aquaculture, Federal University, Gashua
Author's Contact: ashleydejosamuel@gmail.com

ABSTRACT.

The study assessed post-harvest fish losses among small-scale fishermen in Hadejia-Jama'are Komadugu-Yobe Basin Yobe State, Northeast Nigeria. Multi-stage sampling technique was used to select 210 fishermen from the study area. Close-ended questionnaire was used to collect quantitative data which was subjected to descriptive statistics and inferential statistics (multiple linear regression model). The result showed that fishermen in the study area are young, active, experienced, married male with low literacy level. It was further observed that almost one third of fishermen's monthly catch was lost to post-harvest losses which could be attributed to non/low adoption of post-harvest handling practices such as non-availability of ice cube and insulated container to transport catch, exposure of fish to high temperature, obnoxious fishing methods etc. Also, fishermen response to knowledge, attitude and practice (KAP) on post-harvest losses was very poor which could also contribute to high losses recorded in the study area. Linear regression estimates revealed that the model was a good fit fix here: with an R^2 of…. and age, educational qualification, fishing experience, packaging materials and household size are important but negatively significant ($P<0.05$) to post-harvest losses, whereas time frame of fishing activities (hour) and days of fishing in a week are, positively significant ($P<0.05$). Policies that inspire educated youth, provision of fishing gears and preservative facilities at subsidized rates should be advocated for and put in place. Provision of the aforementioned will boost local fish production, check fish post-harvest losses and huge amount of money expended on fish importation.

Keywords: Fishing activities, fish losses, food security, small-scale, spoilage.

INTRODUCTION.

Food security is one of the major challenges faced by developed and developing countries; but it is more critical for developing nations especially in twenty first century. Globally, food losses were estimated to have affected over 1.5 billion people (FAO, 2020). Although several mechanisms have been put in place by many agencies at national and multinational level to correct this phenomenon, such agencies include Sustainable Development Goal (SDG) and Malabo Declaration to mention few who released a communique that by 2025 and 2030 respectively, losses of food along the production supply chain will become insignificant (Aghadi *et al.*, 2020). In achieving the set goals, Post-harvest Loss Alliance for Nutrition, Post-harvest Education Foundation, Agricultural Promotion Policy were established to address food insecurity caused by food losses.

FAO (2020) opined that food security is attainable if post-harvest losses could be checkmated at all stages of food production. Also, Kruijssen *et al*. (2020) opined that to ensure basic food requirements for the populace the following must be met; availability, accessibility, sustainability and utilizations. Food loss at various stages of production has resulted to serious derease in food availability among ever growing population, pose a serious threat on climate change, cause a sharp reduction in farmer's welfare and conflict with global goal of putting an end to food scarcity, poverty and hunger (Natsa 2015; Chaboud and Daviron 2017; United Nations 2016; Kikulwe *et al*., 2018). In view of this, Kitinoja *et al*. (2019) suggested that food loss due to post-harvest losses should be checked at all levels of production supply chain to achieve food sufficiency.

Aghadi, *et al*. (2020) opined that rate of food loss within the African continent is alarming but is more sever in Sub-Sahara Africa and Nigeria is mostly affected, this has been traced to poor storage facilities and handling practices within the production supply chain (Aghadi, *et al*., 2020). About 12.1 million individuals in Nigeria are faced with severe food insecurity (FAO 2018). Gustavsson *et al*. (2013) opined that post-harvest losses are minimal at the consumer's level compared with the production supply chain. Fish and fisheries products are among the major food groups in Nigeria with a high level of post-harvest losses (Akpambang, 2015).

Fisheries sector in Nigeria is divided into aquaculture, industrial and artisanal. The artisanal fisheries (small-scale) is characterized by the use of out dated fishing gears, low capital investment, low innovations etc (Ashley-Dejo *et al*., 2017). Small-scale fisheries serve as sources of income and livelihood to millions of fishers' folks in the inland and riverine communities (Oladimeji *et al*., 2013). In Africa, Nigeria is the second-largest producer of fish after Egypt (FAO, 2016). Despite this, the country still experiences a huge shortfall in fish demand, this shortfall could be reduced if post-harvest losses are checked (Ashley-Dejo and Adelaja, 2021). This has made her to solely depend on fish importation to augment this shortfall which cost the country over USD 625 million annually (Ashley-Dejo and Adelaja, 2021).

Fish is considered wholesome and safe when consumed immediately or preserved after harvest. However, it spoils rapidly if not handled with care as it contaminates with time. Its quality depends on atmospheric temperature, relative humidity, hygiene and handling practices. Fish spoilage is mainly due to enzymatic activity, microbial growth and lipid oxidation. The materials that come in contact with fresh fish are also an important factor in preventing/reducing fish spoilage. Therefore, this sector deserves adequate attention in minimizing spoilage due to post-harvest losses. Also, huge amount of money spent on fish importation annually will be reduced drastically. Although several authors have focused on post-harvest fish losses at the artisanal fisheries sector which contribute significantly to Nigeria fish production Oyero and Oladele, (2016); Tesfay and Teferi (2017). This study fills this knowledge gap by estimating magnitude of losses, identifying causes of post-harvest losses, handling practices and storage facilities used.

Analytical Techniques.

In assessing the influence of these factors on post-harvest fish losses on artisanal fishermen, the Cobb-Douglas production function was used for estimating the coefficients of these factors. According to Hossain and Miah (2009), this production function can generally be written as

$$Y_i = \beta_{0i} X_{1_i}^{\beta_1} + X_{2_i}^{\beta_2} + X_{3_i}^{\beta_3} +, \dots \dots \dots, X_{n_i}^{\beta_n} e^{\varepsilon} \quad \text{(i)}$$

Where;

Yi = Dependent variable (percentage fish lose); β_0, β_1 - β_n = set of parameters to be estimated; Xi = vector of independent variables as shown in Table 1; and ε = error term assumed to follow normal distribution with mean equal to zero and constant variance σ^2. The equation above was transformed to obtain a linear relationship between the dependent variable and explanatory variable as shown in equation (ii).

$$LnYi = ln\beta 0 + \beta 1 lnX1 + \beta 2 lnX2 +, \dots, + \beta 9 lnX9 + \varepsilon \quad \text{(ii)}$$

Where;

Yi = Dependent variable (percentage fish lose); β_0, $\beta_1 - \beta_9$ = set of parameters to be estimated; $X_1 - X_8$ = vector of independent variables; and ε = error term assumed to follow normal distribution with mean equal to zero and constant variance σ^2.

Estimation of total percentage losses

This was expressed as =

$$\frac{\text{Financial Losses}}{\text{Expected Income}} \; x\ 100 \quad \text{(iii)}$$

Where

Financial Losses =

$$(\text{Best price x overall weight low} - \text{quality fish}) - (\text{Reduced price x overall weight low} - \text{quality fish}) \quad \text{(iv)}$$

METHODOLOGY

Study Area.

Hadejia-Jama'are Komadugu-Yobe Basin (HJKYB) as an approximately catchment area 84,000 km^2 in Northeast Nigeria, this basin flow directly into Lake Chad. The basin covers five Northern states, (Kano, Jigawa, Bauchi, Yobe and Borno states). Over 15 million people are supported by the basin through agriculture, fishing. Livestock keeping and water supply. The two major rivers of the basin are the Hadejia, the Jama'are which meet in the Hadejia-Nguru Wetlands.

Sampling Procedure and Sample Size.

Multistage random sampling procedure was adopted for this study. Stage I; selection of landing sites which was done by selecting 50% of landing sites from list obtained from Hadejia-Jama'are River Basin Authority, this resulted to 7 landing sites being sampled. In stage II, 30 respondents were randomly selected from each landing sites which gives 210. In total, 210 questionnaires were administered throughout the selected landing sites. At the end of questionnaire administration, 10 questionnaires were excluded due to incomplete information. Thus 200 questionnaires were used for data analysis.

Data Collection and Analysis.

Farmers' consents were sought and enumerators were trained before the commencement of questionnaire administration. Quantitative data such as demographic characteristics were collected with the use of close-ended questionnaires. Also, information on fishery activities, fishing equipment, handling and causes of post-harvest fish losses were captured in the questionnaire. Data collected were subjected to descriptive statistics (frequencies, percentages, mean, minimum, maximum, and standard deviations). Also, multiple linear regression model (equation ii) was used to assess factors influencing post-harvest fish losses. The model was adopted because of the continuous dependent variables.

RESULTS AND DISCUSSION.

Socio-economic characteristics of respondents.

Socio-economic characteristics of respondents are presented in Table 2. Age range of 20-40 years was dominant (67.5%) with mean age of 38 years. Although most (43.0%) fell between the age range of 31-40 years. This age bracket is termed active, innovative, early adopters, motivated and energetic age range. Majority were male (98.0%), married (65.5%) and had primary education (48.0%). Both genders were represented in fishing activities in the study area but at distinct percentages with the aim of increase fish production, improve household standard of living and ensuring food sufficiency in the country. The findings of the study agree with the study of Ashley-Dejo and Adelaja (2021) who reported that fishing activities are majorly dominated by males due to the labour-intensive nature of fishing operations whereas females are mostly engaged in value addition. It was further observed that majority were married which may be responsible for their commitment as married individuals have greater responsibilities. The result agrees with the study of Ovwigho (2011) who opined that married individuals are saddled with numerous financial responsibilities.

Literacy level was assessed through educational qualification, 15.5 % and 7.0% had secondary and tertiary education respectively with majority (77.5%) having bellow secondary education. This implies that respondents in the study area had low literacy levels which might negatively affect efficiency and rate of adoption of post-harvest technologies. Babalola *et al*. (2010) opined that farmers with low literacy levels hardily adopt nor appreciate most of improved post-harvest technologies. The finding was similar to the result of Adewunmi *et al*. (2012) who observed that majority (51.0%) of artisanal fishermen in North central had primary education.

Fishing experience ranged from 7 to 23 years, with mean fishing experience of fifteen years. Experience is defined as the number of active years used in a particular enterprise characterized with continuous practice which has direct influence on one's managerial ability and decision making (Ashley-Dejo *et al*., 2020). Fishermen's monthly income in the study area ranged between ₦ 89,000 – 220,000 with mean income of ₦ 161,000. Majority (61.0%) engaged in other income generating activities to augment family and personal needs as fishing might be seasonal. Household size ranged from 4 to 19 persons per household with a mean household of 8 persons. Household size could be related to the role (labour) played by individuals on the farm (Amsalu and de Graaff, 2007). The implication of this is that there are adequate hands to assist in fishing related activities. Majority of artisan fishermen in the study area does not belong to any association (55.5%) and do not have access to credit facility (88.5%).

Activities at Landing Site.

Table 3 revealed the various activities of artisanal fishermen at landing site in the study area. Daily fishing hours ranged between 5 – 16 hours, with estimated mean fishing hours of 12 hours. Furthermore, majority (80.5%) fished between 3 - 5 days in a week with average fishing day of 5 days. Majority (62.0%) actively fished between 5 – 10 months with an estimated 9 months of average active fishing month. This implies that the quantity of fish harvested is a function of time spent because the water body is rich in fauna and flora. This shows that the fishery is self-sustenance and serves as a source of food and livelihood to thousands of fishermen in this region. The result further shows that majority

(61.5%) of the fishermen in the study area experiences losses with an estimated average monthly loss of 32.24%.

Almost a third of fishermen’s catch is lost to post-harvest, causing artificial scarcity, food insecurity, protein deficiency to mention few. High losses recorded in this study could be as a result of direct exposure of catch to sunlight, poor handling practices, non-availability of ice cube during fish transportation etc. Yohanna *et al*. (2011) submitted that inappropriate handling practices on harvested fish will expose the fish earlier to deterioration after 12 hours of harvest. Also, Diei-Ouadi and Mgawe, (2011) and Nguvava, (2013) opined that harvested fish exposed to sunlight directly deteriorate faster compared to fish that are prevented from direct contact with sunlight. However, high percentage losses recorded in this study could be blamed on the aforementioned practices, but surprisingly, fishermen in this region hardly trash spoilt fish, the fish will still be purchased in as much it has not gone beyond rigor. This could be attributed to the poverty level in this region. North-eastern Nigeria has the highest poverty headcount rate of 71.86% in the country **(**Bukar *et al*., 2018) coupled with the fact that this region is highly populated and the most consumed animal-based protein in this region is fresh fish.

Knowledge, attitude, and practices of fishermen on post-harvest losses.

Table 5 revealed fishermen’s knowledge, attitude and practice (KAP) on post-harvest losses in the study area. It was observed that almost all the questions raised under this section (KAP) had very low acceptability indicating that fishermen do not adopt nor adhere to the basic recommendation of Food and Agricultural Organization in preventing losses of perishable agricultural products. Fish and fisheries products deteriorate very fast, rate of deterioration is influenced by high temptation, enzymatic action, microbial action etc which make harvest fish in this area to deteriorate easily. Several authors have opined that harvested fish should be gutted almost immediately after the catch to retain it freshness and delay spoilage (Enujiugha and Nwanna, 1998). Harvest fish that are not gutted immediately deteriorate faster than gutted ones (Jeeva *et al*., 2007). Mungai (2014) and Oyero and Oladele (2016) further stressed that gutted fish after catch retains its quality longer than the un-gutted fish. Yohanna *et al*. (2011) revealed that harvested fish could retain its freshness and wholesomeness if properly handled for a minimum period of 12 hours.

Causes of post-harvest fish losses.

Causes of post-harvest fish losses and their weighted scores are presented in Table 6. The results revealed that non-availability of ice cube and insulated container was identified as the most critical causes of post-harvest losses in the study area followed by exposure of fish to high temperature which creates favourable conditions for fish spoilage and obnoxious fishing methods results to quality loss. Out of the nine causes of post-harvest losses examined in this study, one third was not a cause; they are lengthy duration of fishing cycle, post-harvest loses is seasonal and lack of good means of transportation for effective transportation of catch leads to quality lose. Therefore, there is urgent need to address the two third causes of post-harvest losses in the study area in order to ensure food security, improved livelihood of fishermen, enhance fish availability and reduce huge amount of money spend on fish importation.

Relationship between demographic factors and post-harvest fish loss.

Table 6 presents the results of linear regression model. It indicates that R^2 was 0.761 which suggests that the explanatory variables in the model specification were important and they explained 76.0% of the variation in the outcome of the regression were explained by the dependent variable (percentage fish loss) included in the model. This shows that the model is a good fit and has a good predictive ability. The higher the value of R^2, the better the goodness of fit of the specific model, F-ratio was 36.22 and significant at 5.0% probability level, which implies that the independent variables included in the model adequately explained the variation in the outcome of the analysis.

The result revealed that age, educational qualification, fishing experience, packaging materials and household size are important but negatively significant at 5.0% level of probability. Whereas, time frame of fishing activities (hour) and days of fishing in a week were also important, positive and significant at 5.0% level of probability. This means that increase in time frame of fishing activities (hour) and days of fishing in a week would result into an increase in fish post-harvest losses equal to value of coefficient of these significant variables individually.

Negative significant relationship exists between age and post-harvest fish losses this implies that as fishermen age they become less productive as per *a priori* expectation. Post-harvest handling practices become more tedious to carry out thus resulting to loss of catch. Young, energetic and innovative individuals should be encouraged to take up fishing activities either on part time or as main occupation to boost fish production at artisanal level and to prevent losses due to post-harvest by making necessary fishing input and fish preserving facilities available at subsidized rates. Also, educational qualification had negative influence of fish losses which could be improved by encouraging educated individuals to venture into the enterprise.

In addition, post-harvest fish losses in the study area will be reduced by 0.201% with a unit increase in fishing experience. This implies that as fishing experience increases post-harvest losses decreases. Experience is acquisition of more knowledge, skills, and practices which often results in the adoption of improved technologies among fishermen. A unit increase in packaging materials will reduce post-harvest losses by 0.265%. This implies that the availability of packaging materials in the study area will reduce post-harvest losses significantly ($p<0.05$), resulting to increase in the revenue of fishermen.

Table 1: Description of poverty determinants among fish hatchery farmers.

Variables	Description	Unit
Gender	Dummy variable: (1 = male, 0 = female)	Dummy
Age	Artisanal fishermen's age	Years
Marital status	Dummy variable: (1 = married, 0 = single)	Dummy
Educational level	Educational qualification of artisanal fishermen's	Years
Fishing experience	Years of Fishing Experience	Years
Packaging materials	Dummy variable: (1 = yes, 0 = no)	Dummy
Household size	Number of artisanal fishermen's family	Number
Time frame of fishing activities (hour)	Hours spent per fishing trip	Hours
Days of fishing in a week	Number of days used for fishing/week	Number

Table 2: Socio-economic characteristics of respondents

Variables	**Frequency**	**Percentage**
Age (years)		
Less than 20	18	9.0
20 – 30	49	24.5
31 – 40	86	43.0
41 – 50	40	20.0
Above 50	7	3.5
Mean ± std	37.73±8.368	
Gender		
Male	196	98.0
Female	4	2.0
Marital Status		
Single	67	33.5
Married	131	65.5
Widow	2	1.0
Educational qualification		
No formal education	59	29.5
Primary education	96	48
Secondary education	31	15.5
Tertiary education	14	7
Fishing experience (Years)		
Less than 10	68	34.0
10 – 15	105	52.5
16 – 20	21	10.5
Above 20	6	3.0
Mean ± std	14.86±7.297	
Monthly income from fishing (₦)		
Less than 100,000	25	12.5
100,000-150,000	110	55.0
150,001-120,000	49	24.5
Above 200,000	15	8.0
Mean+ std	161,165±59841.900	
Other sources of income aside fishing		
Yes	122	61.0
No	78	39.0
Household size		
Less than 5	63	31.5
5-10	112	56.0
11-15	22	11.0
Above 15	3	1.5
Mean ± std	8.14±4.708	
Member of fish association group		
Yes	89	44.5
No	111	55.5
Access to credit facilities		
Yes	23	11.5
No	177	88.5

Source: field survey, 2022

Table 3: Activities at landing site.

Variables	**Frequency**	**Percentage**
Hours of fishing per trip		
Less than 5	21	10.5
5-10	58	29.0
Above 10	121	60.5
Mean ± Std	12.31 ± 0.81	
Days of fishing in a week		
1 – 2	24	12.0
3 – 5	161	80.5
6 – 7	15	31.0
Mean ± std	5.14 ± 1.34	
Active month of fishing		`
Less than 5	14	7.0
5 – 10	124	62.0
Above 10	63	31.0
Mean ± std	8.88 ± 53	
Non-active month of fishing		
Less than 5	164	82.0
5 – 10	36	18.0
Mean ±std	3.81±1.01	
Fish Loss		
Yes	123	61.5
No	77	38.5
Average Monthly losses	32.24%	

Source: field survey, 2022

Table 5: knowledge, attitude, and practices (KAP) of fishermen on post-harvest fish loss

Variable description	**Yes**	**No**
	Freq %	**Freq %**
Sticking to specific time for setting and hauling of set fishing gears	33 (16.5)	167 (83.5)
Using well insulated containers to transport harvested fish from landing sites to point of sale	56 (28.0)	144 (72.0)
Harvested fish are kept away from direct sunlight during transportation and at point of sale	41 (20.5)	159 (79.5)
Harvested fish are washed and gutted at landing sites prior to sale	12 (6.0)	188 (94.0)
Observation of changes in fish colouration after harvest, during transportation, or at point of sale	35 (17.5)	165 (82.5)
Involve in any training on fish handling and post-harvest losses	43 (21.5)	157 (78.5)

Table 6: Causes of post-harvest fish losses

	Causes of post-harvest fish losses	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (1)	Strongly Disagree (2)	Weighted score	Weighted mean
		Freq (%)	Freq (%)	Freq (%)	Freq (%)	Freq (%)		
1	Lengthy duration of fishing cycle leads to losses	46(23.0)	15(7.5)	47(23.5)	30(15.0)	62(31.0)	553	2.77*
2	Delays in hauling of fishing gears leads to fish loss	49(24.5)	69(34.5)	28(14.0)	25(12.5)	29(14.5)	684	3.42**
3	Exposing of fish to high temperature creates favourable conditions for fish spoilage leading to quality loss	68(34.0)	42(21.0)	43(21.0)	30(15.0)	17(8.5)	714	3.57**
4	Obnoxious fishing methods result to quality loss	56(28.0)	36(18.0)	85(42.5)	12(6.0))	11(5.5)	714	3.57**
5	Poor handling practices during hauling and transportation of catch leads to losses	48(24.0)	57(28.5)	46(23.0)	35(17.5)	14(7.0)	690	3.45**
6	Lack of covering materials during transportation of catch and at point of sales leads to losses	48 (24.0	36 (18.0)	32 (16.0)	57 (28.5)	27 (13.5)	621	3.11**
7	Non-availability of ice cube and insulated container results to quality lose	62(31.0)	52(26)	48(24.0)	20(10.0)	18(9.0)	720	3.60**
8	Lack of good means of transportation for effective transportation of catch leads to quality lose	25 (12.5	31 (15.5)	16 (8.0)	75 (37.5)	53 (26.5)	500	2.50*
9	Post-harvest loses is seasonal	27 (13.5	43 (21.5)	34 (17.5)	39 (19.5)	57 (28.5)	544	2.72*

Decision rule: Critical mean = 3.0, **mean accepted as a cause of post-harvest losses, * mean accepted as not a cause of post-harvest losses

Table 6: Linear regression model on effect of demographic factors and percentage fish loss

Variables	Coefficient	Std. Error	p value
(Constant)	2.098	0.459	0.000*
Age	-0.895	0.298	-0.001*
Marital status	0.014	0.218	0.947
Educational qualification	-0.212	0.102	-0.039*
Fishing experience	-0.201	0.216	-0.002*
Packaging materials	-0.265	0.517	0.031*
Household size	-0.54	0.441	0.233
Time frame of fishing activities (hour)	0.267	0.277	0.001*
Days of fishing in a week	0.196	0.219	0.000*
R^2	0.761		
Adjusted R^2	0.642		
F-value	36.219		
P-value	0.000		

*Significant ($p < 0.05$)

CONCLUSION AND RECOMMENDATIONS,

Fishermen in the study area are young, active, experienced, married male with low literacy level which negatively affects fish handling innovation adoption and usage. Low literacy level observed in this study result to high post-harvest fish losses which amount to almost one third of fishermen catch. This implies that if post-harvest losses are corrected, the enterprise has the potential of addressing food insecurity, protein deficiency and huge amount of money expended on fish importation annually. Non-availability of ice cube and insulated container was identified as the most critical causes of post-harvest losses in the study area. Age, educational qualification, fishing experience, packaging materials and household size influence post-harvest losses. Incidence of post-harvest losses can be checked by providing preservative facilities on credit with flexible means of repayment and/or at affordable interest rates. Also, active and experience fishermen should be encouraged to stay in fishing business while educated youths should be motivated to take up the business while the illiterate in the enterprise should be trained and re-trained on post-harvest handling practices.

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Journal of Applied Agricultural Research 2022, 10(2):64-72
ISSN 2006-750X.

FACTORS INFLUENCING JOB PERFORMANCE OF EXTENSION AGENTS IN KADUNA STATE, NIGERIA

[1]Issa, F. O., [2]Ayuba, N. and [2]Nti, C.
[1]National Agricultural Extension and Research Liaison Services, Ahmadu Bello University, Zaria.
[2]Department of Vocational and Technical Education, Ahmadu Bello University, Zaria.
Author's Contact: katenti687@gmail.com, +2348179705459

ABSTRACT.

This study was designed to assess the factors affecting job performance of extension agents in Kaduna State, Nigeria. The study described the socio-economic characteristics of extension agents, examined the level of job performance of extension agents; determined the factors influencing job performance of extension agents and identified the constraint to extension agents' job performance. All (163) the extension agents in the employment of Kaduna State Agricultural Development Agency (KADA) were totally selected/included as respondents. Structured questionnaire was used to elicit information from the extension agents. Descriptive statistics like frequency counts, mean, weighted mean score and percentages, and inferential statistics were employed to analyze the data collected. Results show that the majority (65.6%) of the extension agents were male, with average of 10 years working experience. Most of them were within the age of 35-45 years. Most (44.2%) had HND certificate. Most (>56%) do not belong to professional associations. Furthermore, the level of extension agents' job performance was low. The major determinants of job performance of extension agents are years of experience, and salary grade level. Major constraints to job performance were high Extension Agent: Farm Family (EA: FF) ratio, inadequate mobility for field work, and inadequate training. The management of KADA should employ more extension agents so as to reduce the high EA: FF ratio. Also, KADA management should improve on the number and quality of in-house and external trainings provided to extension agents in order to enhance their productivity.

Keywords: Extension job, extension agents, extension job performance.

INTRODUCTION.

Agriculture has been the main driver of Nigeria's economy since before its independence in 1960 and ever since the sector has been in a major setback and decline due to challenges faced by the sectors which include inadequate number of extension agents and challenges they face in performing their work. Almost all countries in the world deliver some type of extension services to help rural people advance their agricultural productivity and improve their living standard (Wambura, Acker, & Mwasyete, 2012). Extension is responsible for serving about one billion small-scale farmers in the world (Issa & Adiyu, 2020).). The improvement of agricultural sciences and technology has brought about dramatic changes in the agricultural sector. This has led to the increased need and opportunity for investigating the effectiveness of agricultural extension services in various parts of the world. Also, this situation stimulates the need for new approaches to promote the transition of new innovations into concrete benefits to poor farmers in developing countries (Hellin, 2012). West Africa is among the places with the largest extension system in Africa, and studies have indicated that the agriculture sector in this part of Africa has not shown significant improvement in production and betterment of peoples' lives in rural areas (Wambura *et al.*, 2012).

Nigeria suffers from low agricultural productivity due to a number of factors including an inadequate extension system leading to ineffective dissemination of technologies, poor market linkages, weak links between research and extension, and inadequate government support (Churi, *et al.*, 2012). Other issues affecting efficiency of the extension system include poor organizational structure, poor administrative and institutional structure, lack of clients' involvement in the planning process, and inadequate provision of extension services (Swanson and Samy, 2013). Research has been conducted to address these issues (Abdullah *et al.*, 2013), but there is insufficient research on the factors affecting job performance of extension agents in Kaduna state.

Nigeria's economy relies heavily on agriculture, which accounts for 21.9% ofGDP and employs about 80% of the workforce (National Bureau for Statistics, 2019). Therefore, there is a need to strengthen the extension services by incorporating ideas of small-scalefarmers who dominate this sector in Nigeria. Moreover, the importance of this study relies on the fact that at the end challenges faced by extension agents in performing their jobs will be enumerated and suggestions shall be given on how to overcome those challenges.

The current poor performance of the agricultural extension system is a result of inadequate resources to enable it to perform its role effectively. But perhaps a more important factor is its bureaucratic organization, which tends to contradict its very mission of working closely with farmers and with other service agencies to stimulate agricultural modernization.

Magoro and Hlungwani (2014) insisted on the importance of improved agricultural extension in the 21st century given that the agricultural sector is facing many technological advances, new agricultural laws, and innovative marketing strategies, all of which need to be communicated to farmers through well-established extension education programs. This calls for the need to study all aspects related to extension, including the main stakeholders (farmers), in looking for better means of improving the extension education programs. Campbell (2019) argued that there is a need to create an organizational structure that will ensure effective individual interaction, both formal and informal, for the best achievement of extension's goals. Therefore, the current study aimed to identify factors affecting job performance of extension agents in Kaduna State.

The findings of this study will guide policy makers in their attempt to improving the competency of extension agents. This is because extension agents need to be equipped with specific techniques to help specific groups of people based on their characteristics and identified needs.

The ineffectiveness of agricultural extension services has been noted over the years (Okwoche and Asogwa, 2012; Nnadi *et al.*, 2012a; 2012b; Agbarevo, 2013). Though these researchers provided insights into the ineffectiveness of extension agents and the possible reasons, their studies did not show the factors influencing extension agents' job performance. This makes the understanding of the role performance of extension agents in extension delivery unclear. This has left a gap in research. The main purpose of this research was to assess the factors influencing job performance of extension agents in Kaduna State. The specific objectives were to:

i. describe the socio-economic characteristics of the extension agents in the study area;
ii. examine the extent to which extension agents perform their jobs;
iii. determine factors that influence job performance among extension agents, and
iv. identify constraints to extension job performance.

It was hypothesized that extension agents' job performance is not influenced by their socio-economic characteristics.

METHODOLOGY.

Study Area.

Kaduna, city, capital of Kaduna state, north-central Nigeria. It lies along the Kaduna River, which is a major tributary of the Niger River. Kaduna is located in the northern Guinea savannah zone of Nigeria. It lies between latitudes 10 and 11 degrees north and longitude 7 and 8 degrees east at an altitude of 645 m above sea level. Its area includes the traditional emirate of Zaria and Jemaa town. Kaduna was substantially reduced in size when its northern half became Katsina state in 1987. Kaduna is bordered by the states of Zamfara, Katsina, and Kano to the north; Bauchi and Plateau to the east; Nassawara to the south; and Niger to the west. Abuja Federal Capital Territory also borders Kaduna state to the southwest.

Sampling Technique.

The population for this study consists of all the frontline extension agents in the employment of KADA. As at the time of this study, KADA has 163 extension agents. The entire 163 extension agents were included in the sample. Questionnaire was used to elicit relevant data from the extension agents

Data Analysis.

Data collected were analyzed using descriptive statistics such as frequency, percentage and mean. Multiple regression analysis was used to determine the factors influencing extension agents' job performance.

RESULTS AND DISCUSSION.

Socio-economic Characteristics of Extension Agents.

This section covered the socio-economic variables of the respondents with respect to their gender, age, educational qualification, area of specialization, household size, income, membership of professional associations.

Based on result in Table 1, the majority (65.6%) were male while only 34.4% were female. It implies that extension work is dominated by male. This study agrees with Nnadi *et al.* (2012b) who found that majority of extension agents in Imo state were male.

Most (38.7%) of the extension agents were aged between 35-45years. The mean age of extension agents in Kaduna State was 44 years. This result implies that extension agents were in their productive age. This finding is in agreement with Onumadu, 2014; Kuye and Ettah 2015) who reported that the mean age of extension agents were 44years (in Abuja); 40years (South-East); 43.5years (North Central); and 40.5years (South-South), respectively. Also, the majority (65.6%) of the extension agents were male. This showed that, there were more males than females extension agents in Agricultural Development Project in Kaduna State. This result is similar to the finding of Adesoji and Aratunde (2012) who reported that there are more male extension agents in ADP.

Result in Table 1 also revealed that Diploma/ NCE holders constitute of 39.9%; most (44.2%) had HND/Degree certificate. This implies that majority of them possessed the required qualification of extension agents. This finding is in agreement with (Onumadu, 2014) who found that extension agents in Ekiti and Ogun states were educated.

On area of specialization of extension agents, result indicated that most (29.4%) of the extension agents read agricultural extension and management-related courses in their pre-service training, while 14.1% and 12.9% specialized in agronomy and home economics, respectively. Area of specialization remains a core condition during the recruitment of extension agents in a bid to maintain some balancing across sub-sectors within the system. The result obtained here could be due to the fact that the ADP system preferred specialist in agricultural extension due to the core activity of the agency.

Result in Table 1 further indicates that the majority (56.4) of extension agents did not belong to professional associations. This could be due to the high academic requirement of most agricultural professional associations. This result agrees with Ekpe and Alimba, (2013) and Onumadu, (2014).

Table 1 also reveals that most (44.8%) of the extension agents had working experience of ≤10 years while only 13.5% had working experience of above 10years. The average years of working experience was estimated at 10 years. This implies that majority of the extension agents were highly experienced. This result of this study agrees with Ekpe and Alimba (2013) and Issa and Adiyu (2020) who found high working experience in extension practice among extension agents.

Result in Table 1 indicates that the majority (49.7%) of the extension agents fell on monthly income of < ₦50,000. This indicates that extension agents are poorly remunerated going by the current inflation rate in Nigeria. This could translate to non-satisfaction on the job. Salary is a motivational tool for efficient job performance. The majority (54.6%) of extension agents had farming as their main secondary occupation (Table 1). This result is not unexpected since the farming is officially approved as secondary occupation by Government of Nigeria and most States of the Federation. This finding could be due to the fact that it is easy to engage in agriculture compared to other secondary occupations.

Level of Job Performance of Extension Agents.

Table 2 revealed that Attendance at the Area Review Meeting usually held at Block Level ($\bar{x}$ =2.36), and rendering field report ($\bar{x}$ =2.02) were the most frequently performed activity by the extension agents. Myriads of jobs are performed by extension agents. All the other eight (8) activities were not frequently performed since the mean scores fell below the cut-off point of 2, thus, indicating low level of job performance.

Factors Influencing Extension Agents' Job Performance.

The major objective of this study was to analyze the determinants of extension agents' job performance. Results of multiple regression analysis is presented in Table 3. The adjusted R^2 was 0.62. This implies that 67% of the variations in the extension agents' job performance in Kaduna State was explained by the independent variables specified in the model. Some variables were found to significantly influence extension agents' job performance. Hence, the null hypothesis was rejected. A strong positive and significant relationship was found between extension agents' years of experience and job performance (0.058, P<0.01). Extension agents with higher experience were better performers, a result consistent with the findings of Yasin *et al.* (2013). Higher years of experience is likely to enhance the efficiency and effectiveness of job performance (decision-making and technology dissemination strategies) by extension agents. A more experienced extension agent will most likely possess better skills and acumen to conduct extension activities on the field. Similarly, the relationship between extension agents' job performance and salary grade level was found to be positive and significant (0.019, P<0.05). This implies that the higher the salary grade level; the better the job performance of extension agents. Salary grade level explains the 'take-home' of extension agents. In most cases, transport allowances are paid with along with monthly salary.

Constraints to Extension Agents' Job Performance.

Result in Table 4 revealed that high Extension Agent-Farm Family (EA: FF) ratio and poor mobility were the most severe constraints to extension agents' job performance. According to NAERLS/FMARD (2020), the average EA: FF ratio in Kaduna State was 1:6500. Inadequate training also constitutes a major constraint thereby resulting to greater knowledge gap among extension agents. This implies that much is still required from the government in order to ensure a more effective and efficient extension system in Nigeria. Since training positively impacted on their role performance, extension agents' efficiency could be more enhanced through training. Training is the only springboard for acquisition of knowledge and skill. This result confirms Daneji (2011) who reported that ADP in Nigeria has not been giving the expected results compared to when it started; when training of extension agents was more frequent.

CONCLUSION AND RECOMMENDATIONS.

The study concludes that the level of job performance of extension agents was low. Also, major determinants of job performance of extension agents are years of experience, and salary grade level. In the same vein, extension agents were confronted with constraints of high Extension Agent-Farm Family (EA: FF) ratio and poor mobility.

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

i. The management of Kaduna State Agricultural Development Agency should employ more extension agents so as to reduce the high EA: FF ratio. The management could also leverage on the use of ICTs to ensure wider coverage and delivery of extension services to farmers. Similarly, vehicles and motorcycles should be provided to extension agents in order to ease their field coverage.

ii. Kaduna State Agricultural Development Agency management should improve on the number and quality of in-house and external trainings provided to extension agents in order to enhance their productivity.

Table 1: Gender distribution of extension agents.

Gender	Frequency	Percentage	Mean
Male	107	65.6	
Female	56	34.4	
Age (Years)			
<36	23	14.1	44
35-45	63	38.7	
46-56	48	29.4	
Above 56	29	17.8	
Educational qualification			
NCE/Diploma	65	39.9	
HND/BSc	72	44.2	
PGD/MSc	26	15.9	
Area of specialization			
Agronomy/crop production/Horticulture	23	14.1	
Animal production	14	8.6	
Soil science	10	6.1	
Agricultural extension/management	48	29.4	
Agricultural economics	17	10.4	
Fisheries	19	11.7	
Agricultural engineering	11	6.7	
Home economics	21	12.9	
Membership of professional association			
Belong	71	43.6	
Do not belong	92	56.4	
Years of working experience			
≤ 10	73	44.8	**10**
11-20	68	41.7	
Above 20	22	13.5	
Income (Monthly)			**56,000**
<50000	81	49.7	
50,000-60,000	72	44.2	
>60,000	10	6.1	
Main Secondary occupation			
Farming	89	54.6	
Trading	43	23.4	
Transport business	14	8.6	
None	17	10.4	

Source: Field survey, 2021

Table 2: Distribution of jobs performed by extension agents

Jobs performed by extension agents	Total score	Mean
Conduct field visit to farmers	289	1.77
Attendance at the Area Review meeting at Block Level	384	2.36
Writing field reports	296	1.82
Rendering field Report at the Area review meeting	329	2.02
Proffering solution to field problems	297	1.82
Diagnosing farmers' field problems	304	1.87
Compile farmers' register	288	1.76
Link farmers with inputs, credits and market	276	1.69
Organise and conduct farmers' field day	259	1.59
Facilitates SMS' visit to farm locations where major problems persist	258	1.58
Total	**298**	**1.83**

Source: Field survey, 2021

Table 3: Determinants of extension agents' job performance

Socio-economic characteristics	Coef.	Std.err	Z
Age	-0.017	0.026	-0.15
Sex	0.005	0.068	0.08
Education	0.102	0.912	0.58
Years of working experience	0.058	0.004	14.84***
Salary grade level	0.019	0.018	2.15**
Membership of professional association	0.006	0.007	0.89
Area of specialization	0.506	0.431	1.69
Secondary occupation	0.043	0.026	0.32
R^2			0.647
Adjusted R^2			0.629

Source: Field survey, 2021
***P<0.01, **P<0.05, *P<0.1

Table 4: Constraints faced by the extension agents

Constraints	Frequency	Percentage	Rank
High EA: Farmer ratio	163	100	1st
Poor mobility	163	100	1st
Inadequate training	158	96.9	2nd
Lack of extension kits	147	90.2	3rd
Poor welfare/motivation	128	78.5	4th
Poorly defined job description	104	63.8	5th
Poor delineation of extension Cells/Circles	92	56.4	6th
Too large area of coverage	89	54.6	7th
Delayed promotion	61	37.4	8th

Source: Field survey, 2021
*Multiple responses indicate

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Journal of Applied Agricultural Research 2022, 10(2):73-82
ISSN 2006-750X.

LAND TENURE SYSTEM AND AGRICULTURAL PRODUCTIVITY IN NIGERIA: A SYSTEMATIC REVIEW OF THE LITERATURE.

SANUSI, Saheed Olakunle [1]*, MADAKI, Musa Janga[1], ADEDEJI, Isreal Ajibade[1]
Department of Agricultural Economics and Extension,
Faculty of Agriculture, Federal University Gashua.
P.M.B 1005, Gashua. Yobe State, Nigeria.
Author's Contact: sanusisaheed@yahoo.com

ABSTRACT.

Land tenure is a traditional system of control and claims of land ownership in Nigeria. The research was designed to explore the concept of land tenure, land acquisition, land use act and their implications on agricultural productivity. The study relies on synthesis of literatures and analyzed based on available evidence from previous research. The study concluded that land tenure has affected agricultural production and land uses more than the gains accrued over the years. To this end, the study recommends that land reforms should be instituted. This is necessary to enhance availability and accessibility of land to individuals, groups and institutions for agriculture and other productive uses in order to circumvent the preponderance arising from land tenure.

Keywords: Land tenure, land acquisition, productivity, Nigeria.

INTRODUCTION.

The term tenure means the quantity of rights an individual, household or community may have with respect to land or water or other resources for that matter. It is a mix or sum of entitlements (rights and duties) concerning the use of land resources (Temgu, *et al*., 2017). It covers the rules under which those rights and duties are exercised and the time horizon or guarantee of continued claim to such entitlements. In simple terms, land tenure systems determine who can use what resources for how long and under what conditions. Land remains a limited resource and its distribution as well as tenure structures are key issues in the nation's agricultural developmental strategy. The development of the agricultural production and animal husbandry in Nigeria revolve, largely around the ownership and use of land resources, and type of labour (Hatab *et al*., 2019; Titilola and Jeje, 2008). Land is the main factor for agricultural production and rural livelihoods. It is one of the principal challenges of implementing agricultural programs for improved productivity and resource utilization. Consequently, access to, and security of land rights are major concerns for policies and strategies aimed at increasing agricultural production and food security. Land is therefore, a very strategic socio-economic asset, particularly in poor societies where agricultural output are measured by control of, and access to land. Land tenure system affect agricultural productivity by influencing the efficient use of inputs and adoption of modern technology. This assertion was in line with the findings of host of scholars (Pankhurst and Jacobs, 2019; Baldwin, 2018; Okezie *et al*., 2012) that opined that land tenure system can generally be broadly described as rigid, and creating obstacles in the way of agricultural development.

Land as a factor of production and as a natural resource is critical in agricultural production. Its importance is expressed in terms of availability, accessibility, quantity and quality. In Nigerian agriculture, the accessibility and quality factors stand out as major determinants of productivity. The accessibility of most agricultural lands especially in the North-Central part of the country depends largely on land tenure system and the extent of competition with non-agricultural land uses (Udoh, 2000). Farm size and productivity are two of the oldest issues in the academic arena for analyzing the agrarian structure.

An efficient system of land tenure and land right should contribute to the general economic development by assisting agriculture in contributing to industrial development through the production of food, capital, raw materials, labour, foreign exchange and expanded market. Consequently, the system of land tenure in any place to a large extent determines the pattern of agriculture that prevails in that society. It has potential to determine the allocation of resources, systems of conserving land and the general productivity of the farm. Okezie *et al.,* (2012) reported that land right system determines the type of farming systems, decisions regarding investment of factors of production such as capital, labour and management as well as the productivity of such farming systems. Even though land tenure is believed to strongly impact upon agricultural production in rural areas of Nigeria, relatively little is known about the types and modes of land acquisition, how and the extent of the impact and in what specific areas of agricultural activities the impact in Nigeria. To this end, this research was set to expatiate the concept of land tenure, the types of tenure, modes of land acquisition, and land use act as implemented in Nigeria.

Concept of Land Tenure.

Land tenure is a broad term covering all those relationships established among humans that determine their varying rights in the use of land. It deals with the splitting of property, rights, or their division among various owners, between owner and occupant, and creditor, and between owners and the public, it includes the assessment of taxes on private rights and regulation of land use through various social control devices. It refers also to the period during which rights in land are held (Zhou *et al*., 2020; Paz *et al*., 2019; Riddell, 2000). The system of land tenure in a rural community is the system of rights and duties of the people about the use of land. Chigbu (2019) defined land tenure as the relationship among men, in the use and control of land resources and also sometimes, as the body of rights and relationships that exist between men as individuals, as groups and as public entities in the use and control of the land. This system embodies those legal and contractual or customary arrangements, whereby people in farming gain access to productive opportunities on the land. It constitutes the rules, procedures governing the rights, duties, liberties, and exposure of individuals and groups, in the use and control over the basic resources of land and water (Boone, 2019; Gebremichael, 2019; Herrera, 2000).

Types of Land Tenure.

Land tenure system differs from one country to another and among different communities within the same country (Isaac *et al*., 2019). Under the Nigerian customary land tenure system, there are different kinds of rights to land, including the right of the individual, the right of the group, and the right of the sovereign nature (Clement, 2013). Three types of land tenure ownership forms are common in Nigeria. These include communal, individual, or private and public (state) land. Communal land tenure and private land tenure can be seen in customary or indigenous land tenure systems. Examples of private land tenure and state land tenure can be seen in the state land nomenclature, which is analogous to the western or Euro-American land rights systems.

Communal land is a land that is held under an arrangement which provides for joint or communal use of the land. It could be held by cooperating bodies. These lands are held as corporate aggregate identified in Nigeria in the form of socio-political groups such as rural towns, villages, patrilineal and matrilineal groups, extended and nuclear families. This agrees with Isaac *et al*., (2019) who noted that communal land is sometimes known as village land, clan land, community land, or tribal land. The basis of the land-holding in Nigeria is the family. Originally and traditionally, all land belongs to the community and the customary land tenure system guarantees each member of the extended family some use rights to communal land (Liz, 2018). However, individuals who need land for personal or private uses (residential, agriculture, etc.) obtain such land from the community leaders on payment of stipulated fees and/or performance of the requisite titles. The land so acquired belongs to the individual and would be inherited by his or her descendants as their private property with absolute right to use it as they wished. Yasin (2010) noted that this communal arrangement involves social control of land with periodic or hereditary, reallocation of land for use by farming families. The occurrence of communal land tenure varies from community to community and is related to farming practices, ethnic heterogeneity, and stability of leadership (Liz, 2018). They pointed out that this land can be used jointly, it can be used freely by any member of the community, or it can be divided among the families to use as they wish. A unique feature of a communal land tenure system is that joint decisions are taken on which land to cultivate, which crops are to be grown, the number of seasons during which the land is to be cultivated, and the length of the fallow period (Liz, 2018). Some permit large scope for independent farm decision making, while others exhibit high levels of local group control in production and consumption decisions. In some cases, crops may be produced jointly on communal land and then distributed based on traditional rules implemented by the group leader. Maiangwa *et al*., (2006) supported this line of thought when he noted that land rights have evolved towards full privatization in the presence of increasing commercialization and population pressure. But despite this individualization process, economic trees (such as oil palm, Iroko, etc.) remain the property of the community. In northern Nigeria, however, communal land tenure still exists and it is even the dominant system in many communities in the rain forest zone where it accounts for as much as 65 percent of the total number of land holdings in the community (Liz, 2018) It was also observed that communal control overland under indigenous tenure systems today occurs mainly in areas characterized by relative land abundance and low intensifications; but even then, farmers typically have secure use and inheritance rights (Maiangwa *et al.*, 2006).

Individual Land Tenure system represents the situation where an individual has full ownership and right of use of land. In northern Nigeria, individuals become entitled to parts of family land by birth into a family or clan or under statutory law. The family heads grant land-use rights for food production to members of the family, as well as to "Strangers" who are found acceptable to the community at large. Grants to land made to the individual entitle him and his children after him to use of land (Clement, 2013). Individual members of the family can also enjoy the absolute rights of ownership based on being the first to clear and occupy a plot of land. Isaac *et al*., (2019) identified the following categories of land users: Owner-occupiers, share tenants, cash tenants, mortgage owners, and part owners. These are various means of acquiring individual land in Nigeria.

Land ownership in Nigeria is shifting from communities to individuals. Maiangwa *et al.*, (2006) noted that agricultural intensification, which typically involves more continuous use of land, enhances the process of privatization of rights over land. It has been long observed that the earliest individualization of a broad range of transfer and exclusion rights over land in Africa arose largely in response to the cultivation of commercial crops, primarily oil palm, Cocoa, groundnuts, cotton, coffee. Recently in Northern Nigeria, individual ownership of land has been becoming more common, as lineages or communities no longer exercise use and management control over farmlands once the allocation is made to an individual family member (Isaac *et al.*, 2019). Under individual land tenure, the land is available to Individual owner for agricultural purposes but may be given out to others on a rental basis, especially for cultivation. In many rural areas in northern Nigeria, the outright purchase of such land is difficult; in a few, it is even prohibited by the lineage or clan. Despite these restrictions, the outright sale of land to individuals by either family members or even whole communities is becoming a lucrative business in some rural communities in northern Nigeria, especially in peri Urban areas. (Clement, 2013). This has resulted in a class of well to do landed gentry, members of which have bought out the rural poor' to promote a market economy which in most cases has turned out to be a "money economy illusion". Galor *et al*., (2009) also pointed out that individual land-holding fosters inequality and the emergence of landless class.

Government or State Land Tenure has been described to exist when the rate of change in the socio-economic structure of society is faster than the rate of change in the customary law leading to the state to intervene with policies to facilitate change (Ifediora, 2014). He defined state land as all public lands in northern Nigeria which were subject to the control of the British Crown on 30th September 1960 and held for' public purposes. It also includes all land thereafter acquired by or on behalf of the government of Nigeria held for such purposes. Vivian, (2014) noted that public rights were exercised whenever land was to be used for the ultimate benefit of the public in general. Land acquired for public purposes under customary tenure was used as sites for grazing, defense, marketing, shrines, and worship; but with rapid population growth and urbanization, the large- scale acquisition of land has become rampant. The land is now expropriated to build· schools, hospitals, universities, airports, recreation parks, and game reserves (Liz, 2018).

Modes of Land Acquisition.

There are different modes by which land are acquired for agricultural and other purposes. The modes of acquisition differ from region to region in Nigeria though they are limited (Sanusi, 2021). The most common modes of acquisition are inheritance, purchase, lease and gift. Liz, (2018) observed that the commonest mode of land acquisition in northern Nigeria is through inheritance followed by leasing or purchase in some areas, pledging in others. Acquisition through a gift is less common, and even least common is acquisition through marriage, borrowing, or sharecropping. It was also observed that land acquisition through inheritance is usually patrilineal, but in rare cases, a matrilineal system is practiced and that this mode of acquisition is the major form of social security. In Nigeria, over 77 percent of personal land is acquired through inheritance. This is because when a man dies, his sons usually inherit his lands. It is also customary for a man to allocate some of his lands to his sons as they come of age to help them establish farms and build houses before they marry. The public acquisition of land has meant increasing incursion into agricultural land and has led to thousands of farmers becoming landless and unemployed (Tarisayi, 2019; Yunxian, 2020)

Land Use Act.

According to Chikaire *et al*. (2014) the present law guiding land administration in Nigeria is the Land Use Act, Cap L5, 2004, originally promulgated in 1978. The important statutory interventions into land tenure in northern Nigeria include the Acquisitions by Aliens law, the Registration of Titles and Acquisition of public lands Act, and the land use Decree. The land use Decree of 1978 was an attempt by the Federal Military Government to try to correct some of the problems with the existing land tenure regimes in the country, to provide the country with a uniform land tenure system, and to ensure equitable and secure access to land for productive purposes.

The land considered undeveloped was often the only property owned by the rural poor; thus, the act confiscates the land of the poor and redistributes it to the wealthy. In the same line of thought, Isaac *et al*., (2019) also noted that granting of rights of occupancy under land Use Act has radically modified previously existing notions of ownership, control, and other interests in land and this is particularly manifested in the granting of land rights to wealthy individuals, corporate bodies and cooperatives in the name of "public purposes" for development. The Land Use Act was an effort at solving the multiple land tenure system that existed in the country. The expectation was that it would make land acquisition easier so that a larger number of citizens would have access to land. The Act which essentially adopted the Land Tenure Law of Northern Nigeria to nationalize all land in Nigeria vested all lands comprised within the territory of a state in the Governor of that state (except lands vested in the Federal Government). By transferring the radical title of non-state land to the Governor, the Act sought to introduce a uniform land tenure system throughout the country. According to USAID (2012), the objectives of the Land Use Act were to: (1) make land accessible to all Nigerians; (2) prevent speculative purchases of communal land; (3) streamline and simplify the management and ownership of land; (4) make land available to governments at all levels for development; and (5) provide a system of government administration of rights that would improve tenure security.

According to Unachukwu, (2020); Butler, (2019); and Mabogunje (2010), the Land Use Act has been successful in ensuring the control of all land in the hand of government for public purposes, reduces the burden of land compensation and litigations over land matter. However, there are gaps and a number of serious problems that have emanated from the refusal and lack of government will power to change the land use act that have been in place over forty years. Most of the problem bordered on the implementation of the Land Use Act rather than the provisions of the act itself (Emeka *et al*., 2017). Some of the problems are the lack of prerequisite maps for determining who owns what land; the non-explicit demarcation of urban and rural areas, and the assumption that the prerequisite national cadastre and geospatial data infrastructure, which are very essential for any land tenure reform, were available (Atilola, 2010). Other challenges emanating from the implementation of the Act are the exclusion by the decree of the rights of families or individuals to develop private lay-outs has led to the emergence of a disjointed, uncoordinated and incoherent system of physical planning in Nigerian cities and a declining rate of housing provision as well as agricultural production in the country.

Land Tenure and Agricultural Productivity.

Nigeria has about 84 million hectares of arable land that spreads across all the ecological zones and about 33 million hectares is suitable and available for arable crop production. Nwaru *et al*. (2010) suggested that a much smaller area is available for cultivation leaving little room for agricultural expansion as a result of which great difficulties are going to be faced in producing enough food to sustain future populations, and the impact of tenure on land use and productivity is critical. The customary principle of communal land tenure is seen as setting limits on strategies that could be used to promote agricultural production or as warping the effects of the various strategies in use (Clement, 2013). It is argued that this principle encourages fragmentation of holdings and land immobility which prevents progressive farmers from consolidating fragmented parcels or expanding their holding. The argument advanced by the critics of customary tenure emphasized the utility of private over communal (public) land-ownership, and the starting assumption appears to be that only private tenure can quickly adjust to the rigid social and economic change brought about by modernizing agriculture.

Jialing and Jian (2018) asserted that the dominant source of output growth in Chinese agriculture during 1978-1984 was the change from collective - team large farms to individual household-based farming (despite the often-small size of household plots). Private plots usually are highly productive and account for significant national agricultural output; Individualized tenure facilitates the establishment of commercial agriculture; Communal tenure system under customary arrangement breeds uncertainty and insecurity of tenure (Clement, 2013). Shimelles *et al*., (2009) concluded that ownership insecurity causes low farm productivity due to a lack of investment incentives and limited access to credit; Tenant farmers have generally been found to be neglected in the allocation of credits and are subjected to insecurity as an additional source of risk to farmers. Therefore, its impact on productivity depends on the ability of farmers to bear additional risk. Clement (2013) stated that the right an individual exercise over his portion of communal land usually terminates at the end of the cropping season.

Factors Affecting Land Tenure System.

Various factors have been identified which affect the system of land ownership as well as land use in Nigeria. Population increase is said to be putting increasing pressure on available land and creating problems such as land fragmentation, land litigation, shortening of fallow period, and complexity in social relationships, and individual rights get emphasized over collective interests (Alemu *et al*., 2017). In the face of rapidly growing populations in Nigeria, there is a growing debate about whether indigenous land tenure systems are dynamic or static. Some argued that if the indigenous land tenure systems are static irrespective of changing socio-economic circumstances (especially growing population pressure), then the ambiguity of land use and transfer rights which characterize traditional tenure arrangements would constitute a major obstacle to agricultural and rural development (Emeka *et al*., 2017; Clement, 2013). But others opined that if the indigenous land tenure systems are dynamic, then population pressure will facilitate the transformation of land tenure from systems of communal control towards individualized rights of use and transfer (Mark, 2013; Mabogunje, 2010).

Today, the land tenure system is predominantly individualistic. It can be observed that with the increasing shortage of land, the mode of land transfer and acquisition move progressively towards pecuniary land exchanges (that' is, land for money transactions). Comparing the present land transactions with what contained in the past (15 to 20 years ago), there is a diminishing incidence of land gifts and other forms of non-monetized land exchanges as against the prevailing upsurge in land rentals, pledging and sale. There is the gradual emergence of land markets where land could be rented, loaned, pledged or sold/bought out rightly (Mark, 2013). However, different regions of the country have varying degrees of population pressure on land, resulting in varying land-use patterns (Isaac *et al*., 2019). As population pressure increases, the period of fallow shortens and shifting cultivation is replaced by systems of rotation and soil improvement. These changes may also be precipitated by the introduction of commercial tree crop production, which tends to enhance the rights of exclusion of individuals even though the basic control over outsiders' access to the land continues to be exercised by the community (Maiangwa *et al*. 2006).In response to population pressure, agricultural commercialization and technological change, they emphasized that indigenous African tenure systems have moved along that continuum in the direction of greater individualization of land rights and that three broad categories of tenure regimes can be delineated about the interplay of these forces. With rapid population growth, arid urbanization, the large-scale acquisition of land by the government had become rampant in Nigeria (Liz, 2018). He also noted that the government's land acquisition and various land consolidation programs have weakened the customary tenure system and encouraged individual land ownership.

Specifically, it has been noted that as farmers improve their holding with new seed – fertilizer, technologies, irrigation facilities, and other land improvement techniques, traditional landholding practices give way to individualized rights which limit the access of other members of the community to the land. The performance of land tenure systems in Nigeria have been · recognized to be affected by some factors such as socio-economic, sociological, and cultural factors including traditional and religious as well as institutional factors. Clement (2013) noted that structural changes in the economy are likely to have some impact on the existing tenure system, particularly, the advent of a monetized economy and increased aspirations for material well-being.

CONCLUSION.

The research reviewed land tenure system practiced in Nigeria. It emphasized the types of tenure, modes of land acquisition, and land use act implementation in the country. The study concluded that communal and inheritance are the established forms of land tenure and mode of land acquisition respectively in Nigeria based on the available literature. These identified means of land control constitute constraints and negatively influence land productivity particularly as it reduces their ability to possess full ownership and control of land. Hence, the need for land reform cannot be overemphasized in an environment where people depend on resources like land to cater for deficit infrastructural development.

RECOMMENDATION.

The study recommends that Land use act and policy that is currently in use should be amended. This is necessary to enhance availability and accessibility of land to individuals, groups and institutions for agriculture and other gains. The amendment is also essential in order to mitigate the preponderance associated with the practices of land grabbing and land tenure system.

ACKNOWLEDGEMENT.

The authors sincerely appreciate the support given by the management of Federal University Gashua and Tertiary Education Trust Fund, Tetfund in the course of the research work.

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Journal of Applied Agricultural Research 2022, 10(2):83-90
ISSN 2006-750X.

WHAT FACTORS DETERMINE THE LEVEL OF WATERMELON FARMERS' MARKET PARTICIPATION?

Egbetokun O.A[a] and Amao I.O[b]
[a]Institute of Agricultural Research and Training, PMB 5029, Moor Plantation, Ibadan, Nigeria.
[b]National Horticultural Research Institute, PMB 5432, Idi-ishin, Jericho, Ibadan, Nigeria.
Author's Contact: ifeluv@yahoo.com, oaegbetokun@yahoo.com, Phone no: 08035796464

ABSTRACT.

Market participation is a means of ensuring better income and food security. However, the participation of farmers in watermelon marketing in Ibarapa, Oyo State Nigeria has not been explored to assess the participation level and identify the factors influencing watermelon marketing. A multistage sampling procedure was employed in selecting 120 respondents for the study. Primary data was collected using a well-structured questionnaire and analyzed using descriptive statistics, percentile, and fractional probit regression model. The result showed that 76.7% were male, with an average age of 37 years, while 61.3% were, having an average of 11 household members. Sixty-five percent possess secondary education and an average of 10 years of watermelon farming experience. The average farm size was 4.27 hectares; the level of marketing is high as opined by 66.7% of the farmers and 74.2% are at least at the 50 percentile in the extent of market participation. The result showed a positive and significant effect of years of farming experience on market participation and agrochemical but average cost of labor shows a negative relationship. Therefore, the government should consider years of experience of the farmers in formulating strategies to improve the market participation of watermelon farmers. Government should also give new entrants access to input (agrochemical) and capacity building for improved market participation. Moreover, the farmers should embrace the training received and put it to immediate use in order to increase watermelon market participation in the study area.

Keywords: Fractional probit, farming experience, income, market, participation index, watermelon.

INTRODUCTION.

Watermelon (*Citrullus spp*) belongs to the family *Curbubitaceae*; it's a rich source of vitamins, antioxidants, and is used as drinking water during the drought in parts of Sudan and Nigeria (Ayodele and Shittu, 2013; Goda, 2007). Its consumption has increased due to its nutritional and health benefits. The advantages of watermelon to the national economy of a country are enormous; it can boost food security, foster rural development and support sustainable land conservation (Ufoegbune *et al.*, 2014). Watermelon is the most popular cucurbit (FAO, 2015). Watermelon is the most widely consumed fruit vegetable globally (Paris, 2016); it was more preferable to cantaloupe, squash, cucumber, and pumpkin (Ajewole, 2015) during a survey in the Ibadan metropolis. Watermelon is one of the fruits with high demand due to increased awareness of its health benefits especially in southwestern Nigeria (Kassali *et al.*, 2015). Due to higher consumer demand, the production of watermelon marketing is increasing (Popagu, 2012). However, Dube *et al.* (2020) revealed that more research is needed on watermelon in Africa owing to its viable nature. Watermelon is an important source of income to small-scale farmers in rural communities across Nigeria (Adewole and Folayan, 2008) which is also accessible, available, and affordable by various classes of the population (Odebode *et al.*, 2018). Moreover, when exotic and indigenous vegetables are compared, exotic ones generate higher profit and more income to marketers as well as employment (Isibor and Ugwuaba, 2014).

A commercial outlook to smallholder agriculture is imperative for improved welfare of farmers as it allows them to engage in high-value non-food agribusiness and other non-farm enterprises due to increased household income (Omiti *et al.*, 2009). Forces driving commercialization are increased net demand, urbanization, development of non-farm sector, etc. Markets are important in the agricultural transformation process because they have the potential to lead to economic growth and agricultural development such as gave rise to the market-led rural development paradigm of the 1980s (Readon and Timner, 2007).

Market participation is a means of ensuring better income and food security for rural people. Market access is important for smallholder farmers as it can lead to agricultural and economic development. Increased market access can lead to increased farmers' market participation and the extent of market participation all things being equal (World Bank, 2008; Key *et al.*, 2000). Smallholder farmers can increase their income by increasing their volume of sales (Torero, 2011). However, this can be hindered by different factors such as poor transportation facilities, high transaction costs, inadequate infrastructure, lack of market information (Abafita *et al.*, 2016)..

Ibarapa area of Oyo state is one of the areas noted for fruit and vegetable crops produced in the state with a large number of its inhabitants as farmers (Odebode *et al*., 2018). Arising from the foregoing, this study examined the socio-economic attributes of market participation among the watermelon farmers as well as the factors affecting the level of market participation of this group of farmers.

There are several studies on watermelon marketing both within and outside Nigeria. Kassali *et al.* (2015) carried out an economic analysis of watermelon marketing in Oyo state, the study specifically looked at the profitability of watermelon marketing, market conduct, and performance of watermelon markets and factors determining gross margin of watermelon marketers. Balogun *et al.*, (2018) conducted a similar study in 3 major markets of Lagos state which considered the profitability of the business enterprise, market channels available, frequency of purchase of watermelon by the marketers, determinants of net market margins of watermelon marketers, and the constraints they faced in the course of marketing the vegetable. Oseni (2015) studied the structure of watermelon marketing in Akure Ondo state while Amao *et al.*, (2014) conducted a study on the profitability of watermelon marketing as an alternative crop to melon in Ibarapa Central Local Government Area Oyo state. Ukwuaba *et al.*, (2018) assessed the socio-economic and institutional determinants of watermelon marketing in Enugu state where they specifically examined the factors influencing the net income of watermelon marketers. Oyewole *et al.*, (2015) assessed youth participation in watermelon production; Chogun *et al.*, (2019) studied the market structure and performance of watermelon in

Benin. Toluwase and Owoeye, 2017 examined a cost-benefit analysis of watermelon production in Ekiti state, Otunaiya and Adedeji (2014) examined the technical efficiency of watermelon production in Yewa North Local Government Area, Ogun State. Isibor and Ugwumba (2014) analyzed watermelon marketing in Anambra state. The study used the budgetary method to determine the profitability of watermelon marketing, net returns on investments, and operational efficiency and determined the relationship between net marketing income and socio-economic factors of watermelon marketers. Alfa-Nla, (2014) examined costs and returns of watermelon production, input-output relationship, determinants of technical inefficiency in watermelon production, and constraints to watermelon production. Ohen *et al.* (2013) analyzed factors influencing smallholder rice farmers' market participation using the probit model. Outside Nigeria, Geoffrey *et al.* (2013) examined the determinants of market participation for smallholder pineapple farmers in Kenya while Megerssa *et al.* (2020) also examined factors associated with smallholder market participation of Ethiopian vegetable producers. However, none of these studies have been carried out in Ibarapa Central Local Government Area of Oyo state, one of the areas noted for watermelon production in the Southwestern part of Nigeria. This study, therefore, assessed the socio-economic attributes of watermelon farmers in the study area and the factors that determine their level of participation in watermelon marketing.

MATERIALS AND METHODS.

The study was carried out in Ibarapa Central Local Government Area, Oyo State. The local government is bounded on the South West and North West by Ogun state, on the east by Ibarapa East Local Government, and the North by Ibarapa North Local Government. According to the year 2006 provisional census, the population of the area was put at 102,979 (Oluwafemi *et al.*, 2015).

Sampling Procedure and Sample Size.

The multistage sampling procedure was employed with the first stage being a purposive sampling of Ibarapa Central Local Government Area. This was because of a high concentration of farmers involved in watermelon production and marketing in the area. The second stage was a random sampling of 10 wards from the local government area and then third stage was the random sampling of 12 watermelon farmers from each ward. This gave rise to a total of 120 respondents sampled from the local government area. Primary data was collected from the respondents using a well-structured questionnaire. Data were analyzed using descriptive statistics, market participation index, and fractional probit regression model. Following Ogunleye (2018), the market participation index (sales index) was calculated as the ratio of the total value of crop sales and the total value of crops produced. Fractional probit regression is relevant for an array of dependent variables including fractions, proportions, rate, indices, and probabilities. It computes a robust standard error by default.

The dependent variable (market participation) is continuous, y in (0, 1) and a vector of independent variables x. in order to fit a regression for mean of y conditional on x: E(y/x) y is in (0, 1), E(y/x) is also restricted in (0, 1).

Fractional probit accomplishes this by

$E(y/x) = \emptyset(x\beta)$............................ (1)

The model specification for the ordinary least square model is as follows, in line with Ogunleye, 2018:

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_{10} X_{10} + \mu_i$..... (2)

Y=Market participation index measured as the ratio of total value of watermelon sold and total quantity of watermelon produced (values between 0 and 1)
X_1=age of farmer (in years)
X_2=sex of farmer (male=1, 0 otherwise)
X_3=educational status of farmer (1= Formal education, 0 otherwise)
X_4=Farming experience (in years)
X_5=Farm size (in hectares)
X_6= Average cost of transportation (in Naira)
X_7= Average cost of labor (in Naira)
X_8=Average cost of seeds (in Naira)
X_9=Average cost of agrochemicals (in Naira)
X_{10}=Household size (number of household members)

RESULTS AND DISCUSSION.

Personal and marketing attributes of watermelon farmers.

Table 1 shows the description of some personal and marketing attributes of sampled watermelon farmers in the study area. Most of the respondents are male (76.7%), the average age was 37 years, about 61% were, having an average of 11 household members. Sixty-five percent possess secondary education, 74.2% have farming as the main occupation and they have an average of 10 years of experience in farming. The average farm size of sampled farmers is 4.27 hectares; most of the farmers use hired labor for production (65.8%), 55.8% sell in the town market while 69.2% sell watermelon to wholesalers. A little less than seventy percent (66.7%) of the farmers opined that their level of marketing is high; moreover, 85% have access to market information on the price of watermelon. Furthermore, 67.5% of the farmers source their capital through personal savings; 62.5% do not use storage facility and most of the farmers (72.5%) opined that the condition of the road to the market is good (35.8%) or fair (36.7%). Extent of market participation by watermelon farmers.

The extent of market participation by the respondents is presented in Table 2. The table revealed that 74.2% of farmers have a percentile of at least 50% It showed that the level of market participation is high among the farmers in the area of study. This shows that farmers in the area are well experienced in the cultivation and marketing of watermelon. In addition, factors that could contribute to the high level of market participation are access to the market, price, and years of experience (Egbetokun *et al.*, 2017).

Determinants of level of market participation by watermelon farmers.

A fractional probit regression was run to determine the level of market participation by watermelon farmers and presented in Table 3. The wald chi^2 value of 301.49 and prob chi2=0.0000 shows that the variables included fit the model. A positive and significant effect of years of farming experience on the market participation index among watermelon farmers was observed. The result shows that an additional year of experience a farmer has increased his or her market participation by 0.2%. This implies that the knowledge and experience of farmers could influence their market participation (Egbetokun *et al.*, 2017). Moreover, supporting the finding of this study, Adepoju *et al.*, 2015 revealed a positive and significant effect of years of farming experience on market participation of pineapple farmers. Also, an increase in the average cost of labor reduces the farmers' market participation index by 1.92e-07. On the other hand, one naira increase in the average cost of agrochemical increases the market participation index by 4.76e-06. An increase in the average amount spent to purchase agrochemicals and for labor could imply that more farmland is being put into cultivation thereby leading to more production by the farmers.

1: Descriptive statistics of personal and marketing attributes of the watermelon farmers.

Variable	Frequency(Percentage)	Mean (Standard deviation)
Sex		
Male	92(76.7)	
Female	26(21.7)	
Prefer not to say	2(1.7)	
Age (in years)		37.01(10.29)
20-29	25(20.8)	
30-39	40(33.3)	
40-49	34(28.3)	
50-59	19(15.8)	
Greater than 59	2(1.7)	
Marital status		
Single	41(34.2)	
Married	74(61.3)	
Others	4(3.3)	
Prefer not to say	1(0.8)	
Household size		10.64(6.54)
1-5	27(22.5)	
6-10	45(37.5)	
11-15	17(14.2)	
Greater than 15	22(18.3)	
Educational status		
No formal education	5(4.2)	
Primary education	16(13.3)	
Secondary education	78(65.0)	
Adult education	17(14.2)	
Others	1(0.8)	
No response	3(2.5)	
Major occupation		
Farming	89(74.2)	
Marketing	22(18.3)	
No response	9(7.5)	
Years of farming experience		10.36(7.02)
1-5	36(30.0)	
6-10	39(32.5)	
11-15	-	
Greater than 15	22(18.3)	
Farm size (in hectares)		4.27(3.10)
Less than 1	3(2.5)	
1-5 ha	60(50.0)	
6-10ha	35(29.2)	
No response	21(17.5)	
Source of labour		
Family labour	18(15.0)	
Hired labour	79(65.8)	
Family and Communal labour	20(16.7)	
Others	1(0.8)	
Point of sale		
Farmgate	18(15.0)	
Village market	27(22.5)	
Town market	67(55.8)	
Others	8(6.7)	
Customer base		
Consumers	17(14.2)	
Retailers	15(12.5)	
Wholesalers	83(69.2)	
No response	5(4.2)	
Farmers' perceived level of marketing		
High	80(66.7)	
Low	40(33.3)	
Farmers' access to market information on price of watermelon		
Yes	102(85.0)	
No	14(11.7)	
No response	4(3.3)	
Farmers' source of capital		
Cooperative loan	22(18.3)	
Personal savings	81(67.5)	
Bank loan	3(2.5)	
Contribution (group savings)	10(8.3)	
No response	4(3.3)	
Farmers' access to storage facility		
Yes	41(34.2)	
No	75(62.5)	
No response	4(3.3)	
Perception of the condition of road to the market		
Very good	8(6.7)	
Good	43(35.8)	
Fair	44(36.7)	
Poor	23(19.2)	
Very poor	2(1.7)	

Source: Field data, 2020

Table 2: Extent of market participation of watermelon farmers.

Percentile	Percentage	Mean	Std deviation
25	25.8	141.52	40.883
50	44.2	364.11	115.484
75	30.0	2376.67	4969.554

Source: Field data, 2020

Table 3: Determinants of level of market participation by watermelon farmers.

Variable	Coefficient	Marginal effect	z-value
Sex of farmer (male=1, 0 otherwise)	-0.0067	-0.0038	-0.27
Age of farmer (years)	-0.014	-0.0008	-1.28
Educational status (Formal education=1, 0 otherwise)	-0.110	-0.0057	-0.63
Years of farming experience	0.0260	0.0015	2.05**
Farm size (in hectares)	-0.0127	-0.0007	-0.40
Average cost of transport (in Naira)	-5.83e-06	-3.28e-07	-1.08
Average cost of labor (in Naira)	-3.41e-06	-1.92e-07	-2.05**
Average cost seed (in Naira)	-0.000	-1.95e-06	-0.71
Household size	-0.0195	-0.0011	-1.51
Average cost of agrochemical (in Naira)	0.0001	4.76e-06	2.05**
Constant	4.658	0.976	
No of observations	117		
Wald chi2(7)	39.49		
Prob>chi2	0.0000		
Pseudo R2	0.0510		
Log pseudo-likelihood	-15.026		

CONCLUSION.

The study was carried out to examine the factors that determine the level of market participation among watermelon farmers in Ibarapa Central Local Government Area of Oyo State. The area is notable for horticultural crop production due to its favorable weather condition. Most of the sampled farmers were young, male, and experienced in watermelon production. Farmers in the area attested that they have high market participation. The factors that determine watermelon farmers' participation in the market are farming experience as well as the average cost of labor and agrochemical. This study thus recommends that to improve market participation of watermelon farmers, strategies put in place by the government should consider the years of experience of the farmers. In the same vein, the government should give new entrants into the business access to capacity-building activities for knowledge enhancement. In turn, these capacity building activities should be embraced by the watermelon farmers and put to use in order to increase their market participation.

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SOIL SCIENCE AND CROP PRODUCTION

Journal of Applied Agricultural Research 2022, 10(2): 92-108
ISSN 2006-750X.

APPRAISAL ON THE MAJOR FUNGAL CONTAMINANTS OF SORGHUM GRAINS IN NIGERIA

Garba, M.H.[1], Makun, H.A.[2], Jigam, A.A.[3], Hadiza, L.M.[2], Njobeh, P.B [4],
[1]Department of Department of Biochemistry, Federal University Dutse, P.M.B. 7156, Jigawa State, Nigeria.
[2] African Centre of Excellence on Mycotoxins and Food Safety, Department of Biochemistry, Federal University of Technology, P.M.B. 65, Minna, Niger State, Nigeria.
[3] Department of Biochemistry, Federal University of Technology, P.M.B. 65, Minna, Niger State, Nigeria.
[4] Food, Environment and Health Research Group, Faculty of Health Science, 2028, University of Johannesburg, Doornfontein Campus, 2028 Gauteng, South Africa.
Author's Contact: mharunagarba@gmail.com, Pone no. +2348134809595.

ABSTRACT.

A total of Four hundred and thirty-five (435) samples were collected and composited to 87 samples. The mycological analytical procedures Kaufman *et al*. were performed under aseptic conditions. The macro-and microscopic identifications for Fusarium, Aspergillus, Penicillium and other species were done following appropriate identification keys. The fungal isolates that could not be clearly identified, were confirmed using molecular tools (PCR). *Aspergillus flavus* was the species of aspergillus with the highest frequency while *Emericella quadrilineata* has the lowest frequency. The isolated *Penicillium species* were observed to spread across the six Agro-ecological zones with the samples from the NGS being most contaminated, with 33(98) of the isolates while the Sudan savannah followed with 21(98), the SHS appeared to be least contaminated with 5(98). Fusarium contamination was found in all the agro-ecological zones, in the descending order thus: NGS>SGS>SS>DS>SHS>M-ALT. With regards to contamination by other fungal species, Mid altitude (M-ALT) was the least affected (2/12), while SGS is the most affected with 9/12 of the species isolated. The sorghum grain has been shown to be susceptible to fungi and mycotoxin contamination. The proven presence of fungi in sorghum a highly consumed grain makes it a probable major source of mycotoxins exposure to animals and human beings and therefore of great public health concern.appr.

Keywords: Survey, Fungi, agro-ecological zone, PCR, Mycotoxins.

INTRODUCTION.

With regards to the regulation of agricultural and food industries, the safety of food and feed for human and animal consumption should be of topmost priority. Food commodities are among the major items of international trade for many. West African countries and those involved in farming activities constitute 70% of the population in the region (AFDB/FAO, 2015). In Africa, an estimated $US4 billion ($4.06 billion) worth of grain is lost each year, which is 10 to 20 percent of the full total shipments. This figure could feed up to 48 million people in the region (Charles *et al*., 2016). While the food-borne bacteria constitute the greatest hazard, when compared with the mycotoxins to human food safety, it is the other way round in the case of livestock feeds. Mycotoxin is a term usually reserved for the toxic chemical products produced by fungi that readily colonize crops. (Guozhong *et al*., 2020). When considered from both perspectives, it could be concluded that the mycotoxins produced by fungi play a significant role in the health and performance of both humans and animals (FDA, 2020).

As a result of the significant losses that have been observed to be associated with their impact on human and animal health, coupled with the consequent national economic implications observed thereof, attention has been widely (at international level) been focused on mycotoxins (Marie and, Freire, 2014; Mohamed, 2011). Aflatoxins, fumonisins, ochratoxins, zearalenone, and deoxynivalenol are the most implicated agriculturally important toxins from fungi. Depending on the dosage, sex, and breed of the animal, fungal toxins can cause acute or chronic intoxications, (Ahmad and Jae-Hyuk 2017).

In the sub-Sahara African region, the need to eat outweighs other considerations such as food safety, courtesy, persistent poverty, and hunger. As such, this has made food-borne intoxications to be a serious problem in many parts of the region. According to the World Bank Development Report (1993), diseases caused by mycotoxins lead to reduced life expectancy in developing countries (Miller, 1996). In the same report by Miller (1996), diseases exacerbated by aflatoxins alone caused a loss of 40% productivity in developing countries. Regrettably, ignorance has blinded the majority of the people in the region from realising the dangers associated with the consumption of moldy products.

The West African countries are characterised by a tropical climate that provides optimal conditions for the growth of toxigenic molds. Consequent to an all-year-round high ambient temperature and relative humidity poorly developed infrastructures such as processing facilities, storage, transportation, and skilled human resources are other factors that negatively impact the sub-region.

In Africa, Asia, and Latin America, sorghum provides an ample source of staple grain for over seven hundred and fifty million people. (CAC, 2011). It is traditionally mainly in the semi-arid tropics, for human consumption, animal feeds, and local alcoholic beverage drinks. There are five primary varieties of Sorghum bicolor namely: bicolor, caudatum, durra, guinea and kafir are five primary varieties commonly available, though. Ten intermediate varieties which are all combinations of the basic varieties also exist. Nigeria accounts for about 65-70% of the total sorghum production in West Africa. It is produced in Bauchi, Borno, Zamfara Yobe, Gombe, Adamawa, Kaduna, Jigawa, Niger, Kebbi, Taraba, Plateau, Sokoto, Katsina, and Nasarawa States. (Ogbonna, 2011). On a regional basis, Nigeria ranks fourth sorghum producer next to India (Zalkuwi *et al*., 2015.) and first in Africa (USDA, 2017; FAOSTAT, 2016). Even though accurate losses caused by diseases are difficult to be estimated, it involves the assessment of losses from production to marketing and finally utilization of the grain or seed. On a conservative scale, the annual economic loss due to sorghum grain mold in Asia and Africa has been estimated to be US$ 130 million (Das and Patil 2017).

Although a substantial amount of polyphenols (phenolic acids, flavonoids, and condensed polymeric phenols known as tannins), that protects seeds and seedlings from insect attack and hence microbial colonization (Audrey and Awika, 2018) has been observed to be contained in sorghum grain, susceptibility to fungal infestation and mycotoxin contamination has been regretfully observed. The presence of these toxigenic fungi and their toxic and carcinogenic secondary metabolites (mycotoxins) in sorghum, makes it a major source of mycotoxins exposure, due to the high level of consumption by both animals and humans and therefore of great public health concern.

The main focus of the present study was to sample sorghum from the six agro-ecological zones, isolate the fungal contaminants and identify such fungal species using the most recent genetic technology apparatus and methods available with a view to finding the level of fungal contaminants therein.

MATERIALS AND METHOD.

Sampling.

Survey Sites.

A survey was conducted in the Sorghum producing areas of the six agro-ecological zones of Nigeria, namely: Derived savannah (DS), southern guinea savannah (SGS), northern guinea savannah (NGS), Sudan savannah (SS), the Sahel savannah (SHS) and the Mid-altitude to evaluate the distribution of mycotoxin contamination in sorghum. The DS lies within latitudes 6°8′ and 9°30′ N and longitudes 2°40′ and 12°15′ E and has a bimodal rainfall distribution averaging between 1300 mm to 1500 mm annually, and maximum temperatures varying from 25 to 35 °C. The SGS zone lies within latitudes 8°4′ and 11°3′ N and longitudes 2°41′ and 13° 33′ E, with a bimodal rainfall averaging between from 1000 mm to 1300 mm per year, and maximum temperatures ranging from 26 to 38 °C. The NGS lies within latitudes 9°10′ and 11°59′ N and longitudes 3°19′ and 13°37′ E and has a unimodal rainfall distribution averaging between from 900 mm to 1000 mm annually, and maximum temperatures varying from 28 to 40 °C. Across the regions, temperatures increase and rainfall decreases with increasing latitude with the DS southernmost followed by the SGS, the NGS and the Sudan savannah SS and Sahel savannah SHS in the north (Atehnkeng, *et al*., 2008).

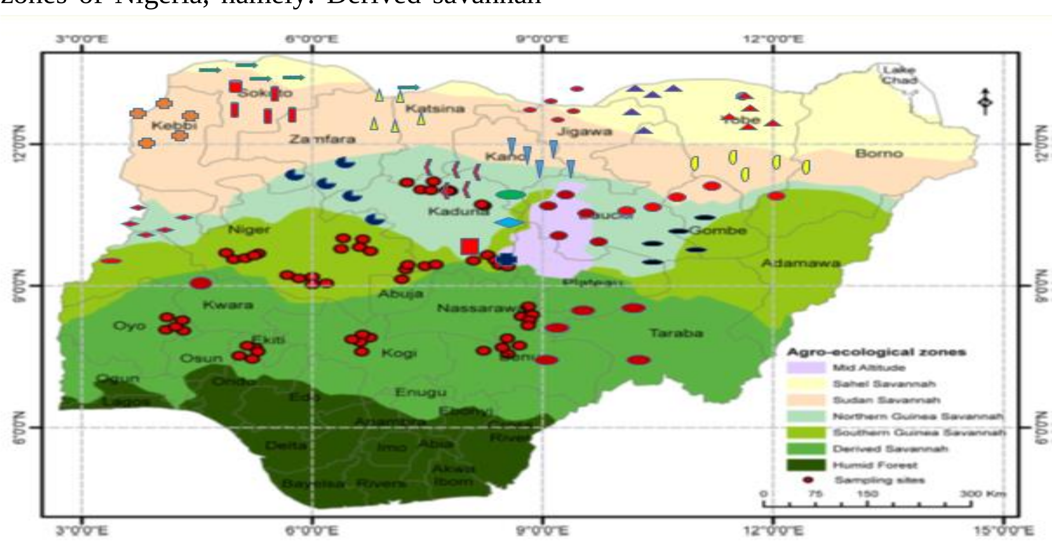

Fig.1: Map of Nigeria showing districts in six agro-ecological zones from which Sorghum samples were collected. (Atehnkeng *et al.,* 2008).

Sampling.

This was based on the method of Atehnkeng *et al*., (2008) with some modifications. Six districts were selected as the study sites, that is, the DS (Ado-Ekiti, Lafia, Lokoja, Makurdi, and Ogbomosho) and the SGS (Abuja, Akwanga, Bida, Minna, and Mokwa) and five districts in the NGS (Zaria, Kontagora, Kaduna, Bauchi, and Rijau) Five districts were also selected in the Sudan savannah SS (Sokoto, Daura, Kebbi, Dutse, and Dawanau), Sahel savannah SHS (Goronyo, Sabon Birni, Baure, Kirikasamma and Guri/Nguru) while in the mid-altitude (M-ALT), Riyom, Toro, Langtang and Wase were selected (Fig 1). In each district, Sorghum grains in stores, markets, and bunches in the field were sampled from five locations, each approximately 20 km from the previous sampling location. At each location, a single farmer who grew sorghum in the previous season was identified and 1kg of sorghum with or without visible signs of fungal growth was arbitrarily selected from the farmer's store. Only Sorghum that had been in storage for up to 2 months was sampled from each farmer during the survey. This duration is long enough for mycotoxin to accumulate in fungi-infected sorghum grains (Olakojo and Akinlosotu 2004; Sauer and Tuite, 1987). A total of four hundred and thirty-five (435) samples were collected in all. Samples collected from the same eco-niche, within the same sampling district in the agro-ecological zone, were pooled together to give eighty-seven (87) composite samples. The samples were placed in polythene bags, properly sealed, and transported to our laboratory at the Federal University of Technology, Minna, before shipment to the Food, Environment, and Health Research Group, laboratory, Faculty of Health Science, University of Johannesburg, Gauteng, South Africa. A hundred grams was taken from each kg in each of the locations and this 100 g was ground into powdered form and used for fungal isolation.

Fungal Screening.

Conventional Identification.

The mycological analytical procedures (Kaufman *et al*., 1963) were performed under aseptic conditions. One gram of milled sample was weighed into a test tube and diluted in 9ml of sterile Ringer's solution, vortexed and serially diluted further to 10-6. One ml from each test tube was cultured by pour plate technique on Ohio Agricultural Station agar (OAESA) and potato dextrose agar (PDA) and incubated for 4-7 days at 25ºC. Plates were counted for fungal colonies using a colony counter and the number of fungal colonies per gram of sample was calculated and expressed in colony-forming units per gram of sample (CFU/g) as:

$$\mathrm{CFU/g} = \frac{\text{Number of colonies}}{\text{Plating volume (1ml)}}$$
$$= \text{reciprocal of the dilution factor}$$

Isolated fungal colonies were further sub-cultured on PDA, Czapek yeast agar (CYA), and malt extract agar (MEA) according to Kaufman *et al*., (1963) under aseptic conditions and incubated at 25ºC for 7 days. Pure fungal colonies were harvested and stained with lactophenol in cotton blue and mounted on microscope slides for identification. The macro-and microscopic identifications of *Fusarium species* were done following the identification keys of Pitt and Hocking, (1997) and Nelson *et al*., (1983) while Hockings, 1999 keys were employed for other species. Both the identified and unidentified fungal isolates were sent to Inqaba Biotechnological Laboratories, Pretoria, South Africa for confirmation and further analysis and identification (In case of the unidentified samples). For preservation, isolates were sub-cultured on PDA slants for 7 days at 25ºC and stored at 4ºC.

DNA Extraction, PCR and Sequencing.

In the case where the morphological characteristics of individual fungal spp are not sufficient for clear identification and depending on the relative importance of the fungus concerning its potential to produce various mycotoxins, further analysis was performed. The technique involving the comparison of nucleic acid profiles of individual fungal species was, therefore employed using a GeneAmp PCR System 9700 and an automated sequencer—ABI PRISM 3700 Genetic analyzer according to Samson *et al*. (2004). In the case where the morphological characteristics of individual fungal spp are not sufficient for clear identification and depending on the relative importance of the fungus concerning its potential to produce various mycotoxins, further analysis was performed. The technique involving the comparison of nucleic acid profiles of individual fungal species was therefore, employed using a GeneAmp PCR System 9700 and an automated sequencer—ABI PRISM 3700 Genetic analyzer according to Samson *et al*. (2004).

DNA Extraction.

Genomic DNA analysis (during confirmation and identification) was performed using a Fungal/Bacterial DNA extraction kit (Zymo Research Corporation, Southern California, USA). The freeze-dried cultures were allowed to stand 1 hour at room temperature and then DNA was extracted. In this case, about 60 mg of sample was mixed with 200 µl of phosphate buffer saline (PBS) contained in a 1.5 ml ZR Bashing BeadTM lysis tube. The lysis tube was then placed in a beater and processed for 5 mins, followed by centrifugation at 10,000 g for 1 min. The supernatant was transferred to a Zymo-SpinTM IV spin filter in a 1.5 ml Eppendorf tube and again centrifuged at 7,000 g for 1 min. The content was filtered into a collection tube and 1,200 µl of fungal/bacterial DNA binding buffer was added and vortexed. The extraction mixture (800 µl) was transferred to a Zymo-SpinTM IIC column in the collection tube which was again centrifuged at 10,000 g for 1 min with the supernatant discarded (X2). A 200 µl of DNA pre-wash buffer I aliquot was added to the Zymo-SpinTM IIC column in a new collection tube and centrifuged at h10, 000 g for 1 min. The filtrate was discarded while retaining the column, which was then placed into a new tube, 500 µl fungal/bacterial DNA wash buffer II was added to the Zymo-SpinTM IIC column and again centrifuged at 10,000 g for 1 min. The Zymo-SpinTM column was transferred to a sterile 1.5 ml Eppendorf tube and 100 µl DNA elution buffer was added directly to the column matrix. This was then centrifuged at 10,000g for 30 secs to elute the DNA.

PCR Analysis.

Identification of fungal spp. in question was done by isolating the translation elongation factor (TEF) 1α region following the sequence obtained from different databases. The primer sequences used were those described by O'Donnell and Cigelnik, (1997) designed in conserved 5' and 3' regions. The primers were synthesized at a 0.01 µM scale and purified using reverse-phase cartridge purification (Inqaba Biotechnical Industries (Pty) Ltd, South Africa). These primers were re-suspended in a 2 µM TE buffer prepared from a stock solution concentration of 100 µM.

Thereafter, PCR was performed using the Fermentas 2 X PCR mix (Fermentas Life Science, Lithuania). The PCR mixed for each sample was made to consist of 25 µl of 2 X PCR mix,1µl of each 2 µM primer, 1 µl of DNA (final concentration of 10 µM), and was constituted to a final volume of 50 µl with nuclease-free water. A negative control, containing all of the reagents except the DNA was also prepared. The PCR was then performed using an Eppendorf 96-well Thermocycler (Eppendorf, USA). The PCR cycling conditions were set as Pre-dwelling at 95ºC for 3 mins, 35 cycles denaturation at 95ºC for 1 min, annealation at 58ºC for 45 secs, extension at 72ºC for 1 min 30 seconds, post-dwelling at 72ºC for 10 minutes and hold at 4ºC and the samples were thereafter retrieved.

Agarose Gel DNA Electrophoresis.

The preparation of 2% agarose gel was carried out by dissolving 2 g of agarose (Fermentas Life Science, Lithuania) in 98 ml 1x TBE buffer (Fermentas Life Science, Lithuania) and then boiled. The solution was thereafter cooled to approximately 60°C. Ethidium bromide (3 µl) (Sigma-Aldrich, St Louis, MO, USA) was then added to the solution and thoroughly mixed. The agarose solution was then poured into a casting chamber (Bio-Rad Laboratories, California, USA) and the combs with 10 wells were carefully inserted. The chambers of the running system (Bio-Rad Laboratories, California, USA) were filled with 1 X TBE buffer (Fermentas Life Science, Lithuania). Each PCR product (2 µl) previously obtained was mixed with 10 µl of 6 X orange loading dye (Fermentas Life Science, Lithuania) and loaded into the wells. The chamber was closed and run at 70 V for 15 minutes. The PCR product so formed were viewed using the Vacutec Gel documentation system and the product size was confirmed by comparing it to the Middle Range FastRuler (Fermentas Life Science, Lithuania).

Sequencing of the PCR Products.

PCR products obtained from the synthesis process were cleaned using shrimp alkaline phosphatase and *E. coli* exonuclease I (Fermentas Life Sciences, Lithuania). The purity of the DNA was confirmed by running a 2% agarose gel (as previously described). Automated DNA sequencing was performed at Inqaba Biotechnical Industries (Pty) Ltd (Pretoria, RSA) using the SpectruMedix model SCE 2410 automated DNA sequencer (SpectruMedix, State College, PA). The sequencing reaction mixture (prepared by Inqaba Biotechnical Industries (Pty) Ltd, South Africa) included the ABI BigDye Terminator Cycle Sequencing kit version 3.1 dye (Applied Biosystems, Foster City, CA) and the same primers used in the original PCR reaction.

Sequence Data Analysis.

Samples were then analyzed on an ABI PRISM 3700 Genetic analyser (AB, Applied Biosystems, Nieuwerkerk a/d Yssel, TheNetherlands). The forward and reverse sequences were assembled using the programs SeqMan and EditSeq from the LaserGene package (DNAStar Inc. Madison, WI). Alignments of the partial β-tubulin gene sequences Samples data were calculated using a software package BioNumerics (Applied Maths BVBA, Saint Martens-Latem, Belgium) and adjustments made manually with the aid of an eye to maximize homology. Some reference sequences for the TEF 1 α coding region referred to by O'Donnell *et al*,(1998; 2000; 2004) and Geiser *et al*.,(2004) was used. These sequences, in FASTA format, were obtained from the FUNGI ID v. 1.0 database (Geiser *et al*., 2004).

RESULTS.

Level of Fungal Contamination.

The sorghum sampled from three eco-niches in the six agro-ecological zones and invariably Nigeria was found to be contaminated and co-contaminated with seven hundred and one (701) fungal isolates, belonging to sixty-two (62) fungal species (Appendix A). Identification on the basis of macro and microscopic features and confirmatory identification using the molecular-based technique (PCR), revealed that *Aspergillus species* made up 347(701) of the isolates belonging to 17 genera (APPENDIX B). Aspergillus section flavi has the highest number (73) followed by the section nigri (58), circumdati (55), fumigatus (40) while other section were observed to occur only in some selected areas and also few in numbers. (Table 3.1).

The isolated *Penicillium species* were observed to be spread across the six Agro-ecological zones were found to constitute 102(701) of the total isolates (Appendix C). The samples from the NGS were found to be the most contaminated with 33(98) of the isolates while the Sudan savannah followed with 21(98), the SHS appeared to be least contaminated with 5(98). It is pertinent to note that, *P. verrucosum* which has been implicated in the production of OTA in the temperate climates, was found to be peculiar with two locations (i.e Toro and Kontagora). Table 3.2 also indicated that *P. fellatum* is peculiar to NGS and the SS only.

In the case of the *Fusarium species*, 189(701) of the isolates were found to fall into this category (Appendix D). As indicated in Table 3.3, Fusarium contamination appeared to be across all the agro-ecological zones, with the NGS being most contaminated in the following order: NGS>SGS>SS>DS>SHS>MALT. The NGS appeared to be most contaminated by the fusarium genera (F. graminaerum, F. proliferatum F. oxysporum, and F. verticilloides) that are known to be FB1 and Trichotecenes producers while the least contaminated were found to be MALT and DS for F. oxysporum, SS and SHS for F. graminaerum, DS and MALT for F. verticilloides and SS, SHS and MALT for F. proliferatum. Of the 17 *Fusarium species* isolated, only 5 were observed to contaminate samples from the M-ALT which infer that this agro-ecological zone is the least contaminated.

Other fungal and yeast species were found to constitute 68(701) of the total isolates

(Appendix E). As indicated in Table 3.4 of all the six agro-ecological zones DS and SHS were the most contaminated with the Alternaria species with 5 and 2 respectively while NGS had only one infection by the same species. In the case of infection by the *Cuvularia species*, while 4 samples from the SHS were infected, 3 and 1 samples from SGS and NGS were observed to be infected by the same Cuvularia.

DISCUSSION.

The key elements involved in determining the type and amount of mycotoxin produced include, the fungi, subsbstrate, and environmental factors (Lacey, 1986). Hot and humid conditions are the two most established environmental factors favouring mold growth and mycotoxin production. Although the optimum temperature and moisture content for growth and toxin production for the various toxigenic fungi are not the same for all species, quite a majority of these fungi achieve the best growth and toxin synthesis between 24ºC and 28ºC and seed moisture content of at least 17.5% (Atanda *et al*.2013); Ominski *et al*., 1994; Trenk and Hartman, 1970). These aforementioned conditions coincide very closely with the ambient climatic conditions in most parts of Africa and therefore, give a very good reason for the high prevalence of fungi and their respective toxins in most of the continent. Out of the 701 isolates, Aspergillus species made up 347(701) of the isolates belonging to 17 genera of which Aspergillus flavus has the highest number (73) followed by the section nigri (58), circumdati (55), fumigatus (40) while another section was observed to occur only in some selected areas and also few in numbers. (Table 3.1).

Table 3.1: Frequency, incidence, and relative density of the Aspergillus species identified in sorghum from the six agro-ecological zones of Nigeria.

Agro-ecological zone	***A.flavus(73)***	***A.fumigatus(40)***	***Aspergillus carbonarius(55)***	***Aspergillus parasiticus(20)***	***Asperegillus oryzae(16)***	***Aspergillus unguis(8)***	***Aspergillus niger(58)***	***Aspergillus ustus(12)***	***Aspergillus versicolor(2)***	***Neosartorya fischeri(17)***	***Aspergillus melleus(4)***	***Aspergillus ochraceus(21)***	***Emericella nidulans(6)***	***Aspergillus japonicum(4)***	***Sclerocleista ornate(5)***	***Aspergillus parodoxus(5)***	***Emericell quadrilineata(3)***	**Total**
Derived savannah	9(12.33)	1(2.50	3(5.45)	11(55.00)	5(31.25)	4(50.00)	7(12.06)	4(33.33)	1(50.00)	11(64..70)	0(0.00)	3(14.28)	2(33.33)	0(0.00)	0(0.00)	1(20.00)	0(0.00)	62
Southern guinea savannah	12(16.44)	10(25.00)	9(16.36)	4(20.0)	5(31.25)	0(0.00)	8(13.79)	2(16.7)	0(0.00)	1(5.88)	0(0.00)	3(14.3)	1(16.7)	0(0.00)	2(40.0)	0(0.00)	0(0.00)	57
Northern guinea savannah	27(36.98)	15(37.50)	15(27.27)	3(15.0)	0(0.00)	2(25.0)	25(43.1)	1(8.3)	1(50.0)	3(17.7)	0(0.00)	5(23.8)	2(33.3)	2(50.0)	2(40.0)	2(40.0)	2(75.0)	107
Sudan savannah	12(16.44	5(12.5)	12(21.82)	1(5.0)	2(12.5)	0(0.00)	7(12.1)	2(16.7)	0(0.00)	0(0.00)	0(0.00)	3(14.3)	0(0.00)	1(25.0)	0(0.00)	0(0.00)	1(25.0)	46
Sahel savannah	8(10.96	4(10.0)	12(21.82)	0(0.00)	4(25.0)	2(25.0)	6(10.3)	2(16.7)	0(0.00)	2(11.8)	4(100.0)	5(23.8)	1(16.7)	1(25.0)	0(0.00)	0(0.00)	0(0.00)	51
Mid-Altitude	5(6.85)	5(12.5)	4(7.27)	1(5.0)	0(0.00)	0(0.00)	5(8.62)	1(8.3)	0(0.00)	0(0.00)	00.00)	2(9.52)	0(0.00)	0(0.00)	1(20.0)	2(40.0)	0(0.00)	26
Relative density	21.78	11.53	15.85	5.76	4.62	3.11	15.76	3.47	0.58	4.93	1.16	6.07	1.73	1.16	1.45	1.45	2.94	347

Table 3.2: Frequency, incidence and relative density of the *Penicillium* species identified in sorghum from the six agro-ecological zones of Nigeria.

Agro-ecological zone	***P. citreonigrum(22)***	***Penicillium restrictum(2)***	***Penicillium crustosum(4)***	***Penicillium implacatum(5)***	***Penicillium verrucosum(2)***	***Penicillium rogulosum(2)***	***Penillium expansum(5)***	***Penicillium janczewskii(4)***	***Penicillium fellatum (2)***	***Penicillium paxillii (11)***	***P. aurentiogresum (12)***	***Penicillium glabrum (7)***	***Penicillium nalgiovense (5)***	***Paecilomyces variotii (9)***	***Penicillium decumbens (7)***	**Total**
Derived savannah	2(4.5)	0(0.00)	0(0.00)	1(20.00)	0(0.00)	0(0.00)	1(20.00)	0(0.00)	1(0.00)	1(9.09)	4(33.33)	1(14.29)	0(0.00)	0(0.00)	2(28.58)	12
Southern guinea savannah	4(18.8)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	1(20.00)	1(25.00)	4(0.00)	4(36.36)	2(16.67)	0(0.00)	1(20.00)	0(0.00)	1(42.87)	16
Northern guinea savannah	8(36.4)	1(50.00)	2(50.00)	2(0.00)	1(50.00)	1(50.00)	2(40.00)	1(25.00)	2(50.00)	1(9.09)	2(16.67)	3(42.86)	3(60.00)	6(66.66)	3(14.29)	31
Sudan savannah	6(27.3)	0(0.00)	1(25.00)	1(20.00)	0(0.00)	0(0.00)	0(0.00)	2(50.00)	2(50.00)	3(27.27B)	2(16.67)	1(14.29)	0(0.00)	2(22.22)	0(14.29)	21
Sahel savannah	2(9.10)	0(0.00)	0(0.0)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	2(0.00)	2(18.18)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	1(14.29)	5
Mid-Altitude	(4.6)	1(50.00)	1(25.00)	1(20.00)	1(50.00)	1(50.00)	1(20.00)	0(0.00)	0(0.00)	0(0.00)	2(16.67)	2(28.58)	1(20.00)	1(11.11)	0(0.00)	13
Relative density	21.57	1.96	3.92	4.91	1.96	1.96	4.90	3.92	3.92	10.78	11.76	6.86	4.90	8.82	6,86	98

Table 3.3: Frequency and distribution of the *Fusarium* species identified from the six agro-ecological zones.

Agro-ecological zone	***Fusarium oxysporum* (40)**	***F. graminaerum* (22)**	***F. verticilloides* (39)**	***Fusarium solani* (35)**	***Fusarium poae* (15)**	***Fusarium acuminatum* (6)**	***F.Chlamydosporum* (11)**	***Fusarium proliferatum* (8)**	***Fusarium subglitinans* (3)**	***Fusarium avenaceum* (3)**	***Fusarium sambicinum* (1)**	***Fusarium trincitum* (1)**	***Fusarium equiseti* (1)**	***F. decemcellulare* (1)**	***Fusarium dimerium* (1)**	***Fusarium longipes* (1)**	***Fusarium laterium* (1)**	***Total 189***
DS	2(5.0)	5(22.73)	1(0.00)	5(14.29)	2(13.33)	1(16.66)	1(9.09)	0(0.00)	3(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(00.000	1(100.0)	1(100.0)	21
SGS	5(12.50)	5(22.73)	7(22.22)	13(37.14)	3(20.00)	0(0.00)	2(18.18)	3(37.50)	(0.00)	1(33.33)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	40
NGS	11(27.50)	9(40.91)	13(40.74)	5(14.29)	3(20.00)	3(50.00)	4(36.36)	5(62.50)	0(0.00)	1(33.33)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	54
SS	14(35.00)	0(0.00)	10(14.81)	9(25.71)	3(20.00)	2(33,34)	3(27.27)	0(0.00)	0(0.00)	0(0.00)	1(100.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	41
SHS	5(12.50)	0(0.00)	5(14.81)	3(8.57)	3(20.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	1(100.00)	0(0.00)	0(0.00)	1(100.00)	0(0.00)	0(0.00)	18
MAL	3(7.50)	3(13.64)	3(7.41)	0(0.00)	1(6.67)	0(0.00)	1(9.09)	0(0.00)	1(0.00)	1(33.33)	0(0.00)	0(0.00)	1(100.00)	1(100.00)	0(0.00)	0(0.00)	0(0.00)	15
Rel. Den	21.51	11.83	14.52	18.82	8.06	3.23	5.91	4.30	1.61	1.61	0.54	0.54	0.54	0.54	0.54	0.54	0.54	

Table 3.4: Frequency and distribution of other fungal species identified in sorghum from the six agro-ecological zones of Nigeria.

Agro-ecological zone	***Alternaria alternate* (15)**	***Alternaria infectora* (4)**	***Cuvularia lunata* (8)**	***Cuvularia pallescens* (1)**	***Endomyces fibuliger* (4)**	***Phoma sorghina* (10)**	***Absidia corymbifera* (5)**	***Rhizomucor pussillus* (11)**	***Rhizopus stolonifer* (7)**	***Candida Krusei* (1)**	***Schizosaccharomyces pombe* (1)**	***Rhodotonila mucilaginosa* (1)**
Derived savannah	2(13.33)	2(50.00)	0(0.00)	0(0.00)	0(0.00)	2(20.00)	1(20.00)	3(27.27)	1(14.29)	0(0.00)	0(0.00)	1(100.00)
Southern guinea savannah	5(33.33)	0(0.00)	3(37.50)	1(100.00)	3((75.00)	5(50.00)	1(20.00)	4(36.36)	3(42.86)	1(100.00)	1(100.00)	0(0.00)
Northen guinea savannah	2(13.33)	1(25.00)	1(12.50)	0(0.00)	0(0.00)	2(20.00)	1(20.00)	2(18.18)	1(14.29)	0(0.00)	0(0.00)	0(0.00)
Sudan savannah	1(6.66)	1(25.00)	0(0.00)	0(0.00)	1(25.00)	1(10.00)	0(0.00)	1(9.09)	1(14.29)	0(0.00)	0(0.00)	0(0.00)
Sahel savannah	5(33.33)	0(0.00)	4(50.00)	0(0.00)	0(0.00)	0(0.00)	2(40.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)
Mid-altitude	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	1(9.09)	1(14.29)	0(0.00)	0(0.00)	0(0.00)
Relative density	23.81	6.40	12.70	1.58	6.35	15.87	7.94	5.91	11.11	1.57	1.57	1.57

This finding is in close agreement with the result obtained by Atenkegh *et al*. (2008) In a similar studies in Northern guinea savannah As indicated in Table 3.1, these species were spread across the six agro-ecological zones, with the northern guinea savannah having the highest number of Aspergillus flavus (27), fumigatus (15), carbonarius (15) and niger (25). The species notorious for aflatoxin production, (A. flavus) were observed to spread across all the six agro-ecological zones as follows: NGS>SGS>SS>DS>SHS>M-ALT.. The predominance of the Aspergillus flavus in the Northern guinea savannah is quite in agreement with findings of Aliyu *et al*.(2016) who reported that, of the total 239 feed samples analyzed for the presence of fungal organisms, 198 (82.8%) revealed the presence of fungal organisms with Aspergillus spp. having the highest isolation rate of 136 (52.71%). However, A. parasiticus, another important aflatoxin producer (Frisvad, *et al*., 2019; Basaran, and Demirbas, 2010) but with less diversity, was found to constitute 20(347) Aspergillus isolates of the samples. It was observed to be more prevalent in agro-ecological zones as follows: DS>SS>NGS>SS/MA>SHS, the low level of incidence and its prevalence mostly in the derived savannah agro-ecological zone was found to agrees with the reports of Ezekiel *et al*. (2014). The SHS was the only zone where the incidence of A. parasiticus was not recorded in the samples; which could be due to the low moisture and low humidity of the area that does not favour the proliferation of the species. From Table 3.1 it is vivid that, A. melleus a fungal species implicated in ochratoxin production (Atanda *et al*., 2011), was isolated in samples from the SHS only. A. parodoxus, A. versicolor, and Emericella quadrilineata were observed in samples from DS/NGS, NGS/SS, and DS/NGS respectively. Findings made from our studies revealed that 82.5% of the fungal isolates co-occurred in the samples from all the Agro-ecological zones. It is also clearly indicated from the data obtained in this study that, sorghum samples from Northern guinea savannah had the highest contamination by Aspergillus species such as A. flavus, A. fumigatus, A.niger, A. ochraceus (from the Aspergillus family). The presence of *A. paradoxus, A. versicolor, Sclerocleista ornate*, *Aspergillus japonicum*, *Emericella nidulans*, *Neosartorya fischeri*, *Aspergillus ustus, and Aspergillus unguis* is of great concern since they have not been previously reported to contaminate sorghum. The metabolites that might be produced by these fungal species may either synergistically or additively interact with the Aflatoxins and or Ocharatoxins/other toxins to give rise to a molecule with greater health consequences.

The isolated Penicillium species were observed to spread across the six Agro-ecological zones constituting 98(701) of the isolates. The samples from the NGS were mostly contaminated with 33(98) of the isolates, while the Sudan savannah followed with 21(98), the SHS appeared to be least contaminated with 5(98). It is pertinent to note that, P. verrucosum has been implicated in the production of OTA in the temperate climates, it is peculiar with two locations (i.e Toro and Kontagora); this is similar with the report by Makun *et al*. (2011) in their sub-chronic toxicity of the fungal extract of samples from the same area. Table 3.2 also indicated that P. fellatum is peculiar to NGS and the SS only. All the isolated Penicillium species except for P. aurentiogresum and P. paxillii are found to be predominant in the Derived savannah and Southern guinea savannah respectively; they were also found to be either non or mildly toxic in the same report by Makun *et al*. (2009) Data obtained also indicated that fungi of the Fusarium species constitute the highest fungal contaminants in the Southern guinea savannah. The former observations and the latter all agreed with the findings of Makun *et al*.,(2009) and Onyike and Nelson, (1999) who evaluated the fungal contamination of sorghum, in Niger State (Middle belt region of Nigeria) and across all the agro-ecological regions respectively.

As indicated in Table 3.3, Fusarium contamination appeared to be in all the agro-ecological zones which agrees with the report of Cynthia *et al*. (2016). Samples from the NGS were found to be the most contaminated, then, followed by others, in the following descending order: NGS>SGS>SS>DS>SHS>MALT. The NGS appeared to be most contaminated by the fusarium genera (F. graminaerum, F. proliferatum F. oxysporum, and F. verticilloides) that are known to be FB1 and Trichotecenes producers (Alessia *et al*., 2018), while the least contaminated were found to be M-ALT and DS for F. oxysporum, SS and SHS for F. graminaerum, DS and M-ALT for F. verticilloides and SS, SHS and M-ALT for F. proliferatum. Out of the 17 Fusarium species isolated, only 5 were observed to contaminate samples from the M-ALT which infer that this agro-ecological zone is the least contaminated (Atanda *et al*., 2013). Data obtained from our study revealed the presence of Fusarium verticilloides, F. solani, F. poae, and F. oxysporum in all the six Agro-ecological zones which are in agreement with the findings made by Onyike and Nelson (1999), Atenkegh *et al*.,(2008), Makun *et al*.,(2011). However, F. proliferatum (A notorious FB1 producer) seems to prevail more in the SGS and NGS agro-ecological zones. The occurrence of the former species in all the Agro-ecological zones is a source of great concern, because finding from our study indicate the production of FB1, ZEA, DON by these strains (Table 3.3).

As indicated in Table 3.4, DS and SHS were the most contaminated with the Alternaria species with 5 and 2 respectively while NGS had only one infection by the same species. In the case of infection by the Cuvularia species, while 4 samples from the SHS were infected, 3 and 1 samples from SGS and NGS were observed to be infected by the same Cuvularia. Interestingly, Baruten in the SGS zone is the only location that had Cuvularia pallescence contamination. The 5 Phoma sorghina species isolated were all observed to be from the SGS while the M-ALT is not contaminated by this fungi species. Inspection of Table 3.4 further revealed that samples from the NGS were contaminated by all the other species except Candida, Schizisaccharomyces spp, and Rhodontila mucigilonosa. The Rhizopus and Rhizomucor spp were observed to contaminate samples from all the AEZ’s except the SHS. In terms of total contamination by all these species across AEZ’s, M-ALT is the least affected (2/12) while SGS is the most affected with 9/12 of the species isolated. The presence of all the aforementioned fungal genera as contaminants in the studied sorghum samples goes to confirm the findings of Makun *et al*. (2009) and Atanda *et al*. (2013) that reported similar observations. If the findings (high prevalence of fungi) reported in this research work is correlated with the recent report of 24.4% to 26% prevalence of chronic kidney disease (CKD) by Chukwuonye *et al*. (2018) and the high prevalence of chronic liver disease in Nigeria of which hepatitis B prevalence was found to be within the range of 2 to 20%, while hepatitis C prevalence, was in the range of 0.5% to 15% (Maisanda *et al*., 2018), the need for urgent mitigation measures to limit the proliferation of these fungi on our food and feed becomes inevitable.

CONCLUSION.

Considering the location of Nigeria and its tropical weather conditions, it is indeed a cause of concern due to the number of fungal species isolated. Aside from contamination and subsequent destruction of the sorghum grain through their extracellular secretion of enzymes, their level of toxigenicity (if determined to be high) will however further aggravate the situation as varieties of mycotoxins will tend to accumulate therein thereby predisposing the populace subsisting on sorghum and sorghum-based products to the risk of mycotoxicosis and mycoses as a result of consuming different mycotoxins cocktails or coming in contact with their spores in the environment. Based on the foregoing, proactive measures both from the sides of the government and the relevant organization (such as the Mycotoxin Society of Nigeria) needed to be taken to mitigate the problem.

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Journal of Applied Agricultural Research 2022, 10(2): 109-114
ISSN 2006-750X.

ECONOMIC ANALYSIS OF RATES OF FERTILIZER APPLICATION AND WEED CONTROL METHODS IN SWEET POTATO (*Ipomoea Batatas* L.) PRODUCTION IN LAFIA, NASARAWA STATE.

[1]Bello, I.H., [1]A.J. Ibrahim, [1]I.M. Ogara and A.A. Girei[2]
[1]Department of Agronomy, Faculty of Agriculture PMB 135, Shabu-Lafia Campus, Nasarawa State University, Keffi, Nigeria
[2]Department of Agricultural Economics and Extension, Faculty of Agriculture PMB 135, Shabu-Lafia Campus, Nasarawa State University, Keffi, Nigeria
Author Contact: abdul@nsuk.edu.ng Phone: +23480 596 711 97

ABSTRACT.

The study was carried out to investigate the profitability of sweet potato production in Lafia under different fertilizer rates application and weed control methods. The research was carried out at Lafia and Agyragu Koro of Nasarawa State. The factors comprised of fertilizer application of two NPK 30 and 60kgha-^{1} and 0kgha-^{1} of untreated control. The weed control methods comprised of herbicides application of PRE S-metalochlor followed by hoe weeding at 6 WAP, Post emergence application of fluazifop-P-butyl followed by hoe weeding at 6 WAP, hoe weeding at 3 and 6 weeks after planting (WAP) and a weedy check (control), and two plant spacing of 35x75cm row in spacing and 45x75cm row in spacing. Data on tuber yield ha-^{1}, and cost of inputswere recorded throughout the period of observation at both locations. Higher tuber weight, numbers of leaves and yield was recorded at both locations with the treatment application of 60kgha-^{1}. The higher yield was recorded with plots treated with Pre emergence application of Smetolachlor followed by hoe weeding at 6 WAP while minimum yield was recorded in the control plots (weedy check). In both locations, the gross margin of the sweet potato increased with the application of fertilizer at the rate of 60 kg ha^{-1}, pre-emergence application of S-metolachlor and planting density of 40 cm intra row spacing.

Key words: Sweet potato, herbicides, fertilizer rates, spacing, gross margin.

INTRODUCTION.

Sweet potato is the seventh-classified food crop produced after wheat, rice, maize, potato, barley, and cassava worldwide (Low *et al.*, 2015). Nigeria is the second leading producer of sweet potatoes after China, followed by Tanzania, Ethiopia, Indonesia, and Uganda (World Atlas, 2021). The annual production in Nigeria is estimated to be about at 3.46 million tonnes per year; with an average yield of 9.8 tons/ha. A total land area planted with sweet potato in Nigeria was 204.7 million hectares as reported by Udemezue (2019). The crop is grown majorly in Benue, Kogi, Plateau, Taraba (Mambilla Plateau) and Borno, other states are Zamfara, Bauchi, Katsina, Gombe, Sokoto, Jigawa, Kano and Kebbi States; although, production is mostly carried out through irrigation (Egeonu and Akoroda, 2010).

It is a root tuber crop that is mostly used for the human diet, animal feeds and as a source of starch and alcohol production. Nutritionally, sweet potato is rich in fiber, potassium, vitamins, carbohydrates, proteins, and other essential nutrients (Low *et al*., 2017; Iese *et al*., 2018). It is also used for income generating in addition to its food value for the producers and retailers in the market channel because the planting material can be multiplied vegetatively, avoiding the market-induced inequalities associated with hybrid crops that require annual purchase to sustain superior yield levels (Brito *et al.,* 2012) and its ability to attained maturity within the short period and can be harvested in piece meal and stored, play very important role in food security strategy by reducing the shortages associated with planting material (Westby *et al*.,2003).

Recent studies have revealed a decline in crop productivity in the tropics and Guinea savanna agro-ecological zone of Nigeria due to weed infestation and soil fertility depletion (Vlek*et al.*, 1997). Resource-poor farmers suffer more from the twin problem of noxious weeds and soil fertility because they do not have sufficient resources to purchase inputs (fertilizers and herbicides) to improve soil fertility and control weeds. In Lafia, sweet potato farmers use hand weeding and pre-plant herbicides (such as glyphosate) as effective tool for weed management. Kemble (2015) reported that there is no registered herbicide for Post-transplant broadleaf weed control in sweet potato. However, the application of S-metolachlor 0 to 14 DAP had been reported to achieve effective weed control of noxious weeds of sweet potato in North Carolina (Coleman *et al.*, 2016). Proper use of fertilizer in sweet potato production is necessary to increase the yield and quality of the crop, previous studies reported that the use of fertilizer by the resource-poor farmer is generally inadequate and most of the fertilizer elements especially Nitrogen (N) is lost as surface run-off, as nitrate leaching in groundwater and by volatilization to the atmosphere (Ju *et al*., 2009). The objective of the study therefore is to determine the profitability of sweet potato production under different fertilizer application rates, plant spacings and weed management practices.

MATERIALS AND METHODS.

The study was conducted at Teaching and Research Farm Faculty of Agriculture Shabu-Lafia Campus of Nasarawa State University Keffi (N 8^{o}33' 49" longitude E 8^{o}33'1"W)**,** with an altitude of 168.47m and Agyaragu koro, with (8^{0}31' 26" N; 8^{0} 39'58"W) with an altitude of 189.1m in the southern agro-ecological zone of Nasarawa State.

The experimental design was a factorial design in Randomize Complete Block with three replications. The factor comprising of two plant spacing (35 and 40 cm within the rows) and 75 cm inter rows, giving planting densities of 21,428 and 18,750 plants per hectare, respectively), two fertilizer application of NPK (30 and 60 kg/ha) and untreated control (0 kg/ha) (No fertilizer), andherbicide application of [Pre-plant S-metolachlor (Dual Magnum; Syngenta), Post emergence fluazifop-P-butyl, Hand-weeding at 3 and 6 WAP and a weedy check (control)], giving 24 treatment combinations. The plant spacing and NPK fertilizer rates was laid to the main plots and herbicides was randomized to the subplots.

Field preparation included slashing, ploughing and harrowing with a tractor and then prepared into ridges using hoes and garden lines. Plot was measured in 4 × 4 m with 1 m space between rows and 1 m within rows. The length of a ridge was 4 m; giving 12 plants per ridge. Vines were multiplied for eight weeks and vine cuttings were 30 cm long containing 4 or 5 nodes. Vines of white variety (O' henry) of sweet potato were used.

Statistical analyses were performed using Genstat. The differences between the means were determined using least significant difference (LSD) at $P < 0.05$ probability. Economic analysis was determined for the profitable combination of tested factors for sweet potato production (Erhabor, 2005). All expenses (variable cost which include total cost of labour (land preparation, planting, weeding, fertilization and harvesting), fertilizer, herbicide, planting material (vine) and transportation and revenue were calculated per hectare thus: (i) GM = TR-TVC where GM is gross margin, TR is total revenue, and TVC is total variable cost (all expressed in N ha^{-1}). Returned per naira invested = $\frac{TR}{TVC}$

The total cost of production of the sweet potato enterprise is shown in table 1.

RESULTS.

The result shows that application of fertilizer rate significantly affected the yield of sweet potato at both locations. High yield of sweet potato was achieved with the plots application of 30 and 60kgha-¹ at both locations (Table 2). Higher yield was recorded at Lafia with the fertilizer rate of 60kgha-¹ which had yield of 6.78 tons ha-¹ compared with the highest yield of 5.54 tonha-¹ at Agyragu koro. Spacing did not differ significantly at both locations. However, higher yield were recorded with the plots of 45x75cm in row spacing compared to 35x75cm in row spacing, while plots treatment of weedy check (control) recorded the lowest yield at both Lafia and Agyragu koro (ranging from 2.91 to 3.48).

The total variable cost increased as the rate of fertilizer application and spacing increased coupled with the application of herbicides (Table 3). Revenue, gross margin and return per naira invested increased as fertilizer application rate increased up to 60 kg N ha^{-1}. Returned per naira invested was highest with the application of with Pre emergence S metolachlor followed by hoe weeding at 6 WAP and post emergence application of fluazifop-P-butyl and hoe-weeded at 3 and 6 WAP while minimum yield was recorded in the control plots (weedy check) with 2.77 and 2.72 and 3.44 at Lafia, respectively. Similar observations were recorded at Agyragu-Koro.

DISCUSSION.

The results showed effect of fertilizer rate application of 30 $kgha^{-1}$ and 60 $kgha^{-1}$ compared to untreated plots (0 $kgha^{-1}$) on yield of sweet potato. Good fertilizer application rates are important options for ensuring good crop growth and yield (Opara and Asiege 1994; Okpara *et al* 2004). In both locations, the total variable cost and total revenue of the sweet potato increased with the application of fertilizer at the rate of 60 kg ha^{-1}, pre-emergence application of S-metolachlor and planting density of 40 cm intra row spacing.This disagrees with the findings Idoko *et al.* (2016) who observed that intra row spacing of 20 cm gave the highest net return per hectare as against 30 cm and 40 cm in sweet potato production.

CONCLUSION.

Results from the study indicated that total yield t/ha was higher with the fertilizer application of 60 $kgha^{-1}$ with the plot treatment of herbicides pre S Metolachlor of 0.803 kgai-ha^{-1} and hoe weeding of 3 and 6 WAPs which reduces weed infestation and subsequent crop yield reduction compared to plots with untreated (weedy check).

The gross margin analysis also showed that S metalochlor at rate of 0.803kgai-ha^{-1} was higher in terms of monetary gain followed by hand weeding and other herbicides weed control methods. Therefore, the application of herbicides will be utmost benefit to the farmers to reduce excessive labour because of the excellent weed control.

Table 1: Costs of production of sweet potato in Lafia and Agyragu-koro.

	Location	
Land Preparation	**Lafia ₦/ha**	**Agyaraku Koro ₦/ha**
Land Rent	25,000	25000
Ploughing	20,000	20,000
Harrowing	15,000	15,000
Ridging	25,000	25,000
Sub-total	**85,000**	**85,000**
Planting		
Transportation of planting materials	15,000	12,000
planting materials (vine)	64,000	64,000
Labour cost	30,000	30,000
Sub-total	**109,000**	**106,000**
Field Supplies		
Herbicide (Paraquat)	12,850	12,850
Herbicide (Fluozifop-butyl)	10,500	10,500
Herbicide (S-metolachlor)	10,500	10,500
Herbicide spraying	24,000	24,000
Fertilizer NPK 15:15:15	57,000	57,000
Urea	32,000	32,000
Sub-total	**146,850**	**146,850**
Maintenance and Harvesting		
Weeding (2 times)	42,000	28,000
Harvesting of tubers	40,000	36,000
Sub-total (Harvesting)	82,000	64,000
Other cost		
Fuel	10,000	10,000
sub-total	**10,000**	**10,000**
Total cost of production	**436,850**	**411,850**

Table 2: Effect of Fertilizer Rate, Spacing and Weed Control Methods on Tuber Yield.

Treatment	**Lafia**	**Agyragu-Koro**
		Yield/ha (tons)
Fertilizer rates (F) kg ha^{-1}		
0	5.08	4.14
30	6.18	5.09
60	6.78	5.54
LSD	0.526	0.507
Spacing (S)		
Narrow	5.89	4.91
Wide	6.14	4.94
LSD	0.257	0.192
Weed control methods (W)		
S-metalochlor	6.42	5.23
Fluozifop-P-butyl	6.39	5.15
HW 3 and 6 WAP	7.79	6.40
Weedy check	3.48	2.91
LSD	0.396	0.359
CV%	0.7	2.4
Interaction		
F x W	NS	NS
F x S	NS	NS
W x S	NS	NS
F x W x S	NS	NS

NS – Not significant; ** - Significance at 5 % level of probability

Table 3: Gross Margin Analysis of Sweet Potato as influenced by Fertilizer Rates, Spacing and Weed Control Methods at Lafia and Agyragu-koro.

Descriptions (₦ ha^{-1})	**Fertilizer rates (kg ha^{-1})**			**Spacing (cm)**		**Weed control methods**			
	0	**30**	**60**	**35**	**40**	**S-metalochlor + HW at 6 WAP**	**Fluozifop-butyl + HW at 6 WAP**	**Hoe-weeded 3 and 6 WAP**	**Weedy check**
						₦ Lafia			
Total variable cost	347,850	392,350	436,850	436,850	423,225	375,350	375,350	366,850	338,850
Output (t ha^{-1})	5.08	6.18	6.78	5.89	6.14	6.49	6.39	7.79	3.04
Revenue*	812,800	988,800	1,084,800	942,400	982,400	1,038,400	1,022,400	1,246,400	486,400
Gross margin	464,950	596,450	647,950	505,550	559,175	665,050	647,050	879,550	147,550
Return per naira invested	2.34	2.52	2.48	2.16	2.32	2.77	2.72	3.40	1.44
						Agyragu-koro			
Total variable cost	322,850	367,350	411,850	411,850	398,225	379,350	379,350	366,850	338,850
Output (t ha^{-1})	4.14	5.09	5.54	4.91	4.94	5.23	5.15	6.40	2.91
Revenue*	662,400	814,400	886,400	785,600	790,400	836,800	824,000	1,240,000	465,600
Gross margin	339,550	447,050	474,550	373,750	392,175	457,450	444,650	873,150	126,750
Return per naira invested	2.05	2.22	2.51	1.91	1.98	2.21	2.17	2.38	1.37

* Selling price estimated at N160 per kg (farm gate price).

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Journal of Applied Agricultural Research 2022, 10(2): 115-124
ISSN 2006-750X.

EFFECT OF BIOCHAR BLENDED WITH POULTRY MANURE ON THE PRODUCTIVITY OF OKRA (*Abelmoschus esculentus* L. Moench) IN LAFIA.

Muntaka, H.A.[1] and Jayeoba, O.J.[2]
[1]Agricultural Research Council of Nigeria, Plot 223D Cadastral Zone B6 MabushiAbuja
[2]Department of Agronomy Faculty of Agriculture Nasarawa State University Keffi, Nigeria
Author's contact: muntaqaharuna@gmail.com

ABSTRACTS.

Field experiments were conducted in the research farm of Faculty of Agriculture, Nasarawa state University Keffi; Lafia campus during 2017 and 2018 rainy season; to evaluate the potentials of biochar blended with poultry manure as soil amendments on the growth and yield of okra. The treatments consisted: Control (no amendment) 2t biochar + 10t/ha poultry manure; 4t biochar + 10t/ha poultry manure; 6t biochar + 10t/ha poultry manure; 8t biochar + 10t/ha poultry manure; 10t biochar + 10t/ha poultry manure; and 10t/ha poultry manure). The treatments were laid in a Randomized Complete Block Design (RCBD) and replicated three times. The results showed that the soil has high sand particles and the textural class before cropping was sandy loam. Incorporation of biochar blended with poultry manure brought about reduction in active acidity and significantly improved the physical and chemical properties of soil in both years of cropping. Biochar blended with poultry manure had a significant ($p<0.05$) increase in both growth and yield parameters of okra in both years of cropping. From this study, it can be concluded that mixture of 8t biochar + 10 t ha^{-1} poultry manure is the optimal rates of blending biochar and poultry manure in both years that can enhanced good growth, yield and environmentally friendly production of okra in Southern Guinea Savanna agro ecological zone of Nigeria.

Keywords: Biochar, Poultry Manure, Growth, Yield, Okra.

INTRODUCTION.

Okra *(Abelmoschus esculentus* L.Moench*)* is a yearly, herbaceous flowering plant which belongs to the Malvacea family. This plant originated from tropical and subtropical Africa and is natural to the West Africa (Aladele et al**.,** 2008).Okra is mainly cultivated for its young immature fruits and consumed as a vegetable in countries like Sudan, Egypt and Nigeria. It is also important in other tropical areas including Asia, central and South America often used as ingredient for soups and sauces. The fruits can be conserved by drying; the roasted seed is considered as coffee substitute; the leaves, flower buds, flowers and calyces can be eaten greens (Ajari et al**.,** 2003). In Nigeria, okra can be grown all year round (both wet and dry season), but attract a larger profit in the dry season when the demand is often higher than limited supplies (Ayeni et al., 2012). However, the major factors limiting the production of okra and other vegetables include: low soil fertility and weed management (Iyagba *et al.,* 2012). This assertion was also upheld by Fagwalawa and Yahaya (2016) who reported that okra production in Nigeria is currently faced with the challenges of low yield and they attributed the reasons of this low yield to poor soil fertility and deficiency in important mineral nutrients in the soil. Intensification of crop production, inappropriate agricultural land uses and management practices, deforestation and soil erosion have contributed to the decline in soil quality and crop yields in Nigeria (Vanlauwe *et al.,* 2001).

In Nigeria today, there is no more opportunity to practice shifting cultivation or allow the farm land to rest through fallowing as it was in olden days. There is intensive competition for land between peasant farmers and cattle herders, which sometime results to dangerous conflict. Therefore, to achieve food adequacy in Nigeria; there is the need to amend our soil with external nutrients. The use of chemical fertilizer is a well-known global practice in rejuvenating a depleted soil by farmers. However, the excessive uses of these chemical fertilizers have negative consequences like river pollution, soil acidity and nutrient disparity in the soil (Ojoniyi, 2000). Hence animal manure and plant wastes (biochar) are better alternative and a necessary option for improved okra productivity. Biochar is a stable form of charcoal produced from heating natural organic materials (crop biomass, woodchips, manure and other agricultural waste) in a high temperature of below 1000°C and low oxygen (Lehmann and Joseph, 2009). Studies conducted by these scientists (Chan *et al.,* 2008; Glaser *et al.,* 2002; Karhu *et al.,* 2011; Liang *et al.,* 2006; Ndor *et al.,* 2015; Steiner *et al.,* 2008; Woolf *et al.,* 2010; Zeelie., 2012) have discovered that biochar itself is not fertilizer but can aid in soil nutrients improvement, enhanced cation exchange capacity in the soil, decrease soil acidity, improve soil structure, nutrient use effectiveness, improve water-holding capacity with carbon sequestration. On the other hand, poultry manure has been adjudged to be the most valuable of all manures produced by livestock (Omisore *et al.,* 2009). Moreover, the nutrient contents of poultry manure are among the highest of all animal manures and the use of it as soil improvement for agricultural crops will provide appreciable quantities of all the major plant nutrients. Poultry manure also improves biological activities, soil tilt and soil chemical properties (Michael and George, 1998).

Therefore, blending these organic materials (biochar and poultry manure) and incorporating them into the soil as substitute for chemical fertilizer may result to sustainable crop productivity. This is because both biochar and poultry manure are relatively cheap, readily available, improvement crop yield and soil physical properties than inorganic fertilizer. Also, increasing demand for organic farm produce in developed countries and its attendant health benefits and risk- free characteristic is another dimension to the use of organic materials in improving soil health for long time crop productivity; especially in vegetables and fruits production. The aim of this study was to evaluate the effect of biochar – blended poultry manure on growth and yield of okra.

MATERIALS AND METHODS.

Description of Experimental Site.

The two trials were established during the rainy season of 2017 and 2018 at the Research Farm Faculty of Agriculture, Nasarawa State University, Keffi, Shabu-Lafia Campus Nassarawa State.The area lies between latitude 080 33’N, longitude 080 33’E and at an altitude of 181.53m above sea level.

Climate.

The study area falls within southern guinea savanna agroecological zone of Nigeria. Rainfall period is usually from March –

October and the average monthly rainfall figures range from 40mm-350mm. The months of July and August usually record heavy rainfall. The daily maximum temperature ranges from 20.0°C–38.5°C and daily minimum ranges between 18.7°C–28.2°C. The months of February to early April are the months that have the highest maximum temperature while the lowest maximum temperature are recorded in December and January because of the prevailing cold harmattan wind from the northern part of the country at this period. The relative humidity rises from April to a maximum of about 75- 90 percent in July (NIMET, 2014).

Soil.

The soil type of the study area is composed of highly leached alfisols with high base saturation. The soil is strongly acidic and has high content of iron and aluminium oxides hence reddish brown in colour with very low organic matter content and low total nitrogen and available phosphate (Agbede *et al*., 2011).

Treatment and Experimental Design.

The treatments consisted of four application rates of biochar blended poultry manure (control, 10t PM, 2t biochar +10PM, 4t biochar + 10PM, 6t biochr + 10PM, 8t biochar + 10PM, 10t biochar + 10PM/ha) and laid in a Randomized Complete Block Design (RCBD) and replicated three times.

Biochar Production and Blending with Poultry Manure.

Rice husk was collected from rice mill for the production of biochar. An improvised kiln was produced which was an empty drum that was perforated but had a cover. The rice husk materials were poured inside the drum half full, then fired was ignited inside the drum and more sawdust materials were added and the drum lid was covered to encourage slow burning and the content in the drum was consistently stirred to enhance uniformity of burning. After 3-4hours the content of drum was poured out and the fire was quenched with water (by sprinkling water on the hot char) and dried in the sun for 2 days (Ndor *et al.,* 2016). Then, this biochar was mixed with poultry manure according to the treatment.

Agronomic Practices.

The land was cleared, ploughed and harrowed in both locations, then biochar blended poultry manure was incorporated into the plots according to treatment and allowed to stay for two weeks before planting. The Okra seeds were bought from the Lafia market local variety (Dansiriya). Planting spacing of 50cm X 50cm was carried out. Three seeds were sown per hole and later thinned to two plants per stand at two weeks after sowing. Hoe weeding was carried out at 3 and 5 WAS and supplementary weeding was also carried out through hand pulling before the maturity of the crops. The okra plants were sprayed against beetles and caterpillars, by applying Cyperforce which has a systemic and contact action, at the rate of 0.5 litres per hectare (30 mls per 15 litres of water) four times during plant growth period.

Data Collection.

Five plants were randomly sampled from each plot in the fieldand tagged for observation of some growth parameters and yield of okra. The growth parameters (Plant height, Number of leaves per plant, Leaf Area) and yield parameter (Number of fruits per plant, Fresh fruit weight, Fruit length, Fruit diameter)

Data Analysis.

The amended soil and crop data collected were subjected to analysis of variance using GENSTAT (2008 Ed), and where there was a significant difference; the means were separated using F-LSD at 5% probability level.

RESULTS AND DISCUSSION.

RESULTS.

The results of the Physical and Chemical Properties of the soil before planting.

The result of the soil analysis revealed that the textural classes in the experimental sites before cropping was sandy loam; low in nitrogen, phosphorus, potassium, organic matter and also cation exchange capacity. Also, the soil was acidic in nature with pH of 5.63; high in percent sand fraction (88.00%) and also very high in percentage base saturation of 90.94%. While, the biochar pH was slightly alkaline (7.34); total nitrogen was 0.59%; organic carbon 3.78 %; ashes (13.36 gkg^{-1}). Then organic matter was 6.50%; available phosphorus 3.01 $cmolkg^{-1}$; and low C.E.C of 6.18$cmolkg^{-1}$but, high percentage base saturation of 96.52%. The poultry manure used was very high in both organic carbon (20.42%) and organic matter (35.12%); nitrogen (2.81%) and potassium (4.41%); while the pH was almost neutral (6.70).

Effect of Biochar - blended Poultry with Manure on Number of Leaves of Okra.

Biochar blended poultry manure had a significant ($p<0.05$) increase in the number of leaves of okra in both years (Table 2).Application of 10 t biochar + 10 t ha^{-1} poultry manure produced the highest number of leaves (7.33, 10.00 and 17.67) in 2017 cropping season at 3, 5 and 7 weeks after sowing. The control plots in 2017 cropping season produced the lowest number of okra leaves (3.97, 4.96 and 8.08) at 3, 5 and 7 (WAS). The same trend was also observed in 2018 cropping season, where application of 10 t biochar + 10 t ha^{-1} poultry manure produced the highest number of okra leaves (8.87, 14.10 and 15.20) at 3, 5 and 7 WAS. The control plots also produced the lowest number of okra leaves (5.17, 8.07 and 11.23) at 3, 5 and 7 WAS.

Effect of Biochar – blended Poultry Manure on Plant Height of Okra.

Biochar blended poultry manure had a significant ($p<0.05$) increase on plant height of okra in 2017 and 2018 cropping season (Table 3).Application of 10 t biochar + 10 t ha^{-1} poultry manure produced the tallest okra plants (18.47, 26.13 and 35.73cm) in 2017 at 3, 5 and 7 weeks after sowing (WAS) .The control plots in 2017 produced the shortest okra plants (5.90, 8.25 and 9.55cm) at 3, 5 and 7 WAS. Similar results was obtained in 2018; application of 10 t biochar + 10 t ha^{-1} poultry manure produced the tallest okra plants (8.87, 14.10 and 15.20cm) at 3, 5 and 7 WAS. The control plots produced the shortest okra plants (6.12, 10.34 and 12.30cm) in height at 3, 5 and 7 WAS compare to other rates.

Effect of Biochar blended Poultry Manure on Leaf Area of Okra.

The result on table 4 showed that Biochar combined with poultry manure had a significant ($p<0.05$) increase on leave area of okra in both 2017 and 2018. Application of 10 tbiochar + 10 t ha^{-1} poultry manure produced the widest leaf area(51.94, 99.24 and 130.53) in 2017 at 3, 5 and 7 WAS.The control plots in 2017 produced the smallest leaf area of okra (15.95, 27.30and 45.54) at 3, 5 and 7 WAS. In 2018, application of 10 tbiochar + 10 t ha^{-1} poultry manure produced the widest leaf area (50.48, 106.69 and 150.48) at 3, 5 and 7 weeks after sowing; which is statistically at par with application of 8t biochar + 10t ha^{-1} poultry manure. The control plots produced the smallest okra leafarea (24.21, 49.12 and 71.45) at 3, 5 and 7 WAS compare to other rates.

Biochar blended Poultry Manure Application on Yield Parameters of Okra.

The result on Table 9 showed that Biochar combined with poultry manure had a significant ($p<0.05$) increased on all yield parameters (number of fruit, fruit length and fruit diameter) of okra assessed in 2017 and 2018 cropping season. Application of 10 tbiochar + 10 t ha^{-1} poultry manure produced the highest number of okra fruits (36.77), fruit length (10.35cm) and fruit diameter of 2.93cm; this is statistically the same with application of 8 biochar + 10 t ha^{-1} poultry manure in 2017. While, the control plots produced the lowest number of okra fruits (14.30), fruit length of (6.48cm) and fruit diameter (1.56cm). Also in 2018, application of 10 t biochar + 10 t ha^{-1} poultry manure produced the highest number of okra fruits (69.87), fruit length (5.39cm) and fruit diameter of 3.85cm which is statistically similar with application of 8 t biochar + 10 t ha^{-1} poultry manure. The control plots in 2018 produced the lowest number of okra fruits (34.95), fruit length (2.36cm) and fruit diameter (2.11cm).

Biochar blended Poultry Manure Application on Yield of Okra.

The result on (Table 6) showed that Biochar blended with poultry manure had a significant ($p<0.05$) increased on fruit yield (fruit weight per plant and weight of okra tons per hectare) of okra assessed in 2017and 2018. Application of 10 t biochar + 10 t ha^{-1} poultry manure produced the highestweight of okra fruits per plant (241.57g), and total weight of fruit yield of 6.44 t ha^{-1} in 2017 cropping season. The control plots in the same year, produced the lowest weight of okra fruits (88. 44g), andtotal weight 2.36 t ha^{-1}. Application of 10 tbiochar + 10 t ha^{-1} poultry manure in 2018 alsoproduced the highestweight of okra fruits per plant (289.12g), and total weight of fruit yield of 7.71 t ha^{-1}. The control plots in 2018 produced the lowest weight of okra fruits (108.69g), and total fruit weight 2.90 t ha^{-1}.

Table 1: Results of Soil, Biochar and Poultry manure before incorporating into soil.

Properties	**Soil**	**Biochar**	**Poultry manure**
Physical properties			
Sand%	88.0	ND	ND
Silt%	3.4	ND	ND
Clay %	8.6	ND	ND
Textural class	Sandy loam	ND	ND
Chemical properties			
pH in H_20	5.63	7.34	6.7
Ashes(gkg^{-1})	ND	13.56	ND
Organic carbon%	13.8	3.78	20.42
Organic matter($g\ kg^{-1}$)	2.37	6.50	35.12
Total nitrogen($g\ kg^{-1}$)	2.1	0.59	2.81
P ($ppm/mgkg^{-1}$)	3.01	3.01	0.78
Ca($cmolkg^{-1}$)	3.48	0.31	1.13
Mg($cmolkg^{-1}$)	2.63	1.34	0.51
K($cmolkg^{-1}$)	0.25	3.01	4.41
Na($cmolkg^{-1}$)	0.27	0.52	0.31
EA(cmolkg)	0.66	0.20	ND
CEC($cmolkg^{-1}$)	7.29	6.18	ND
BS%	90.94	96.28	ND

ND = Not determined

Table 2: Effect of Biochar – blended Poultry Manure on Number of Leaves of Okra

	3WAS		5WAS		7WAS	
Treatments	2017	2018	2017	2018	2017	2018
Control	3.97	4.17	4.96	8.07	8.08	11.23
10t/ha PM	6.00	7.00	8.00	10.40	13.00	13.93
2t biochar + 10t PM/ha	6.67	8.10	7.67	10.60	13.33	14.27
4t biochar + 10t PM/ha	6.33	8.21	8.33	11.13	14.00	14.50
6t biochar + 10t PM/ha	6.33	8.43	8.33	11.80	15.33	14.63
8t biochar + 10t PM/ha	7.00	8.47	9.33	12.20	15.67	14.80
10t biochar + 10t PM/ha	7.33	8.57	10.00	14.10	17.67	15.20
LSD	1.11	0.50	1.04	0.35	1.02	0.30
CV%	8.00	2.00	6.30	1.80	5.20	0.20

Source: - (2017 & 2018 field Survey)

Table 3: Effect of Biochar - blendedPoultry Manure on Plant Height (cm) of Okra

Treatment	3WAS		5WAS		7WAS	
	2017	2018	2017	2018	2017	2018
Control	5.90	6.12	8.25	10.34	9.55	12.30
10t/ha PM	13.13	8.23	19.13	16.79	24.10	23.14
2t biochar + 10t PM/ha	14.53	9.50	21.27	17.59	25.47	24.94
4t biochar + 10t PM/ha	15.53	10.14	19.67	18.47	28.73	26.10
6t biochar + 10t PM/ha	16.27	10.43	20.00	20.17	31.40	29.24
8t biochar + 10t PM/ha	16.50	10.78	23.37	22.64	33.30	32.72
10t biochar + 10t PM/ha	18.47	11.67	26.13	25.05	35.73	34.57
LSD	2.26	0.62	5.98	1.01	2.35	2.21
CV%	0.41	1.70	9.80	1.20	3.10	7.50

Source: field Survey 2017 & 2018.

Table 4: Effect of Biochar blended Poultry Manure on Leaf Area (cm^2) of Okra

Treatment	3WAS	3WAS	5WAS	5WAS	7WAS	7WAS
	2017	2018	2017	2018	2017	2018
Control	15.94	24.21	27.30	49.12	45.54	71.45
10t/ha PM	31.99	40.36	55.38	66.47	97.76	116.23
2t biochar + 10t PM/ha	34.07	40.70	61.42	73.23	107.52	118.18
4t biochar + 10t PM/ha	37.52	42.42	67.34	77.03	112.96	120.69
6t biochar + 10t PM/ha	42.10	45.19	84.49	86.35	115.32	124.00
8t biochar + 10t PM/ha	47.87	47.25	90.24	92.34	120.71	128.43
10t biochar + 10tPM/ha	51.94	50.48	99.23	106.69	130.53	150.48
LSD	1.56	1.072	3.40	4.056	3.14	1.732
CV%	1.5	0.5	0.9	1.0	0.8	0.6

Source: field Survey 2017 & 2018.

Table 5: Effect of biochar blended poultry manure on Yield Parameters of okra at Lafia

Treatment	Fruit length (cm) 2017	Fruit length(cm) 2018	Fruit width(cm) 2017	Fruit width(cm) 2018	No. of Fruits 2017	No. of Fruits 2018
Control	6.48	2.36	1.56	2.11	14.30	34.95
10t/ha PM	8.48	3.95	2.35	3.10	28.20	58.67
2t biochar + 10t PM/ha	8.74	4.25	2.44	3.80	29.20	61.60
4t biochar + 10t PM/ha	9.06	4.53	2.60	3.35	30.70	63.23
6t biochar + 10t PMha	9.34	4.83	2.72	3.49	32.93	66.10
8t biochar + 10t PM/ha	9.70	5.09	2.81	3.59	34.90	67.88
10t biochar + 10t PM/ha	10.30	5.39	2.93	3.85	36.77	69.87
LSD	0.50	0.52	0.11	0.54	2.10	2.11
CV%	0.60	8.20	1.90	6.00	2.60	2.20

Source: field Survey 2017&2018

Table 6. Effect of biochar blended poultry manure on Yield of okra at Lafia

Treatment	Fruit weight plant(g)	Fruit weight plant(g)	Yield (t/ha)	Yield (t/ha)
	2017	2018	2017	2018
Control	88.44	108.69	2.36	2.90
10t/ha PM	158.84	193.42	4.23	5.16
2t biochar + 10t PM/ha	172.32	226.74	4.597	6.05
4t biochar + 10t PM/ha	184.04	250.70	4.91	6.69
6t biochar + 10t PM/ha	204.81	260.77	5.46	6.96
8t biochar + 10t PM/ha	218.88	275.48	5.83	7.35
10 biochar + 10tPM/ha	241.57	289.12	6.44	7.71
LSD	12.35	9.99	0.33	0.27
CV%	3.5	2.3	3.5	2.3

Source: field Survey 2017&2018

DISCUSSION.

The study revealed that the soil is sandy loam, slightly acidic and generally low in soil nutrients and therefore very low in fertility and required nutrients supplementation before crops can be grown. This confirmed the findings of (Jayeoba, *et al.,* 2012) who reported that the soils around Nasarawa state were acidic and low in fertility because of the removal of top soil by process of erosion. The incorporation of biochar and poultry manure brought about the reduction in active acidity of the soil. This may be attributed to the presence of large quantity of ashes in biochar which serve as liming materials (Table 1). This result agrees with the findings of Ndor *et al.,* (2016) who worked on effect of biochar on soil properties and organic carbon sink in degraded soil of southern guinea Savanna Zone, Nigeria. Also, Ayeni *et al.,* (2012) earlier reported that pH decreases with increase organic manure application. The vigorous performance in vegetative growth (number of leaves, number of branches, plant height) of okra plant exhibited by application of higher rates of biochar mixed with poultry manure in both years compared to poultry manure application alone; could be attributed to the fact that the soil in the study area consist of higher quantity of sandy particles, low clay content and deficient in some macronutrient (Table 1). When biochar and poultry manure were integrated into the soil it reduces the sizes of the soil pores thereby increasing water holding capacity, increased Cation Exchange Capacity (CEC), and providing a medium for adsorption of minimal plant nutrients and enhance conditions for soil micro-organisms (Sohi *et al.*, 2009). In addition, poultry manure that was used contains some mineral elements like N P and K (Table 1). These mineral elements especially nitrogen is responsible for growth of green plants. This explains why incorporating the soil with biochar and poultry manure brought about visible improvement in the growth performances of okra plant. This result is supported by Odeleye *et al*., (2005), who reported a significant increase in all the growth parameter of okra plant, when they used organic and inorganic fertilizer. This is also in agreement with the results obtained by Agbede and Adekiya (2013), who worked on the effect of wood ash, poultry manure and NPK fertilizer on soil and leaf nutrient composition, growth and yield of okra (*Abelmoschus esculentus*). Also, the significant response of okra yield and yield parameter (number of fruits, fruit length, fruit diameter and fresh fruit yield) recorded in the mixture of biochar and poultry manure supplement in this study in both years of cropping may be as a result of proper soil nutrient amendment which result to improvement in the soil fertility. This finding is in tandem with the earlier observation of Blay *et al.* (2001). Also, Moyin-Jesu and Ojeniyi (2000) reported the effect of animal manure and crop wastes on yield of okra (*Abelmoschus esculentus L. Moench*) and found that the amendment of wood ash, ground cocoa husk, rice bran, spent grain and saw dust with goat, pig and poultry manures enhanced okra yield. The superiority exhibited by application of 10 t biochar + 10 t ha^{-1}poultry manure which is statistically at par with the application of 8t biochar + 10 t ha^{-1}poultry manure in both years was as a result of adequate released and availability of nutrient within the soil because of reduction in leaching and nutrient immobilization brought about by blending poultry manure with biochar. Therefore, enough soil nutrients were available for uptake by okra plant and subsequently translated to luxuriant vegetative growth in both years of cropping.

CONCLUSION.

From the result of the study, it can be concluded that mixture of 8t biochar + 10 t ha^{-1}poultry manure is the optimal rates of organic materials that can enhance a good growth and environmentally friendly production of okra in North central agro-ecological zone of central Nigeria.

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Journal of Applied Agricultural Research 2022, 10(2):125-132
ISSN 2006-750X.

EFFECT OF SEED PRODUCTION ENVIRONMENTS ON SEED YIELD ATTRIBUTES OF PIGEON PEA (*Cajanus cajan* (L.) Millsp.) GENOTYPES

OLUFELO J.O AND ADETUMBI J.A
Department of crop production, University of Agriculture and Environmental Sciences Owerri, Imo State, Nigeria.
Author's Contact: jolufelo@yahoo.com

ABSTRACT

Genotype and seed production environments are important factors affecting seed yield attributes in crop species. However, there is paucity of information on seed yield and quality characteristics under different seed production environment in pigeon pea genotypes, hence, this study investigated the performances of 30 pigeon pea genotypes for seed yield attributes under two seed production environments of derived savanna (Ibadan, Oyo State) and rainforest (Ife, Osun State) in Nigeria. The experiment was carried out in 2016 and 2017 cropping seasons in a Randomized Complete Block Design with three replicates. Data collected were subjected to Analysis of Variance and significant means were separated using Tukey HSD test at 5% probability level. Correlation and principal component analyses (PCA) were also carried out. Seed yield characters were higher in 2017 than 2016 cropping year with superiority performance of between 13.36 and 35.83%. Seed yield characters were higher and better under rainforest environment compared to derived savanna environment. Genotypes A8125, ICPL87, NSWCC-50, NSWCC-34a, TCC-1, TCC- 5 and TCC-151 recorded outstanding performances for seed yield attributes within and across seed production environments. The PCA identified all the seed-yield attributes examined as characters majorly responsible for discrimination among the genotypes. The study concluded that rainforest agro-ecology is better for pigeon pea production while NSWCC-50 and NSWCC-7D were promising genotypes for seed yield (256.74g) and thus recommended for future seed improvement program.

Keywords: Pigeon pea, cropping environment, seed yield.

INTRODUCTION.

Pigeon pea (*Cajanus cajan*) is a perennial legume of family Leguminosae. The seeds have become a common food grain in Asia, Africa, and Latin America. (Harvey, 2006). It is referred to as 'orphan crop' because it falls into the group of least researched crops world-wide (Odeny, 2007). It is used in combination with soybean to produce one of the popular fermented, flavouring product soy sauce (Muangthai *et al*., 2009) The chemical composition of this valuable food suggested that the crop is rich in protein (21.5 %), while the fiber content is about 2.5 % (Akande and Balogun., 2010). This makes it a very important protein source in the region. In combination with cereals, the crops make a well-balanced human food. The dried peas may be sprouted briefly, cooked for a flavor different from the green or dried peas. The crop is an important crop for green manure, providing up to 90 kg nitrogen per hectare (Adu-Gyamfi *et al.*, 2007). Due to its deep rooting system, pigeon pea offers little competition to associated crops and is therefore much used in intercropping systems with cereals such as millet, sorghum and even maize (Odeny, 2007).

Consistent increase in population growth and climate change has threatened food security in most part of the world. Therefore, agriculture has been under pressure to produce more quantities of food on limited land resources. Reliance on only major crops (maize, cowpea, yam, cassava among others) has inherent agronomic, ecological, nutritional and economic risks and is probably not enough to mitigate the threat to food security. Crop diversification enhances resilience to threats to food insecurity because it can result in a significant decrease in the use of agrochemicals and fertilizers without having a negative impact on yield and profitability. Thus opening up a great potential for the expansion of the crop in Nigeria and the entire world, where it could be used to counteract the declining soil fertility and mitigate food insecurity.

There is little record of research efforts to improve existing accessions of pigeon pea, hence there is need to search for promising genotypes. Therefore, this research attempt to collect available pigeon pea genotypes within the whole country for evaluation to determine accessions with high yield potentials and superior characters that can be adopted by farmers for production.

METHODOLOGY.

Thirty pigeon pea accessions comprising of nine (9) genotypes obtained from International Institute of Tropical Agriculture (IITA) and twenty-one (21) genotypes obtained from Institute of Agricultural Research and Training (IAR&T) Ibadan, Oyo State, Nigeria were planted on two research fields (Ile-Ife and Ibadan) of IAR&T Ibadan during the early season of 2016 and 2017 cropping season. Ile-Ife is located in rain forest agro-ecology, while Ibadan falls within transitional derived savannah. The field was laid out in a Randomized Completely Block Design (RCBD) with three replicates. Each plot was 3m by 3m and the spacing adopted was 1m by 1m. Two to three seeds were planted per stand and this was later thinned to one plant per stand at 3 weeks after planting. Weed management was done twice. The first weeding was done through the use of combination of Paraforce™ and Atrazine™ herbicides at the rate of 150mls in 16 litres of water, while the second weeding was done manually at eight weeks after sowing. Insect control was carried out using Cypermetrin™ at 40mls in 16 litres of water during flowering stage. Data were collected on number of pods/plant, pod weight/plant, number of seeds/pod, seed yield/plant, 100 seed weight/plot seed production efficiency according to Ogunbodede (1997) on five randomly selected plants within the inners rows in each plot. The data sets were subjected to analysis of variance (ANOVA) using SPSS version 17.0 for windows statistical software package and treatment means were separated using Tukey's HSD test at 5 % level of probability. The relationships among various characters in the experiment were estimated by Pearson correlation analysis, while Principal component analysis was used to identify characters that majorly contributed to variation within the genotypes.

RESULTS.

Analysis of variance for the effect of production environments on seed yield traits of 30 pigeon pea genotypes.

There was no significant difference between the results obtained in the two years for all the traits. (Table 1) Also, there was no significant difference between the results obtained in the replicates, except for in the pod weight/plant and seed weight/plant. However, the seed production environment had a highly significant effect on all the seed-yield attributes except number of pods/plants and seed production efficiency. Also, there were highly significant differences in the 100 seed weight, number of pods per plant and pod weight per plant among genotypes. The first-order interactions between genotype and seed production environment was not significant for all the seed yield attributes. Similar effect was observed for seed production environment and cropping year interaction on all the characters except in pod weight /plant and seed weight/plant ($p \leq 0.05$). The effect of interaction between cropping and genotype was highly significant for 100 seed weight. However, the three-way interaction of cropping x environment x genotype was not significant for some seed yield attributes except in 100 seed weight and pod weight/ plant at $p \leq 0.05$.

Effect of seed production environment on seed yield attributes Pigeon pea genotypes.

There were no significant differences in the number of seed per pod and seed production efficiency of the seed production environments. Most of the seed yield attributes of pigeon pea grown in Ile-Ife (rain forest agro-ecology) were significantly higher than those planted in Ibadan (transitional derived savannah) except for the seed production efficiency of the plants grown in Ibadan (36.8%) that was lower than those planted in Ile-Ife (34.7%) (Table 2).

The mean performance of pigeon pea genotypes for seed yield related attributes across two cropping years and seed production environments.

The mean performance of pigeon pea genotypes for seed yield attributes across two cropping years and seed production environment is presented in Table 3. The number of seeds per pod (NSP) of the genotypes were not significantly different from each other. The highest NSP (4.4) was recorded in NSWCC-50 while the lowest NSP (3.6) was recorded in TCC8129. Similar result was recorded in the 100-seed weight of the genotypes. 100 seed weight of most of the genotypes were not statistically different, however NSWCC-18b recorded the highest mean weight of 10.1g which was not statistically different from other genotypes except CITA-2 (6.90g) which recorded the lowest mean. (Table 3). The number of pods /plant (911.8) recorded in NSWCC-35 was the highest but it was not significantly different from means obtained from other genotypes except TCC-6 (210.83) and TCC 8111(157.33) which had significantly lowest means. The pod weight/plant of Tcc-1 (373.13g), TCC-151 (303.99g), ICPL87 (275.09g) and NSWCC-34a (271.08g) were significantly higher than other genotypes, but they were not significantly different from each other, while TCC 8126 (112.79g), CITA-1 (117.93g), A078-99 (125.80g), CITA-2 (124.12g), Nswcc-7D (144.29) and Tcc-8 (121.26) had the lowest mean values. Similar trend occurred in seed weight/plant. ICPL-87(103.4g), TCC-1(119.4g), NSWCC-34a (110.9g) and Tcc-151 (99.1g) had the high mean values that are not significantly different from each other whereas CITA-1(39.23g) recorded the least mean value. The seed production efficiency of the genotypes were not statistically different, but values range from 67.5% in genotype NSWCC-34a to 28.0% in genotype TCC-8129.

Pearson coefficient of correlation between seed related characters of 30 Pigeon pea genotypes.

The Correlation co-efficient among seed-yield attributes across seed production environments and cropping season is presented in Table 4. The100-seed weight recorded positive and highly significant correlation with number of pods /plant (r = 0.28) and significant correlation with pod weight /plant (r = 0.13). The correlation values of number of pod/plant was positive and highly significant with pod weight/plant (r = 0.37) and seed weight /plant (r = 0.31), while it was negatively correlated with seed production efficiency. Pod weight/plant showed positive and highly significant correlation with seed weight/plant (r = 0.87). Similarly seed weight per plant was positively and highly significantly correlated with seed production efficiency (r = 0.27).

Eigenvalues and percentage contributions of each seed yield related trait to variation among pigeon pea genotype.

It is a common rule to treat co-efficient greater than 0.03 as having enough effect to be considered enough for determining the significance of a trait co-efficient, therefore, the arithmetic sign of the co-efficient is not of any importance. All the seed related traits recorded the significant factor scores (0.43 – 0.95) within the first three component axes and there was no significant factor in PC4 and PC5. Therefore, the relative discriminating power of the principal component analysis (PCA) revealed that the first three component axes, which had eigen values that are higher than one jointly accounted for 58.7% of the total variation (Table 5). Principal Component (PC) 1 accounted for 32.7% of the variation and is most loaded with number of pods per plant (0.95) and seed weight per plant (0.95) while PC 2 and PC 3 accounted for 16.45 and 9.52 % of the variability respectively (Table 5).

Table 1: Mean square values of seed yield attributes in 30 pigeon pea genotypes grown in two seed production environment and two cropping years.

SV	df	NSP	100SW	NPP	PWP	SWP	SPE
Rep	2	0.77	10.02	441714.68	188523.87**	24431.29**	1231.19
Year (Y)	1	1.07	2.09	218152.62	12374.08	159.44	332.38
Error (a)		0.54	1.05	109076.31	6187.04	79.72	166.19
Environment (E)	1	0.15	190.05**	435348.01	605557.47**	37709.28**	365.44
Genotype (G)	29	0.38	8.49**	610379.28**	44628.38**	4981.37	968.26
E x G	29	0.25	5.46	236195.12	30515.95	5011.48	1065.39
Y x E	1	0.27	0.46	1123.84	119944.24*	22570.15*	1921.93
Y x G	29	0.37	7.06**	298296.34	46491.13	7160.47	648.04
Y x E x G	29	0.14	6.39*	182640.18	61243.36*	6283.62	1110.26
Error (b)		0.36	4.05	207409.28	39309.04	5958.98	1199.91

**, * - Significant at 1 and 5 % level of probability respectively.

NSP: Number of seeds/pod; 100 SW: 100 seed weight; NPP: Number of pods/plants, PWP: Pod weight/plant, SWP: Seed weight/plant, SPE: Seed production efficiency

Table 2: Main effect of seed production environment on seed yield attributes across 30 pigeon pea genotypes.

Seed yield traits	Ibadan	Ile Ife	S.E.	LSD (0.05)	sign
Number of seed/pod	4.0	4.1	0.5	2.9	ns
100-seed weight (g)	7.9	9.4	0.2	0.3	*
Number of pods/plant	466.5	538.5	35.1	57.6	*
Pod weight/plant (g)	152.0	236.9	15.3	25.1	*
Seed weight /plant (g)	55.3	76.5	6.0	9.8	*
Seed production efficiency (%)	36.8	34.7	2.7	4.4	ns

ns: not significant, * significant at $P \leq 0.05$

Table 3: Mean performance of pigeon pea genotypes for seed yield and related characters across two cropping years and seed production environments.

Genotypes	NSP	100seedwt	NPP	PWP	SWP	SPE
A8125	3.83[a]	8.28[ab]	463.50[ab]	196.38[b]	72.81[b]	39.17[a]
AO78-99	3.91[a]	8.65[ab]	418.75[ab]	125.80[c]	46.20[b]	37.67[a]
AO/TB-78-9	4.08[a]	9.31[ab]	480.41[ab]	161.68[b]	52.84[b]	30.43a[a]
CITA-1	4.08[a]	8.35[ab]	218.08[ab]	117.93[c]	39.23[c]	33.01[a]
CITA-2	4.08[a]	6.90[b]	274.16[ab]	124.12[c]	53.54[b]	59.04[a]
CITA-3	4.16[a]	7.00[ab]	281.91[ab]	216.22[b]	69.64[b]	33.54
1CPL 87	3.66[a]	7.20[ab]	448.50[ab]	275.09[a]	103.41[a]	31.25[a]
NSWCC-18	3.91[a]	9.08[ab]	706.79[ab]	202.33[b]	64.33[b]	32.43[a]
NSWCC-18b	4.25[a]	10.10[a]	675.50[ab]	203.26[bs]	78.43[b]	37.92[a]
NSWCC-19	4.00[a]	9.28[ab]	686.00[ab]	164.54[b]	58.80[b]	35.46[a]
NSWCC-28	4.00[a]	9.63[ab]	746.25[ab]	191.86[b]	57.46[b]	29.71[a]
NSWCC-29b	4.33[a]	9.26[ab]	520.91[ab]	184.69[b]	55.49[b]	30.59[a]
NSWCC-32	4.08[a]	9.75[ab]	804.00[ab]	179.14[b]	60.39[b]	33.67[a]
NSWCC-34	3.83[a]	9.80[ab]	777.75[ab]	231.62[b]	64.79[b]	28.09[a]
NSWCC-34c	4.00[a]	9.04[ab]	575.00[ab]	170.77[b]	54.17[b]	28.29[a]
NSWCC-34b	3.66[a]	8.42[ab]	837.83[ab]	197.29[b]	59.10[b]	35.26[a]
NSWCC-35	4.33[a]	9.25[ab]	911.75[a]	241.28[b]	67.34[b]	29.06[a]
NSWCC-35a	4.16[a]	9.52[ab]	846.25[ab]	243.45[b]	69.27[b]	31.21[a]
NSWCC-50	4.41[a]	8.25[ab]	647.91[ab]	205.31[b]	73.91[b]	30.47[a]
NSWCC-7D	4.16[a]	9.07[ab]	369.50[ab]	144.29[c]	49.21[b]	33.91[a]
NSWCC-34a	4.00[a]	8.27[ab]	457.91[ab]	271.08[a]	110.93[a]	67.45[a]
TCC-I	4.08[a]	8.57[ab]	382.58[ab]	373.13[a]	119.41[a]	31.18[a]
TCC-151	4.08[a]	8.26[ab]	340.75[ab]	303.99[a]	99.08[a]	33.20[a]
TCC-2	4.08[a]	9.00[ab]	339.16[ab]	133.63[c]	63.12[b]	47.95[a]
TCC-6	4.16[a]	7.92[ab]	210.83[b]	168.02[b]	49.11[b]	29.87[a]
TCC-8	4.16[a]	8.03[ab]	261.25[ab]	121.46[c]	43.51[b]	40.90[a]
TCC-8111	4.08[a]	8.25[ab]	157.33[b]	184.14[b]	67.47[b]	39.04[a]
TCC-8126	3.91[a]	7.70[ab]	230.16[ab]	112.79[c]	41.97[b]	32.26[a]
TCC-8127	4.06[a]	9.70[ab]	801.02[ab]	179.24[b]	60.31[b]	33.61[a]
Tcc8129	3.63[a]	9.61[ab]	774.75[ab]	220.62[b]	64.72[b]	28.02[a]
S.E	0.17	0.58	131.47	57.23	22.28	10.00

Mean followed by the same alphabets along the columns are not significantly different from each other at 5 % probability level. SWP – Seed weight/plant, NPP – Number of pods/plants, PWP – Pod weight/plant, NSP – Number of seeds/pod, SPE – Seed production Efficiency.

Table 4: Correlation coefficients among seed- yield related traits of 30 pigeon pea genotypes across seed production environment and cropping season

Variables	100SW	PPP	PWP	SWP	SPE
100SW		0.28**	0.13*	0.11	0.07
PPP			0.37**	0.31**	-0.06
PWP				0.87**	-0.05
SWP					0.27**

** - Significant at 1 %level of probability,

* - Significant at 5 % level of probability,

100SW-100 seed weight; PPP-Pod per plant; PWP-Pod weight per plant; SWP- Seed weight per plant; SPE-– Seed production efficiency.

Table 5: Eigen Values and percentage contributions of seed yield related traits to variation in 30 genotypes of Pigeon pea.

Variables	PC1	PC2	PC3	PC4	PC5
100-seed weight	**0.43**	**-0.47**	**0.50**	-0.10	0.17
Pod/plant	**0.95**	-0.10	-0.12	0.002	-0.06
Pod weight/plant	**0.91**	-0.11	-0.13	0.02	-0.11
Seed weight/plant	**0.95**	-0.08	-0.15	-0.01	-0.03
Seed production efficiency	**0.89**	-0.07	-0.17	-0.09	0.07
Eigen value	4.25	2.13	1.23	1.13	1.02
Proportion of variation (%)	32.7	16.45	9.52	8.74	7.89
Cumulative variation (%)	32.75	49.20	58.73	67.47	75.37

*Value above **0.30** was considered with major contribution*

DISCUSSION.

The concentration of seed production of some crops in specific agro-ecology is an indication of the influence of environmental factors on seed development and quality (Singh *et al*., 2016). It has been reported that the environment during seed production has major impacts on the behavior of progeny seeds (Penfield and Macgregor, 2016) The result of this study further revealed that some pigeon pea seed yield related characters were significantly affected by environment of production. The rain-forest agro-ecology significantly produced pigeon pea with higher seed related traits. This may be attributed to high phytomas (the total amount of living organic plant matter, of both higher and lower plants, accumulated at a given moment in the aboveground and underground spheres of the soil) associated with soil in the rainforest agro-ecology. It therefore implies that Pigeon pea positive responds to rainforest environment is critical to its production so as to achieve its full seed yield potentials. Similarly, Bolan˜os-Aguilar *et al*, (2002) reported that environments with high above ground phytomas potential are likely to have high seed yield potential. Although there was no significant difference recorded between the years of production, 2017 gave higher means than 2016 in all the characters. These differences can be attributed to different weather conditions in those periods. Rainfall amount in 2016 was smaller and not well distributed during the production, with a total rainfall of 682.2 mm (97.46 mm per month), while a fairly high amount and evenly distributed rainfall was recorded in 2017 with 798 mm (114 mm per month). Hence, it could be ascertained that there was a reduction in the environmental stress due to moisture shortage at crucial stage in 2017. Snehal *et al*. (2017) had investigated the impact of climatic change on 30 genotypes of pigeon pea in three different environments and reported that temperature and rainfall were the most outstanding factors that contributed to major variation observed among the genotypes. This report is also in agreement with Adebisi *et al*., (2011), Singh *et al*., 2016 where they attributed higher seed yield in sesame and pigeon pea respectively, to a better growth environment characterized with optimum temperature, favorable soil conditions, regular and adequate rainfall. Significant variability in the genotypes for 100-seed weight, number of pods/plant and pod weight/plant implies that the genotypes differed in all the above attributes, thereby providing opportunity for selecting pigeon pea genotypes with superior seed yield characters. Correlation analysis indicated that pod weight/plant and pod/plant had very strong and positive relationships with 100-seed weight across seed production and cropping season environments. In character association analysis, increase in any of these above characters will lead to increase in the other. The principal component analysis revealed that all the seed related characters (100-seed weight, number of pod/plant, pod weight/plant, seed weight/plant and seed production efficiency) are of importance in selection criteria for seed yield improvement in pigeon pea. Vaniseree *et al* (2013) has listed higher seed weight, number of pods per plant and plant height among the traits to be given more consideration while deciding on selection criteria for increasing the seed yield per plant in pigeon pea. Adekoya *et al,* (2010) suggested that these characters could be used in selection criteria because of their high genetic contribution to genotypic variation.

CONCLUSION.

Conducive environment in terms of adequate rainfall is critical for Pigeon pea establishment for seed production. There is positive and significant correlation between seed weight /plant and seed production efficiency, therefore, concerted improvement efforts should be directed towards increasing seed weight of pigeon pea. Genotypes A8125, ICPL87, NSWCC-50, NSWCC-34a, TCC-1, and TCC-151 recorded moderately outstanding performance among the genotypes. However NSWCC 50 and NSWCC 7D were more promising in terms of seed yield and are hereby recommended as parental material in the development of high seed yielding varieties.

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Journal of Applied Agricultural Research 2022, 10(2):133-141
ISSN 2006-750X.

EFFICACY OF FORMULATED PLANT-BASED EMULSION INSECTICIDE AGAINST POST-FLOWERING INSECT PESTS OF COWPEA (*Vigna unguiculata* (L.) Walp) IN SAMARU, NIGERIA.

Utono, I.M. and Magaji, B.T.
Department of Crop Protection, Institute for Agricultural Research,
Ahmadu Bello University, Zaria.
Author's Contact: imutono@yahoo.com; Phone No: 08038381767

ABSTRACT.

A field experiment was conducted at the research farm of the Institute for Agricultural Research (IAR), Samaru Zaria to evaluate the efficacy of application rate and spray regime of plant-based emulsion pesticide from the leaves of *Tephrosia vogellii* (Hook) and *Azadirachta indica* (Juss) seed kernel on damage and yield of cowpea by insect pests. Three application rates (5%, 10% and 15% v/v) for each plant formulation and a combination of the two different plants formulations at 10% in a 1:1 ratio was evaluated at two spray regimes of three and four sprays. Cyper plus (Cypermethrin + Dimethoate) was used as the standard check in addition to untreated control. Data were collected on insects infestation, pod damage and grain yield. The data were subjected to ANOVA and significant differences among means were separated using SNK. Three sprays had significantly ($p<0.05$) higher insects count and percentage pod damage than the four sprays. Cyper plus significantly ($p<0.05$) had the lowest count of all the insects and percentage pod damage than all the treatments. Neem and Tephrosia formulations at 15% and their combination at 10% in a 1:1 ratio significantly ($p<0.05$) had the lowest percentage pod damage than other concentrations of the different formulations ($p<0.05$). The yields of Tephrosia at 15%, Neem seeds 15% and the Tephrosia 10% + Neem seed 10% were similar but higher than the yield of other pesticidal plant formulations and significantly lower than the yield on Cyper plus. Based on the present studies, the Neem seeds or *T. vogellii* leaves extract formulations at 15% v/v or their combination at 10% v/v in a 1:1 ratio could be used to manage insect pests of cowpea where insecticide is not available or affordable.

Keywords: Efficacy, Formulations, Insects, Cowpea, Management, Maruca

INTRODUCTION.

Cowpea is an important leguminous crop that is widely grown and consumed in sub-Saharan Africa simply due to its nutritional (Olakoja *et al*., 2007; Owolabi *et al*., 2012) and economic benefit (FAOSTAT, 2011) in addition to its importance in increasing soil fertility (Gungula and Garjila 2005). However, the yield of cowpea is threatened by various biotic and abiotic factors. Insect pest is one of the most damaging pests of cowpea, particularly the post-flowering insects such as *Aphis craccivora* Koch, the flower Thrips, *Megalurothrips sjostedti* Tryb; the legume pod borer, *Maruca vitrata* Fab and a complex of pod sucking bugs such as *Clavigralla tomentosicollis*, Stal; *Anoplocnemis curvipes* Fab; *Riptortus dentipes* Fab (Fatokun, *et al*., 2002). Insect pests attack and damage on cowpea account for over 70% of cowpea grain yield loss (Ogunwolu, 1990).

Insect pests of cowpea have largely been controlled using synthetic pesticides. However, the detrimental effect of such insecticides on human health and the environment on one hand and the cost of procuring them by small-scale farmers, on the other hand, have been an issue of concern. Because of this and the desire of crop farmers to use affordable and readily available alternative control measures, the focus must be made toward the development of affordable, environmentally friendly and efficient plant-based pesticides.

Several researchers have indicated that extracts from various plant materials such as Fish poison bean, *Tephrosia vogelii,* Hook*;* Violet tree, *Securidaca longipendiculata,* Fresen and Neem tree, *Azadirachta indica,* (Isman, 2006; Cork *et al*., 2009; Belmain, 2002) to have potential as insect pests control agents, although variability in their active compounds and their fast degradation characteristic poses a challenge to their effective performance in the field (Isman, 2006 & 2008). However, a good formulation of plant extract may improve their efficacy. This research is aimed at evaluating the effect of application rate and spray regime of plant-based emulsion pesticide from the leaves of a Fish poison bean plant and Neem seed kernel on insect pests damage and yield of cowpea.

MATERIALS AND METHODS.

Plot establishment and management.

A field experiment was conducted during the 2017 and 2018 wet seasons at the research farm of the Institute for Agricultural Research (IAR), Samaru Zaria (11^0 11^1 N, 07^0 38^1 E and 686m above sea level). The experimental field (2285m^2) was sprayed with Glyphosate at the recommended dose of 4 L/ha, two weeks later the land was ploughed, ridged and planted with improved cowpea variety (SAMPEA-7) obtained from cowpea breeding unit of the Department of Plant Science, IAR. Seeds were dressed with Apron plus 42WS® (Thiamethoxam 20% + Metalaxyl-M 20% + Difenoconazole 2%) at 4Kg/10g. The seeds were planted in a plot of 5 m long by 5 rows at 0.25m x 0.75m intra and inter-row spacing at the rate of two seeds/hole. Two weeks after germination (WAG) the stands were thinned to a single stand per hole. The plots were kept weed-free by regular manual weeding. Each plot was sprayed with Mancozeb at 2.5g/L 4 and 5 weeks after sowing (WAS) to control fungal infections.

Preparation of plant-based insecticide.

A plant-based emulsion pesticide was prepared from two pesticidal plants (Fresh leaves of *T. vogellii*, and Seed kernel of *A. indica*). The plant materials were obtained within Samaru environment. They were prepared by shade drying each of the plant materials over three days and ground into powder. The plant's crude extract was obtained by sucking 500g of each of the powder into 1 L of water in a 2L plastic bucket and allowed to stay for 48 hours. Double layers of muslin cloth were used to sieve crude extract. The extracts from different plants were added with 5% v/v of palm oil and10% v/v Morning Fresh® (liquid soap) which serve as an emulsifier. The mixture was vigorously stirred to form a stable emulsified stock solution which was used to spray the trial plants.

Application of plant-based insecticide.

The stock solution was used to treat the cowpea plant at three doses (5%, 10% and 15% v/v) and a mixture of the two solutions at 10% in a 1:1 ratio. The three different concentrations of the formulations were used to spray cowpea at two spray regimes i) spray three times at ten days intervals, starting at bud initiation. ii) spray four times at a one-week interval starting at bud initiation. Cyper plus® (Cypermethrin + Dimethoate) was used as standard control at 1.5L/ha and untreated control plot. The experiment was arranged in a split plot design in Randomized Complete Block Design (RCBD) arrangement with the spray regime as the main plot and plants concentrations as sup-plots. The experiment was replicated three times. Each plot was separated by 1.5 m unplanted walkways to check for the effect of spray drift.

Data Collection.

Data were collected on insects infestations, pod damage and grain yield. All observations were based on 3 central rows on each plot. Twenty flowers were sampled, 2 from each of 10 randomly sampled plants from three central rows in each plot for the presence of Maruca and Thrips. Pod sucking bugs (PBS) were recorded based on visual observation and counting of both adult and nymph at 60 days after sowing (DAS). Data on pod damage was taken at harvest by counting damaged and undamaged pods per 10 randomly selected plants in each plot and converted to percentage pod damage per plot. The yield was obtained based on threshed grain weight from three central rows harvested per plot and extrapolated to kg/ha. All the data were subjected to ANOVA.

RESULTS.

Table 1 shows that in the 2017 and 2018 wet seasons, there was no significant ($p>0.05$) difference in the number of insects counts between three and four spray regimes. However, there was a significant ($p<0.05$) difference in the number of insects counted among the rates of pesticidal plants. The number of *M. vitrata*, Thrips and Pod sucking bugs in the untreated control was significantly ($p<0.05$) higher than in all the rates of pesticidal and the standard control. In 2017 Cyper plus had significantly the least Maruca count than all the other treatments. This was followed by the formulation of the two plants at 15% and their respective combination at 10% each. Untreated control significantly had the highest Maruca count. In 2018, the number of *M. vitrata* in the Cyper plus, Tephrosia 15%, Neem seed 15% and Neem seed 10% + Tephrosia 10% was similar ($p>0.05$) but significantly lower than Tephrosia 5% and 10%, and Neem 5% and 10% standard control. The two years combined result indicated that Maruca count in untreated control was significantly higher than all the treatments which were all at par. The number of Thrips and Pod sucking bugs in the Cyper plus treatment was significantly ($p<0.05$) lower than in all the pesticidal plant's rates in 2017, 2018 and the two years combined. There was no significant ($p>0.05$) difference in the number of Thrips and Pod sucking bugs (PBS) among rates of all the pesticidal plants except for Thrips count in 2017 where Cyper plus had a significantly higher Thrips count than all the treatments. This was followed by a 5% formulation of all the plants. The 15% formulations and combination of the two plants at 10% each in 2017 had significantly lower Thrips count than untreated control and 5%. There was no interaction effect ($p>0.05$) of spray regime and the rates of pesticidal plants in the number of insects count.

Table 1 Effect of spray regime and rates of formulated plant-based pesticide on infestation by Maruca, Thrips and Pod sucking bugs

Treatment	Maruca count/flower			Thrips count/flower			PSB count/m²		
Spray Regime (S)	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
Three spray	3.60	4.1	3.85	6.60	5.10	5.85	1.16	4.1	2.63
Four spray	3.39	3.8	3.60	6.17	4.57	5.37	1.08	3.8	2.44
SE±	0.25	0.29	0.27	0.61	0.73	0.67	0.28	0.28	0.28
	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pesticide rate (P)									
Tephrosia 5%	4.09b	3.66b	3.88b	7.75b	6.15b	6.95b	1.21b	2.84b	2.03b
Tephrosia 10%	3.48bc	4.11b	3.80b	5.71cd	4.11b	4.91b	1.17b	2.28b	1.73b
Tephrosia 15%	2.96d	2.69cb	2.83b	5.48cd	3.18b	4.33b	1.04b	2.54b	1.79b
Neem seed 5%	3.91cb	3.22b	3.57b	6.89cb	5.29b	6.09b	1.26b	2.76b	2.01b
Neem seed 10%	3.30cd	3.21b	3.26b	5.56cd	3.96b	4.76b	0.87b	2.30b	1.59b
Neem seed 15%	2.96d	2.89c	2.92b	4.93d	3.33b	4.13b	0.83b	2.30b	1.83b
Neem 10%+ Tephrosia 10%	3.30cd	2.80c	3.05b	5.63cd	4.03b	4.83b	0.96b	2.83b	1.90b
Cyper plus	2.22e	2.81c	2.51b	3.60e	1.60c	2.60bc	0.74b	1.33c	1.04b
Untreated control	5.13a	7.31a	6.22a	11.66a	9.66a	10.66a	2.04a	10.17a	6.11a
SE±	0.72	0.61	0.67	1.79	1.21	1.5	0.81	0.99	0.90
Interaction									
S x P	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not significant, Mean followed by the same letter within the same column are not significantly different at 5% level of probability using SNK.

The result in Table 2 indicates the percentage of pod damage by the post-flowering insect pests of cowpea during 2017 and 2018 wet season farming. The percentage of pod damage was significantly ($p<0.05$) higher in three sprays than in four sprays of pesticidal plants formulation in both seasons and two years combined. The percentage of pod damage in Cyper plus treatment was significantly ($p<0.05$) lower than pod damage in all the rates of pesticidal plants in all the seasons and the two years combined result. The percentage pod damage in the Tephrosia 15%, Neem seed 15% and Tephrosia 10% + Neem 10% was similar ($p>0.05$) but significantly ($p<0.05$) lower than all the rates of the pesticidal plants in both the season except in 2017 where 10% formulation of each plant was at par with 10% of each plant formulation combined. The percentage of pod damage in untreated control, Tephrosia 5% and Neem 5% were similar ($p>0.05$) and was significantly higher than all the treatments in both seasons. However, the combined result indicated that Cyper plus significantly had the least pod damage followed by the formulation of the plants at 15%, 10%, Tephrosia 10% + Neem 10%, 5% and untreated control by this order. There was a significant ($p<0.05$) interaction effect ($p>0.05$) of spray regime and pesticidal plants rates on percentage pod damage.

Table 3 shows grain yields as affected by different spray regimes and rates of pesticidal plants in 2017 and 2018. The yield of four sprays was significantly ($p<0.05$) higher than the yield of three sprays in both seasons and the two years combined. The yield of Cyper plus was significantly ($p<0.05$) higher than the yields of all the treatments in both seasons and the two years combined. In the 2017 season the yields of Tephrosia 10% and 15%, Neem seeds 10% and 15% and the Tephrosia 10% + Neem seed 10% were similar and significantly ($p<0.05$) higher than 5% of the two plant formulations which was at par with untreated. However, in 2018, the yields of

Tephrosia 15%, Neem seeds 15% and the Tephrosia 10% + Neem seed 10% were similar ($p>0.05$) but significantly ($p<0.05$) higher than the yield of Tephrosia 5% and 10%, and Neem seeds 5% and 10% which were similar in yields. The untreated control had the lowest grain yield which was significantly ($p<0.05$) lower than all the treatments in both seasons and two years combined. There was no interaction effect ($p>0.05$) of spray regime and the rates of pesticidal plants on grain yield

Table 2 Effect of spray regime and rates of formulated plant-based pesticide on cowpea Pod damage.

Treatment	Mean Percentage Pod damaged		
Spray Regime (S)	2017	2018	Mean
Three spray	53.20a	46.6a	49.90a
Four spray	40.95b	32.6b	36.78b
SE±	2.55	2.73	2.64
Pesticide rate (P)			
Tephrosia 5%	64.81b	56.46a	60.64b
Tephrosia 10%	51.06c	42.71b	46.89c
Tephrosia 15%	30.81d	25.46c	28.14e
Neem seed 5%	61.61b	53.26a	57.44b
Neem seed 10%	49.81c	40.42b	45.12c
Neem seed 15%	33.14d	26.79c	29.97e
Neem 10% + Tephrosia 10%	44.60c	36.25c	40.43d
Cyper plus	10.23e	17.35d	13.79f
Untreated control	77.64a	61.33a	69.49a
SE±	7.45	5.09	2.09
Interaction			
S x P	*	*	

* = Significant, Mean followed by the same letter within the same column are not significantly different at 5% level of probability using SNK.

Table 3 Effect of spray regime and rates of formulated plant-based pesticide on cowpea grain yield.

Treatments	Mean Grain yield (Kg/ha)		
Spray Regime (S)	2017	2018	Mean
Three spray	390.82b	410.37b	400.06b
Four spray	473.91a	599.01a	536.46a
SE±	63.1	49.71	56.41
Pesticide rate (P)			
Tephrosia 5%	182.05c	176.43c	179.24c
Tephrosia 10%	449.84b	399.12c	424.48bc
Tephrosia 15%	534.31b	737.41b	635.86b
Neem seed 5%	210.32c	223.26c	216.79c
Neem seed 10%	466.12b	401.11c	433.61bc
Neem seed 15%	547.12b	783.79b	665.45b
Neem 10% + Tephrosia 10%	466.32b	676.25b	571.29b
Cyper plus	813.84a	1165.66a	989.75a
Untreated control	221.38c	298.38c	259.88c
SE±	187.280	120.731	154.0
Interaction			
S x P	NS	NS	

NS = Not significant, Mean followed by the same letter within the same column are not significantly different at 5% level of probability using SNK.

DISCUSSION.

A study conducted to evaluate the effect of plant-based formulation (Tephrosia and Neem seed) at three different concentrations (5, 10 and 15% w/v) applied either 2 or 3 times on insect pest of cowpea showed that the insect count of Maruca, Thrips and Pod sucking bugs on synthetic insecticide was not significantly different from the plant-based formulations but the count was much higher in the untreated control. Several research workers (Isman, 2006; Cork *et al*., 2009; Belmain, 2002; Phambala *et al*., 2020) have indicated the potential of extracts from various plant materials such as *T. vogelii, S. longipendiculata, Cymbopogon citratus* and *A. indica*, to have the potential as insect pest management with no adverse effect to the environment. Pesticidal plants possess some secondary metabolites that may have feeding deterrents, repellent and are toxic to insects. The toxicity and feeding deterrents properties of Neem and Tephrosia on several larvae of insects have been reported by Belmain (2002); Isman (2006). Alao *et al.* (2011) indicated that *T. vogelii* and its combination with *Petiveria alliacea* was effective in reducing the population of *M. sjostedti* and *Apion varium* on cowpea. Phambala *et al*. (2020) had found that methanol and aqueous extract of some plants such as Neem affect the development of fall armyworm larvae. It could be that the extract sprayed on the plant deterred the insects from feeding and consequently reduced the number of insects around the plant. The combined result of insect counts indicated no significant difference in insect count between 2 or 3 sprays.

This study showed the significance of the Tephrosia and Neem seed formulation in reducing cowpea pod damage. The cowpea pod damage in four sprays (37%) was lower than in three sprays (50%). Tephrosia and Neem seed formulation applied at 15% w/v had between 28-30% pod damage which was much lower than the other concentrations (0, 5, and 10% w/v) with pod damage of between 40-69% except the Cyper plus treated plot which had the least (13.8%) percentage pod damage. The reduction in cowpea pod damage by 15% of the plant (Tephrosia and Neem seed) extract formulations could be a result of deterrent or toxic effect of the formulations on the insects (Belmain, 2002; Roel *et al*, 2010; Amoabeng *et al*., 2013) thus reduced the number of insects that can cause significant cowpea pod damage. Similarly, the active ingredients in the highest concentration (15% w/v) formulations might be higher than in the other concentration. Jackai *et al*., (1992) had successfully managed insect pests of cowpea using Neem extract at 10% w/v. This is in agreement with the findings of Oparaeke (2006) who observed a 35% reduction in pod damage with a consequent increase in yield of cowpea treated with 10% w/v Neem seed and breadfruit extract. The disparity in efficacy could be as a result of the role of environment on concentration and type of active ingredients (Isman, 2006 and 2008).

Interestingly, this study established that cowpea pod damage by insect pests can also be reduced using a combination of the two plants formulation at 10% w/v each. This study agreed with the finding of Oparaeke *et al*. (2006) who indicated that a combination of two plant extract in ratio 1:1 (10:10 %) had an advantage over the use of a single plant extract in reducing cowpea pod damage. This suggests that the two plants have a synergistic advantage in reducing cowpea pod damage and where synthetic insecticides are difficult to be procured by farmers, the formulation of Tephrosia and Neem seed at 15% or a combination of both at 10% w/v each could be used to manage cowpea pod damage by a post-flowering insect pest.

Our study had supported the findings of Panhwar (2002) who reported that when plant extracts are applied on cowpea plants, it leads to an increase in flower production per plant with a resultant increase in grain yield. This study showed that the mean grain yield of four sprays treatment was higher (between 473-599 kg/ha) than that of three sprays treatment (390- 400kg/ha). The amount of pod damage in Cyper plus treatment was lower which consequently had the highest grain yield (813-1165 kg/ha) than all the rates of pesticidal plants (182- 783 kg/ha), thus Cyper plus was better in reducing cowpea pest infestation and increase in grain yield. Among the rates of pesticidal plants, the mean grain yields of 10 and 15% w/v Tephrosia and Neem seed formulation (534- 783 kg/ha) and combination of the two plants at 10:10% (466-676 kg/ha) were higher than the yields of cowpea plant treated with 5% of any of the plant extract formulation, which had yields ranging between 182- 223 kg/ha. These are in strong agreement with the reports of Olaniran and Adebayo (2013) who found that treatment of Roselle (*Zobo* plant) with extracts of *Tephrosia vogelii* and *Azadirachta indica* both singly or in combination, reduced the populations of Podagrica spp and Zonocerus variegatus and increased yield. Similarly, Lashin *et al*. (2013) had found that the growth and yield of cowpea grain were enhanced by 10% aqueous extract of *Malva parviflora* and the mixture of 10% *M. parviflora* with 20% of *Artemisia ludia*. This highlights the importance of plant extract in managing cowpea pests and improving grain yield.

it was observed from the present study that four applications of Tephrosia and Neem seed formulations at 10, 15% w/v % or combination of both plants formulation each at 10% w/v was effective in reducing insect pests of cowpea (Maruca, Thrips and Pod sucking bugs) and increase cowpea yield better than 5% w/v and untreated control. This study indicated the potentials of Tephrosia and Neem seed formulations as an alternative to synthetic insecticides in managing insect pests of cowpea and improving cowpea grain yield. Therefore, four applications of Tephrosia or Neem seeds formulation at from 10% w/v or combination at 10% w/v each could be used where farmers could not afford insecticides or where environmental concern on the negative effect of insecticide is paramount. Tephrosia or Neem seeds formulation from 10% w/v or combination at 10% w/v each should be explored as a component of the Integrated Pests Management (IPM) approach. Furthermore, more research is required on optimizing the use of these plants for the effective management of cowpea pests.

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Journal of Applied Agricultural Research 2022, 10(2):142-150
ISSN 2006-750X.

GENETIC VARIABILITY ASSESSMENT OF GREEN PEPPER *(Capsicum annuum* L) GENOTYPES IN TWO CROPPING YEAR IN SOUTH–EAST NIGERIA.

Olufelo, Joseph Olusola
Department of Crop Production, University of Agriculture and Environmental Sciences, Umuagwo Owerri, Imo- State, Nigeria.
Author's Contact: jolufelo@yahoo.com, Phone no. 08035727117.

ABSTRACT.

Nine varieties of green pepper *(Capsicum annuum)* popularly called *"*Bell fruit shape" or "Tattassai" in south-west, and "ose oyibo" in south-east Nigeria, were evaluated in the laboratory and screen house in two cropping years of 2020 and 2021. The research studied the genetic variability and inter-character relationship among seed quality attributes. Physiological evaluations were made on seed germination, plumule length, root length, seed vigour index 1 and 2, seedling emergence and seedling emergence plumule length. Data collected were subjected to analysis of variance, mean separation was done using Tukey HSD at 5% level of probability, variance components and heritability values were also estimated. Correlation coefficient analysis and Principal Component Analysis (PCA) were also determined. The result revealed that significant variations existed among genotypes and seedling traits evaluated for all the laboratory and screen house seed vigour traits. Significant and positive correlation coefficients were observed between seed germination and other seedling vigour traits except seedling emergence and plumule length in 2021. In the year 2020, Magda (Emrapa), Rubia R (sakata) and Dahra Rx (sakata) were genotypes with best seedling vigour characters, while Magali. R. (sakata) and F102 were genotypes with best seedling vigour characters for the 2021 cropping years. These genotypes could be considered in future seed improvement programmes in green pepper. The cropping year is also a determinant of seed physiological quality in green pepper *(Capsicum annuum)* genotypes.

Keywords: Pepper, environment, seed vigour, heritability, interaction, seed viability.

INTRODUCTION.

Pepper (*Capsicum sp.*), is an economically important crop grown worldwide as vegetable, spice, ornamenta.It is one of the most important vegetable crops in Nigeria with numerous uses. It is found within the family *Solanaceae* of the genus *Capsicum* and is believed to have originated from tropical South America with Brazil as the major centre of diversity, where all cited levels are found (Datta and Das, 2013). The genus *Capsicum* has five domesticated species (*C. annuum, C. pubescens C. chinense, C. baccatum and C. frutescens*) which were thought to have been domesticated through at least five independent events (Gonzalez *et al*., 2014). Among these five, *Capsicum annuum* L. is the most widespread and economically important *Capsicum* species worldwide as well as the most used in commercial cultivar breeding programs (Bosland and Votava, 2000).

It is the world's most important vegetable after tomato and can be used as fresh, dried or processed products, as vegetables and spices or condiments (Berhanu *et al*., 2011). Nutritionally, green pepper like any other *Capsicum* species is rich in vitamin A and C, calcium, phosphorus and potassium. In Nigeria, green pepper is placed third among vegetables because of its enormous usages. It helps in the nutritional stability of rural and urban dwellers, by supplying vitamins and minerals in their diets (Janaki *et al*., 2015; Hasan, 2014). Pepper is used at length in food flavouring in the daily diet of over 160 million Nigerian irrespective of their socio-economic status (Nsabiyera *et al*., 2013). It is used in cooking of soup and stew, which are among the most important compliments of major cereals and root crops (Pujar *et al*; 2017 Rosmaina *et al*., 2016). The crop is also one of the important vegetables that serve as the source of income particularly for smallholder producers in many parts of rural Nigeria (Berhanu, *et al*., 2011; Shimeles, 2018). Moreover, green pepper contributes 40 - 60% to the household income (Shimeles, 2018).

The productivity of the crop is low due to many limiting factors such as shortage of adapted high yielding varieties, using unknown seed sources and poor-quality seeds, poor irrigation system, poor soil fertility, the prevalence of fungal and bacterial as well as viral diseases, lack of awareness on existing improved technologies and poor marketing system (Abiham *et al*., 2017). For efficient and effective breeding result, investigation and better understanding of the variability among existing genotypes is germane to developing new improved varieties with the desired traits. Similarly, information on the extent and nature of interrelationship among plant characters will help in formulating efficient index selection and the relative contribution of various components traits to yield (Hasan, 2014). However, the greater the variability in a population, the greater the chance for an effective selection of desirable types (Kumari, 2017). Sequel to the above, this study was initiated to determine the extent of genetic variability and inter-character association among seed and seedling vigour characteristics in nine varieties of green pepper *(Capsicum annuum* L.*)* genotypes. It was also aimed at identifying the characters that best describe the variations observed among the nine varieties.

MATERIALS AND METHODS.

The following are the nine seeds varieties of the C*apsicum annuum* (L) used for the study- Magda (Emrapa), Rubia Rx (sakata), Dahra Rx (sakata), Magali. R. (sakata), F102, Pepper Eppo (S7G0), BRS Tico (Embrapa), Margadeth (Embrapa) and Pimento magma super). They were all sourced from National Horticultural Research Institute (NIHORT), Ibadan and Agricultural Development Programme (ADP), Kano State.

All experiments were carried out in the Department of Crop production Laboratory and Teaching and Research Farm, University of Agriculture and environmental Science, Umuagwo, Imo State in 2020 and 2021 cropping years. The same seed lots were grown in the two cropping years. Seed samples from each cropping year were evaluated in both the laboratory and screen house in Completely Randomized Design with three replicates.

Laboratory Test.

Seed samples of the different varieties were evaluated in the laboratory for standard germination test. The test was performed according to ISTA (1995). Hundred seeds were replicated in three places for each variety. The seeds were germinated in 11cm diameter petri-dishes with moistened paper towel with 10 ml of distilled water and placed inside an incubator at 25°C. The following data were taken after 7days to assess the seedling vigour traits.

Germination Percentage: Germination counts were taken after 7 days and expressed in percentage (ISTA, 1995).

Plumule Length: Plumule lengths of ten randomly selected normal seedlings were measured in centimeters.

Root Length: Root lengths of 10 randomly selected normal seedlings were also measured in centimeters.

Seedling Vigour Index1: This was determined using the formula below.

$$SV\ 1 = \frac{\text{germination (\%) x plumule length}}{100}$$

(Adebisi, 2004)

Seedling Vigour Index 2: This was determined using the formula below.

$$SV\ 2 = \frac{\text{germination (\%) x root length}}{100}$$

(Adebisi, 2004)

Heritability: Broad sense heritability (h^2) =

$$\frac{V_G}{V_{ph}}$$

Where V_G = Genotypic variance

V_{ph} = Phenotypic variance

Screen House Test

100 seeds of each variety were sown in 23 cm wide plastic buckets filled with sandy loam soil, arranged in a Randomized complete block design with three replications. The following seedling vigour traits were evaluated:

Seedling Emergence:

$$\frac{\text{Number of emerged seedling at 15th day}}{\text{Number of seeds sown}} \text{ x 10}$$

Plumule Length: Plumule lengths of 10 randomly selected seedlings were taken from each replication in centimeter and average values were computed.

Data Analysis

Data collected on each trait were subjected to the following statistical tools using SPSS statistical packages. Analysis of variance (ANOVA) was carried out to determine significant difference among the genotypes for the different traits while Tukey HSD at 5% level of probability was used for the mean separation. Estimates of variance components for each trait were estimated, heritability in the broad sense was also estimated for each trait. Principal component analysis and correlation coefficient analysis was carried out to determine the extent of relationships among the evaluated characters.

RESULTS.

Mean squares from the analysis of variance (ANOVA) of the seed vigour characteristics in *Capsicum annuum* varieties are presented in Table 1. All the characters measured recorded highly significant differences among the pepper varieties in both years except seedling emergence, seedling emerging at 15th day and plumule length in the year 2020.

Magda (Embrapa), Dahra Rx (sakata) had the highest seed germination percentage of 98.67 and 94.67, respectively (Table 2), while Magali. R. (sakata) had the lowest with 53.33% in 2021. Magali. R. (sakata) and Pepper Eppo (S7G) had the highest seed germination percentage with 79% and 73%, respectively whereas BRS Tico (Embrapa) and F102 had the lowest seed germination with 3.3% and 8.8%, respectively in 2020. The highest seedling shoot length was observed inRubia .R. (sakata) with 3.53 cm in 2020, Magali. R. (sakata) with 2.48 cm in 2021. Magali. R. (sakata) (1.97cm) in 2020 and F102 andDahra Rx (sakata) with 0.52 and 0.57cm, respectively, were the lowest in 2021 (Table 2). In the seedling root length category, the highest values were observed with Rubia .R. (sakata), Pimento magma super and Dahra Rx (sakata) with 5.85, 5.14, 4.73cm, respectively in 2020 and Magali. R. (sakata) and Pimento magma super with 2.69 and 1.80 in 2021, the lowest were seen in Magali R. (sakata) and Magda (Embrapa) with 3.15 and 3.29 in 2020. Pimento magma super and Dahra Rx (sakata), F102 with 0.61and 0.75, respectively in 2021. For the seedling vigour index 1, Rubia .R. (sakata), Dahra Rx (sakata) and BRS Tico (Embrapa) with 3.01, 2.89 and 2.79 in 2020. Magali. R. (sakata) and Pimento magma super with 193.04 and 96.07, respectively were the highest, while Magali. R. (sakata) (1.06) in 2021; BRS Tico (Embrapa) (3.33) and F 102 (5.33) in 2020 as the lowest seed vigour index 1. The highest seed vigour index 2 was Dahra Rx (sakata), and with 4.47and 4.38 in 2020 and Magali. R. (sakata) and Pimento magma superwith 211.20 and 118.80 in 2021, while the lowest was recorded for genotypeMagali. R. (sakata) with 1.67 in 2020 and BRS Tico (Embrapa) andF 102 with 5.67 and 7.77, respectively, in 2021. For seedling emergence, genotypes Magali. R. (sakata) and Magda (Embrapa) with 89.33 and 85.33 in 2020 and pepper Eppo (S7G9), Pimento magma super with 63.33 and 53.33, respectively in 2021 had the highest seedling emergence, while Dahra Rx (sakata) and F102 with 61.33 and 65.33, respectively in 2020 and BRS Tico (Embrapa) and F102 with 10.0 and 11.10 were the lowest. In the seedling emergence shoot length, Magali. R. (sakata) and Pimento magma super with both 2.11 in 2020 andMargadeth (Embrapa), and Pepper Eppo (S7G) with 2.40,2.37,respectively in 2021 were the highest while Margadeth (Embrapa), with 1.94 in 2020 and F102 with 1.47 had the lowest (Table 2)**.**

The genotypic estimates ranged from 0.0027 for seedling emergence plumule length to 151.94 for seed germination in 2020 year and 0.25 for seedling emergence plumule length to 14794.24 for seedling vigour index 1 in 2021 year (Table 3). Phenotypic variance estimate ranged from 0.007 in seedling emergence plumule length to 1666.73 for seed germination in 2020 year and 0.48 for seedling emergence plumule length to 14849.86 for seed vigour index 1 in 2021 year. However, the highest heritability estimate was obtained for plumule length, while root length, seedling vigour I and II, seed germination, field emergence and seedling emergence plumule length had heritability values of between 38.57% and 95.07% in 2020 year (Table 3). In 2021 year, the highest broad sense heritability value was obtained in seed vigour index iwhile seedling vigour II, seed germination, root length, plumule length, field emergence and seedling emergence plumule length had heritability values ranges from of 52.08 and 99.63%.

Result on Table 4 shows that seed germination had positive and significant correlation with plumule length (r=0.496), seedling vigour index I (r=0.867), seedling vigour index II (r=0.721) and seedling emergence at 15th day (r=0.59) in the 2020 cropping year. In the same vein, seedling length recorded positive and significant correlation with root length (r=0.679), seed vigour index I (r=0.829) and seed vigour index II (r= 0.647). Root length had positive and significant correlation with seed vigour index I (r=0.500) and seedling vigour index II (r=0.738). Seedling vigour index I had positive and significant correlation with seedling vigour index II (r=0.757). In 2021 year, strong and positive correlation coefficient values were recorded between seed germination and all the other characters except seedling emergence plumule length in which the values were positive and weak. However, plumule length recorded significant, and positive correlation with root length (r=0.84), seedling vigour index l(r=0.89), and seedling vigour index 2 (r=0.81). Also, root length had positive and significant correlation coefficient with seedling vigour index l(r=0.07) and seed vigour index 2 (r=0.75). The correlation between seed vigour index 1 and seed vigour index 2 was significant and positive (r=0.94) - Table 4.

In 2020, all the characters accounted for major variation in PCA 1 with values of between 0.39 and 0.88, while in PCA 2, characters such as seed germination, seedling vigour I,seedling vigour index II, seedling emergence and seedling emergence plumule length with values of 0.47, 0.49, 0.37,0.56 and 0.68, respectively had the most significant values (Table 5).

In 2020, all the characters gave major contribution with values of between 0.67 and 0.37 in PCA 1, while seed germination, emergence at 7days and seedling emergence plumule length gave the most significant contribution with 0.53, 0.92 and 0.54, respectively. PCA 1 accounted for 40.86% and 54.08% in 2020 and 2021, respectively, while PCA 2 had 59.27 and 79.63% in 2020 and 2021, respectively (Table 5).

Table 1: Mean squares in the analysis of variance of seed vigour characters evaluated in *Capsicum annuum*in two cropping seasons

SV	**DF**	**SG (%)**	**PL (cm)**	**RL (cm)**	**SV 1**	**SV 2**	**SE**	**SEP (cm)**
2020								
Replication	2	11.2	0.13	0.2	0.19	0.61	84.4	0.01
Variety	10	500.21** * *	0.59**	2.03**	0.97**	2.19**	306.15^{ns}	0.02^{ns}
Error	20	44.39	0.31	0.17	0.08	0.19	134.78	0.01
2021								
Replication	2	99.5	0.3	0.17	43.71	479.5	37.75	0.32
Variety	10	2130.64**	1.69**	1.18*	14794.24**	13254.04**	393.93**	0.25*
Error	20	142.83	0.16	0.46	555.62	625.02	230.35	0.23

Where *, ** indicate that Correlation is significant at 5% and 1% level of probability, respectivelyns= not significant *SG = seed germination, RL = root length, PL = plumule length, SV2 = seedling vigour index 2, SV I = seedling, vigour index I, SE= seedling emergence at 15th day, SEP- seedling emergence plumule length.*

Table 2: Mean performance of seed quality traits of 9 varieties of green pepper seeds

Variety	**SG (%)**	**PL (cm)**	**RL (cm)**	**SVI 1**	**SV 2**	**SE**	**SEP (cm)**
2020							
Pimento magma super	85.33^{a}	3.05^{abc}	5.14^{ab}	2.60^{ab}	4.38^{a}	82.6	2.11^{a}
Magali.R. Sakata	53.33^{c}	1.97^{c}	3.15^{c}	1.06^{c}	1.67^{b}	89.3	2.11^{a}
Pepper Eppo(S7G0	84.00^{ab}	2.45^{de}	4.01^{bcde}	2 .27^{ab}	3.36^{a}	82.6	1.68^{a}
Dahra Rx (Sakata)	94.67^{a}	3.06^{abc}	4.73^{abc}	2.89^{a}	4.47^{a}	61.33^{a}	2.05^{a}
Rubia Rx (Sakata)	85.33^{ab}	3.53^{a}	5.85^{a}	3.01^{a}	4.42^{a}	73.33^{a}	1.95^{a}
BRS Tico (Embrapa)	86.67^{ab}	3.23^{ab}	3.85^{cde}	2. 79^{ab}	3.34^{a}	77.33^{a}	1.98^{a}
Margadeth(Embrapa)	88.00^{ab}	3.07^{abc}	4.26^{bcde}	2.7 l^{ab}	4.12^{a}	71.33^{a}	1.94^{a} ’
Magda (Embrapa)	98.67^{a}	2.67^{cd}	3.29^{de}	2.63^{ab}	3.24^{a}	85.33^{a}	2.02^{a}
F 102	70.67^{c}	2.86^{bcd}	4.46^{abcd}	2.04^{b}	3.43	65.33^{a}	2.00^{a}
2021							
Pimento magma super	63^{abcd}	1.48^{abcd}	1.80^{ab}	96.07^{b}	118.80^{b}	53.33^{ab}	2.20^{a}
Magali.R. Sakata	79.00^{ab}	2.48^{ab}	2.69^{a}	193.0^{a}	211.20^{a}	22.00^{ab}	2.27^{a}
Pepper Eppo(S7G0	73.00^{abc}	0.69^{d}	0.87^{ab}	51.73^{bc}	64.00^{cd}	63.33^{a}	2.37^{a}
Dahra Rx (Sakata)	33.00^{def}	0.57^{cd}	0.6 l^{ab}	27.67^{bc}	29.6	36.67^{ab}	1.87^{a}
Rubia Rx (Sakata)	29.00^{def}	1.00^{cd}dd	1.10^{ab}	31.98^{bc}	32.1	22.22^{ab}	2.17^{a}
BRS Tico (Embrapa)	3.30^{f}	0.67^{d}	1.13a^{b}	3.33^{bc}	5.67^{d}	10.00^{b}	1.80^{a}
Margadeth(Embrapa)	40.00^{cd}	1.36$^{b“}$	1.36^{ab}	54.91^{bc}	57.20^{cd}	25.33^{ab}	2.40^{a}
Magda (Embrapa)	45^{bcd}	1.86^{abc}	1.43^{ab}	82.75^{b}	61.17^{cd}	16.00^{ab}	2.20^{a}
F 102	8.8^{af}	0.52^{d}	0.75^{ab}	5.33^{c}	7.77^{d}	11.10^{b}	1.47^{a}

Means followed by the same alphabet along the column are not significantly different from one another*SG — seed germination, RL = root length, PL = plumule length, SV2 - seedling vigour index 2,* SVI= *seedling vigour index 1, SE = seedling emergence at 15th day, SEP- seedling emergence plumule length*

Table 3: Estimates of variance components and heritability values of seed quality traits evaluated in nine varieties of green pepper

Character	Genotypic Variance	Phenotypic Variance	Error Variance	Heritability (H^2_B)%
2020				
SG%	151.94	1666.74	14.8	91.13
PL	0.19	0.20	0.01	95.07
RL	0.62	0.68	0.05	92.05
SV 1	0.30	0.32	0.02	92.05
SV 2	0.67	0.73	0.06	91.56
SE	57.13	102.05	44.9	55.98
SEP	0.0027	0.007	0.00	38.57
2021				
SG%	2130.64	2273.47	142.	93.72
PL	1.69	1.85	0.16	91.35
RL	1.19	1.64	0.46	71.95
SV1	14794.24	14849.86	55.6	99.63
SV 2	13254.04	13879.06	625.	95.50
SE	932.76	1191.73	258.	78.31
SEP	0.25	0.48	0.23	52.08

Means followed by the same alphabet along the column are not significantly different from one anotherSG — seed germination, RL = root length, PL = plumule length, SV2 - seedling vigour index 2, *SVI* = seedling vigour index 1, SE = seedling emergence at 15th day, SEP- seedling emergence plumule length

Table 4: Correlation coefficients among seed quality characters evaluated in nine varieties of green pepper.

Character	**SG**	**PL (cm) (%)**	**RL (cm)**	**SV 1**	**SV 2**	**SE**	**SEP (cm)**
2020							
SG 1	0.50**		0.25	0.87**	0.71**	0.59**	0.16
PL		1	0.68**	0.83**	0.65**	0.43	0.48
RL			1	0.50**	0.74**	0.51	0.21
SV 1				1	0.76**	0.32	0.35
SV 2					1	0.58	0.34
SE						1	0.23
SEP							1
2021							
SG I	0.64**.		0.49**	0.83**	0.84**	0.48**	0.32
PL		1	0.84**	0.89**	0.81**	-0.05	0.12
RL			1	0.67**	0.75	-0.34	0.11
SV1					1 0.94**	0.20	0.20
SV 2			1			0.23	0.27
SE						1	0.34
SEP							1

** Correlation is significant at 1% level of probability, *= Correlation is significant at 5% level of probability, ns= not significant

SG = seed germination, RL = root length, PL = plumule length, ***SV2*** = seedling vigour index 2, ***SV1*** = seedling vigour index 1, SE= seedling emergence at 15th day, SEP= seedling emergence plumule length

Table 5 Principal component analysis of the seed quality characters evaluated in green pepper

Characters	**PCA 1 2020**	**PCA1 2021**	**PCA2 2020**	**PCA2 2021**
Seed germination (%)	0.72*	0.76*	0.47*	0.53*
Plumule length (cm)	0.86*	0.95*	0.09	-0.01
Root length (cm)	0.66*	0.87*	0.13	-0.09
Seedling vigour index 1	0.88*	0.94*	0.49*	0.21
Seedling vigour index 2	0.81*	0.93*	0.37*	0.23
Emergence at 15days (%)	-0.58*	0.27	0.56*	0.92*
Seedling emergence plumulelength (cm)	-0.39*	0.16	0.68*	0.54*
Eigen value	4.90	4.32	2.21	2.04
Variance%	40.86	54.08	18.41	25.55
Cumulative%	40.86	54.08	59.27	79.63

*= Values above 0.30 recorded significant contribution.

DISCUSSIONS.

This study revealed that highly significant variation existed among green pepper seed varieties for the observed seed quality characters. This therefore suggests that, in a population of *Capsicum annuum* varieties, there is an opportunity to select desirable varieties with increased seed quality which may be able to withstand unfavourable field conditions and give increased seed yield. Considerable variations were observed by Adebisi (2004) in sesame and Datta *et al*., (2013) in *Capsicum annuum* seed quality attributes.

The findings from this study have also identified important seedling characters which can be considered in selecting for improved seedling vigour. These characters have been confirmed through genotypic and phenotypic components of variation, correlation coefficients and principal component Eigen values. All the seedling vigour characters, except seedling emergence plumule length had heritability estimates of over 56%. This indicated that the variation for these characters is largely controlled by heritable factors, and that selection can be based on the phenotypic appearance of the varieties, while low heritability obtained with seedling emergence plumule length showed that the varieties were probably influenced more by the environment rather than their genetic make-up.

The significant positive correlations among any of the characters observed in this study suggested that these characters can be jointly selected in seed improvement programmes of *Capsicum annuum*. The results from this study have revealed that seed germination, plumule length, root length, seed vigour index, as well as seedling emergence appeared to be dependable selection criteria for seedling vigour improvement ingreen pepper population, and this is because of high genetic contribution to the total variation. All the seed quality characters assessed had heritability estimates of over -55% except for seedling emergence plumule length in 2020 and 2021. This indicated that variation for these characters were largely controlled genetically and hence heritable factors. Low heritability value obtained in seedling emergence plumule length in 2020 and 2021 indicated that these were most likely influenced by the environment. These results generally agreed with the conclusion reached by Abrham*et al*. (2017) and Shimeles, (2018) who reported higher genotypic correlation coefficients than the phenotypic ones, implying the inherent associations between various characters in Ethiopian *Capsicums*. Also, Kadwey *et al.*, 2015; Chakrabarty and Aminul , (2017); Kumari *et al.*,(2017) reported genotypic and phenotypic correlations between plant height, number of primary branches per plant, fruit length, fruit diameter in *Capsicum annuum.* Furthermore, because of the existence of strong correlations of standard germination with plant height, seedling vigour indices I and II, standard germination or seedling emergence, it may also be used as a single dependable criterion for identifying rapidly-growing varieties in green pepper. Conclusively, Dahra Rx (Sakata) and Rubia. R. (Sakata) genotypes had higher seedling vigour characters in 2020 while Magali .R. (Sakata) had the best seed quality traits than other genotypes assessed.

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Journal of Applied Agricultural Research 2022, 10(2): 151-158
ISSN 2006-750X.

IMPACT OF IRRIGATED AND RAIN-FED LANDUSE ON CHEMICAL PROPERTIES OF SOILS OF GALMA FLOODPLAIN, ZARIA, KADUNA STATE

Aliyu, Jamila
Department of Soil Science, Institute for Agricultural Research
Ahmadu Bello University /Faculty of Agriculture, Ahmadu Bello University, Zaria, Nigeria.
Author's Contact: jamilabintaliyu@gmail.com, Jaliyu@abu.edu.ng, Phone No: +2347037479843

ABSTRACT.

Knowledge about soil properties associated with land use is vital for sustainable soil management practices. Our study focuses on an irrigated and rain-fed land within the Galma floodplain in Kaduna state, where rain-fed and irrigation farming were the dominant land uses practices. Samples from Four profile pits were collected and analyzed. T-test was adopted to investigate the effects of land use on the selected soil properties. The results showed that statistically significant differences were found for OC, TN, Ca, Mg, pH, EC, and SAR between the land-use types. Mean contents of OC (9.81 g/kg), TN (0.63 g/kg) and Ca (8.54 cmol (+)/kg) in irrigated fields were higher than in rainfed lands (P < 0.05). Mean values of Mg (2.20 cmol (+)/kg), K (0.32 cmol (+)/kg), CEC (20.86 cmol (+)/kg) and SAR (11.26) pH (6.26 and 5.37 in water and salt solution respectively) in rain-fed fields were higher than in irrigated lands (5.60 and 4.98 respectively) (P < 0.001).

Keywords: landuse, floodplain, T-test, exchangeable calcium and organic carbon.

INTRODUCTION.

Irrigation development has introduced major changes in the environmental and socio-economic conditions in areas where irrigation practices. In the process, existing equilibrium are disturbed and over time, new ones established with the underlying premise that the new conditions established satisfy human kinds' objectives better than those practiced before (Pereira *et al.*, 1996). Irrigation development, while contributing to the economic well-being of many countries, has potential negative effects. Irrigation could change soil properties that play an important role in the transformation, retention, and movement of nutrients present in the applied water (Magesan *et al*., 1998). It was reported that irrigation with poor quality irrigation water reduces soil productivity, changes soil physical and chemical properties, creates crop toxicity and ultimately reduces yield (Wong *et al*. 2005). A higher concentration of soluble salts in irrigation water leads to salinity and toxicity effects of the individual ions which impair seed germination, delay crop maturity, fertility needs, irrigation system performance and longevity (Aderoju and Festus, 2013).
Perhaps one of the most researched aspects of irrigation is the effect on soil chemical properties. There are several reports on changes in soil properties resulting from irrigation although, these changes vary greatly and are largely dependent on the

quality of the irrigation water used. Moreover, the effects of irrigation on soil chemical properties in arid and semi-arid environments were well documented. However, there is little information on the effects of irrigation on soil chemical properties in the soil of Galam basin; therefore, the objective of this study is to assess the effect of irrigation on soil chemical properties of Galma irrigation scheme in Zaria

MATERIALS AND METHODS.

This study was conducted in Galam floodplain at Dakace in Zaria Local Government area in Kaduna State, Nigeria. The study site was located between Longitude N11 05.150 to N11 04.879 and N11 05.137 to N11 04.866 and Latitude E7 44.206 to E7 44.192 and E7 44.480 to E7 44.467 as shown in Figure 1.

The area is situated in the Northern Guinea Savanna ecology with a monomodal annual rainfall of about 1011±161 mm concentrated almost entirely in the five months (May/June to September/October), and mean daily temperatures (minimum and maximum) range between 15ºC and 38ºC (Oluwasimere and Alabi, 2004). The geology of the Galma Basin is dominated by undifferentiated basement complex rock. The vegetation of the area falls within the northern Guinea savanna. Land use around the area is basically agriculture. Crops such as maize rice and vegetable carrot, tomato, onion red pepper are grown.

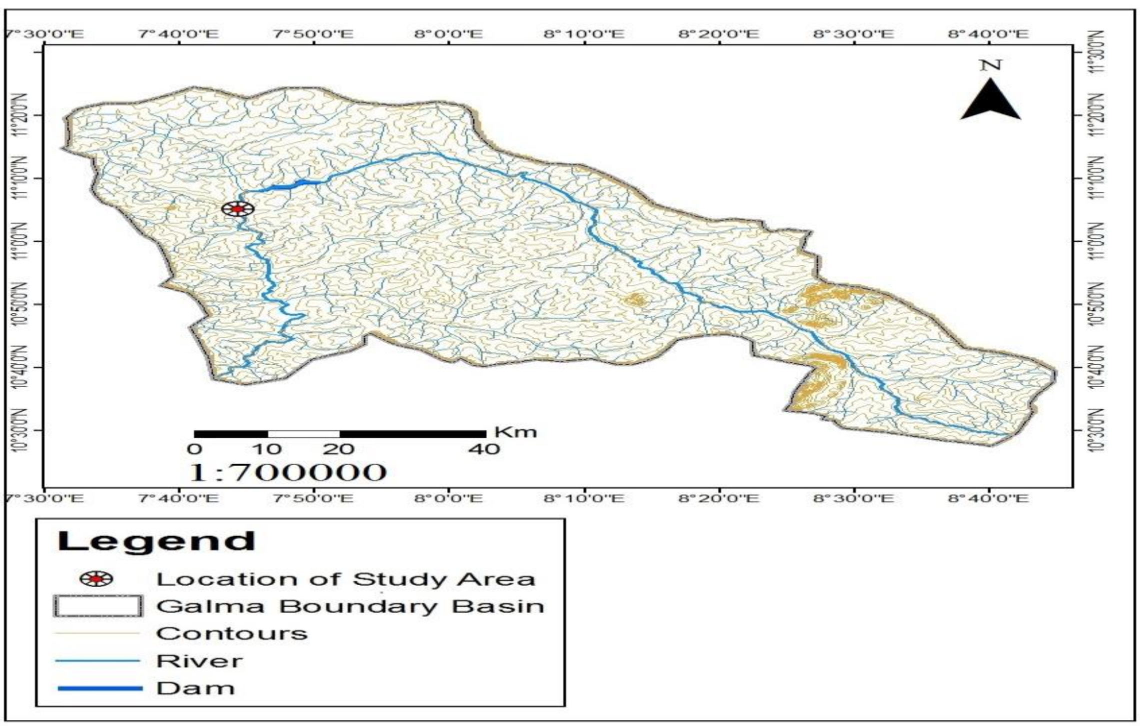

Figure 1 Digitized and geo-referenced drainage and contour map of Galma basin showing the location of the study area

Soil Sampling and Laboratory Analysis.

Fieldwork was carried out so as to investigate the land resource across the study area. An exploratory survey was carried out in other to identified irrigated and rain-fed fields. The site for the profile pit was randomly selected. A total of Four pits each were sited on irrigated and rain-fed fields and describe according to the soil survey manual (Soil Survey Staff 2006). Field descriptions and sample collections were made during the dry season to ensure freedom from groundwater disturbance. Additional Surface and sub-surface samples were also collected randomly.

Soil Analysis.

Soil samples collected were air-dried, crushed and sieved passed through a 2 mm sieve mesh. Then soil pH was measured by pH meter using suspension of distilled water to soil solution ratio (1:2.5) and electrical conductivity was measured after saturated paste extracts (Agbenin,1995). Exchangeable bases and cation exchange capacity (CEC) of the soils were determined by the 1 M ammonium acetate (pH 7) method according to the percolation tube procedure (Van Reeuwijk, 1993). Sodium and potassium were read using an atomic absorption spectrophotometer (AAS), while Ca and Mg were read using the flame photometer. Available phosphorus was determined following the procedure described by IITA (1979) using the Bray- 1 extraction method (Bray and Kurtz, 1945) Total nitrogen content of the soil was determined by wet-oxidation. (Bremner and Mulvaney, 1982) and organic carbon content by the wet combustion procedure of Walkley and Black as described by Nelson and Sommers (1982). The soil will be leached with 1M KC1 solution. Total exchange acidity (H+A1) will be determined by titrating the extract with a standard NaOH solution (Thomas, 1982). Sodium adsorption ratio was calculated using the following equation

$$SAR = \frac{Na}{\frac{\sqrt{Ca + Mg}}{2}}$$

The exchangeable sodium percentage was calculated as the proportion of the CEC (NH_4OAc) occupied by sodium cations as follows (Agbenin, 1995):

$$\text{ESP} = \frac{\text{Exchangeable Sodium}}{\text{CEC } (\text{NH}_4\text{OAc})} x\ 100$$

Data Analysis.

Data obtained were subjected to student T-test for statistical analysis to compare the means of soil properties between irrigated and rain-fed fields using the SPSS statistical package.

RESULTS AND DISCUSSIONS.

Chemical characteristics and impact of land use on the selected soil properties within the study site are shown in Table 1 and Table 2 respectively. Organic carbon was higher than 10 g/kg in the surface soil and less than 10 g/kg (Table 1) hence surface soil was considered to have a medium concentration of organic carbon while the subsurface soil was rated low. A higher concentration of organic carbon at the surface soil could be attributed to the deposition of organic matter followed by rapid decomposition and mineralization.
There was a significant difference ($P<0.05$) in the concentration of organic carbon between the land use types under consideration (Table 2) with irrigated land use having a higher concentration. Factors such as high moisture content create a condition of low aeration (slow oxidation) and low temperature which slows down the rate of decomposition of organic matter. In the rain-fed field, the types of crops grown might also bring about this observed difference (Bewket and Stroosnijder, 2003). Land use practice that has detrimental effects on organic carbon content have far-reaching implication because of the multiple roles soil organic carbon have on soil (Wild, 1996).

Total Nitrogen

Data for total nitrogen presented in Table 1 indicated that the total nitrogen content of the soils across the land use types is low (<1.50 g/kg) and decrease down the soil profile. The total N content of the soils showed a decreasing concentration with a depth similar to soil organic carbon distribution. It reached a maximum of 1.30% in the surface soils under the irrigated field and 0.80% for rain-fed fields. In all the land use types, total N content was higher in the surface layer than in the subsurface layer, as was the soil organic matter distribution. There was a significant difference ($P<0.05$) in the concentration of total nitrogen (Table 2) across the land use type. A higher concentration of total nitrogen in the irrigated field could be attributed to higher soil organic matter distribution due to the low decomposition of organic matter.

Soil Reaction.

The variations in the pH of soils under the different land-use types were generally small (Table 2). Soils under rain-fed land use were slightly acidic (pH ranging from 6.11 to 6.55), while soil under irrigated land use had pH ranging from strongly acid to slightly acidic (pH ranging from 5.15 to 6.56). In both land use types; the soil pH was higher in the surface layers than in the subsurface layers (Table 1). Higher pH in surface than the subsoil, and may be attributed to the influence of organic matter through biogenetic cycling of bases, capillary rise in water within the basin this process reduces the acidification of soils (Mohammad, 2011), the addition of bases cation to the surface soil layer as loess during the harmattan (Aliyu, 2016) or partly due to the aluminosilicate clay minerals releasing Al^{3+} and H^{+} into the soil solution through isomorphous substitution (Lawal *et al.*, 2012a). The pH value across the land-use types falls within the normal range of 5.5-7.0 reported being optimum for the release of plant nutrients (Sharu *et al.,* 2013).

Available phosphorus.

The available P content ranged from 3.85 to 44.97 mg/kg in the rain-fed field and from 3.68 to13.65 mg/kg in the irrigated field (Table 1). The mean available P-value content in the irrigated field was lower compared with the rain-fed field. A low concentration of available P in the irrigated field could be attributed to a low mean pH value (<5.5) of the soil (Table 2). Akpan-Idiok *et al*. (2013) attributed low available P in irrigated land to P fixation. The difference among the land use types was not significant, as shown by the t-test.

Exchangeable base, cation exchange capacity and exchangeable acidity.

The exchangeable calcium accounted for the lion’s share of the exchangeable bases in the exchange site followed by exchangeable Magnesium. The soils under the different land-use types significantly differed in exchangeable Calcium content ($P<0.05$) (Table 2), with higher content being in the irrigated field. This may be ascribable to the deposition of calcium bearing material during irrigation. The general trend in these two essential plant nutrients is a decrease with an increase in profile depth (Table 1).

The irrigated land-use has the largest mean value (0.32) for exchangeable potassium and the rain-fed has the least (0.09). The result of the T-test (Table 2) shows that there was highly significant more exchangeable potassium in irrigated land-use ($P<0.001$). This is most likely due to the higher K content of the water used in irrigating the field. Exchangeable Na contents of the soils show statistically insignificant differences among the land use types and between the villages. This suggests the absence of any effect that can be linked to land-use dynamics in the watershed. Similarly, soils in irrigated fields showed significantly higher CEC compared to soils under rain-fed land-use type. Higher CEC in irrigated land-use could be due to higher organic matter accumulation in this soil (Table 2).

Table 1 Chemical properties of soils Galma irrigation scheme

Land use type	Horizons	Depth (cm)	OC <-(g/kg)	TN -->	A P (mg/kg)	Ca <---	Mg	K (cmol(+)kg^{-1})	Na	AL+H --->	CEC	BS %	pH H_2O	pH $CaCl_2$	EC dS/m	SAR
Rainfed																
	Pedon G1P1 Location (Latitude N11 04.921 Longitude E7 44.44 Elevation 612.00 m)															
	Ap	0-17	11.00	0.80	44.97	8.36	0.80	0.08	0.11	0.80	11.90	78.52	6.55	5.46	0.09	0.07
	Bt1	17-51	3.60	0.30	6.30	6.94	0.59	0.07	0.10	0.40	12.50	61.54	6.53	5.27	0.08	0.07
	Bt2	51- 82	4.10	0.20	5.60	5.11	0.90	0.10	0.14	0.40	14.80	42.21	6.04	5.35	0.06	0.11
	BC	82-173	2.20	0.10	5.60	1.85	0.49	0.08	0.11	0.40	7.70	32.75	6.10	5.26	0.04	0.14
	Pedon G1P2 Location (Latitude N11 04.896 Longitude E7 44.413 Elevation 611.70 m)															
	Ap	0-29	11.10	0.60	16.63	8.66	1.35	0.09	0.33	1.10	12.90	80.85	6.34	5.56	0.06	0.21
	Bt1	29-52	4.40	0.10	5.43	5.13	0.80	0.06	0.23	0.60	12.50	49.72	6.28	5.40	0.05	0.19
	Bt2	52-79	4.00	0.03	4.55	4.87	1.13	0.08	0.33	0.60	11.40	56.20	6.13	5.25	0.04	0.27
	Bt3	79-168	2.60	0.01	3.85	4.93	2.31	0.14	0.33	0.20	13.30	57.92	6.11	5.39	0.03	0.25
Irrigated																
	Pedon G3P1 Location (Latitude N11 05.059 Longitude E7 44.394 Elevation 607.80 m)															
	Ap	0-30	13.20	1.30	7.35	9.81	2.47	0.51	0.31	1.20	19.40	67.54	5.84	5.08	0.05	12.11
	Btg 1	30-69	10.10	0.30	7.18	8.29	2.48	0.36	0.23	1.00	20.10	56.50	5.36	4.93	0.03	10.08
	Btg 2	69-94	7.20	0.20	3.68	7.90	2.31	0.30	0.21	0.50	22.20	48.31	5.28	4.62	0.02	4.23
	Pedon G3P2 Location (Latitude N11 05.012 Longitude E7 44.254 Elevation 607.20 m)															
	Ap	0-45	14.40	1.10	13.65	11.29	2.27	0.21	0.48	1.25	20.90	68.16	6.29	5.19	0.04	11.47
	Bt1	45-82	9.00	0.70	5.96	10.34	2.31	0.27	0.38	1.20	18.50	71.90	6.07	5.15	0.02	10.87
	Bt2	82-116	7.60	0.40	5.95	6.51	2.00	0.24	0.28	1.00	20.80	43.42	5.15	5.00	0.03	11.21
	2Ag	116-137	7.20	0.40	5.95	5.66	1.53	0.38	0.18	0.60	24.10	32.15	5.22	4.91	0.05	10.87

Table 2 Impact of irrigation on soil chemical properties

Land use	OC	TN	AP	Ca	Mg	K	Na	EA	CEC	BS	pH water	pH salt	EC	SAR
Irrigated	9.81	0.63	7.10	8.54	2.20	0.32	0.30	0.96	20.86	55.43	5.60	4.98	0.05	11.26
Rain fed	5.38	0.28	11.61	5.73	1.05	0.09	0.21	0.56	12.13	57.46	6.26	5.37	0.03	0.16
t-value	2.64	2.41	0.084	2.55	4.77	5.99	1.59	2.65	8.05	-0.25	-3.52	-4.69	-2.51	7.29
LOS	*	*	NS	*	***	***	NS	NS	***	NS	*	**	*	***

Irrigated plot lies in the floodplain and has reduced condition (poorly drained) which favours accumulation of organic matter due to reduced microbial activities. Exchangeable acidity (EA) was rated low (Table 1) in all the land use. Low EA indicates the absence of the possibility of aluminum toxicity and cloud be attributed to intensive weathering of parent material in the tropic. There was no significant difference in EA concentration across land use.

Salinity status of the soil and alkalinity Hazard.

The electrical conductivity of the soil saturation extract (ECe) is a good indicator of the degree of salinity of the soil. The exchangeable acidity of the soil in the study area was low (EC< 4 dSm^{-1}) (Table 1). All the land use showed low ECe values with a mean of 0.03 to 0.05 dSm^{-1} (Table 2) for rain-fed and irrigated land-use respectively indicating the non-saline nature of the soils. Exchangeable acidity showed significant ($P <$ 0.05) variation with land use (Table 1). ECe variability was caused by extrinsic factors such as irrigation water and fertilizer application. Malgwi (2001) reported that higher value ECe in irrigated land use may be due to the accumulation of salts brought by irrigation water and subsequent deposition.

Alkalinity hazard was determined using the sodium absorption ratio (SAR). All the land use type located in the study area have SAR values lower than 13 which the critical limit of alkalinity hazard proposed by Richards (1954), which indicates that the overall alkalinity hazard of the soil is very low, thus the soil is safe for crop production and irrigation use. The mean value of SAR shows a significant ($P < 0.05$) difference across the land use types. Higher SAR value in irrigated land use could be attributed to the accumulation of salts brought by irrigation water (Malgwi, 2001).

CONCLUSION.

This study sought to demonstrate how irrigation and rain-fed land-uses influence soil chemical and properties. Organic carbon, total nitrogen calcium CEC, and SAR were significantly higher in irrigated field compared to soils under rain-fed land-use type. Soil Under rain-fed land use had a statistically significant higher pH than soils under the irrigated land-use type. In contrast, differences in the distribution of soil available phosphorus, Na, exchangeable acidity and base saturation values among the two land-use types were statistically insignificant, suggesting an absence of a considerable effect that could be directly associated with land-use dynamics.

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Journal of Applied Agricultural Research 2022, 10(2):159-174
ISSN 2006-750X.

SOIL FERTILITY MANAGEMENT OF FARM HOUSEHOLDS AND FOOD SECURITY NEXUS: EMPIRICAL EVIDENCE FROM ABIA STATE, NIGERIA

[1]Amusa, T. A., [2]Umunna, M. C and [3]Esheya, S. E.
[1&2]Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike.
[3]Department of Agricultural Economics and Extension, National Open University of Nigeria, Kaduna Campus.
Author's Contact: amusa.taofeeq@mouau.edu.ng; hamfeeq@yahoo.com

ABSTRACT.

The study examined soil fertility management of farm households and food security nexus in Abia State, Nigeria. Through a carefully structured questionnaire, primary data were collected from 180 arable crop farm households. Data collected were analysed using descriptive statistics such as frequency, percentage, food security index and inferential statistics such as binary logistic regression, multinomial logit model and principal factor analysis. The results of the study showed that majority (53.9%) of the farm households are food insecured while 46.1% are food secured. Majority of the food insecured farmers engaged the use of organic manuring while the highest proportion of the food secured farmers engaged the use of inorganic manuring. The result of the binary logistic regression was highly significant at 1% (prob> chi^2 = 0.000), Pseudo R^2 = 0.8219 and showed that age, sex, education, household size, farm size, credit access and farm income significantly (p=??) influenced poverty status of the farmers. The result of multinomial logistic regression also showed good fit with prob> chi^2 = 0.000 and Pseudo R^2 = 0.7410. Age, sex, education, household size, farm size, extension visits, credit access and farm income significantly (p=??) influenced farmers' choice of soil fertility management options. Through data reduction, the challenges of farmers in soil fertility management practices are instructional, financial and social factors. Based on the findings, this study among others recommended increased knowledge and technical know-how of farmers in effective use of fertilizers for improved yield and productivity, increased provision of credit facilities to farm households to increase their purchasing power of relevant farm inputs such as fertilizers to boost agricultural production and consequently reduce food insecurity.

Keywords: Soil fertility, organic, inorganic manure, food security, Abia State.

INTRODUCTION.

One of the fundamental components of socioeconomic development of any society is adequate food production and security. Food security is a condition where all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (Eme *et al.*, 2014). Food security exists at five different levels which include: individual, household, national, region and global (Perez-Escamilla *et al.*, 2017). To a household for instance, Ugo (2021) described food security as access by all members of the household at all times to enough food for an active, healthy life. The issue of food security has been on the front burner in Africa continent due to her low capacity to cope with food requirement of the rising population.

Africa is regarded as the most food-insecure continent in the world, and for decades hunger has always been a serious problem in the continent (Bwalya, 2013). Food insecurity and poor nutrition have been found to be prevalent in Sub-saharan Africa, Nigeria as poverty headquarters inclusive. Dwindling trend in food production across Africa is not unconnected with soil degradation and depletion in soil fertility. About 2.6 billion people are estimated to depend directly on agriculture for their livelihood and 52% of the land used for agriculture is either moderately or severely affected by soil degradation (Gabathuler *et al.,* 2009). One of the reasons for recurrent failure of food self-sufficiency plans is underestimation of the importance of soil fertility status and lack of clear-cut intervention plan to address soil nutrients depletion problems. Soil nutrients depletion has become serious threats to agricultural productivity in sub-Saharan Africa. It is getting worst in Nigeria and southeast zone in particular due to increased pressure on available farmland. Most arable lands have been affected by degradation thereby reducing agricultural productivity, which in turn results in poor economic growth and food insecurity in sub-Sahara African countries (Bekele, 2003). Soil degradation will remain an important global concern because of its adverse impacts on agricultural production and food security. Inappropriate soil management, particularly in areas with high population densities and fragile ecosystems, further increases loss of productivity of resource poor farmers. This in turn worsens food insecurity status and livelihood of farm households in developing countries (FAO, 2001).

There is a strong tie between soil fertility management and food security through improved food production. For instance, Jorhan (2022) stated that to achieve and maintain food security, strong policies and decision making are required at local and global levels to increase food production through sustainable soil fertility management. Effective soil fertility management, no doubt will play significant role in achieving Sustainability Development Goal (SDG) 2 which aims to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture. Gebrehiwot (2022) pointed out that soil fertility management enhances food security of the world population. Soil fertility can be maintained or increased through several soil management practices. FAO (2021) noted that farmers can improve soil fertility and soil health by optimizing soil nutrient management in terms of maximizing net returns, minimizing the soil nutrients depletion, and minimizing nutrient losses or negative impacts on the environment.

Farmers have options of boosting or managing the fertility of the soil for improved productivity through the use of organic manures, inorganic fertilizers or the combinations of both (Ullah *et al*., 2008). The productivity of some arable lands had declined by 50% as a result of soil fertility depletion, erosion and desertification (Mitiku, Herweg and Stillhardt, 2006). Hence, there is need to emphasize the importance of soil fertility management as a means of improving agricultural productivity to solve food insecurity problems in Africa (FAOSTAT, 2016). In this regards, this study examined soil fertility management of farm households and food security nexus in Nigeria with empirical evidence from Abia State. The study specifically, examined food security status of the farmers, soil fertility management and food security nexus, determinants of food security status of farmers, factors influencing soil fertility management practices and challenges of farmers in soil fertility management practices.

METHODOLOGY.

Area of Study.

The study area was Abia State in southeast geopolitical zone, Nigeria. The state lies between longitudes 7^{O} 10^{1} and 8^{O} East of the Greenwich meridian and latitudes 4^{O} 40^{1} and 6^{0} 14^{1} North of the equator. Abia State is made up of 17 Local Government Areas (LGAs) broadly divided into three agricultural zones namely: Aba, Ohafia and Umuahia agricultural zones. The population of the state is 3,256,642 people and land area of about 5,243.775sq.km (National Bureau of Statistics, 2012). Abia State is an agrarian state making it suitable for housing notable agricultural institutions such as National Root Crops Research Institute (NRCRI) and Michael Okpara University of Agriculture. Agricultural activities ranging from production, processing to marketing constitute means of livelihood of the people, providing employment and income for more than 65% of the population.

Sampling Techniques.

This study adopted multi-stage sampling technique for selecting 180 smallholder arable crop farmers across the state. The first stage involved purposive selection of the three agricultural zones (Aba, Ohafia and Umuahia) due to wide spread cultivation of arable food crops across the entire state. At the second stage, two LGAs were randomly sampled from each of the three agricultural zones, making a total of six LGAs for the study. The third stage of the sampling equally involved random selection of two communities from each of the six LGAs making 12 communities for the study. With the help of agricultural extension agents at the local government and key informants in the selected communities, the lists (sampling frame) of the smallholder arable crops farmers were compiled from which the sample was drawn. Hence, the fourth stage of the sampling involved random selection of 15 smallholder arable crop farmers from each of the 12 selected communities making a total of 180 farmers that constituted the sample (respondents) for the study.

Data Collection and Analysis.

Data for this study were obtained from primary source through the use of structured questionnaire between April and May, 2021 by the researchers and research assistants through personal contacts with the farmers. The questionnaire was structured to collect data on socio-economic characteristics of the farmers, food security status, soil fertility management practices and challenges facing the farmers in soil fertility management. Data collected were analysed using descriptive statistics such as frequency, percentage, food security index and inferential statistics such as binary logistic regression, multinomial logit model and principal factor analysis.

Estimation procedure.

Food Security Index.

Food security index in this study was estimated using expenditure approach as used by Zubairu and Maurice (2014) and Haddabi, Ndehfru and Aliyu (2019) to categorize the farm households into food secured and food insecured. This is given as;

$$Fi \frac{per\ capita\ food\ expendirure\ for\ the\ ith\ household.}{2/3\text{ mean per capita food expenditure for all households}} \ldots (1)$$

Where:

Fi = Food Security Status.

When Fi ≥ 1, the ith household is food secured.

When Fi ≤ 1, the ith household is food insecured.

Therefore, from the above estimation, food secured households are those whose per capita monthly food expenditure fell above or is equal to two-third (2/3) of the mean per capita food expenditure while food insecured households are those whose per capita food expenditure fell below two-third (2/3) of the mean monthly per capita food expenditure.

Binary Logistic Regression

The binary logistic analysis was used to estimate the determinants of food security status of the arable crop farmers' households. The food security status (Y) of the farmers' households was already obtained as 1 if a farm household is food secured and 0 if the farm household is food insecured. The logistic model is specified explicitly as:

$$Fi = b0 + b1X1 + b2X2 + b3X3 + b4X4 + b5X5 + b6X6 + b7X7 + \cdots .. e \ldots \ldots \ldots \ldots .. \ldots \ldots (2)$$

Where:

*F*i = Food Security Status (1 = if food secure, 0 = if food insecure).

X_1 = Age of farmers (in years)

X_2 = Sex (1 = if male, 0 = if female)

X_3 = Educational level (number of years spent in school)

X_4 = Farming experience (number of years)

X_5 = Household size (number of persons)

X_6 = Membership of associations (1 = 1f a member, 0 = if otherwise)

X_7 = Farm size (in hectare)

X_8 = Extension contact (number of visits)

X_9 = Access to credit (in naira)

X_{10} = Labour (in mandays)

X_{11} = Farm income (in naira)

b_1 – b_{11} = Coefficient of independent variables

X_1–X_{11} = Determinants of farmers security status

e = Stochastic error term.

Multinomial Logit Model

Multinomial logit (MNL) regression model was used in this study to express the probability of an arable crop farmer using a particular soil fertility management option being organic manure, inorganic fertilizers or engaging both organic and inorganic. The general form of the multinomial Logit model is:$\Pr(yi = j)$

$$= \frac{exp(Xi\beta j)}{1 += \sum_{j=1}^{j} exp(Xi\beta j)} \ldots \ldots \ldots \ldots \ldots . (3)$$

$\Pr(yi = 0)$

$$= \frac{1}{1 += \sum_{j=1}^{j} exp(Xi\beta j)} \ldots \ldots \ldots \ldots \ldots .. (4)$$

Where:

For the ith farmer, *yi* is the observed outcome and *Xi* is a vector of explanatory variables. βj is the unknown parameters. This model for this study was summarized as follows:

$$\text{P ij} = \frac{exp(YjXi)}{1 + \sum_{j=1}^{3} exp(YjXi) \ for \ j = 1, 2, 3} .. (5)$$

Pij is the probability of being in each of the groups 1, 2 and 3.

$$P \ io = \frac{1}{1 + \sum_{j=1}^{3} exp(YjXi) \ for \ j = 0} .. (6)$$

Pi_o is the probability of being in the reference group or group 0. In practice, when estimating Multinomial Logit model, the coefficients of the reference group are normalized to zero (Maddala, 1990; Greene, 1993). Hence, for the 3 choices only (3-1) sets of parameters can be identified and estimated. The natural logarithms of the odd ratio of equations (1) and (2) give the estimating equation (Greene, 1993) as:

$$\text{In} \left(\frac{Pij}{Pi0}\right) Xi \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .. (7)$$

This denotes the relative probability of each of the groups 1, 2 and 3 to be reference group. The estimated coefficients for each soil fertility management choice therefore reflect the effects of Xi's on the likelihood of the farmers using that alternative relatives to the reference group. The coefficients of the reference group may be recovered by using the formula:

$$Y_3 = -(Y_1 + Y_2) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

In this study however, group 1 are farmers using organic manuring, group 2 are farmers using inorganic fertilizers while group 3 are farmers engaging the use of both organic and inorganic fertilizers in managing soil fertility. For each explanatory variable, the negative of the sum of its parameters for groups 1 and 2 is the parameter for the reference group. The reference group (base outcome) in this study is group 3 (engaging both organic and inorganic fertilizers). The explicit form of the functions is specified as follows:

$$Pij = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6X6 + \beta 7X7 + \beta 8X8 \ldots\ldots\ldots + n \ldots. (9)$$

$P_{i\,j}$ = (probability of using organic manure, inorganic fertilizers or combination of both)

X_1 = Age of farmers (in years)

X_2 = Sex (1 = if male, 0 = if female)

X_3 = Educational level (number of years spent in school)

X_4 = Farming experience (number of years)

X_5 = Household size (number of persons)

X_6 = Labour (in mandays)

X_7 = Farm size (in hectare)

X_8 = Extension contact (number of visits)

X_9 = Access to credit (in naira)

X_{10} = Membership of associations (1 = 1f a member, 0 = if otherwise)

X_{11} = Farm income (in naira)

X_{12} = Food Security Status (1 if food secure, 0 if food insecure)

e = Stochastic error term.

Factor Analysis

Principal component factor analysis model was employed for analysing the challenges of farmers in soil fertility management in the area:

$$
\begin{aligned}
Y_1 &= a_{11}X_1 + a_{12}X_2 + * * * + a_{1n}X_n \\
Y_2 &= a_{21}X_1 + a_{22}X_2 + * * * + a_{2n}X_n \\
Y_3 &= a_{31}X_1 + a_{32}X_2 + * * * + a_{3n}X_n \\
* &= \qquad\qquad\qquad * \\
* &= \qquad\qquad\qquad * \\
Y_n &= a_{n1}X_1 + a_{n2}X_2 + * * * + a_{nn}X_n
\end{aligned}
$$

***Where*:**

$\mathbf{Y_1, Y_2 \ldots Y_n}$ = observed variables/challenges to arable crop farmers in soil fertility management.

$\mathbf{a_1 - a_n}$ = factor loadings or correlation coefficients.

$\mathbf{X_1, X_2 \ldots X_n}$ = unobserved underlying factors facing arable crop farmers in soil fertility management.

RESULTS AND DISCUSSION.

Food Security Status of the Farmers.

Table 1: Food Security Status of Smallholder Arable Crop Farmers in the Abia State.

Indicators	**Food Security Indexes**	**Frequency**	**Percentage (%)**
THEFPM	= ₦6,458,299.20		
MPCHE	= ₦35,879.44		
2/3 MPCHE	= ₦23,919.63		
Food secure		83	46.1
Food insecure		97	53.9
TOTAL		**180**	**100.0**

Note: THEFPM = Total Households Expenditure on Food per Month;
MPCHE = Mean Per Capita Household Expenditure
Source: Field Survey, 2021.

The result in Table 2 established the nexus between farm households' food security status and soil fertility management. From the result, only 8.3% of the food secured farm households are sole organic manure users while 36.1% of food insecured farm households are organic manure users. On the other hand, 25.6% of the food secured farm households are inorganic manure users while only 7.8% of food insecured farm households use inorganic manure. About 12% of the food secured households combine both organic and inorganic manure while 10.0% of the food insecured farm households practice the combination of organic and inorganic fertilizers for soil fertility management. The results clearly showed that the highest proportion of the food insecured farm households engaged in the use of organic manuring while the highest proportion of the food secured farm households engaged the use of inorganic manuring (fertilizers) for soil fertility management. The rising cost of inorganic fertilizer in Nigerian markets will naturally place the commodity out of the reach of the resource poor farmers and therefore may be responsible for the shift of food insecured farmers towards organic manure use. Alabi, Adams and Abu (2016) affirmed that inorganic fertilizers are becoming more expensive in Nigerian markets, thereby forcing resource poor farmers to consider organic manure use. Olayide *et al.* (2010) noted that inorganic fertilizers is not affordable for an average farmer in Nigeria and that may be responsible low use of inorganic fertilizers by the farmers. Obisesan, Akinlade and Fajimi (2013) in a study found that access to credit and fertilizer price were significant factors influencing the use of inorganic fertilizer among farmers.

Determinants of Food Security Status of the Farmers.

The result of the binary logistic regression analysis in Table 3 showed that the explanatory power of the specified variables as indicated by the pseudo R^2 value of 0.8214 was high and good. This indicates that the estimated independent variables in the logistic regression are responsible for about 82% variation in arable crop farmers' food security status. The overall goodness of fit of the result as reflected by Prob>Chi^2 (0.000) was also good. In terms of consistency with *a priori* expectations on the relationship between the dependent variable (poverty status) and the explanatory variables, the model had behaved well. Out of the eleven explanatory variables specified in the model, seven statistically and significantly influenced poverty status of the farmers. The significant variables include: age, sex, education, household size, farm size, credit access and farm income.

Age of the farmers was significant and negatively related with poverty status at 5%. This indicates that as age of the farmers increase, their food security status reduces. In other words, aged or older farmers are more likely to be food insecured considering their weakness and possible decline in economic activities which may affect their food security status. Haddabi, Ndehfru and Aliyu (2019) noted that older household heads may not have the ability to obtain off-farm jobs and income to improved their food security like the younger household heads. Oluwatayo (2012) in a study identified age of households' heads as a major factor influencing food security status of households. Sex of the farmers was highly significant and positively signed with poverty status at 1% indicating that male farmers tend to be more food secured. Hence, male farmers are more mobile and able to seek other means of likelihood to achieve food security than women. Ndobo (2013) found that the probability of food security decreases if household is headed by a female.

Year of formal education was positive and significantly related with food security at 1%. This suggests that increase in education enhances the likelihood of farm households being food secured. This is expected, as educated farmers are likely to be more productive in farming and other economic activities that will boost their food security status than illiterate ones.

Table 2: Soil Fertility Management and Food Security Nexus of Smallholder Arable Crop Farmers in Abia State.

Indicators	Food Security Indexes	Frequency	Percentage (%)
THEFPM	= ₦6,458,299.20		
MPCHE	= ₦35,879.44		
2/3 MPCHE	= ₦23,919.63		
Organic manure users			
> 2/3 MPCHE (Food secure)		15	8.3
< 2/3 MPCHE (Food insecure)		65	36.1
Inorganic manure users			
> 2/3 MPCHE (Food secure)		46	25.6
< 2/3 MPCHE (Food insecure)		14	7.8
Users of both organic & inorganic			
> 2/3 MPCHE (Food secure)		22	12.2
< 2/3 MPCHE (Food insecure)		18	10.0
TOTAL		**180**	**100**

Note: THEFPM = Total Households Expenditure on Food per Month;
MPCHE = Mean Per Capita Household Expenditure,
Source: Field Survey, 2021.

Table 3: Binary Logistic Regression Estimates of Determinants of Food Security Status of Arable Crop Farmers in Abia State.

Regressors	Coefficients	*Z*-ratios
CONSTANT	0.8213153 (0.0720643)	11.39***
Age of farmers (X_1)	-0.0676606 (0.0292415)	-2.31**
Sex of farmers (X_2)	0.0359089 (0.0099968)	3.59***
Years of education (X_3)	0.1506238 (0.0343821)	4.38***
Farming experience (X_4)	0.002915 (0.0234885)	0.12
Household size (X_5)	-0.0451466 (0.0239725)	-1.88*
Cooperative membership (X_6)	0.0060749 (0.1708392)	0.04
Farm size (X_7)	0.0334686 (0.0087769)	3.81***
Extension visits(X_8)	0.052217 (0.1102829)	0.47
Credit access (X_9)	1.361908 (0.2667186)	5.10***
Labour (mandays) (X_{10})	-0.2683162 (0.4857895)	-0.55
Farm income (X_{11})	1.730436 (0.4623602)	3.74***
LR chi^2	233.31	
Pseudo R^2	0.8219	
Prob> chi^2	0.000	
Observations	180	

Note: Figures in parentheses are standard errors.
*** denotes sig. at 1%; ** denote sig at 5% while * denotes sig. at 10%
Source: Field Survey, 2021.

Opaluwa, Opeyemi, Ajibade and Jonah (2019) in a study identified education as a strong factor improving food security of farming households. The coefficient of household size was also significant but negatively signed with food security status at 10%. This indicates that as member of household increase, the probability of food security decreases as the households now have more members to feed and cater for. Abu and Soom (2016) in a study equally established negative relationship between household size and food security.

The coefficient of farm size was highly significant at 1% and positively signed with food security. This implies that the larger the household farm size, the higher the probability of the household being food secured. Large farm sizes could translate to higher farm outputs and productivity that will enhance food security of the household. The findings of Henri-Ukoha, *et al.*, (2013) and Osuji *et al*. (2017) showed that significant and positive relationship exist between farm size and food security of farming households. Access to credit was highly significant at 1% and positively related to food security status of the farmers. This indicates that as farmers have more access to credit, their probability of being food secured equally increases. This is in line with *a priori* expectation as farmers' access to credit will increase financial resources at their disposal to purchase needed inputs such as improved seeds, fertilizers, labour and agrochemical for improved output. This corroborated the findings of Pappoe (2011) and Osuji *et al*. (2017) that availability of farm credit is crucial factor that enhance food security of farmers' households. The coefficient of farm income was highly significant a 1% and positively signed with poverty status. As farmers' incomes increase, their purchasing power naturally step up and there is likelihood to invest in more income generating activities that will increase their access to food in both quantity and quality. Babatunde *et al*. (2007) reported that farm households' income is the sum of earnings from both off-farm and on farm sources. Abu and Soom (2016) found that income of farm households heads had a positive impact on their households' food security.

Factors Influencing the Choice of Soil Fertility Management Practices of the Farmers.

The determinants of choice of soil fertility management in this study were hypothesized to depend on a number of socio-economic factors. Multinomial logit (MNL) model was used to estimate socioeconomic factors that influenced farmers' choice of soil fertility management option (sole organic manuring, sole inorganic manuring and engagement of both). This was estimated by normalizing one category, which is referred to as the "reference state," or the "base category." In this analysis, the base category is the group 3 that engaged both organic and inorganic manuring against which comparisons are made in each case.

The likelihood ratio statistics as indicated by Prob> chi^2 (χ^2) statistics is highly significant ($p<0.0000$) at 1%. The explanatory power of the factors as reflected by Pseudo R^2 was high 0.7410, indicating that the hypothesized variables in the model are responsible for about 74% variation in the farmers' choice of soil fertility management option. In terms of consistency with *a priori* expectations, the model had behaved well. Identified socioeconomic variables that significantly influenced farmers' choice of soil fertility management include: age, sex (gender), education, household size, farm size, extension visits, credit access, farm income and food security status.

Age of farmers was significant at 5% and positively related to the probability of using organic manuring but was negative and significantly related to inorganic fertilizer use. The result indicates that as farmers grow older, their tendencies to use organic manure increase while their likelihood to engage the use of inorganic fertilizers decreases. The coefficient of sex (gender) of farmers was not significant for organic manure use but significant and positively related to inorganic fertilizer use at 5%. This implies that male farmers are more disposed to the use of inorganic fertilizers than their female counterparts. Beshir, Emana, Kassa and Haji (2012) found that age, farm land size and gender significantly influence adoption of inorganic fertilizer. Years of formal education was highly significant at 1% and inversely (negatively) related to organic manure use but positively and significantly related to inorganic fertilizer use at 1%. It is expected that educated farmers are likely to be more knowledgeable about the composition and application of inorganic fertilizers. Obisesan, Akinlade and Fajimi (2013) reported that farmers with higher level of education are more likely to prefer inorganic fertilizer to boost crop production.

Household size was significant at 5% but inversely related to organic manure use. It was highly significant (1%) and positively signed with inorganic fertilizer use for soil fertility management. The implication of this result is that, as household size increases, the tendencies to shift towards organic manure use decreases while the likelihood to use inorganic fertilizer increases. The coefficient of farm size was highly significantly at 1% and negatively related to organic manure use but positively and significantly related to inorganic fertilizer use at 1%. Application of organic manure for large expanse of land will definitely be labour intensive and hence can greatly be discouraged as farm size increases. Milkessa (2020) in a study found that farm size and membership to farmer groups influenced the use and intensity of adoption inorganic fertilizer use.

Extension visits was significantly at 5% and negatively signed with organic manure use but positively and significantly related to inorganic fertilizer use at 5%. This indicates that the more the number of extension visits to farmers, the less their likelihood to use organic manure and the more their tendencies to use inorganic fertilizers. Beshir *et al.* (2012) found that extension and credit services enhance the adoption of inorganic fertilizer. The coefficients of access to credit and farm income were both highly significantly at 1% and negatively related to organic manure use but positive and significantly related to inorganic fertilizer use at 1%. Obisesan, Akinlade and Fajimi (2013) observed that credit access increases the level of inorganic fertilizer adoption and use. Farmers' increased credit and farm income will enhance their purchasing to buy required farm inputs such as inorganic fertilizers even at increased price. Similarly, Andre and Mulat (1996) in a study found that access to banking, extension services and education play significant role in inorganic fertilizer adoption.

Food security status of the farmers was highly significantly at 1% and inversely (negatively) influences organic manure use but positive and significantly related to inorganic fertilizer use at 1%. This suggests that food secure farmers are less likely to engage the use of organic manure but likely to tend towards the use of inorganic fertilizers due to their financial stability. Alabi, Adams and Abu (2016) affirmed that inorganic fertilizers are more expensive and out of the reach of average farmer. This explains the positive and significant relationship between farmers' food security status and the use of inorganic fertilizer.

Challenges of Farmers in Soil Management Practices.

The table 5 below presents the varimax-rotated principal component factor analysis of challenges of farmers in soil fertility management in the study area. From the result presented in the Table, three (3) factors were extracted based on the responses of the respondents (crop farmers). The naming of each factor is based on the set of variables or characteristics the factor is composed of (Kessler, 2006). Hence, this study group the variables into three major components factors as; Factor 1 (instructional factor), factor 2 (financial factor), and factor 3 (social factor).

Under factor 1 (Instructional factors), the specific challenging variables of farmers in soil fertility management include; lack of access to extension visits (0.538), poor access to soil fertility management information (0.497), lack of knowledge about some fertility management practices (0.494), erosion challenges in the area causing leaching (0.422) and weak social network among farmers such as cooperatives (0.466). Poor access to soil fertility management information (0.497) was among the challenges reported by Amusa and Enete and Okon (2015) to have loaded under the input factor as one of the specific challenging variables against farmers' practice of agronomic soil conservation. The challenges that fitted under factor 2 (Financial Factor) include, Non-availability of fertilizers in the market (0.438), High cost of inorganic fertilizers (0.514), Lack of finance/capital for purchasing fertilizers (-0.513), Inadequate farm labour in the area (0.416), porous nature of the soil in the area (0.407), poor access to credit sources (-0.407), Scarcity and competition on organic waste for livestock feeding (0.453).

Similarly, Ebe, Obike and Nnamani (2019) posited that major constraints hindering the farmers from practicing the soil management practices were inadequate finance, high cost of labour, cost of soil management practices, high cost/unavailability of some farm inputs and poor knowledge of some of the oil management practices. Supporting, the report of FAO (2017) shows that inadequate finance for acquiring farm inputs by farmers in developing countries further worsen the present hunger and poverty rise in the area. Enete (2003) reported that most financial institutions in developing countries do not usually lend to agriculture, not only because the farmers lack the basic collateral as a result of poverty, but also because the farming is considered very risky

The challenges that fall under factor 3 (social factors) are; tedious nature of soil fertility management practices/activities (0.421), unwillingness of some farmers to manage soil fertility (0.489), poor knowledge in organic fertilizer formation (0.498), low level of experience in fertilizer formation (0.532), poor access to and control over farm land (0.467), land tenure system practiced in the area (0.423), Poor attitudes of farmers towards fertility management (0.469). This is in line with the findings of World Bank (2018) showed that soil conservation efforts by most farmers in Nigeria is still very low resulting in the recorded high rate of soil degradation.

CONCLUSION.

The study examined soil fertility management of farm households and food security nexus in Abia State. From the data collected and analysed, the study found that majority (53.9%) of the farm households are food insecured while 46.1% are food secured. Highest proportion of the food insecured farm households engaged the use of organic manuring while the highest proportion of the food secured farm households engaged the use of inorganic manuring (fertilizers) for soil fertility management. Age, sex (gender), education, household size, farm size, credit access and farm income significantly influenced poverty status of the farmers. Also, age, sex, education, household size, farm size, extension visits, credit access, farm income and food security status significantly influenced farmers' choice of soil fertility management. The challenges of farmers in soil management practices are categorized into three factors which are instructional, financial and social factors. Based on the findings, this study recommended that:

i. Government and its relevant agencies at all levels should ensure increase knowledge and technical know-how of farmers in effective adoption and use of fertilizers for improved yield and productivity of crop farmers to boost food security status of farming households in the state and country in general.
ii. There should be increased provision of credit facilities to farm households in order to increase their purchasing power of relevant farm inputs such as fertilizers and agrochemical to boost agricultural production and consequently reduce food insecurity challenge.
iii. Government should also help farmers in mobilizing savings and make crucial inputs such as fertilizer readily available to the farmers at subsidized price to serve as incentive in improved food production that will guarantee food self-sufficiency and security.

Table 4: Multinomial Logit (MNL) Regression Estimates of Determinants of the Choice of Soil Fertility Management Practices by Arable Crop Farmers in Abia State.

	Organic Manuring		**Inorganic Manuring**	
Regressors	**Coefficients**	***Z*-ratios**	**Coefficients**	***Z*-ratios**
CONSTANT	-6.448059 (0.5723271)	-11.27***	1.108631 (0.0922676)	12.02***
Age of farmers (X_1)	0.0480909 (0.0231728)	2.08**	-0.0577226 (0.0246656)	-2.34**
Sex of farmers (X_2)	0.0373173 (0.8023891)	0.05	1.620107 (0.7149271)	2.27**
Years of education (X_3)	-0.0855255 (0.0248760)	-3.44***	0.3449075 (0.081032)	4.26***
Farming experience (X_4)	-0.0061664 (0.0385601)	-0.16	-0.0066218 (0.0304230)	-0.22
Household size (X_5)	-0.214566 (0.0956724)	-2.24**	0.0949620 (0.0246474)	3.85***
Labour (mandays) (X_6)	0.2950089 (0.3155776)	0.93	-0.2217512 (0.2068538)	-1.07
Farm size (X_7)	-0.2679274 (0.0611384)	-4.38***	0.3561431 (0.0773022)	4.60***
Extension visits(X_8)	-0.5295924 (0.2438209)	-2.17**	0.3322975 (0.1352458)	2.46**
Credit access (X_9)	-1.727612 (0.4988526)	-3.46***	2.084170 (0.6556445)	3.17***
Cooperative membership (X_{10})	0.5111507 (0.7177884)	0.71	0.0465219 (0.6551505)	0.07
Farm income (X_{11})	-1.313149 (0.3176135)	- 4.13***	2.865323 (0.7375423)	3.88***
Food security status (X_{12})	-0.0864321 (0.0264950)	-3.26***	0.0307434 (0.0065430)	4.70***
LR chi^2	210.69			
Prob> chi^2	0.000			
Pseudo R^2	0.7410			
Observations	180			

Note: Group (3) Choice of combining both organic and inorganic manuring is the Base Outcome
Figures in parentheses are standard errors. *** denotes sig. at 1%; ** denote sig at 5% while * denotes sig. at 10%
Source: Field Survey, 2021.

Table 5: Challenges of farmers in soil fertility management in Abia State.

SN	Challenges of farmers in soil fertility management:	Principal Components Factors: Instructional Factor	Financial Factor	Social Factor
1	High level of illiteracy among farmers	0.381	-0.220	**0.487**
2	Lack of access to extension visits	**0.538**	-0.105	0.361
3	Poor access to soil fertility management information	**0.497**	-0.063	0.029
4	Lack of enough knowledge of fertility management	**0.494**	-0.261	-0.167
5	Tedious nature of soil fertility management practices	0.196	0.111	**0.421**
6	Non-availability of fertilizers in the market	0.215	**0.438**	0.229
7	High cost of inorganic fertilizers	0.212	**0.514**	0.233
8	Unwillingness of some farmers to manage soil fertility	0.355	0.227	0.**489**
9	Poor knowledge in organic fertilizer formation	0.137	0.365	**0.498**
10	Lack of finance/capital for purchasing fertilizers	0.189	**-0.513**	0.025
11	Low level of experience in fertilizer application	-0.225	0.093	**0.532**
12	Erosion challenges in the area causing leaching	**0.422**	-0.092	-0.096
13	Inadequate farm labour in the area	-0.154	**0.416**	-0.286
14	Inadequate farm land resulting in continuous cropping	0.299	**-0.515**	**0.411**
15	Poor access to and control over farm land	0.011	-0.230	**0.467**
16	Land tenure system practiced in the area	0.270	-0.276	**0.423**
17	Porous nature of the soil in the area	-0.288	**0.407**	0.111
18	Rough topography of farm lands in the area	0.257	-0.064	-0.344
19	Poor attitudes of farmers towards fertility management	-0.167	0.193	**0.469**
20	Increased pressure on farmlands for other uses	**0.485**	**0.444**	-0.084
21	Poor access to credit sources	0.309	**-0.407**	0.355
22	Offensive odour of organic fertilizers/manure	0.385	0.044	0.089
23	Aversion of risks about profitability of fertilizer inputs	0.262	-0.196	-0.086
24	Weak social network among farmers e.g cooperatives	**0.466**	0.177	-0.323
25	Competition on organic waste for livestock feeding	0.059	**0.453**	-0.232

Note: Factor loading of 0.40 was used.
Variables with factor loadings of less than 0.40 were not used.
**Variables 14 and 20 were discarded for loading in more than one factor.
Source: Field Survey, 2021.

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Journal of Applied Agricultural Research 2022, 10(2):174-184
ISSN 2006-750X.

SPATIAL ANALYSIS OF PLANT NUTRIENT CONCENTRATIONS IN PARTS OF RIVERS NIGER AND KADUNA CATCHMENT, NORTH CENTRAL, NIGERIA

[1]IDRIS, A. J., [4] Yahaya, T.I., [1]Abubakar, A. S., [2]Jigam, A. A., [3]Musa M.
[1]Department of Geography, Federal University of Technology Minna, Niger State, Nigeria.
[2]Department of Biochemistry, Federal University of Technology Minna, Niger State, Nigeria.
[3]Agricultural Research Council of Nigeria
[4]National Environmental Standards and Regulations Enforcement Agency
Author's Contact: aliyuidrisjaagi@yahoo.com, +2348034576625

ABSTRACT

Spatial concentrations of nitrate (NO_3), nitrite (NO_2) and phosphate (PO_4) attributable to synthetic fertilizers in parts of Rivers Niger and Kaduna catchment, North Central Nigeria was investigated.Rivers Niger and Kaduna catchments are arable land where people practice farming with intensive use of agrochemicals. This practice can lead to degradation of water quality and disproportionate adverse effects on the socioeconomic well-being of communities. Given that the comprehensive distribution of these nutrients within the study area is of great interest, there is a significant opportunity to consider a GIS-assisted spatial coverage study. Thirty-two samples of water and sediments were taken during the rainy and dry seasons to determine plant nutrients. The samples were analysed using a combination of laboratory methods, descriptive statistics and geographical information system (GIS). The study established that the spatial distribution of plant mineral concentrations in the water and sediment samples were within the ranges of 0.02 to 3.147 ppm for $NO_{3,}$ 0.02 to 1.16 ppm for NO_2 and 0.228 to 5.771 ppm for $PO_{4,}$ in the rainy and dry seasons periods, respectively. The study found that the presence of plant nutrients in water and sediment in the study area was well in excess of national regulatory limits and should be of great concern as the communities around the study area largely depend on the rivers for their domestic and agricultural needs.The study therefore recommends that there should be a continuous sensitization of all stakeholders, particularly farmers in the study area, to adopt sustainable farming practices such as bio-based and organic agriculture so as to guarantee cleaner and healthier environment for all.

Keywords: Agrochemicals, Environment, Nutrients, Rivers, Sediments, Water Quality.

INTRODUCTION.

Plant nutrients are intended to facilitate plant growth and productivity. Although they are primarily used to improve crops and production, they still have negative effects on water quality (Gogoi*et al.,* 2018). Plant nutrients move into the surrounding water bodies, thereby having a widespread effect on the physical, chemical, and biological processes water (Bassi *et al.,* 2016;Joko *et al.,* 2017). In addition to degrading the physical, chemical, and biological status of water, plant nutrients can have significant social and economic costs on communities through polluting drinking water, degrading fisheries, and potentially increasing food risks (Bashir*et al.*, 2020; Borowski and Patuk, 2021).

Excess nitrogen and phosphates in rivers, lakes, reservoirs, and ponds can lead to massive overgrowth of algae and deplete the oxygen levels that fish, shellfish and other aquatic organisms need for survival (Abila, 2021). High levels of nitrogen in drinking water can pose particular risk to infants and children. In Nigeria, plant nutrients are widely used to enhance crop production and productivity (Itelima*et al.,* 2018). Farming is a major occupation in the study area which the communities, mostly depend on for a livelihood (Ogwueleka, 2014).

Rivers Niger and Kaduna catchments are arable land where people practice farming activities involving intense use of plant nutrients (Ogwueleka, 2014). This practice can eventually degrade the quality of water and disproportionate effect on the socioeconomic wellbeing of the communities in the area.The objective of this study was to determine the spatial concentrations of plant nutrients in the study area.

Spatial analyses are any types of data analyses that extract and/or produce spatial information based on operations on different layers of data (Clarke*et al.*, 2019). GIS provides the organizational framework which allows numerical and statistical analyses to be easily applied on real-world data. The simple, but essential and fundamental ability to overlay a basically unlimited number of GIS layers together with hundreds of tools (GIS functions performing computations on spatial data) used for solving issues of spatial analysis and spatial statistics is what makes GIS so different from using hardcopy maps (Clarke *et al.*, 2019).

Righini*et al.*2014 used spatial analysis functions embedded in GIS to combine different layers of emission sources of selected pollutants to assess spatial variability of pollution as one of the key parameters for monitoring station location representativeness. In this study, other GIS layers such as road network, settlement and land cover were employed to explain the acquired values of emissions spatial variability. In study of Hafner*et al.*2005, ArcGIS was used for calculation of population within the radius of 25 km of sample sites to serve as an input to a regression analysis. Sharma *et al.* 2015 used spatial analysis for delineating watersheds and calculating the percentage of glacier-covered area within the watersheds to better estimate the melt water contribution to the flow of the Ganges River.

These are only a few examples of studies where spatial analysis with GIS demonstrates the breadth of its utility in the field of environmental sciences. While spatial analysis studies in respect of environmental contaminants have become a norm in many developed nations, developing countries which include Nigeria have little consideration for this interesting research approach. It is in view of this, that spatial analysis was adopted for this study to overlayed the value of plant nutrient concentrations acquired through laboratory processes against each sample points.

Studies on pollution of aquatic environment caused by various chemicals have been carried out in several areas in North Central Nigeria and reported by various researchers. A study in Tunga-Kawo area irrigation scheme revealed contamination of water by plant nutrients (Jimoh*et al.,* 2003). A study on identification of pollution sources and water quality in Kaduna River in Niger State also indicated the influence of anthropogenic effects which include plant nutrients on the river (Ogwueleka, 2014). Ojutiku *et al*. 2016 also worked on phytoplankton distribution and physico-chemical characteristic of Lapai-Agaie Dam in Minna, Niger State, Nigeria. Sidi*et al.* 2016 worked on assessment of the chemical quality of water from shallow alluvial aquifers in and around Badeggi, Central Bida Basin, Nigeria. All these studies were limited in spatial coverage but suggested, however, that continued monitoring is needed as a means of protecting the waters in the area from potential contamination from agrochemical use.

Also, the communities in the study area relies on this river for their livelihood (Ogwueleka, 2014) and lack of comprehensive research information about the concentrations of plant nutrients in the rivers informed the need for immediate investigation in the area. As comprehensive distribution of water quality parameters in the study area is of great interest, there exists an excellent opportunity to consider a study with spatial coverage. Finding of this study provides background information for researchers and relevant stakeholders to improve on future studies and overall environmental performance.

MATERIALS AND METHODS.

Study Area Description.

The study area for the investigation is communities in parts of Rivers Niger and Kaduna Catchment areas, Niger State lies between longitude 3˚30'N and 7˚20'E and latitude 8˚22'N and 11˚30'N; located at the Guinea Savanah vegetation zone in the north central part of Nigeria (Figure 1) (Ogwueleka, 2014; Ahmed. 2001). The study area was divided into zones according to agroecological factors. Along River Niger, the Upper zone is from Rabba village in Mokwa Local Government Area (LGA), Middle zone is at Muregi and the Lower zone is after Muregi in Mokwa LGA down to Baro village in Agaie LGA. Study area along River Kaduna was divided into two zones. Upper zone is from Wuya village in Lavun LGA and the lower zone from half way down to Muregi. The major economic activities of the communities living around the area are agriculture and fishing. These are the leading sector in terms of employment, income earning and overall contribution to the socio-economic wellbeing of the people. The Kaduna and Niger River flood plains are many kilometers wide at the downstream of Nupe basement boundary, two major streams namely Yanko ikko and Dumi Ebigi (Ahmed. 2001). All these streams empty their waters into Niger River (Ahmed. 2001).

Sampling Point’s Identification.

Water and sediment samples were collected from eight selected sampling points in the study area (Figure 2). The eight sampling points were based on altitude and information from the key stakeholders (District officers, extension agents and farmers) in the area. Samples of water and sediments were collected, prepared and analysed using standard procedures described by American Public Health Association/American Water Work Association/Water Environmental Federation (APHA/AWWA/WPCF), 2005. Each sampling point was geo-referenced using Global Position System (GPS) device in longitude and latitude in degree, minutes and seconds (DMS) format.

A total of thirty-two (32) samples of water and sediment were collected during rainy and dry season for plant nutrients analysis. Water samples were collected using grab technique, while sediment samples were collected at the river banks and at 0–20 cm depths in each sampling *site, simply* because sediments at this depth are anticipated to be more contaminated and having probable exchanges with *a column* of water.

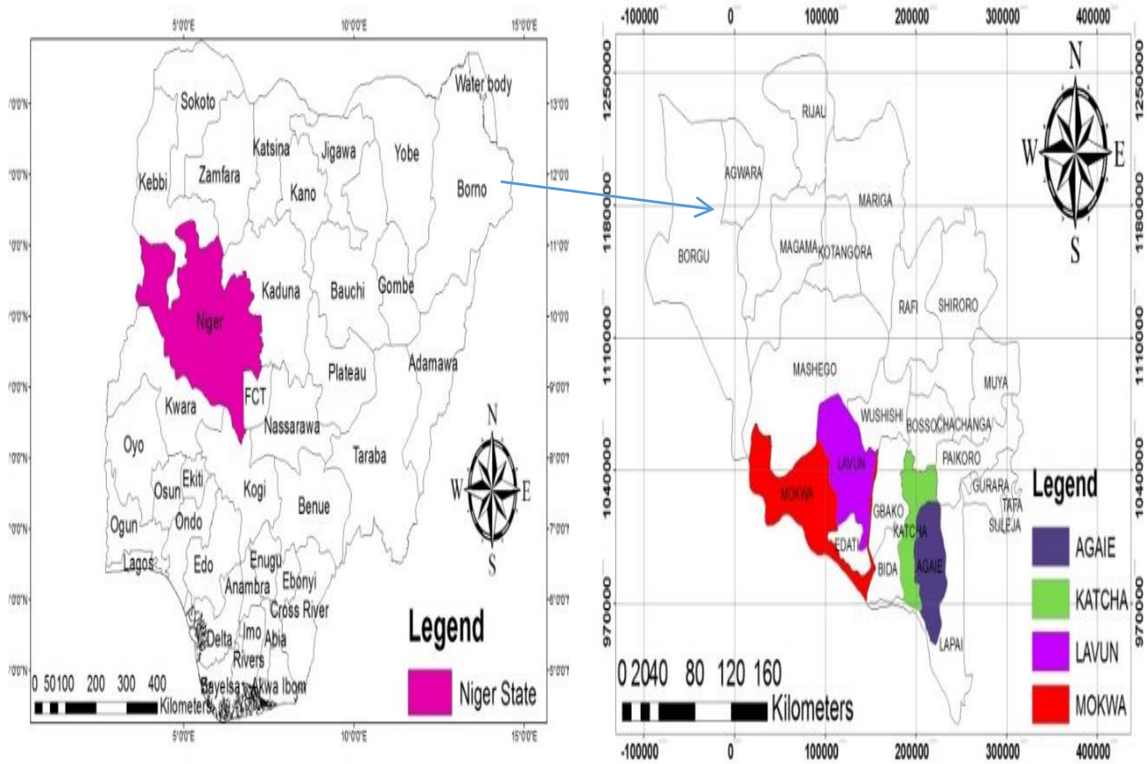


Figure 1: Map of the study area showing parts of Rivers Niger and Kaduna Catchment, North Central, Nigeria.

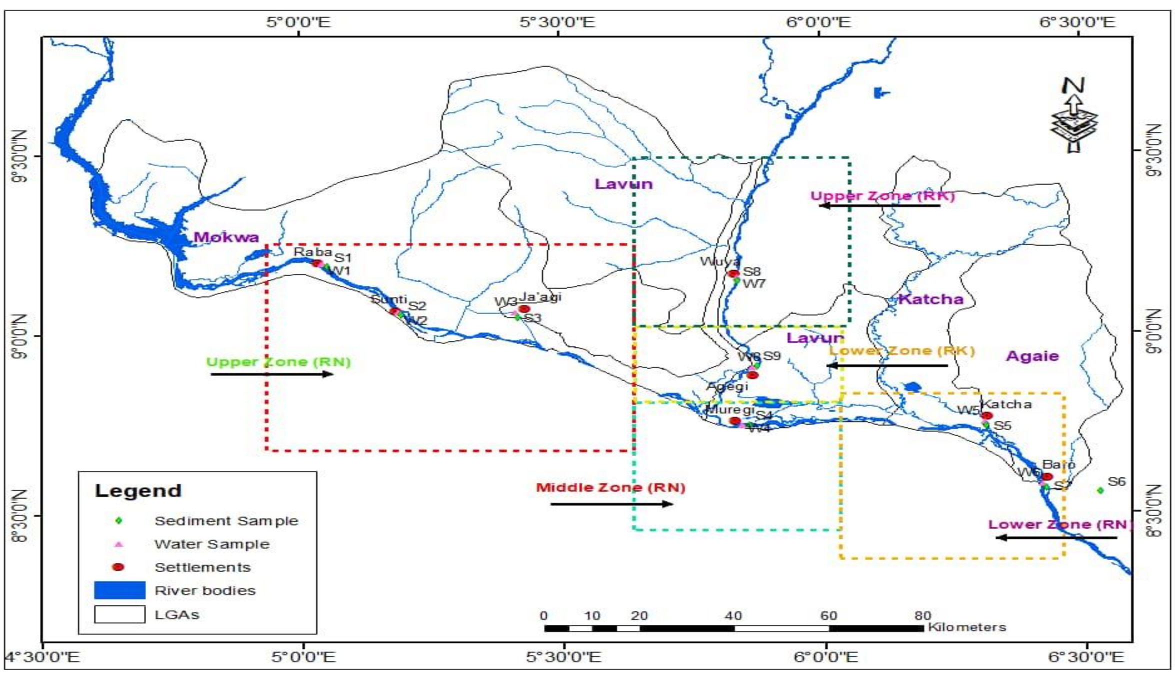


Figure 2: Map of the study area showing study zones and the sample points Water and Sediments Sampling Points.

The sediment samples were collected using a shovel, then wrapped safely in aluminium foil sheets, clearly labelled, and sealed in closed air plastic bags. Both water and sediment samples were preserved in ice flasks and transported immediately to the reference laboratory (Dr. Olukoya Research Laboratory of University of Lagos, Nigeria). Upon arrival, the samples were extracted via liquid-liquid and solvent extraction methods, respectively, and subsequently analysed following APHA/AWWA/WPCF, 2005 for three (3) parameters namely nitrate, nitrite and phosphate.

Nitrate nitrogen (NO_3^-–N) was determined by the cadmium reduction process where NO_3^- is quantitatively reduced to nitrite NO_2^- in the presence of cadmium using Cd copper sulphate ($CuSO_4$) granules which are commercially available to form Cu layers. The resulting NO_2^- is then determined by diazotization with sulfanylamide and combined with N-(1-naphthyl) ethylenediamine to form a very colourful azo dye, which was measured by colorimetry process. Adjustments were made for originally like NO_2^-, which were initially analysed without a reduction step. Nitrite nitrogen (NO_2^-–N) was determined by the formation of azo red-violet dyes which were obtained at pH 2.0 to 2.5 by combining diazotized sulfanylic acid with N-(1-naphthyl) ethylenedinedehydrochloride.Phosphate (PO_4^{3-}–P) was measured using the methods of ascorbic acid, ammonium molybdate and potassium antimony tartrate which reacts in acidic media with orthophosphate to form heteropoly acid - phosphomolibdic acid which is reduced to strong coloured molybdic acid. Colour intensity was measured spectrophotometrically using an infrared photo tube at 880 nm. The quality of the analysed data obtained was carefully ensured by blind and double analysis in accordance with standard work instructions from the reference analysis laboratory.

Spatial Data Analysis

The GPS location data earlier captured from all sample points and the values for the plant nutrients parameters obtained from the laboratory analytical process were transferred into Excel package of the Microsoft Office software, sorted, and saved in Tab delimited file format that is compatible in ArcGIS environment.

As described in Schwanghart and Scherler, (2014), Arc Map was lunched and the prepared dataset was imported into the table of content in the GIS interface using the tab delimited file format, Universal Transverse Mercator (UTM) Projection system was chosen and set to Zone 32N. Therefore, interpolation was done using the spatial analysis extension toolbox of the ArcGIS (version 10.5), the Inverse Distance Weighted (IDW) technique was chosen because it uses the measured values surrounding the prediction location to predict a value for any unsampled location, based on the assumption that things that are close to one another are more alike than those that are further apart (Munyati and Sinthumule, 2021).

Finally, at the tab of IDW interface, the sample points were selected separately and imported; the output was saved and then submitted for processing. The result maps were then exported in JPEG format after adding neat-line, grid, north arrow, scale and legend for presentation and discussion.

Statistics Analysis

Subsequently, concentrations of plant nutrients values acquired from the laboratory were further processed in Microsoft Excel by way of descriptive analysis, namely percentage and represented in charts for proper demonstration of the percentage occurrence of plant nutrients in water and sediment samples of rainy and dry seasons across the sample points.

RESULTS.

Spatial Distribution of Plant Nutrients in Water Samples during Rainy Season.

As revealed in Figure 3a, b and c, the value of nitrate ranges between 1.01ppm and1.5ppm, nitrite ranges between 0.03ppm and 0.13ppm and value of phosphate ranges between 0.71ppm and 28ppm across the study area during the rainy season.

Spatial Distribution of Plant Nutrients in Water Samples during Dry Season.

As revealed in Figure 4, the value of nitrate ranges between 0.26 ppm and 2.63 ppm, nitrite ranges between 0.02 ppm and 0.56 ppm and value of phosphate ranges between 0.23 ppm and 4.58 ppm across the study area during rainy season.

Spatial Distribution of Plant Nutrients in Sediment Samples during Rainy Season.

As revealed in Figure 5a, b and c, the value of nitrate ranges between 1.09 ppm and 2.4 ppm, nitrite ranges between 0.15 ppm and 0.95 ppm and value of phosphate ranges between 0.45 ppm and 1.53 ppm across the study area during rainy season.

Spatial Distribution of Plant Nutrients in Sediment Samples during Dry Season.

As revealed in Figure 6a, b and c, the value of nitrate ranges between 1.9 ppm and 3.15 ppm, nitrite ranges between 0.07 ppm and 0.16 ppm and value of phosphate ranges between 1.27 ppm and 5.77 ppm across the study area during rainy season.

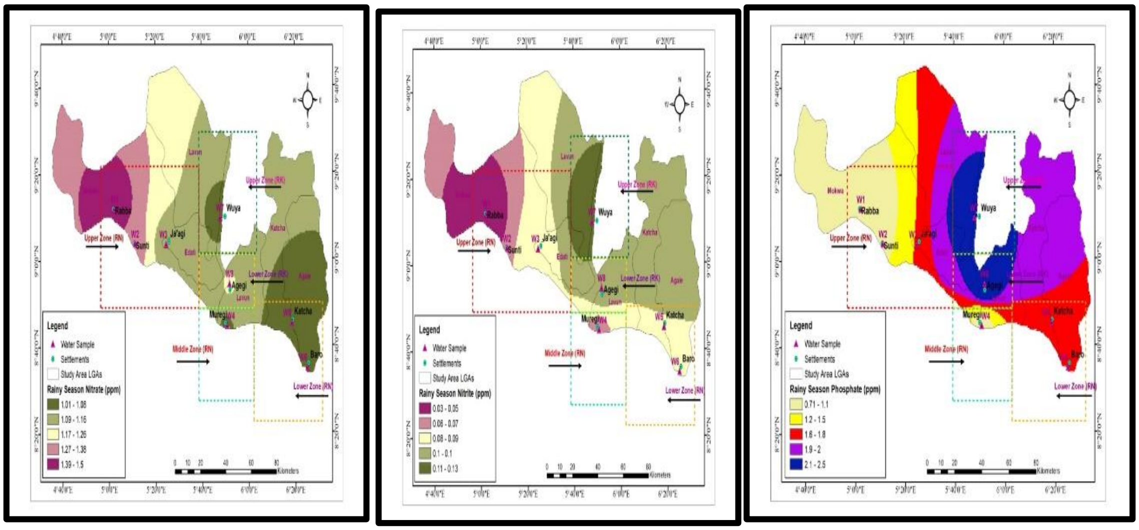
Percentage Occurrence of Plant Nutrients Detected in Water Samples during Rainy and Dry Across the Sample Points.

As indicated in Figure 7, 87% of the surface water sample points in the study area were contaminated by nitrate (NO_3^-) during rainy and dry season. The finding also indicated that 62.5% of the surface water sample points in the area were contaminated by nitrite (NO_2^-) during rainy season, the concentration increased to 100% in dry season covering the whole sample points. Finding further shows that 50% surface water sample points in the area were contaminated with phosphate (PO_4^{-3}) during rainy season, which increased to 100% in dry season covering the whole sample points.

Percentage Occurrence of Plant Nutrients Detected in Sediment Samples during Rainy and Dry Across the Sample Points.

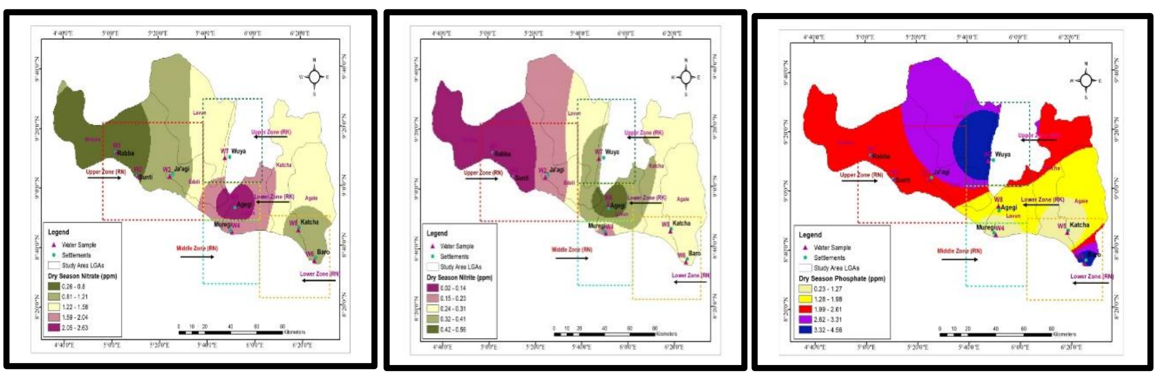
As indicated in Figure 8, 87% of the sediment sample points were contaminated with nitrate (NO_3^-) during rainy season, which increases to 100% of all the sample points during dry season in the study area. The finding also shows that 100% of the sample points in both rainy and dry seasons were contaminated by nitrite (NO_2^-). Finding further shows that 75% of the sample points were contaminated with phosphate (PO_4^{-3}) during rainy season which increases to 100% in dry season covering the whole sample points.

As indicated in Figures 3-8, the finding shows that the nitrate concentrations were spatially distributed across the zones. The concentrations were higher in the water samples during dry season as against low concentrations during rainy season. Also, in sediment samples, the concentration of nitrate was higher in dry season than the corresponding rainy season. The values of nitrate in water and sediment samples in all locations were within regulatory limits which is 9.0 ppm (National Environmental Standards and Regulations Enforcement Agency (NESREA), 2010).



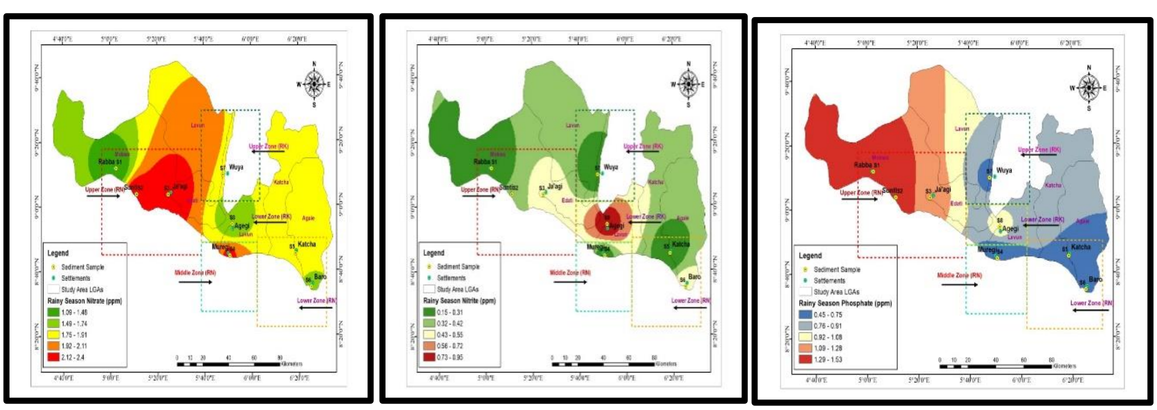
(a) Nitrate (b) Nitrite (c) Phosphate

Figure 3(a-c): Interpolated Distance Weighted Maps of Nitrate, Nitrite and Phosphate of Water Samples during Rainy Season.



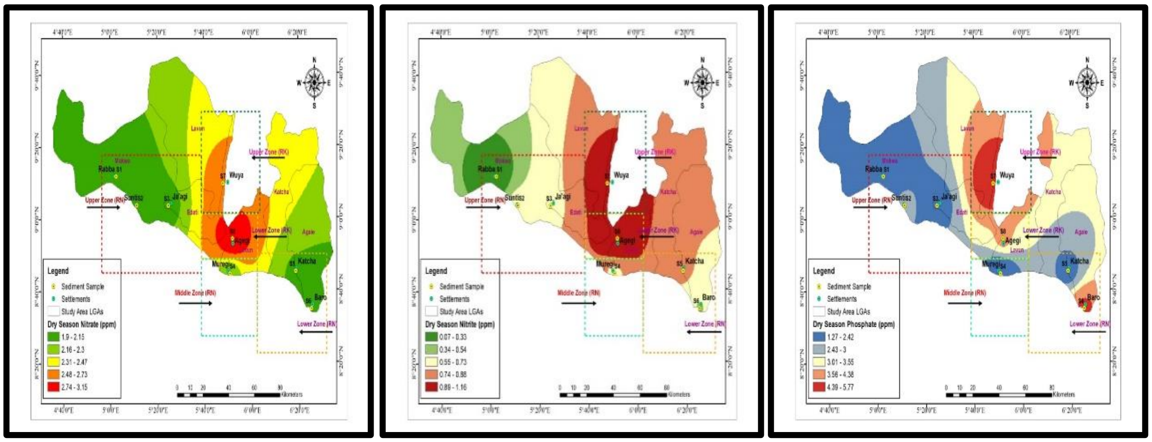
(a) Nitrate (b) Nitrite (c) Phosphate

Figure 4(a-c): Interpolated Distance Weighted Maps of Nitrate, Nitrite and Phosphate of Water Samples during Dry Season.



(a) Nitrate (b) Nitrite (c) Phosphate

Figure 5(a-c): Interpolated Distance Weighted Maps of Nitrate, Nitrite and Phosphate of Sediment Samples during Rainy Season.



(a) Nitrate (b) Nitrite (c) Phosphate

Figure 6 (a-c): Interpolated Distance Weighted Maps of Nitrate, Nitrite and Phosphate of Sediment Samples during Dry Season.

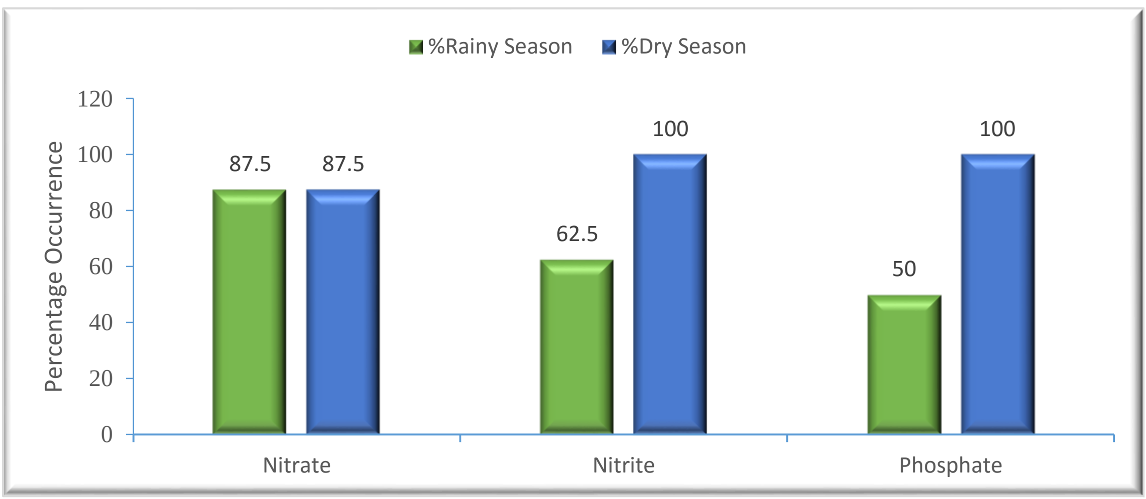


Figure 7: Percentage Occurrence of Plant Minerals Detected in Water Samples across the Sample Points during Rainy and Dry season

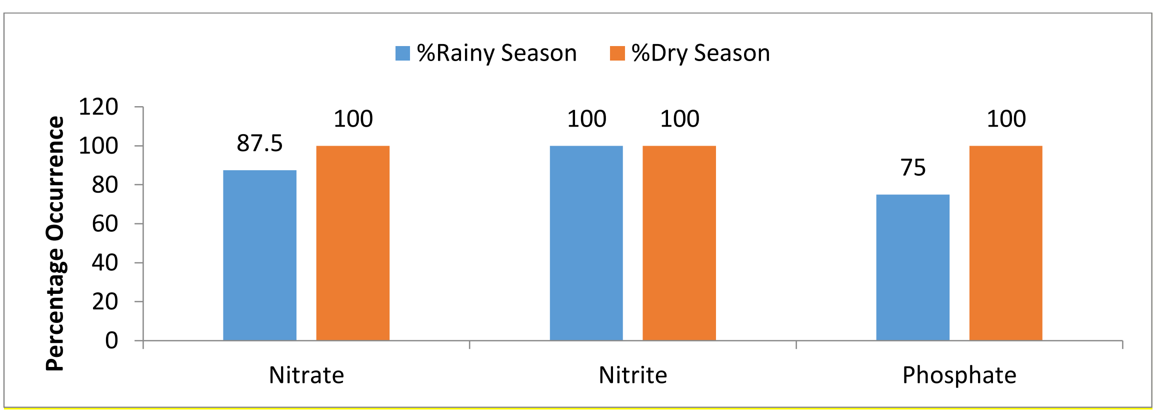


Figure 8: Percentage Occurrence of Plant Nutrients Detected in Sediment Samples across the Sample Points during Rainy and Dry season

DISCUSSION.

The nitrite concentrations were higher in water and sediment samples in dry season than that of rainy season. The values of nitrite which were spatially distributed across the study zones were largely above the national regulatory limits which are 0.05 ppm (NESREA, 2010). Also, phosphate concentrations were spatially distributed across the study zones and confirmed to be largely higher in dry season than the corresponding rainy season. Natural background of phosphate is normally at the range of 0.0005 to 0.002 mg/l. Any value above the range is an indication of anthropogenic influx of chemical use. The values of phosphate were largely above Nigeria regulatory limit which is 3.5 ppm (NESREA, 2010). The presence of nitrite and phosphate in water above regulatory limits is an indication of polluted water in the study area during dry season (NESREA, 2010).

The higher concentrations of these plant nutrients (nitrate, nitrite and phosphate)in dry season against that of the rainy season may be due to the fact that concentrations of nutrients aremostly higher in dry season due to absence of precipitation and low dilution factors (Adeyinka and Olayinka, 2019). Similar situations have been reported by similar studies in developing countries including Nigeria (Adeyinka and Olayinka, 2019; Magami and Sani, 2019; *Iliya et al.*, 2019; Onyenechere*et al.*, 2021).

The study establishes the spatial distribution of plant nutrients namely nitrate, nitrite and phosphate across the study zones during rainy and dry season. These nutrient contaminants are attributable to intense fertilizers use by farmers in the study area. The presence of these chemical compounds in waters of the study area can lead to serious socioeconomic disruptions. It is therefore recommended that farmers should be educated to change farming practices and adopt sustainable fertilizers usage. It is further recommended that effective and laudable environmental research approach like GIS techniques be encouraged among researchers. This will guarantee cleaner and healthier environment for all.

ACKNOWLEDGEMENTS.

The authors would like to thank and appreciate the support accorded to this work by Dr.BasheeruKazeem Adebayo of the Dr Olukoya Research Laboratory, University of Lagos, Nigeria, for analysing the study's environmental samples in a reputable laboratory.

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Journal of Applied Agricultural Research 2022, 10(2):185-192
ISSN 2006-750X.

STUDIES ON THE LIFE CYCLE OF *Empoasca dolichi* PAOLI (1930) ON COTTON IN SAMARU, ZARIA, NIGERIA

*Aliyu, M. K[1]., Onu, I.[2], Mani, U[3]. and Mbah, C. E.[4]
[1]Agricultural Research Council of Nigeria, Mabushi, Abuja
[2]Department of Crop Protection, Faculty of Agriculture, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria
[3]Division of Agricultural Sciences, Ahmadu Bello University, Zaria
[4]Department of Zoology, Faculty of Life Sciences, Ahmadu Bello University, Zaria
Authur's Contact: aliyumuhammad75@gmail.com, +2347066494121.

ABSTRACT.

A laboratory experiment was carried out to assess the life cycle of *Empoaca dolichi* on cotton. The life cycle of *E. dolichi* was studied on cotton variety SAMCOT-9, and the result revealed that there were five nymphal instars and adult which complete their developmental stages in 4-21 days.The average length and breadth of first, second, third, fourth and fifth instar were 0.71 ± 0.05 mm and 0.21 ± 0.03 mm; 1.10 ± 0.09 mm and 0.34 ± 0.05 mm; 1.34 ± 0.07 mm and 0.52 ± 0.03 mm; 1.57 ± 0.08 mm and 0.63 ± 0.03 mm; 2.07 ± 0.04 mm and 0.74 ± 0.05 mm, respectively. The average length and breadth of adult male and female were 2.48 ± 0.12 mm and 0.57 ± 0.02 mm; 2.62 ± 0.16 mm and 0.65 ± 0.007 mm, respectively. The findings can be used to target the most vulnerable developmental stages for maximum efficacy of insecticides.

Keywords: Cotton, leafhopper, *Empoasca dolichi*, life cycle.

INTRODUCTION.

Cotton leafhopper (*Empoasca dolichi)* (Homoptera: Cicadellidae) is a major agronomic crops, vegetables and ornamental plants pest. Among the sucking insect pests, it is the most destructive (Prithiva *et al*., 2019). Both nymphs and adults suck the plant sap, releasing a salivary toxin that inhibits photosynthesis in proportion to the amount of food consumed. Before drying and shedding, the affected leaves curl downwards; turn yellowish, then brownish (Patel and Radadia, 2018). If not managed properly, the effect of leafhopper feeding on cotton can reduce average cotton yield by up to 30%, even Bt cotton hybrid recorded yield losses of up to 48.89% (Renuka, 2013), Bt-cotton adoption has changed not just the cultivation profile, but also the pest scenario. Changes in insect pest complex were visible when the micro-climate changed. Sprays applied for bollworm control in the non-Bt era were able to keep sucking pest population in check (Nagrare *et al*., 2012). While the bollworm's pest status has declined, the sap sucking insect has arisen as a severe pest (Micheal *et al*., 2019). Leafhopper has been selected for more than one mechanism of resistance, they have developed resistance to various frequently used insecticides like Imidacloprid, Thiomethoxam, Acephate and

Monocrotophos up to 5040, 2500, 110 and 54 times respectively in some regions of India, according to studies done by Central Institute for Cotton Research (CICR) in 2010.

Pest management practices are primarily based on the insect's life cycle parameters in order to target susceptible stages before they reach the economic threshold levels. There hasn't been a detailed study on the life cycle parameter of leafhoppers on SAMCOT-9 cotton variety, especially as cropping systems change. Since abiotic factors such as fluctuating temperature and humidity, as well as food condition, can influence developmental threshold, the developmental threshold of leafhoppers differs between laboratory and field conditions. The integrated management of *E. dolichi* requires a thorough understanding of the pest's life cycle. Early detection and control of the leafhopper population are essential for successful pest management. Leafhopper populations can readily reach high levels and inflict severe damage to cotton due to high survival rates, rapid development, reproductive capabilities, and a lack of adequate control. It is critical to analyze population variations through life cycle study in order to accurately identify the weak link in the insect's life cycle while looking for an alternative pest management method. The objective of this study was to determine the development of *E. dolichi* on cotton throughout the season in order to gather knowledge on susceptible stages in the life cycle that might be utilized to improve management.

MATERIALS AND METHODS.

Location.

The biology of cotton leafhopper, *E. dolichi* was studied from August to October 2019 and August to October 2020 at the Institute for Agricultural Research (I.A.R.) Samaru, Zaria (11º10' N latitude and 7º37' E longitude) on cotton variety SAMCOT-9 under the laboratory conditions at 25-30ºC and 60-70% RH.

Pure Culture Maintenance.

Leafhopper infested cotton leaves were collected from the cotton field to obtain newly emerged nymphs. These nymphs were fed in transparent rearing kilner Jars (1.5L capacity) till they reach adult stage and these adults were collected using aspirator and were used for the studies. The male and female sexes were identified based on the genitalia and abdominal characters (Nagrare *et al*., 2012).

Rearing of *E. dolichi.*

Fresh leaves were collected from non-infested cotton plant grown in cages; the leaves were washed under running tap water and the leaves were spread on laboratory bench to dry. Leave stalks were wrapped with cotton soaked in water. Twenty (20) nymphs from the newly emerged one day old nymphs were transferred to fresh cotton leaves using camel hair brush and were kept individually in transparent Kilner Jar, covered with muslin cloth. Daily observation of instars and days required for each instar development were recorded based on the moulted skin. The colour and the shape of each nymphal instar were observed. The individual nymphal period and instar number was recorded. The total nymphal period was calculated from the period of egg hatching till the adult emergence. The newly developed adults were observed and record was made of their colour, shape and sex differences (Nagrare *et al*., 2012).

Fecundity.

Ten pairs of freshly emerged adult *E. dolichi* of both sexes obtained from the pure culture were collected and released into rearing jars containing fresh single cotton leaf. Fresh cotton leaves were provided daily as oviposition site. Rearing jars were opened daily and the leaves were observed under microscope for oviposition and this continued till the first egg was laid and duration was recorded.

Morphometric Study.

Observations were made on all the life stages namely; egg, nymph and adult stages. The body measurements (mm) of these stages were taken using the Miscope Digital Microscope (ZARBECO-Portable digital microscope) and were recorded.

RESULTS.

Life Cycle Studies Of *E. Dolichi* on Cotton.

The life cycle study of *E. dolichi* is presented on Table 1. The result showed that the incubation period varied from 6 to 7 days with an average of 6.55 ± 0.50 days. The duration of first instar nymphal stage ranged from 1.00 to 3.00 days with an average of 1.80 ± 0.81 days. The duration of second instar nymphal stage ranged from 1.00 to 4.00 days with an average of 1.90 ± 0.99 days. The third instar ranged from 1. 00 to 2.00 days with average of 1.35 ± 0.48 days, while the fourth and the fifth instars ranged from 1.00 to 3.00 and 1. 00 to 4. 00 with an average of 1.80 ± 0.81 and 2.60 ± 0.79 days respectively.

The nymphs of *E. dolichi* undergo five nymphal instars. The newly emerged nymphs are transparent and yellowish in colour, eyes were whitish in colour and oval in shape (Plate I). Unlike first instar, the second instar nymphs (Plate II) have small wing pad which varied in length from 0.36 to 0.38 mm with average 0.36 ± 0.02 mm (Table 2), they also have on their head a white spot like eye (ocelli). Third instar are yellowish green with small wing pad which varied in length from 0.39 to 0.46 mm with average 0.42 ± 0.03 mm (Plate III). The fourth instar are yellowish with a larger wing pad (0.47 to 0.52 mm length, average 0.50 ± 0.02 mm) than the third instar (Plate IV), while the fifth instar are fully developed, greenish yellow in colour, they have enlarged wing pad and their eyes are whitish in colour (Plate V).

Table 1: Duration of different developmental stages of *E. dolichi*, under laboratory condition.

Parameter	Duration in days	
	Range	Mean ± SD
Incubation period	6-7	6.55 ± 0.50
First instar	1-3	1.80 ± 0.81
Second instar	1-4	1.90 ± 0.99
Third instar	1-2	1.35 ± 0.48
Fourth instar	1-3	1.80 ± 0.81
Fifth instar	1-4	2.60 ± 0.79
Nymphal period	5-16	9.45
Pre oviposition period	5-7	6.05 ± 0.86
Oviposition period	16-19	17.45 ± 1.24
Post oviposition period	4-5	4.55 ± 0.50
Fecundity	15-20	17.35 ± 1.74
Male longevity	15-21	17.60 ± 2.01
Female longevity	16-27	19.45 ± 4.39
Total life cycle	4-21	11.35 ± 6.81

Plate I: First instar nymph.

Plate II: Second instar nymph.

Plate III: Third instar nymph.

Plate IV: Fourth instar nymph.

Plate V: Fifth instar adult.

The total number of eggs laid by individual female varied from 3 to 6 per day with average 4.3 ± 0.9 egss, while the total nymphal period varied from 5.00 to 16.00 days with an average of 9.45 days. Pre-oviposition period varied from 5.00 to 7.00 days with average of 6.05 ± 0.86 days, ovipositional period varied from 16.00 to 19.00 days with average of 17.45 ± 1.24 days, while post-oviposition period varied from 4.00 to 5.00 days with average of 4.55 ± 0.50 days. Fecundity varied from 15 to 20 with average of 17.35 ± 1.74 days, while the male and female longevity ranged from 15.00 to 21.00 and 16.00 to 27.00 days respectively. The average longevity ranged from 17.60 ± 2.01 days, 19.45 ± 4.39 days in male and female respectively. The total life cycle ranged from 4.00 to 21.00 days with average of 11.35 ± 6.81 days. The males are smaller with blunt abdomen (Plate VI), while the females are larger with pointed abdomen (Plate VII).

Morphometry of Different Stages of *E. Dolichi*.

In the present study, Table 2 showed the morphometry of the different stages of growth of *E. dolichi*. Egg length varied from 0.47-0.64 mm with average of 0.58 ± 0.07 mm and egg breadth ranged from 0.18 - 0.24 mm with average of 0.21± 0.02 mm. while the average length and breadth of first, second, third, fourth and fifth instar were 0.71 ± 0.05 mm and 0.21 ± 0.03 mm; 1.10 ± 0.09 mm and 0.34 ± 0.05 mm; 1.34 ± 0.07 mm and 0.52 ± 0.03 mm; 1.57 ± 0.08 mm and 0.63 ± 0.03 mm; 2.07 ± 0.04 mm and 0.74 ± 0.05 mm, respectively. The average length and breadth of adult male and female *E. dolichi* were 2.48 ± 0.12 mm and 0.57 ± 0.02 mm; 2.62 ± 0.16 mm and 0.65 ± 0.007 mm, respectively.

PlateVI: Male *E. dolichi* showing blunt abdominal tip.

Plate VII: Female *E. dolichi* showing pointed abdominal tip.

Table 2: Morphometry of different stages of *E. dolichi*

Life stages	Length (mm)		Breadth (mm)		Wing pad length (mm)	
	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
Eggs	0.47 - 0.64	0.58 ± 0.07	0.18 - 0.24	0.21 ± 0.02		
I instar	0.63 - 0.75	0.71 ± 0.05	0.17 - 0.24	0.21 ± 0.03	- -	- -
II instar	0.98 - 1.20	1.10 ± 0.09	0.28 - 0.40	0.34 ± 0.05	0.36 - 0.38	0.36 ± 0.02
III instar	1.24 - 1.42	1.34 ± 0.07	0.48 - 0.57	0.52 ± 0.03	0.39 - 0.46	0.42 ± 0.03
IV instar	1.48 - 1.68	1.57 ± 0.08	0.59 - 0.66	0.63 ± 0.03	0.47 - 0.52	0.50 ± 0.02
V instar	2.0 - 2.12	2.07 ± 0.04	0.67 - 0.78	0.74 ± 0.05	0.59 - 0.76	0.65 ± 0.07
Adult						
Male	2.37 - 2.65	2.48 ± 0.12	0.56 - 0.59	0.57 ± 0.02		
Female	2.46 - 2.78	2.62 ± 0.16	0.64 - 0.65	0.65 ± 0.007		

DISCUSSION.

Life Cycle Studies Of *E. Dolichi* on Cotton.

Environmental and food factors are the determinants of most insect development which tend to vary between laboratory and field conditions (Nagrare *et al*., 2012). An understanding of the weak link in the life history of insect is very crucial to the integrated management of this pest. In the present investigation the incubation period of *E. dolichi* was found to be 6.55 ± 0.50 days (range 6-7 days). This is in agreement with the report of Hussein and Al-karboli (2018), Jayarao *et al*. (2015), Jayasimha *et al*. (2012) and fairly close to report of Parh and Tailor (1981). The difference observed in the report of Parh and Tailor (1981) could be due to rearing condition or genetic variability.

However, in the present study the first, second, third and fourth life periods are in line with the findings of Jayasimha *et al*. (2012) and slightly related with that of Nagare *et al*. (2012). The result of Hussein and Al-karboli (2018) regarding fifth instar duration was similar with present investigation.

In the present study, total nymphal period varied from 5-16 days with an average of 9.45 days is slightly different from the results obtained by Kumar *et al*., (2020), Jayarao *et al*., (2015) and Jayasimha *et al*. (2012). The result is in confirmation with the result of Al-Hamadany and Al-Karboli (2017). Such developmental period for immature stages of *Empoasca* are however, liable to variation due to temperature change in the rearing conditions.

The pre-oviposition, oviposition and post-oviposion periods in the present findings are in agreement with the report of Jayasimha *et al*. (2012) who reported similar findings in India.

The fecundity period for total individual female varied from 15 to 20 with average 17.35 ± 1.74 days which agrees with the report of Jayasimha *et al*., (2012) who reported 14 to 20 days with average 16.60 ± 1.98 in India.

The result of male and female longevity corresponds to that of Al-Hamadany and Al-Karboli (2017) who found that adult longevity ranged 15-19 days with average of 17 days. This result is in contrast with the one obtained by jayasimha *et al*., (2012) who reported that mean male and female longevity were 22.85 and 26.66 days.

In the present study, the total life cycle of *E. dolichi* was lower than what was obtained by Jayasimha *et al*. (2012) and Sharma and Sharma (1997) in India. The result also indicated that more than 7 generations of *E. dolichi* can be found on cotton field.

The differences observed in the morphology of *E. dolichi* above may be due to rearing condition i.e. temperature and relative humidity or the host plant selected for the study.

Adults of *E. dolichi* have well developed wings and are green in colour, the nymph and adult walk diagonally, face usually pale green, and forewings were yellowish green in colour. The males are smaller with blunt abdomen, while the females are larger with pointed abdomen. Similar observations were recorded by Shivanna *et al*. (2009) with respect to biology and duration.

Morphometry of Different Stages of *E. Dolichi*.

The current study was conducted to check the morphological parameters of *E. dolichi* on cotton leaf under laboratory conditions. Many other studies related to morphological parameters and general biology have been conducted by many researchers in the world (Ramzan *et al*., 2019; Murtaza *et al*., 2019).

In the current study, morphological study was performed using cotton leaf. The eggs of *E.*

dolichi are creamy to pale green, elongate and a little curve shape. Eggs are found dispersed singly in leaf vein and in the tissue of cotton leaf. Eggs length and breadth was close to what was reported by Prasada Rao (2015).

The newly emerged nymphs were transparent and yellowish in colour. Eyes were conspicuous, dull white in colour and oval in shape. The second instars also have dull white eyes; rudimentary wing pads were present all along the posterior margin of meso and meta thorax. The third instar nymph were similar to second instar nymphs in its appearance but a little larger than second instar nymph, they are yellowish green and have prominent wing pads. The fourth instar nymph are bigger than the third instar nymph, they have wing pads which extends up to the fourth abdominal segment, they are also yellowish green. The fifth instar nymph was greenish yellow in colour with wing pad reaching up to ninth abdominal segment. Similar types of observations were recorded by Hussein and Al-Karboli (2018); Prasada Rao (2015) and Jayasimha, (2012). The mean length and breadth of first, second, third, fourth and fifth nymphal instars which were0.71 ± 0.06, 0.21 ± 0.03; 1.1 0 ± 0.09, 0.34 ± 0.05; 1.34 ± 0.07, 0.57 ± 0.03; 1.57 ± 0.08, 0.631 ± 0.03; 2.07 ± 0.04, 0.74 ± 0.05 respectively were similar to the report of Prasada Rao (2015) and Jayasimha, (2012).

The mean length of wing pad of second, third, fourth and fifth nymphal instars were; 0.36 ± 0.02, 0.42 ± 0.03, 0.50 ± 0.02 and 0.65 ± 0.07 respectively.

CONCLUSION.

E. dolichi develops through five nymphal instars which completed the life cycle in 5-16 days and that male longevity is 15- 21 days while the female is 16-27 days.

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Journal of Applied Agricultural Research 2022, 10(2):193-107
ISSN 2006-750X.

STUDIES ON PHYSICOCHEMICAL AND FUNCTIONAL PROPERTIES OF FLOURS OF NIGERIAN WHEAT AND SORGHUM VARIETIES FOR FOOD APPLICATIONS.

Ugwuona[1*], Fabian U. Ukom[1], Anthony N, Agwo[1], Obinna E., Asogwa[2], Ifeyinwa S. and Agbo[1], Miriam C.
[1]Department of Food Science & Technology, College of Applied Food Sciences and Tourism, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria,
[2]Department of Food Science & Technology, Faculty of Agriculture, University of Nigeria, Nsukka
Author's Contact: ugwuonafu@yahoo.com; ugwuona.fabian@mouau.edu.ng, +2347039073421

ABSTRACT.

Diverse blends of Nigerian-grownwheat and other cereals willyield composite flours of distinct functional properties, reduce wheat importation and incidence of celiac disease among Nigerians. This study investigatedcomposition and functional properties of composite flours produced from Nigerian grown wheat and sorghum for various food applications.Batches (500g each) of wheat (WW), brown (SB) and white (SW) sorghum varieties and their blends were processed into flours; and analysed for physical and chemicalproperties. Flours differed significantly ($p < 0.05$) in composition; and were rich in carbohydrate (79.28 – 81.69), fibre (2.11 - 2.64%) and ash (2.06 – 2.87%). WWhad highest mineral contents. Flours were poor in sodium (0.13 – 0.23 mg/100g), potassium (0.09 – 0.12 mg/100g), phosphorus (0.48 – 0.94 mg/100g), magnesium (0.26 – 0.33 mg/100g) and calcium (0.04 – 0.11 mg/100g) but rich in zinc (1.35 – 1.83 mg/100g). Flours had low vitamin contents (0.13 mg/00g of B_3 to 0.67 mg/100g of B_1 and C). Flours had high tannin (11.74 - 19.35 mg/100g) but low oxalate content (0.73 - 1.0%) contents. whole wheat flour and its composite with WWhad relatively lower tannin, phytate and oxalate contents. There was no significant difference ($p > 0.05$) in oil absorption capacities (10.00 to 10.33%) of the flours. Wheat flour and its composite with 10% WW had higher water absorption capacity (16.66 and 15.00%) and gelatin capacity (10.00 and 8.60%) but low foaming capacity (20.59 and 21.82%); implying higher dough forming properties of these flours than the brown sorghum variety.Compositing WW at 10% and 20% wheat yielded flours with highest nutrients and functional quality.

Keywords: Wheat, sorghum, flours, composition, functional properties.

INTRODUCTION.

Evidence from food consumption survey in Nigeria revealed an increasing demand for cereal-based foods, includingfufu, breakfast cereals, breads, cookies and confectionaries. Wheat (*Triticum vulgare*) has been a major base ingredient for theseproducts.Wheathas four distinct proteins, namely albumin, globulin, gliadin and glutenin which offer distinct baking quality. Glutenin and gliadin are collectively called gluten and produce distinctive functional quality in wheat flour that is rarely found in other cereal flours

(Mohammed et al., 2012). Gluten enables the flour to form elastic dough capable of retaining carbon-dioxide generated by leavening agents during dough fermentation. Consequently, Nigeria's demand for wheat has continued to increase each year (Bojňanská*et al*., 2012).

However, wheat is a temperate crop, and most wheat flour consumed in the tropics, including Nigeria is imported (Khan and Zeb, 2007).A little quantity, though the soft wheat, is produced in northern part of Nigeria, mainly in Bauchi State. Again, researches show that wheat proteins pose health challenges to certain individuals who take to wheat as regular staples (Mohammed *et al.*, 2012).Gliadin, and glutenin proteins from wheat cause celiac disease to these individuals. Celiac disease is an inflammation characterized by atrophy and hyper lasing of the small intestinal crypts in presence of the multiple proline and glutamine residues. This makes these two proteins resistant to gastro-intestinal digestion and prone to deamination by tissue transglutaminase (Bernardo and Pena, 2012). Again, a new gluten-related syndrome, known as non-celiac gluten sensitivity (NCGS) has been identified and confirmed, through double-blind placebo-controlled trials (Voltes*et al*., 2013; Biesiekerski*et al*, 2013; Catassi*et al*., 2013). In recent years, the incidence of NCGS has grown rapidly in both adult and children (Catassi*et al*., 2013). Many developing countries in the tropics are initiating programmes to source feasibility of alternative locally available flours as a substitute for imported wheat (Abdelghafor*et al*., 2011). Demand for composite flour is on the increase.Sorghum has some advantages over wheat for people allergic to gluten (Catassi*et al*., 2013). The protein and starch in sorghum endosperm are more slowly digested than those of other cereals and this slow rate of digestibility of sorghum products may be beneficial to diabetics (Khan et al., 2014).

Composite flour technically means flour containing two or more flours from different crops. The raw crop or processed flours from the different materials could be the starting raw material for composite flour production. Composite flours could be made from blends of different cereal grains, cereals and legumes, cereals and tubers, different legume seeds or even tubers; and must be made from two or more of such combinations basically to certify certain specific functional characteristics and nutrient composition. Composite flour could be made by mixing the flours of the component crop in a desired proportion or processing the composite from blends of the raw seed crops, tubers and /or roots as the case may be. Composite flour is considered advantageous in developing countries as it reduces the importation of wheat flour and encourages the use of locally grown crops as flour (Hugo *et al*., 2003; Hasmadi*et al*., 2014). Mixing wheat with local crops for composite flours is increasing in Nigeria due to the growing demandfor Fufu, bakery goods and confectioneries (Noor Aziah and Komathi, 2009).

Fortunately,Nigeria is endowed with other cereals grains includingmaize (*Zea mays*), rice,Millet(*Pennisetum glaucum*),hungry rice (acha) (*Digitariaexilis*)and Sorghum (*Sorghum bicolor*) which can be blended with the indigenous wheat to reduce cost and health risks associated with high wheat consumption.Sorghum is third in abundance among these grains, after rice and maize. It has a comparable nutrient composition except in protein to wheat (Enwere, 1998), and is used in many Nigerian traditional dishes. Composite flours fromNigerian grown wheat and sorghum (*Sorghum bicolor*) would add value to these our indigenous crops, reduce Nigerian foreign expenditureand prevent health risks associated with high wheat consumption (Taylor and Dewar, 2000; Mohammed *et al.*, 2012). This study is poised to produce composite flour of good functional quality from blends of Nigerian wheat (white variety) and sorghum (white and brown varieties)

MATERIALS AND METHODS.

Materials: Wheat (*Triticum aestivum*) grains were sourced from rural farmers in Bouchi State while sorghum (*Sorghum bicolor*L.Monech) grains (white and brown varieties) were sourced from rural farmers in Nasarawa State, both in Nigeria. All the reagents used were of analytical quality and were purchased from Government-authorized dealer, LAVANS Nig. Ltd, based at Nsukka, Nigeria.

Production of straight and compositeflours: Sorghum (brown and white) and wheat grains were processed into flour according to the method of Elkhalifa and E1-Trnay (2002) with slight modification. Each grain sample (2 kg wheat, 500 g sorghum) was sorted to remove dirt, immature seeds, stones and other extraneous material. These were soaked in portable water for 4 h for conditioning in excess portable water, drained out of water and then dried at 60 ^{O}C for 6 h in hot air oven (Shellab model VWR=1370G). The 500g sample of each of the grain was first milled lightly with Hammer mill (Betsch 5657 GmbH, Germany) to detach bran from the grains, and the bran removed by winnowing. These were milled into fine powders using Attrition mill (model GX 160), then sieved through 250µm mesh sieve to get fine flour. Each of the flours was packaged in a cellophane bag and stored in an air-tight container for use.

Each of the white and brown sorghum flours were respectively mixed with wheat flour at proportionsof 50 g: 450 g and 150 g: 350 g in the laboratory flour mixer to give 500 g of each flour blend. These correspond to ratios of 1: 9 and 3: 7 of sorghum to wheat respectively.Also 500 g each of the wheat (WW), white (SW) and brown (SB) sorghum flours were weighed out as straight flours. Table 1 shows composition of the flour samples.

Table 1: Composite flour blends formulation

Sample	Wheat flour (%)	Brown sorghum flour (%)	White sorghum flour (%)	Total (%)
CB1	90	10	-	100
CB2	70	30	-	100
CW1	90	-	10	100
CW2	70	-	30	100
WW WW	100	-	-	100
SB	-	100	-	100
SW	-	-	100	100

WW = wheat flour, SB = brown sorghum flour, SW = white sorghum flour,
CBI = 50 g SB flour: 450 g WW flour blends, CB2 = 150 g SB flour: 350 g WW flour blends,
CWI = 50 g SW flour: 450 g WW flour blends, CW2 = 150 g SW flour: 350 g WW flour blends.

Proximate analysis: Moisture, crude fat, protein, fibre and ash contents were determined according to the method of Association of Official Analytical Chemists (AOAC) (2005) and each analysis was done in triplicates. Moisture content was reported as the loss in weight after drying 2±0.01 g of each bread sample at 105^{O}C for 4h in a hot air oven(Shellab model VWR=1370G). Crude fat content was reported as the percentage loss in weight after exhaustive extraction and quantification of fat from 2g of flour sample using n-hexane as the extracting solvent in all Clevenger Soxhlet apparatus. Crude protein content was determined using the Kjeldhal nitrogen assay (N x 6.25) method of AOAC (2005). Total ash content was determined by incinerating 2 g of the flour sample in a muffle furnace at 550 ^{O}C for 4 h. The net weight of the 2 g flour sample after cooling was reported as the ash content and expressed as a percentage of the flour sample. Crude fibre content was determined by digesting fat-free sample (2g) with 1.25% sulphuric acid (H_2SO_4) (w/w) and 1.25% sodium hydroxide (NaOH) (w/w) respectively, and the residue dried at 104^{O}C in a hot air oven for 5 h. The residue was weighed and ignited at 550^{O}C for 4h in a muffle furnace. The loss in weight from the residue was reported as the crude fibre content and expressed as a percentage of the flour sample. The carbohydrate content was determined by difference, calculating100 – (% moisture + % ash + % protein + % fat + crude fibre) as the percentage carbohydrate content in the bread sample.

Mineral content determination: The mineral contents, namely calcium, iron, potassium, sodium, zinc and phosphorus were determined on the ash samples after dissolving in distilled water, using a Buck Model 200A flame atomic absorption spectrophotometer while phosphorus content was determined using the molybdova date method (AOAC, 2005)**.**

Vitamin content determination: Ascorbic acid, thiamin, riboflavin and niacin contents of the flours were determined using the method of AOAC (2005). Beta carotene content of flours was determined using the HarvestPluse spectrophotometric method of Rodriguez-Amaya and Kimura (2004).

Determination of phytochemcal properties: Tannin content was determined spectrophotometrica; ly as per the vanillin–HCl method of AOAC (2005).Also, phytate content was determined using the method of AOAC (2005) while oxalate content was by gravimetric method as described by Oke (1966).

Determination of Functional Properties.

The oil absorption capacity and water absorption capacity were determined using the method of Onwuka (2018); and bulk density by the method of Babajide *et al.*, (2008). Both foam capacity (FC) and stability (FS) were determined according to the method of Coffman and Garcia (1977). Emulsification capacity and emulsion stability were determined as described by Padmashree *et al*. (1987).

Experimental Designs and Statistical Analysis: The experimental design used was completely randomized design (CRD). Analysis of variance was used to determine effect of different composite flour samples and means where significantly ($p < 0.05$) different were separated using Duncan multiple range test (DMRT).

RESULTS AND DISCUSSION.

Proximate composition of flours ofNigerian sorghum, wheat and their composites.

Proximate composition of theflours of Nigerian wheat and its composite with white and brown varieties of sorghumis shown in Table 2. Moisture content ranged from2.35% in100% white sorghum flour to 4.12%100% wheat flour; and was 2.73% in the 100% brown sorghum flour. Moisture content was higher in the composite flours than in the 100% sorghum flours; and was higher in the composite flours of the white sorghum and wheat than in the composite flours the brown sorghum and wheat. Within the composite flours, it was3.35% for CB1 (10% brown sorghum), 2.6% for CB2 (20% brown sorghum), % for CW1 (10% white sorghum) and 3.93 for CW2 (20% white sorghum). All the flour samples had very good low moisture contents. Low moisture contents (≤12.5%) are needed for longer shelf life against microbial and biochemical spoilage, packaging and general acceptability(Sefa-Dedeh and Saalia, 1997; Sani *et al*. 2006; Adebowale *et al*., 2012).Moisture contents of flours obtained in this study were lower than the values (4.18 to 9.83%) earlier obtained incomposite flours of wheat and malted sorghum (Ifedayo, 2014) and 13.8-14.4% obtained in composite flours of wheat and tiger nut (Ade-Omodaye*et al*., 2008). Higher moisture content of 8.90 to 10.10% for composite flours of sorghum, wheat and maize; and 9.70-10.0% for composite flours of wheat and maizewere also obtained in earlier study by Amir *et al*., (2015). However, the lower moisture contents of the flours in this study may be attributed to low gluten content of Nigerian soft wheat, and subsequent low bound water in the native state of the flour.

Both the sorghums and wheat were good sources of ash which ranged from 2.06% in the 100% brown sorghum flour (SB) to 2.87% in the 30% white sorghumcomposite flour (CW2).The ash content was 2.06% in brown sorghum flour, 2.21% in white sorghum and 2.22% in wheat flour but ranged from 2.51% to 2.87% in the composite flours. The wheat had lower ash content (2.22%) than the brown sorghum but the brown variety had higher (2.75%) content than the white variety (%). Thus, the composites had higher ash content than the straight flours. The higher ash content in the white sorghum variety also reflected in the composite flours, and this ranged from 2.51% in the 10% brown sorghum composite flour (CB1) to 2.87% in the 20% white sorghum composite flour (CW2). The higher ash content in the composite than in the straight flours in this work is unusual but may be attributed to the processing method of the flours. Therewas no significant difference ($p>0.05$) in ash contents of the 10% (CB1) and 20% (CB2) brown sorghum, and 10% white sorghum (CW1) composite flours. High ash content implies high mineral contents in the food (Igbabul*et al*., 2015).

Fat (%) content was 1.27 in the 100% sorghum flours but 2.41 in the 100% wheat flour. This (%) however ranged from 1.09 in CW2 to 2.14 in CB1, among the composite flours. Compositing wheat with sorghum decreased the high fat content in the wheat, this decrease was however more significant ($p < 0.05$) with white sorghum than with brown sorghum in the composite flours.These flours had relatively moderate fat content. Similar fat contents of 1.5%for wheat flour, 1.75-2.27% for wheat-maize flour, 1.62-1.87% for wheat-sorghum flour and 0.86-2.19% for malted sorghum- wheat flourswere earlier reported by earlier researchers(Ade-Omowaye*et al*., 2008; Ade-Omowaye*et al*., 2008; Amir *et al*., 2015; Ifedayo, 2014). Fat increases the palatability of foodby absorbing and retaining itsflavour but too high fat content in flours accelerates rancidity spoilage.

Both the white and brown sorghums had higher protein content than the wheat flour. The brown sorghum flour (SB) had higher (11.82%) protein content than the white sorghum (9.82%). As a result, protein content (%) of 9.46 in the 100% wheat flour improved to 11.04 in 30% brown sorghum composite flours (CB2), and to 10.25 in the 20% white sorghum composite flour (CW2). Various protein contents (%) of 14.2 to 14.8% for wheat/sorghum flour, 12.09 to 13.30% for wheat/maize flour and 13.50% for composite flours of wheat, sorghum and maize have been reported (Amir *et al*., 2015). The higher protein contents in these composite flours may be due to differences in varieties and species used.High protein content in flours improves functional and nutritional properties of food. Ifedayo (2014) reported that flour from composite flours of malted sorghum and wheat had protein content of 9.03 to 18.52%, implying that malting increases protein content of sorghum. Okafor (1981) reported that malting, fermentation, and cooking are known to improve the protein digestibility of sorghum by reducing its tannin and phytate content.

All the flours were rich in fibre (%), and this ranged from 2.11 in CB1 All the flours were rich in fibre (%), and this ranged from 2.11 in CB1to 2.64 in SW. The wheat flour had lower fibre content than the sorghum flour while the white sorghum had higher fibre content than the brown sorghum. to 2.64 in SW (100% white sorghum flour). The wheat flour had lower fibre content than the sorghum flour while the white sorghum had higher fibre content than the brown sorghum.Amir *et al*. (2014) reported a lower value (1.73%) for wheat flour. Other researchers reported higher crude fibre content of 2.21 to 3.19% for wheat and sorghum composite flours, and of 1.66 to 2.50% for wheat/maize composite flours. A value of 2.85% was also reported of wheat/sorghum/maize composite flour (Amir *et al*., 2014). This variation could be attributed to the variety and the processing method used.Crude fibre is known to aid digestive system of human.

Cereal flours are generally good sources of carbohydrate.Carbohydrate contents of the flourswere high and ranged from 79.28-81.69%. The composition of carbohydrate content of the flours is important. This implies that sample CB1 would be useful to people that need low carbohydrate foods leading to enhanced health for over- weight and obese persons. High content of resistant starch in the flour is important to aid slow digestion and low glycemic index to consumers.

Mineral composition of Nigerian sorghum, wheat and their composites.

Table 3 shows mineral composition of flours of the Nigerian wheat, sorghum and their composites. The flours were generally low in sodium, potassium, phosphorus, magnesium and calcium, all of which had a close range of values less than 1mg/100g of the flours. Balota, (2012) reported that the phosphorous content of sorghum flour was 0.281mg/100g and that that of wheat flour was 0.015mg/100g. The values are closely related to the ones in this study. Calcium content was the least of all the minerals and ranged from 0.04 to 0.06mg/100g in all the flours except in the 100% white sorghum flour which had 0.11mg/100g of it. However, zinc content was relatively high and ranged from 1.35 to 1.83mg/100g of the flour. Sodium: potassium ratios in most of the flour were approximately 1.5: 1. Of all the composite flours, CB2 (30% brown sorghum composite flour) and CW2 (30% white sorghum composite flour) had the most closely comparable mineral content with the 100% wheat flour.

Low sodium intake causes hyponatremia – low sodium in the blood. However, excessive sodium intake causes hypernatremia and hypertension. Both potassium and sodium control water balance in the body (Onyeike, 2012). Excess water intake without replenishment of sodium and potassium salts also causes hyponatremia which can lead to water intoxication. Potassium deficiency in the dietleads to hypokalemia while excess potassium causes hyperkalemia and palpations.

Magnesium is needed for more than 300 biochemical reactions in the body. It helps maintain normal muscle and nerve function, keeps heart rhythm steady, supports a healthy immune blood and regulates blood sugar levels (Saris *et al*., 2000). Magnesium is an essential constituent of all cells and is necessary for the functioning of enzymes involved in energy utilization and it is also a component of bone (ADA, 2002).

Calcium is essential for proper bone and teeth formation (Wardlaw and Kessel, 2002). Trace amounts of calcium in the diet is essential for blood clotting, intracellular signaling and muscle contraction while large amount is required during infancy, childhood and pregnancy for stronger, dense bone and teeth formation. Long term calcium deficiency leads to rickets; and in menopausal women, it can lead to osteoporosis with bone deterioration leading to increased risk of fractures. However, excessive calcium intake or absorption causes hypercalcaemia (elevated level of calcium in the blood), development of kidney stones, impaired kidney function, nausea, vomiting, constipation and increased urination (Onyeike, 2012).

Zinc is needed for the body's defensive (immune) mechanism to properly work (Wardlaw and Kessel, 2002). It helps in cell division, cell growth, wound healing, and in the breakdown of carbohydrates. In children, deficiency may lead to impotence and delayed sexual maturation, diarrhea, susceptibility to infection and death. Deficiency may be due to low dietary intake or malabsorption (Onyeike, 2012).

Vitamincomposition ofNigerian sorghum, wheat and their composites.

The vitamin composition of Nigerian sorghum, wheat and their composites are shown in Table 4. Both the sorghum and wheat were not good sources of vitamins. There were low vitamin contents (0.25 – 0.57 mg/100g) in the wheat flour, and compositing with either brown or white sorghum produced composite flours of comparable vitamin contents (0.12 -0.67mg/100g).Vitamin B_1 ranged from 0.48 to 0.63mg/100g; B_2 ranged from 0.22-0.37mg/100g while B_3 ranged from 0.13-0.28mg/100g. There were significant differences ($p<0.05$) among B3, vitamin C and carotenoid (provitamin A) in the flours. However, there was no significant difference ($p>0.05$) in Vitamin B_2contents of the flours CB1 (10% brown sorghum composite flour), CB2 (30% brown sorghum composite floor) and SW (100% wheat flour). Also, there was no significant difference in vitamin B_1contents of the flours CB1 (10% white sorghum composite flour), CW1 (10% of white sorghum composite flour) and SB (100% brown sorghum flour).The B vitamins help the human body to metabolize energy, and are also necessary for a healthy nervous and digestive system. The little quantity contained in the flours will go a long way in contributing to the individual’s health.Importantly, compositing wheat flour with other seed grains is known to improve both nutrient composition and functional properties of food products (Appiah *et al*., 2011). Carotenoids are among the most widespread natural pigments with yellow, orange, and red colors in plants (Krinsky, 1993). Carotenes are hydrocarbons soluble in nonpolar solvents such as hexane and petroleum ether. The oxygenated derivatives of carotenes, xanthophylls, dissolve better in polar solvents such as alcohols.Vitamin C is useful in the healing of wounds. Vitamin C as part of water-soluble vitamins regulates metabolic reactions and help to ensure healthy living (Onyeike, 2012). This anti-stress vitamin protects the cells from toxic wastes and is the most powerful and effective of all the antioxidants, destroying 100 percent of the free radicals at the cellular level before they enter the cells.

Phytochemicalcomposition of Nigerian sorghum, wheat and their composites

Table 5 shows the phytochemical composition of the straight and composite flours. Tannin content (mg/100g) in the flours was high and ranged from 117.74 in the 100% wheat flour to 193.49 in the 100% brown sorghum flour. Tannin content was higher in the sorghum flours than in the wheat flour; and in the brown sorghum flour than in the white sorghum flour. The composite flours had higher tannin content than the wheat flour, but lower tannin content than the sorghum flour. The flours had a closed range of phytate contents which ranged from 2.16 to 2.84 mg/100g. Also, the sorghum had higher phytate content than the wheat but the brown sorghum had higher phytate content than the white variety. However, CW1 had the lowest value of 2.14 mg/100g tannin, and could be regarded the best in this regard.

The flours were generally low in oxalate content which ranged from 73.00 to 1.00 mg/100g.

Major phytochemical constituents present in sorghum grain include polyphenols and phytic acid. Polyphenols bind and inhibit proteins present in grain and make them indigestion by protease and unavailable for intestinal absorption. phytic acid is also present in sorghum in the form of 6-inositol phosphate. Phytic acid at higher concentration usually forms insoluble compounds with divalent metals like calcium, iron, magnesium and zinc; thereby makes them unavailable for intestinal absorption. Excessive tannins in food can provoke astringency in the mouth and make the food unpalatable, complex with and precipitate protein in the gut, reduce its digestibility or inhibit its digestive enzymes. Recent research findings on polyphenol and phytic acid indicate that these constituents at low concentrations increases immunity in animal and human systems against several diseases (Ratnavathi and Patil, 2013).

Functional propertiesof Nigerian sorghum, wheat and their composite flours

Table 6 shows functional properties of the flour samples. Composite flours of wheat with 10% and 30% of white sorghum produced composite flours of comparable functional properties with the 100% wheat flour.

Straight and composite flours had constant 10%oil absorption capacity (OAC) of 10.0%. However, water absorption capacity (WAC) differed significantly ($p < 0.05$) among flour samples. WAC was 10.0% in CB1, CW2, SB and SW; and 13.33 in CB2, 15.0% in CW1 and 16.66% in WW. Compositing wheat with 10% white sorghum decreased WAC to approximately 94%. Sorghum decreased WAC of wheat in the composite flours. Oil absorption capacity reflects the emulsifying capacity of flour and is an important parameter of flour for baking (Kaur *et al*., 2007; Ikpeme-Emmanuel et al., 2010). It enhances flavour and mouth-feel of food (Appiah *et al*., 2011). Igbabul*et al* (2014) reported a lower OAC of 1.59-2.14% for composite flours of wheat, swe*et* potato and hamburger bean. The higher OAC in CW1 suggests presence of non-polar amino acids. Protein concentration and conformity influence oil absorption. These composites flours could serve as functional ingredients in whipped toppings, sausages and baked products.

The observed differences in water absorption capacity of the flours may be due to differences in protein concentration, degrees protein of interactions with water and protein conformational characteristics (M_C Watters *et al*., 2003). Also, lower water absorption capacity could be due to lose of association of amylose and amylopectin in the native granules of starch and weaker associative forces maintaining the granular structure (Nasr and Abufoul, 2004). Water absorption capacity is important in bulking and consistency of products as well as in baking application (Loreng and Collins, 1990). The ability of protein to bind water is an indicative of its water absorption capacity. Higher WAC was observed by Chandra and Samsher, (2013) for wheat flour (1140%), rice flour (192%), green gram flour (196%) and potato flour (752%). Water absorption capacity represents the ability of the product to associate with water under conditions where water is limiting such as in dough and batter in order to maintain freshness in such products (Gianni and Bekebain, 1992; Singh, 2001). Water absorption capacity is a critical function of protein in various food products like soups, dough and baked products (Adeyeye and Aye, 1998).

Gelling capacity (GC) ranged from 8% to 10%, emulsion capacity (EC) from 36.25 to 40.27%, and emulsion stability (ES) from 25.11 to 27.62%. Thus, both the straight and composite flours had high GC, EC and ES. The temperature range where for gelling and emulsion capacity and stability is an important parameter for diet preparations and in determining starch utilization in industries. Gelation involves swelling of starch granules on heating; and it is influenced by nature of the starch and protein present, and also their interaction during processing (Oluwamukomi*et al*., 2011). Composite flours CB1 and CB2 formed gels quickly at very low concentrations (8%) while SW formed gel at high concentration (10.33%). Bothmay be used for food products that require thick paste, high gel strength and elasticity. Chandra and Samsher (2013) reported higher values (38.38%) for wheat flour, 37.31% for rice flour and 41.92% for potato flour.

Foaming capacity (FC) and stability (FS) of the flours differed significantly ($p < 0.05$) and ranged from 20.59 to 21.84%, and 3.22 to 4.21% respectively. Foaming capacity refers to the amount of interfacial area created by protein (Ordorica and Paredes, 1990).Sample CW1 had the highest foam capacity while sample WW (100% WF) had the lowest foam capacity. Values of foaming capacity obtained here were higher than 12.02-13.52% reported on cassava and cucurbitaseed composite flours (Falola *et al*, 2011) and 1.17 - 4.12%) reported on wheat and swe*et* potato composite flours (Adeleke and Odedeji, 2010). Lower values of 3.52% for rice flour and 6.84% for potato flour were reported by Chandra and Samsher (2013). Foam formation is a function of the type of protein, pH, processing methods, viscosity and surface tension or due to protein denaturation (Falola *et al*., 2011; Butt and Batool, 2010). High FC is a desirable attribute of flours intended for varied baked products such as angel cakes, muffins, cookies, fudges, akara; and also, for flours that act as functional agents in other food formulations (El-Adawy, 2001).

Bulk density of the flours differed significantly ($p < 0.05$), and ranged from 1.05 in SW (100% white sorghum) to 1.48% in CB2 (70% wheat: 30% brown sorghum).Higher bulk density is desirable for ease of dispensability of flours. In contrast, low bulk density is desirable for formulating complimentary foods (Akpata and Akubor, 1999). Bulk density helps to enhance both caloric and nutrient intake per quantity served (Onimawo*et al*., 1998); reflects the load that the flour samples can carry if allowed to rest directly on one another (Falola *et al*., 2011); and reflects the relative volume and type of packaging material required (Udensi and Okoronkwo, 2006). It is generally affected by particle size and true density of matter in the flours. Thus, CB2 had the highest particle size. Sorghum has some advantages over wheat for people allergic to gluten (Khan et al., 2014). The protein and starch in sorghum endosperm are more slowly digested than those of other cereals and this slow rate of digestibility of sorghum products may be beneficial to diabetics.

Table 2: Proximate composition of Nigerian sorghum-wheat flour composites.

Samples	**Moisture (%)**	**Ash (%)**	**Fats (%)**	**Protein (%)**	**Fibre (%)**	**Carbohydrate (%)**
CB1	3.35 ± 0.00^{d}	2.51 ± 0.00^{b}	2.14 ± 0.00^{b}	10.59 ± 0.00^{c}	2.11 ± 0.00^{g}	79.28 ± 0.01^{f}
CB2	2.6 ± 90.00^{f}	2.55 ± 0.00^{b}	1.69 ± 0.00^{c}	11.04 ± 0.00^{b}	2.27 ± 0.00^{e}	79.75 ± 0.01^{c}
CW1	3.66 ± 0.00^{c}	2.54 ± 0.00^{b}	1.49 ± 0.00^{d}	8.41 ± 0.00^{g}	2.36 ± 0.00^{c}	81.54 ± 0.01^{b}
CW2	3.93 ± 0.00^{b}	2.87 ± 0.11^{a}	1.09 ± 0.00^{f}	10.25 ± 0.00^{d}	2.29 ± 0.00^{d}	79.51 ± 0.01^{e}
WW	4.12 ± 0.00^{a}	2.22 ± 0.00^{c}	2.41 ± 0.00^{a}	9.46 ± 0.00^{f}	2.25 ± 0.00^{f}	79.52 ± 0.01^{e}
SB	2.73 ± 0.00^{e}	2.06 ± 0.00^{d}	1.27 ± 0.00^{e}	11.82 ± 0.00^{a}	2.49 ± 0.00^{b}	79.62 ± 0.01^{d}
SW	2.35 ± 0.00^{g}	2.21 ± 0.00^{c}	1.27 ± 0.00^{e}	9.82 ± 0.00^{e}	2.64 ± 0.00^{a}	81.69 ± 0.01^{a}

Values are means ± standard deviations of 3 determinations; means with the same superscript within the same column are significantly ($p<0.05$) different; CB1 and CB2 are respectively composite flours of Nigerian wheat with 10 and 30% of brown sorghum seed flours; CW1 and CW2 are composite flours of Nigerian wheat with 10 and 30% of white sorghum seed flours; WW= whole wheat flour; SB= whole brown sorghum seed flour; SW= whole white sorghum seed flour.

Table 3: Mineralcomposition of Nigerian sorghum-wheat flour composites

Samples	**Sodium (mg/100g)**	**Potassium (mg/100g)**	**Phosphorus (mg/100g)**	**Magnesium (mg/100g)**	**Calcium (mg/100g)**	**Zinc (mg/100g)**
CB1	0.13 ± 0.00^{f}	0.09 ± 0.00^{c}	0.48 ± 0.00^{d}	0.27 ± 0.00^{e}	0.06 ± 0.00^{b}	1.35 ± 0.00^{e}
CB2	0.15 ± 0.00^{d}	0.11 ± 0.00^{b}	0.93 ± 0.04^{a}	0.31 ± 0.00^{d}	0.05 ± 0.00^{c}	1.35 ± 0.00^{e}
CW1	0.14 ± 0.00^{e}	0.11 ± 0.00^{bc}	0.53 ± 0.00^{c}	0.32 ± 0.00^{c}	0.06 ± 0.00^{b}	1.75 ± 0.00^{b}
CW2	0.18 ± 0.00^{b}	0.12 ± 0.00^{a}	0.92 ± 0.00^{a}	0.33 ± 0.00^{b}	0.06 ± 0.00^{b}	1.45 ± 0.00^{d}
WW	0.21 ± 0.00^{a}	0.11 ± 0.00^{b}	0.94 ± 0.00^{a}	0.33 ± 0.00^{b}	0.04 ± 0.00^{c}	1.65 ± 0.00^{c}
SB	0.16 ± 0.00^{c}	0.12 ± 0.00^{a}	0.94 ± 0.00^{a}	0.34 ± 0.00^{a}	0.05 ± 0.00^{c}	1.83 ± 0.00^{a}
SW	0.18 ± 0.00^{b}	0.12 ± 0.00^{a}	0.56 ± 0.00^{b}	0.26 ± 0.00^{f}	0.11 ± 0.00^{a}	1.35 ± 0.00^{e}

Values are means ± standard deviations of 3 determinations; means with the same superscript within the same column are significantly ($p<0.05$) different; CB1 and CB2 are respectively composite flours with 10 and 30% of brown sorghum seed; CW1 and CW2 are composite flours with 10 and 30% of white sorghum seeds; WW= whole wheat flour; SB= whole brown sorghum flour; SW= whole white sorghum flour.

Table 4: Vitamin composition of Nigerian sorghum, wheat and their composites

Samples	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	Carotenoid (mg/100g)	Vita C (mg/100g)
CB1	0.53 ± 0.00^{bc}	0.23 ± 0.01^{c}	0.15 ± 0.00^{f}	0.33 ± 0.00^{c}	0.66 ± 0.00^{b}
CB2	0.48 ± 0.00^{c}	0.22 ± 0.00^{c}	0.13 ± 0.00^{g}	0.19 ± 0.00^{e}	0.59 ± 0.00^{f}
CW1	0.53 ± 0.00^{bc}	0.33 ± 0.00^{b}	0.18 ± 0.00^{d}	0.46 ± 0.00^{b}	0.62 ± 0.00^{e}
CW2	0.63 ± 0.00^{a}	0.36 ± 0.00^{a}	0.23 ± 0.00^{c}	0.12 ± 0.00^{g}	0.67 ± 0.00^{a}
WW	0.57 ± 0.11^{b}	0.33 ± 0.01^{b}	0.25 ± 0.00^{b}	0.27 ± 0.00^{d}	0.56 ± 0.00^{g}
SB	0.55 ± 0.00^{b}	0.24 ± 0.01^{c}	0.16 ± 0.00^{e}	0.18 ± 0.00^{f}	0.63 ± 0.00^{d}
SW	0.57 ± 0.00^{b}	0.37 ± 0.00^{a}	0.28 ± 0.00^{a}	0.48 ± 0.00^{a}	0.64 ± 0.00^{c}

Values are means ± standard deviations of 3 determinations; means with the same superscript within the same column are significantly ($p<0.05$) different; CB1 and CB2 are respectively composite flours with 10 and 30% of brown sorghum seed; CW1 and CW2 are composite flours with 10 and 30% of white sorghum seeds; WW= whole wheat flour; SB= whole brown sorghum flour; SW= whole white sorghum flour.

Table 5: Phytochemicalcomposition of Nigerian sorghum, wheat and their composites

Samples	Tannin (mg/100g)	Phytates (mg/100g)	Oxalate (mg/100g)
CB1	131.04±0.00^{f}	2.84±0.00^{a}	0.82±0.00^{b}
CB2	169.95±0.00^{c}	2.56±0.00^{b}	0.99±0.00^{a}
CW1	133.08±0.00^{e}	2.14±0.00^{c}	0.94±0.00^{a}
CW2	156.64±0.01^{a}	2.16±0.00^{c}	0.73±0.00^{c}
WW	117.74±0.00^{g}	2.75±0.00^{a}	0.89±0.00^{ab}
SB	193.49±0.00^{b}	2.90±0.00^{a}	1.00±0.00^{a}
SW	147.94±0.00^{d}	2.79±0.00^{a}	0.88±0.00^{ab}

Values are means ± standard deviations of 3 determinations; means with the same superscript within the same column are significantly ($p<0.05$) different; CB1 and CB2 are respectively composite flours with 10 and 30% of brown sorghum seed; CW1 and CW2 are composite flours with 10 and 30% of white sorghum seeds; WW= whole wheat flour; SB= whole brown sorghum flour; SW= whole white sorghum flour.

Table 6: Functional properties of Nigerian sorghum, wheat and their composites

Sample	OAC (%)	WAC (%)	GC (%)	EC (%)	ES (%)	FC (%)	FS (%)	BD (%)
CB1	10.00±0.00^{a}	10.00±0.00^{b}	8.00±0.00^{b}	36.78±0.00^{b}	25.38±0.00^{c}	21.42±0.00^{b}	3.42±0.00^{b}	1.22±0.00^{b}
CB2	10.00±0.00^{a}	13.33±2.88^{ab}	8.00±0.00^{b}	40.27±0.00^{a}	27.62±0.00^{a}	21.56±0.00^{ab}	4.21±0.00^{a}	1.48±0.00^{a}
CW1	10.33±5.77^{a}	15.00±0.00^{a}	10.00±0.00^{a}	37.34±0.00^{b}	25.59±0.00^{b}	21.84±0.00^{a}	3.36±0.00^{bc}	1.09±0.00^{c}
CW2	10.00±0.00^{a}	10.00±0.00^{b}	8.60±1.15^{b}	39.53±0.00^{a}	26.24±0.00^{b}	21.32±0.00^{b}	3.54±0.03^{b}	1.47±0.00^{a}
WW	10.00±0.00^{a}	16.66±5.77^{a}	10.00±0.00^{a}	36.91±0.00^{b}	25.11±0.00^{c}	20.59±0.00^{c}	3.22±0.00^{c}	1.51±0.00^{a}
SB	10.00±0.00^{a}	10.00±0.00^{b}	10.00±0.00^{a}	36.25±0.00^{b}	25.38±0.00^{c}	21.63±0.00^{a}	3.42±0.01^{b}	1.18±0.00^{b}
SW	10.00±0.00^{a}	10.00±0.00^{b}	10.33±0.57^{a}	38.21±0.00^{ab}	26.12±0.00^{b}	21.77±0.00^{a}	4.24±0.00^{a}	1.05±0.00^{c}

Values are means ± standard deviations of 3 determinations; means with the same superscript within the same column are significantly ($p<0.05$) different; CB1 and CB2 are respectively composite flours with 10 and 30% of brown sorghum seed; CW1 and CW2 are composite flours with 10 and 30% of white sorghum seeds; WW= whole wheat flour; SB= whole brown sorghum flour; SW= whole white sorghum flour.

CONCLUSION.

Composite flours from different blends of wheat and sorghums (brown and white varieties) differed significantly ($p < 0.05$) in compositions and functional properties. Composite flours had higher protein, carbohydrate, ash and fibre contents than the wheat flour. Some had higher and others lower mineral, vitamin and phytochemical contents thanthe wheat flour. Results suggest feasibility of wide applications of composite flours in food processing. Flour with high oil content is suitable for foods with high flavour; flour with high emulsion capacity for salad dressing, cake batters and comminuted meat; and flour with high foaming capacity and stability for cakes, breads, whippings and toppings.

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Journal of Applied Agricultural Research 2022, 10(2):208-219
ISSN 2006-750X.

SURVEY TO DETERMINE THE INCIDENCE OF *Empoasca dolichi* IN PARTS OF KATSINA STATE.

*ALIYU, M. K[1]., ONU, I.[2], MANI, U[3]. AND MBAH, C. E.[4]
[1]Agricultural Research Council of Nigeria, Mabushi, Abuja
[2]Department of Crop Protection, Faculty of Agriculture, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria
[3]Division of Agricultural Sciences, Ahmadu Bello University, Zaria
[4]Department of Zoology, Faculty of Life Sciences, Ahmadu Bello University, Zaria
Author's Contact: aliyumuhammad75@gmail.com, +2347066494121

ABSTRACT.

Survey was conducted during the 2019 and 2020 growing seasons, to determine the incidence of *Empoasca dolichi* in some parts of Katsina state. The local government areas visited in the state included Faskari, Kankara and Malumfashi. Three cotton producing villages were randomly selected and two cotton fields of one hectare and above were considered for *E. dolichi* and its predators survey. The result of the study showed that all the LGAs surveyed were hotspot for *E. dolichi* at early (June/July), mid (August) and late-season (September). At early stage of cotton growth. *E. dolichi* had higher occurrence in Daudawa (1.11/3 leaves), Dan mabu and Burdugau (1.06/3 leaves) villages of Faskari, Kankara and Malumfashi local government areas, respectively. At mid-season Kankara had (2.76/3 leaves), Daudawa (2.74/3 leaves) and Mararaban kankara (2.73/3 leaves) of Kankara, Faskari and Malumfashi local government areas, respectively had higher occurrences of *E. dolichi*, while at late-season higher occurrences of *E. dolichi* was observed on cotton plants in Burdugau (1.39/3 leaves) and Mararaban kankara (1.32/3 leaves) of Malumfashi LGA and Daudawa (1.27/3 leaves) of Faskari LGA. Similarly, the predator survey showed that all the LGAs surveyed had higher occurrence of spiders (*Cheiracanthium aeculeatum* and *Lycosidae hogna*) feeding on *E. dolichi* at the various stages of cotton growth, while lady bird beetle (*Coccinella septempunctata*) and green lacewing (*Chrysoperla carnea*) occurred in lower densities.

Key words: *Empoasca dolichi*, predators, incidence and LGAs

INTRODUCTION.

Cotton is a major field crop in some countries, constituting a valuable cash crop for many small-holders in developing countries. It is an important industrial crop in both developed and developing countries (Gyi, *et al*, 2015). Insect pest causes considerable damage to cotton plants at almost all growth stages. About 162 insect pests have been recorded on cotton during its growth period, out of which only 15 species have been reported as major insect pests (Bhoge *et al*., 2019). Cotton insect pests can primarily be divided into sucking pests, foliage pests and bollworms or boll feeders (Momtaz *et al*., 2018). During the early growth stage of the crop, sucking pests like aphids, *Aphis gossypii* (Glover), leafhopper, *Empoasca spp*, thrips, *Thrips tabaci* (Hood), whitefly, *Bemisia tabaci* (Gennadius) and mealy bug, *Phaenococcus solenopsis* are of major importance. Amjad and Aheer (2007) reported that the extent of losses caused by sucking pests had been estimated to be in the range of 40-50%. The sucking pests of economic importance are the cotton leafhopper and whitefly that cause both qualitative and quantitative losses in cotton (Dhaliwal *et al.*, 2006), among the sucking pests, leafhoppers, are of major importance in cotton crop. Severe attack by cotton leafhopper can reduce yield by 24- 45% (Tariq *et al;* 2017). *E. dolichi* Nymphs and adults suck the sap from under surface of the leaves during the early stage of the crop development. Their feeding activity cause stunting, downward curling and browning of leaves leading to the production of typical *"*hopper burn*"* symptom. They can also cause shedding of leaves, squares and young bolls with significant yield losses even on resistant varieties of cotton (Prasada-Rao, 2015). Chemical control methods are the only control measures for these pests in many countries. To prevent cotton from the attack of pests and diseases, judicious and optimal use of pesticides for cotton is needed. But too much application of pesticide disrupts the growth of cotton, killing beneficial insects on cotton and providing opportunity to harmful insect to attack the crop. In cotton systems, for example, information about understanding the crop-ecosystem leads reduction in the pesticide use while simultaneously increasing production and profit (Khan *et al*, 2005). Monitoring is an important part of the Integrated Pest Management (IPM) programs. It aids in the detection of potential problems as well as the assessment of overall field conditions (Godfrey *et al*, 2013). During the growing season, insect populations vary from year to year and field to field. During the season, all fields should be monitored for both insect pests and beneficial insect populations at least once a week, ideally twice a week after blossoming has commenced (Steward and McClure, 2014). Scouting is used to assess whether or not a pest is present and whether or not a control technique is necessary. Scouting is also useful for determining whether crop health is being harmed by nutrients deficits, soil compaction or other disorders. Because it is impossible to inspect every plant in a field, fields are sampled to determine the extent of infestation. The sampling plan is a method of getting a sample in order to estimate a pest population or the degree of crop injury in the field. The area of the field where a single sampling unit is inspected, counted or collected is referred to as a "survey stop". The "sample" is the total number of observations from all the survey stops. (Fishel *et al*., 2001). In the framework of integrated pest management (IPM), the information gathered will serve as the foundation for a holistic strategy to managing insect pests on cotton. As a result, this study was carried out to determine the natural infestation level in three local government areas of Katsina State.

MATERIALS AND METHOD.

Location.

Field surveys were conducted in early-season (June/July), mid-season (August) and late-season (September) of 2019 and 2020 in parts of Katsina State. Local government areas that were survey in Katsina state included Faskari (11^0 32'N, $7^0$19'E), Kankara (11^0 93N, $7^0$41'E) and Malumfashi (11^0 48'N, 7^0 37'E), in northwestern Nigeria. In each local government area, three (3) villages were survey. In each village two cotton fields were selected for the *E. dolichi* and predators' surveys in each village.

Data Collection.

Visual counting of nymphs and adult stages of *E. dolichi* and its predators was carried out on the three sites of sizes 25 m^2. *E. dolichi* count was done on five randomly selected cotton stands. The leafhopper and the predominant pests that prevailed during the study were recorded during the period of the survey. All observations and records were taken in the morning between 0700- 1000hr and 1630-1830 hrs. The insect population data recorded was subjected to analysis of variance (ANOVA). Difference among treatments means was separated using SNK at 5% probability level using SAS, software package 2003.

RESULTS.

Incidence of *E. dolichi* in parts of Katsina state during 2019 and 2020 growing season**.**

The result of the surveys conducted in early season (June/July), mid-season (August) and late season (September) in the 2019 and 2020 rainy seasons is presented on Figure 1. The population density of *E. dolichi* from the farmers' cotton field in the early- season of 2019 showed that cotton plants in Faskari (1.10/plant) and Malumfashi (1.07/plant) Local Governments recorded significantly lower (P≤0.05) incidence of *E. dolichi* than in cotton plants in Kankara (1.17/plant), but in early B-season of 2020 and combined result showed no significant difference (P≥0.05) in the incidence of *E. dolichi* recorded on cotton plants in the three (3) Local Government areas.

The result at mid-season showed that there was no significant difference in the incidence of *E. dolichi* in the three (3) Local government areas. While at late-season of 2019 no significant difference was observed in the incidence of *E. dolichi* in the three (3) Local Government areas, but in 2020 and the combined result showed cotton plants in Faskari (1.10 and 1.19/plant respectively) recorded significantly lower (P≤0.05) incidence of *E. dolichi* than those recorded on cotton plants in Kankara and Malumfashi, but was similar (P≥0.05) to those recorded on cotton plants in Kankara Local Government area.

Figure 2 showed the result of the villages surveyed in the three (3) Local Government areas visited in 2019 and 2020 wet seasons. The result showed that in the early-season of 2019 cotton plants in Sheme (1.05/plant) and Kadisau (1.08/plant) in Faskari Local Government area, Kankara (1.05/plant) Kankara Local Government area, Mararaban kankara (1.05) and Kuka sheka (1.01/plant) in Malumfashi Local Government area recorded significantly lower (P≤0.05) incidence of *E. dolichi* than those recorded on cotton plants in Dan mabu (1.30/plant) in Kankara Local Government area, but was similar (P≥0.05) to those recorded on cotton plants in Daudawa (1.17/plant) Faskari Local government area, Mararaban gundawa (1.17/plant) Kankara Local Government and Burdugau (1.14/plant) Malumfashi Local Government area, while in 2020 the combined result showed no significant difference (P≥0.05) in the incidence of *E.dolichi* on cotton plants in all the villages visited.

In mid-season of 2019 and 2020 the combined result showed no significant difference (P≥0.05) in the incidence of *E. dolichi* on cotton plants in all villages visited. At late-season 2019 and 2020 the result showed no significant difference (P≥0.05) in the population of *E. dolichi* recorded on cotton plants in the villages surveyed. While the combined result showed cotton plants in Sheme (1.15/plant) and Kadisau (1.14/plant) in Faskari Local Government area recorded significantly lower ($P \leq 0.05$) incidence of *E. dolichi* than those recorded on cotton plants in Burdugau (1.39/plant) (Figure 2) Malumfashi Local Government area, but were similar ($P \geq 0.05$) to those recorded on cotton plants in other villages (Figure 2).

Predators.

Spiders (*Cheiracanthium aeculeatum* and *Lycosidae hogna*)

The result of the survey conducted early-season (June/July), mid-season (August) and Late season (September) in 2019 and 2020 rainy seasons and the combined results are presented on Figure 3. The incidence of spiders on cotton plants in the early-season of 2019 and combined result were lowest in Faskari local government ($0.82/25m^2$ and $1.11/25m^2$ respectively), these figures were significantly lower ($P \leq 0.05$) than those recorded on cotton plants in Kankara ($1.55/25m^2$ and $1.65/25m^2$ respectively) and Malumfashi local government areas ($1.70/25m^2$ and $1.75/25m^2$ respectively) which were similar ($P \geq 0.05$), while in 2020 there was no significant difference ($P \geq 0.05$) in the incidence of spiders on cotton plants in the three local government areas.

At the mid-season of 2019 the result was similar ($P \geq 0.05$), at the mid-season of 2020 the result was similar ($P \geq 0.05$) and in the combined the result was also similar ($P \geq 0.05$) but with cotton plants in Kankara having the lowest while Faskari having the highest population in the two seasons.

In the late-season of 2019 and the late-season of 2020 rainy seasons, there was no significant difference ($P \geq 0.05$) in the incidence of spiders on cotton plants in the three local governments areas, even though Faskari ($1.57/25\ m^2$ and $1.86/25\ m^2$ respectively) recorded the lowest incidence of spiders over other local governments areas, while Malumfashi ($1.94/25\ m^2$ and $2.02/25\ m^2$ respectively) recorded the highest incidence. While the combined result showed that cotton plants in Faskari ($1.71/25\ m^2$) and Kankara ($1.75/25\ m^2$) recorded lowest incidence and were similar ($P \geq 0.05$) and significantly lower than those recorded on cotton plants in Malumfashi ($1.98/25\ m^2$).

Figure 4. Showed the result of incidence of spiders recorded on cotton plants in 3 villages of each of the 3 local government areas surveyed. In the early-season of 2019 and combined result showed that the incidence of spiders on cotton plants in Sheme, Daudawa and Kadisau in Faskari local government, Dan mabu and Mararaban gundawa in Kankara local government, Burdugau and Kuka sheka in Malumfashi local government were similar ($P \geq 0.05$) and significantly lower ($P \leq 0.05$) than those recorded on cotton plants in Kankara, Kankara local government, Mararaban kankara and Kuka sheka in Malumfashi local government. While in early-season of 2020 the result showed there was no significant difference in the incidence of spiders on cotton plants in the villages.

In the mid-season of 2019 and mid-season of 2020 and their combined result showed there was no significant difference ($P \geq 0.05$) in the population of spiders among all the villages surveyed in the three (3) local government areas, even though Burdugau had the lowest incidence and Mararaban kankara had the highest incidence in the two seasons.

In late-season of 2019 and late-season of 2020 and their combined result showed there was no significant difference ($P \geq 0.05$) in the population of spiders among all the villages surveyed in the three (3) local government areas, even though Mararaban gundawa had the lowest incidence and Burdugau had the highest incidence in the two seasons.

Lady bird beetle (*Coccinella septempunctata*)
The result of the survey conducted early-season (June/July), mid-season (August) and late season (September) in 2019 and 2020 rainy seasons and the combined result is presented on Figure 5.

In the early-season, mid-season and late-season 2019 and early-season, mid-season and late-season 2020 and their combined results showed there was no significant difference (P≥0.05) in the population of lady bird beetles on cotton plants in the three Local Government areas surveyed. Even though cotton plants in Kankara and Malumfashi recorded the lowest (0.79/25 m^2 each) while Faskari recorded the highest number of Lady bird beetle (0.87/25m^2).

Figure 6 showed the result of incidence of lady bird beetle recorded in 3 villages in each of the 3 local governments surveyed. There was no significant difference (P≥0.05) in the number of lady bird beetle recorded on cotton plants in each of the villages surveyed in early-season, mid-season and late-season 2019 and 2020 rainy seasons.

Green lacewing (*Chrysoperla carnea*)
The result of the survey conducted early-season (June/July), mid-season (August) and Late season (September) in 2019 and 2020 rainy seasons and the combined results are presented on Figure 7.

The result showed there was no significant difference (P≥0.05) in the number of Green Lacewing recorded on cotton plants in each of the Local Governments surveyed in early-season, mid-season and late-season 2019 and early-season, mid-season and late-season 2020. Even though cotton plants in Malumfashi Local Government recorded the highest number of Green Lacewing (0.82/25 m^2).

Figure 8 showed the result of incidence of Green Lacewing recorded on cotton plants in 3 villages in each of the 3 local governments surveyed. There was no significant difference (P≥0.05) in the number of Green Lacewing recorded on cotton plants in each of the villages surveyed in early-season, mid-season and late-season 2019 and early-season, mid-season and late-season 2020. Even though cotton plants in Daudawa in Faskari Local Government, Kankara, Kankara Local Government, Mararaban kankara and Kuka sheka in Malumfashi Local Government recorded the highest number of Green lacewing (0.88/25 m^2 each).

Other arthropods found on cotton plant during the survey period in Faskari, Kankara and Malumfashi local governments in Katsina state are shown on Table 1.

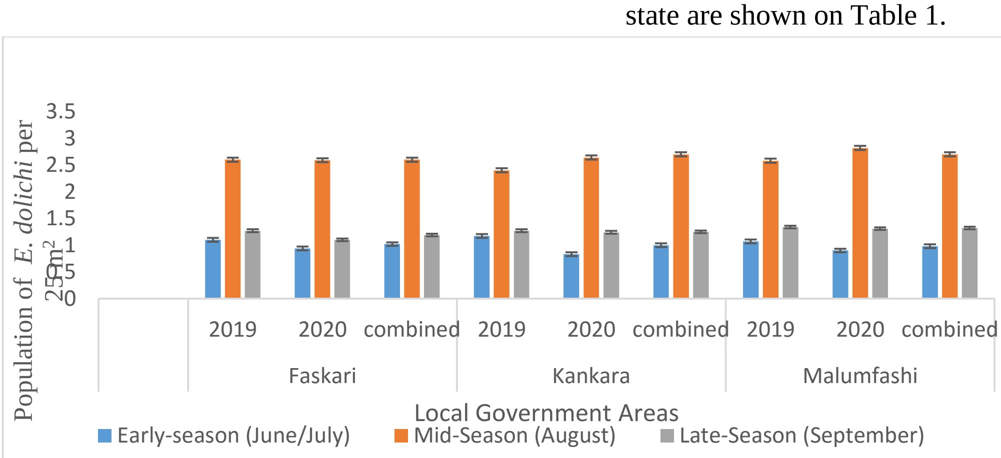

Figure 1: Incidence of *E. dolichi* in three (3) Local Government Areas in Katsina State.

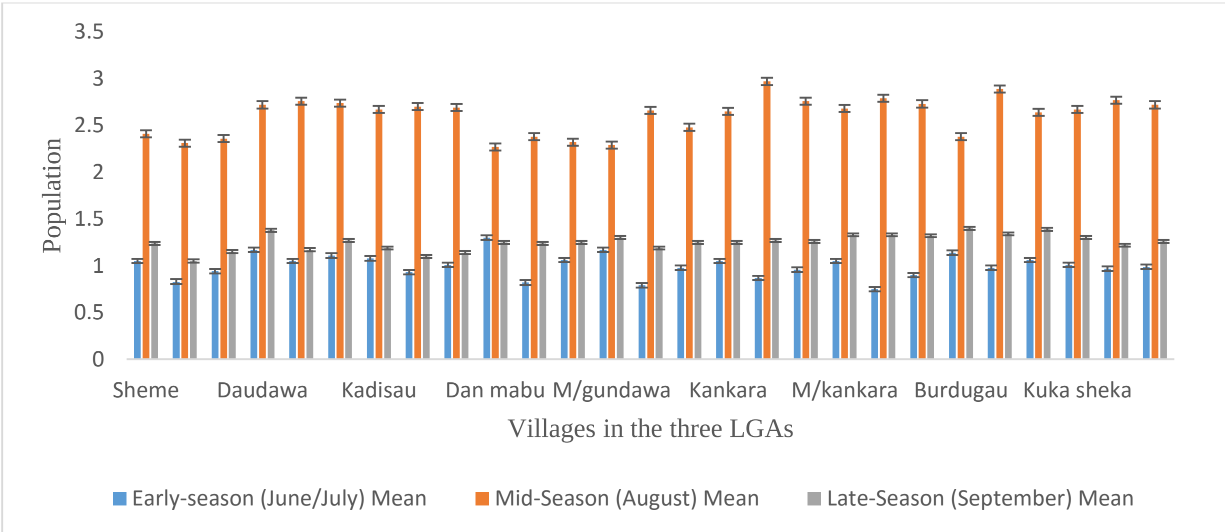

Figure 2: Mean population of *E. dolichi* on cotton plants in three LGAs in 2019 and 2020.

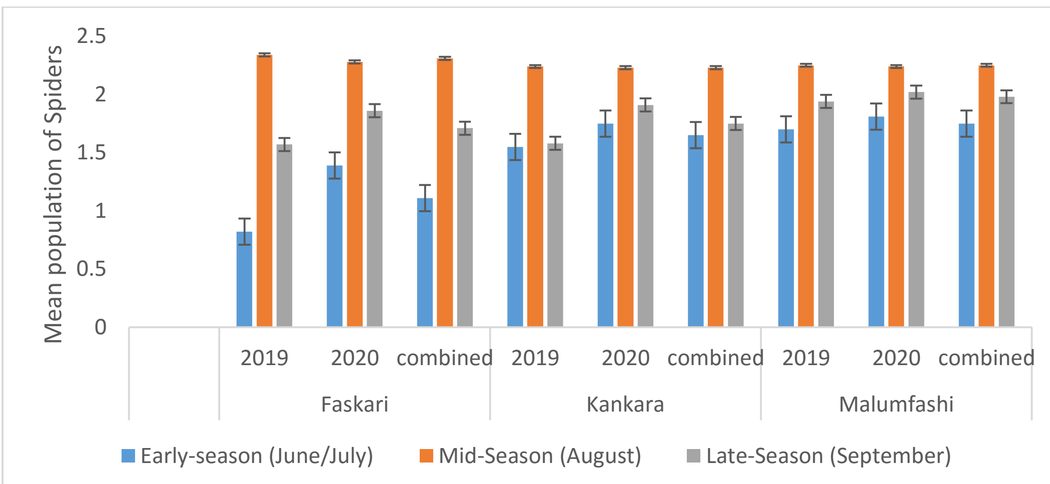

Figure 3: Incidence of Spiders (*Cheiracanthium aeculeatum* and *Lycosidae hogna*) in three (3) Local Government Areas in Katsina State.

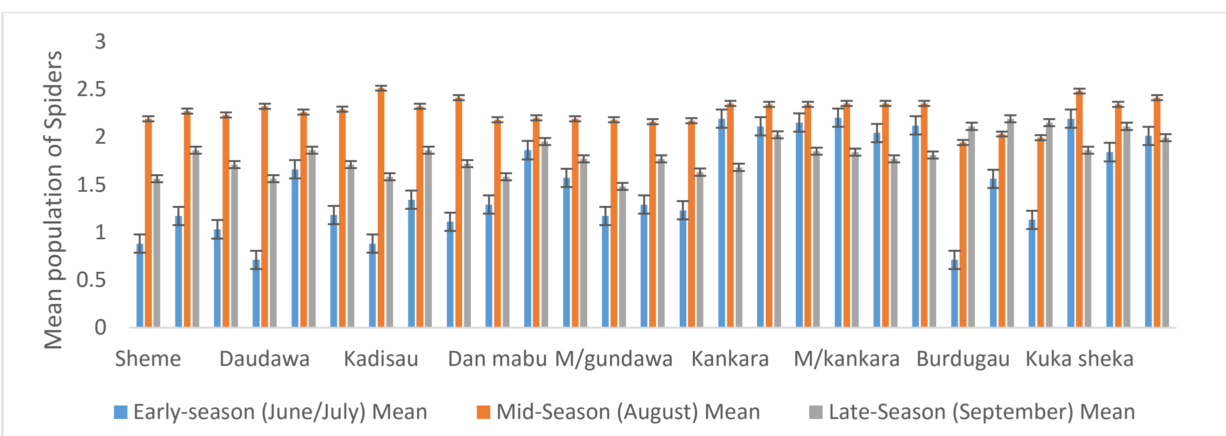

Figure 4: Mean population of Spiders (*Cheiracanthium aeculeatum* and *Lycosidae hogna*) on cotton plants in three LGAs in 2019 and 2020.

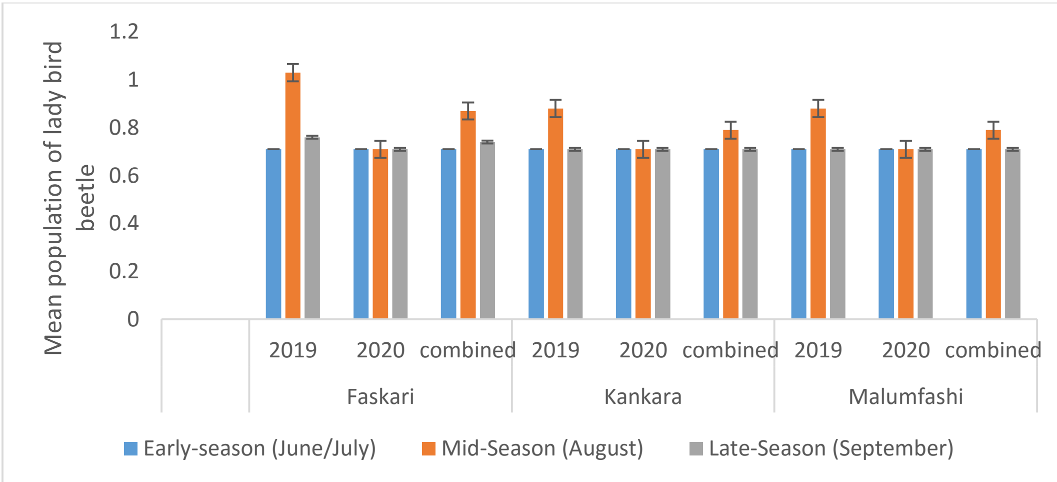

Figure 5: Incidence of Lady bird beetle (*Coccinella septempunctata*) in three (3) Local Government Areas in Katsina State.

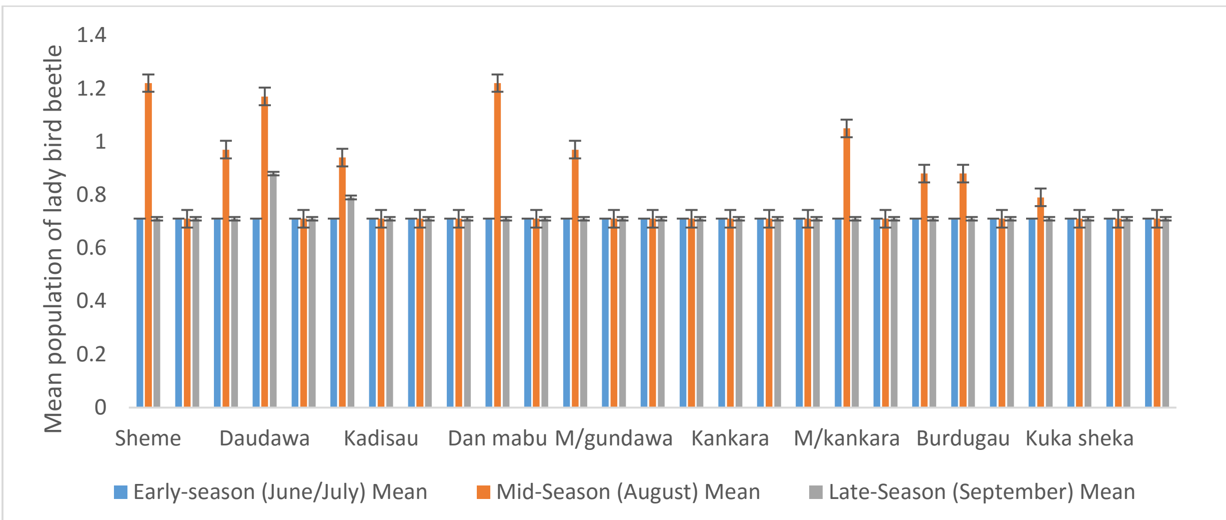

Figure 6: Mean population of Lady bird beetle (*Coccinella septempunctata*) on cotton plants in three LGAs in 2019 and 2020.

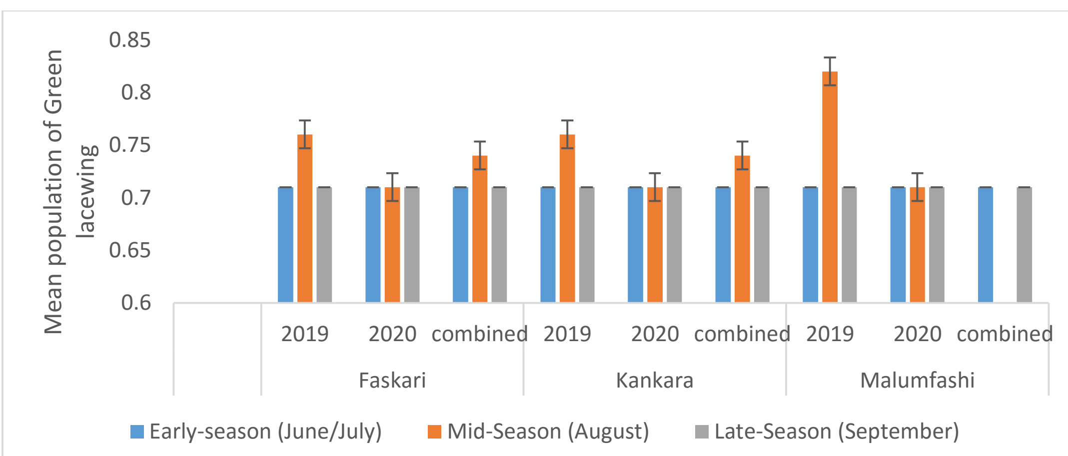

Figure 7: Incidence of Green lacewing (*Chrysoperla carnea*) in three (3) Local Government Areas of Katsina State

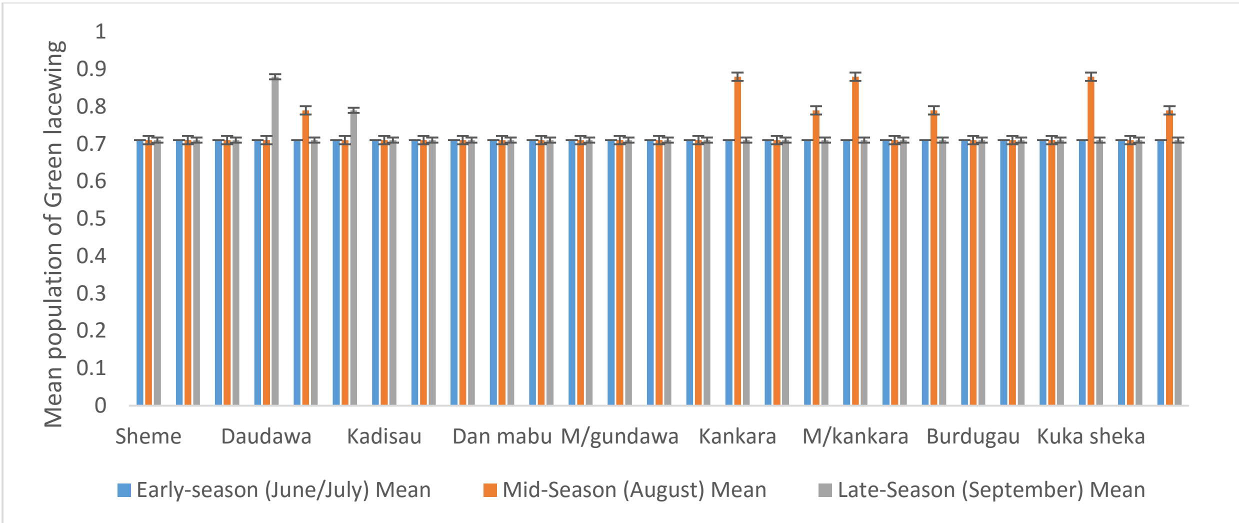

Figure 8: Mean population of Green lacewing (*Chrysoperla carnea*) on cotton plants in three LGAs in 2019 and 2020.

Table 1: List of arthropod recorded on cotton plant during the survey in 2019 and 2020

Order	Family	Genus	Specie
Coleoptera	Meloidae	*Hycleus*	*lugens* (Gyllenhaal, 1810)
Heteroptera	Coreidae	*Anoplocnemis*	*curvipes* (Fabricius, 1781)
Heteroptera	Coreidae	*Clavigralla*	*tomentosicollis* (Stal,1855)
Heteroptera	Pyrrhocoridae	*Dysdercus*	*volkerii* (Fallen, 1814)
Heteroptera	Alydidae	*Riptortus*	*Dentipes* (Stal, 1860)
Lepidoptera	Pyralidae	*Sylepta*	*derogata* (Fabricius, 1775)
Lepidoptera	Noctuidae	*Helicovepa*	*armigera* (Hubner, 1808)
Homoptera	Aleyrodidae	*Bemisia*	*tabaci* (Gennadius, 1889)

DISCUSSION.

Survey to Determine the Incidence of *E. dolichi* and its Predators.

From the result it can be concluded that the incidence and population build-up is determined by the phenological stage of cotton plant, and could also be determined by weather factors such as rainfall, relative humidity and temperature.

The observations for *E. dolichi* showed that in early-season (seedling stage of cotton plant) during the survey period low population density of *E. dolichi* was observed and high population was observed during the vegetative and pre-flowering stage. This showed that population of *E. dolichi* is higher on older cotton plants than on younger ones; decline in population was also observed in the reproductive stage when the leaves, petiole and stem become older and are not succulent for *E. dolichi* to feed on or lay their eggs, similar observations were reported by Solangi *et al*. (2008). The low population density of *E. dolichi* at the seedling stage might be that the individual that might have moved in from other host plant most breed first for their population to build-up, if the conditions necessary for their growth, development and reproduction are right. It might also be possible that at the seedling stage the canopy is not enough to protect them from predators and other adverse environmental conditions. Investigations have shown that *E. dolichi* was a major pest of cotton which infest cotton throughout the growing period (Gyi *et al*., 2015). This result agrees with that of Madar and Katti (2010) who reported that Jassid occur throughout growth period and indirect yield losses are incurred as a result of their attack.

The present study also showed that high population densities of *E. dolichi* were recorded on cotton plants in Faskari followed by Kankara then Malumfashi Local Government during the early stage of crop development in the months of June and July. At mid-season cotton plants in Malumfashi recorded highest population densities of *E. dolichi* followed by Faskari and Kankara local governments. These higher population densities were found and recorded during the vegetative and pre flowering stage of cotton in the months of August and September in these local government areas. Decline in population density was observed at the reproductive stages, where cotton plant in Faskari recorded the highest population densities of *E. dolichi* followed by Kankara then Malumfashi Local Government. The result was in accordance with Solangi *et al*. (2008), Majeed *et al*. (2016) and Arti *et al*. (2017) who reported that the population of sucking pest was recorded at maximum during the months of August and September, at the vegetative and early flowering stage when the leaves of cotton plants are juicy and succulent for the pest to feed on, and decreases as plant reaches maturity stage.

In the present study, Daudawa in Faskari Local Government had the highest population density of *E. dolichi* followed by Dan Mabu in Kankara Local Government, Burdugau in Malumfashi Local government then Kadisau in Faskari Local Government at the early crop stage development in the months of June to July (early-season). This may be attributed to favorable weather condition (conditions right for their growth and development). This is in line with other works which showed that *E. dolichi* attack cotton at all stages of growth (Madar and Katti 2010; Gyi *et al*., 2015). At mid-season Kanakara in Kankara Local Government had the highest population density of *E. dolichi* followed by Daudawa in Faskari Local Government then Mararaban kankara in Malumfashi Local Government. This may be attributed to synchronization of *E. dolichi* and vegetative and early flowering stage of cotton. This is in line with Bhattacharyya *et al*. (2019) who reported the peak activity of sucking pest in the month of August, this peak period remains up to middle of September at similar trend. The study was contrary to the report of Chaudhan *et al*. (2017) who obtained the peak period of sucking pest of cotton in the months of October to November. While at late-season the population of *E. dolichi* started to decline, during this periods Burdugau and Mararaban kankara in Malumfashi Local Government had the highest population of *E. dolichi* followed by Daudawa in Faskari Local Government then Dan mabu in Kankara Local Government. This declining in population of *E. dolichi* can be attributed to age of crop. This is in line with the work of Macharia *et al*. (2004) who reported that aphids tend to disappear as crops tend to head.

Continuous cropping was practiced by cotton farmers in the Local Government Areas surveyed. This might have caused migration of *E. dolichi* from one field to another to survive from one season to the next, favorable environmental conditions in these areas might have also contributed to the population build-up in all the three Local Governments surveyed.

Predators Survey.

In the Local Government Areas surveyed in Katsina State during the 2019 and 2020 rainy season, three types of predators were found. The predators were the Coccinellids beetle, spiders (Arachnida) and lacewing (Chrysopada spp). Spider occurring at low density beginning from early-season June/July and continue to late-season September/October. These general predators (lady bird beetle *Coccinella septempunctata*, Neuroptera; Green lacewings *Chrysoperla carnea* and Arachnoidea spiders) are also known to prey on cereal aphid in kenya (Macharia *et al.*, 2016).

The present study showed that cotton plants in Malumfashi had the highest mean population of spider in the early-season followed by Kankara then Faskari Local government. At mid-season cotton plants in Malumfashi had the highest mean population of spider followed by Kankara then Faskari Local government, while cotton plants in Faskari had the highest mean population of lady bird beetle followed by the other two local governments. Cotton plants in Malumfashi had the highest mean population of green lace wing followed by the other two Local Governments. At late season cotton plants in Malumfashi had the highest population mean of spider followed by Kankara then Faskari Local Government. This may be due to different weather conditions or the phenology of the cotton plants in the three Local Government Areas. Cotton plants in Faskari had the highest number of lady bird beetle followed by the other Local governments, green lace wing was not observed at late-season during the cotton growing period. This is supported by the work of Macharia *et al*. (2004) who reported that natural enemies occurred at different times during cropping season, but often when sucking pest population have passed damaging levels. The occurrence of the natural enemies at different times may be contributing to some control of sucking pest. The study indicated that lady bird beetle and green lacewing were only present at mid-season when *E. dolichi* must have bred and increased in their population, when damage to cotton crops had already taken place.

There was population increase of *E. dolichi* in cotton during vegetative and pre flowering stage, this can be attributed to absence of *E. dolichi* predators. This finding is supported by the work of Macharia *et al*. (2016) who reported that the absence of successful *E. dolichi* predators to cause rapid population increase of cereal aphid. Therefore, the study revealed the need for understanding seasonal variations in the population of *E. dolichi* and their natural enemies including the population dynamics, for development of an integrated pest management strategy.

CONCLUSION.

This study provides better understanding on the periods of natural incidence of *E. dolichi* in the survey areas. Incidence of *E. dolichi* was found throughout the growing season in all the survey areas. Its highest population was observed at the reproductive stage.

RECOMMENDATIONS.

- There is need for a better synergy with breeders to encourage development of resistant cultivars.
- There is need to enlighten farmers on population variations so that they can plan appropriate management measures.

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ANIMAL PRODUCTION

Journal of Applied Agricultural Research 2022, 10(2): 221-228
ISSN 2006-750X.

EFFECTS OF CASSAVA *(Manihot esculenta)* AND PLANTAIN *(Musa paradisiaca)* PEELS MIXTURE AS PARTIAL REPLACEMENT FOR MAIZE ON GROWTH PERFORMANCE AND NUTRIENT RETENTION OF BROILER CHICKENS

[1]Eleleh, O. J., [2]Kidda, D., [1]Oluwafemi, R. A., [1]Alagbe, J. O., [2]Egberuare, T.A and [1]Akintayo B.O
[1] Department of Animal Science Faculty of Agriculture University of Abuja, Nigeria
[2]Agricultural Research Council of Nigeria, P.M.B. 5026, Wuse-Abuja, Nigeria
Author's Contact: email:jessimeidaelele@gmail.com, Phone no. +2349061653428,

ABSTRACT.

The objective of this study was to determine the effects of cassava and plantain peels mixture (CPPM) as partial replacement for maize on the growth performance and nutrient retention of broiler chickens. Two hundred and twenty-five one-day-old broiler chicks (Abor Acre) were randomly allocated into five treatments with three replicates per treatment consisting of 15 birds each in a completely randomized design. Birds in treatment 1 (T1) were fed basal diet with 0 % inclusion of CPPM, while T2, T3, T4 and T5 were given 5 %, 10 %, 15 % and 20 % CPPM as replacement for maize respectively. Clean feed and water were offered *ad libitum* and all other management practices were strictly observed throughout the experiment which lasted for 56 days. Results obtained were used to determine weight gain (WG), average daily weight gain (ADWG), total feed intake (TFI), average daily feed intake (ADFI), feed conversion ratio (FCR), and nutrient retention. Results showed that no significant (P>0.05) effect was observed among birds for all the treatments. Growth performance increased as CPPM level increased across the treatments. Birds in T4 and T5 recorded high ADWG, T1 (27.25 %), T2 (27.57 %), T3 (27.78 %), T4 (29.86 %), and T5 (30.37 %) respectively. Nutrient utilization showed significant (P<0.05) difference among treatments, treatments with high inclusion level recorded better utilization of the nutrients compared to the control treatment, for DM retention, T1 (71.00 %), T2 (72.11 %), T3 (74.61 %), T4(73.18 %) T5 (85.60 %), for CP retention, T1 (54.56 %), T2 (51.08 %), T3 (55.45 %), T4 (57.10 %), T5 (59.10 %) respectively. Highest mortality was recorded in T1 (1.33 %) followed by T2 (1.00 %), T3 (0.66 %), T4 (1.00 %), while none was recorded in T5 (0 %). Based on this study, inclusion of cassava and plantain peels mixture up to 20 % in the diets of broilers supported their growth performance and nutrient digestibility.

Keywords: Broilers, Cassava peels, Plantain peels, Nutrient, Maize.

INTRODUCTION.

Agriculture continues to play significant roles in the livelihood and economic development of nations all over the world. Low animal protein intake among the resource is a major concern in developing countries including Nigeria. This could be attributed to the widening gap between demand and supply of food of animal origin. There is a need to develop livestock production strategies which will lead to improved production of high quality products such as meat, milk, and egg, using local resources. This is now more compelling especially in view of developing emergencies due to climate change and loss of biodiversity. Reducing feed imports by using local resources is one way of responding to these emergencies as intensive industrial-scale production of maize and soybean in the exporting countries is one of the factors contributing to loss of biodiversity (LRRD, 2019).

Availability of animal feed is one of the greatest constraints to the expansion of the livestock industry in Nigeria due to the increasing cost and decreasing supply of the conventional feed ingredient (Oloruntola, 2016). Maize is a commonly used ingredients in the diet of poultry to supply energy needs of poultry. According to USDA (2015), the price of maize increased by about 71% from September 2005 to September 2015. Also the cost of these ingredients in recent years has increased due mainly to global inflationary trends coupled with its industrial use for ethanol production, energy drinks, as starch for binding tablets and as staple food for people. This scenario has compelled research into alternative energy sources to replace part of maize in poultry diets. Exploring the nutritional potential of cheaper agro-industrial by-products such as cassava root wastes as feed ingredients for poultry continues to be the focus of animal scientists (Ogunsip, 2015). In Nigeria today, there are large number of non-conventional feed stuffs that are regarded as waste and also contributes to environmental nuisance, some of these feed stuffs include cassava peel and plantain peel. During processing of roots and fruits for food and industrial use, large quantities of peels are produced which are of low economic valve and may pose disposal problems in most producing regions. One of the way of utilizing peels efficiently is by incorporating it into poultry feed as ingredients. Incorporation of cassava waste into broilers feed will reduce the environmental pollution and the cost of finished feed. A study on the nutritional status of cassava peel shows that the protein content of the peel was 5.35%, cellulose 5.40% and hemicellulose 21.65%. It has low energy content, high fiber and high presence of anti-nutritional factors known as hydrocyanic acid (HCN). The level of the hydrocyanic acid can be reduced through the process of sun drying. Plantain peel is also one of the non-conventional feedstuff that are readily available and cheaper. Plantain peel are highly digested and is an excellent source of energy containing about 1300Kcal/kg, which compares favorably with maize expect in crude fiber and ether extract (Etuk, 2011). In addition, plantain peels also contain higher levels of mineral such as calcium, iron and phosphorus (Nsa, 2010). The use of plantain peel is limited because of the presence of tannin's, it exists in two form:" active and bound tannin's", the active impart strong bitter taste and the bound tannins are insoluble. Through sun drying process, this level is reduced (Dupiez and Leener, 2009). Nigeria is one of the largest plantain producing countries in the world; available data shows that Nigeria produced 2,103 million tons of plantain harvested from 389,000ha in the year 2004 (FAO, 2016).

MATERIALS AND METHODS.

Experimental Site.

This study was carried out at the University of Abuja teaching and research farm, main campus, Gwagwalada, Abuja. Gwagwalada is one of the six area council of the federal capital territory of Nigeria. It lies between latitude 8˚51′ and 9˚37′N longitude 007˚20′ and 007˚51'E and the land mass covers 65sq km, the weather generally warm, characterized by dry season which lies between November-April. Rainfall is moderate with annual total rainfall approximately 1100mm-1650mm with about

60% of the annual rainfall during the month of July, August and September.

Source and Processing of Test Ingredient.

The wastes material (cassava and plantain peels) were obtained from local cassava and plantain processing industries in Mararaba, Nassarawa State. It was identified and authenticated at the laboratory, University of Abuja, Nigeria. It was air sundried for 13 days, milled and stored in an air tight container for further analysis.

Experimental Animals and their Management.

Two hundred and twenty-five unsexed one-day- old (Arbor acre) broiler chicks were purchased from a commercial hatchery in Ibadan and were randomly allotted into five dietary treatments, each treatment was replicated thrice with fifteen (15) birds in a completely randomized design. Anti-stress was administered on arrival. All routine such as provision of water, light, feed and ventilation was provided for proper growth and development of the broiler chickens. The cage was disinfected using a disinfectant (Izal) before the arrival of the chicks in other to kill microorganisms. Vaccinations were administered based on the prevailing disease in the environment. Fresh feed and water was supplied *ad libitum.* The experiment last for eight weeks and all other management practices were strictly observed.

Experimental Diet.

Five experimental diets were formulated with CPPM replacing maize at 0%, 5%, 10%, 15%, 20% as presented in Table 1 and 2 respectively.

Performance Characteristics.

Feed intake (g) was determined by subtracting feed left over from feed served, it was estimated for each of the replicate daily.

Weight gain (g) was calculated by finding the difference between initial weight and final weight at the end of the experiment.

Average daily weight gain (ADWG) = Final body weight – Initial body weight

Total days of the experiment

Average total feed intake (ADFI) = Feed intake

Total days of the experiment

Nutrient retention.

At the end of the feeding trail, two birds per replicate were kept in the metabolic cages for seven days to measure nutrient digestibility by total feacal collection method. Three days' acclimation period was allowed to enable the chickens adapt to the feed offered *ad libitum*. Feed intake was measured during the last four days and all excreta were collected and dried daily. Daily feacal collection was weighed and dried to constant weight at 65ºC for 48h. At the end of the metabolic trail, the dried feaces from each treatment was pooled and ground to obtain homogeneous feacal samples. The representative dried feacal samples were analyzed for crude protein, crude fiber, ash, ether extract according to standard procedures of AOAC (2015).

Statistical Analysis.

All data were subjected to one -way analysis of variance (ANOVA) using SPSS (23.0) and significant means were separated using Duncan multiple range tests of the same software. Significant was declared if ($P \leq 0.05$).

RESULTS.

Proximate Composition of Sun Dried Cassava Peel Meal

Proximate composition of sun dried cassava meal is presented in Table. 3 the proximate composition contains moisture, crude fibre, crude protein, ether extract, ash and energy at 14.88 %, 6.11 %, 1.12 %, 1.56 %, 17.22 % and 3080.6 Kcal/kg.

Table 1 Gross composition of the experimental diet (%) for broiler starter.

Ingredients	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	T5 (20%)
Maize	50	47.5	45	42.5	40
CP+PPM	-	2.5	5	7.5	10
Soya bean	25	25	25	25	25
GNC	7.8	7.8	7.8	7.8	7.8
Fish meal	1.0	1.0	1.0	1.0	1.0
PKC	4.30	4.30	4.30	4.30	4.30
Bone meal	6.0	6.0	6.0	6.0	6.0
Limestone	3.0	3.0	3.0	3.0	3.0
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20
*Premix	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated analysis					
CP	23.8	23.5	23.3	28.8	22.5
ME:Kcal/kg	3200	3102	3004	2906	2808
EE (%)	5.91	5.80	5.69	5.58	5.47
CF (%)	3.88	3.81	3.75	3.69	3.62
Ca (%)	1.17	1.17	1.17	1.16	1.16
Avail P (%)	0.65	0.65	0.64	0.64	0.64

* Premix supplied per kg diet :- Vit A, 7,000 I.U; Vit E, 5mg; Vit D3, 3000I.U, Vit K, 3mg; Vit B2, 5.5mg; Niacin, 25mg ; Vit B12, 16mg ; Choline chloride, 120mg ; Mn, 5.2mg ; Zn, 25mg ; Cu, 2.6g ; Folic acid, 2mg ; Fe, 5g ; Pantothenic acid, 10mg ; Biotin, 30.5g ; Antioxidant, 56mg

Table 2 Gross composition of the experimental diet (%) for the broiler finisher

Ingredients	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	T5 (20%)
Maize	52.00	49.50	47.0	44.5	42
CP+PPM	-	2.5	5	7.5	10
BDG	5.00	5.00	5.00	5.00	5.00
GNC	10.00	10.00	10.00	10.00	10.00
Fish meal	3.20	3.20	3.20	3.20	3.20
SBM	19.00	19.00	19.00	19.00	19.00
Bone meal	6.50	6.50	6.50	6.50	6.50
Limestone	3.30	3.30	3.30	3.30	3.30
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20	0.20
Premix	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated analysis					
%CP	20.33	23.5	23.3	23.0	22.8
ME:Kcal/kg	3200	3102	3004	2906	2808
EE (%)	5.91	5.80	5.69	5.58	5.47
CF (%)	3.88	3.81	3.75	3.69	3.62
Ca (%)	1.17	1.17	1.17	1.16	1.16
Avail P (%)	0.65	0.65	0.64	0.64	0.64

* Premix supplied per kg diet :- Vit A, 7,000 I.U; Vit E, 5mg; Vit D3, 3000I.U, Vit K, 3mg; Vit B2, 5.5mg; Niacin, 25mg ; Vit B12, 16mg ; Choline chloride, 120mg ; Mn, 5.2mg ; Zn, 25mg ; Cu, 2.6g ; Folic acid, 2mg ; Fe, 5g ; Pantothenic acid, 10mg ; Biotin, 30.5g ; Antioxidant, 56mg

Proximate Composition of Sun Dried Plantain Peel Meal.

Table 4. Reveals the proximate composition of dried plantain peel. The sample contains moisture (12.08 %), crude fibre (7.70 %), crude protein (4.71 %), ether extract (1.55 %), ash (12.51 %), energy (2900.1 %).

Growth Performance of broiler chickens fed varying dietary levels of cassava and plantain peel.

The effects of partial replacement of cassava and plantain peel mixture on growth performance of broiler chickens is presented in Table 5. Initial body weight (IBW), Final body weight (FBW), weight gain (WG), total feed intake (TFI), average daily weight gain (ADWG), average daily feed intake (ADFI), feed conversion ratio (FCR) and mortality (MOT) range between 40.87 - 40.94g , 1566.66 - 1718.33 g, 1525.72- 1700.78 g, 4159.00 - 4385.66 g, 27.24 - 30.37 g,74.26 - 78.31 g, 2.49 - 2.92 g, 0.66-1.33 g respectively. FBW and ADWG was highest in T5, though not at a significant level (P>0.05).

Analyzed Nutrient Composition of Experimental Diet.

The analyzed nutrient composition of the experimental diet is shown in Table 6. The samples for each treatment had energy (Kcal/kg): 3100.8 (%), 3102.8 (%), 3100.6 (%), 3100.2 (%), and 3100.1 (%), representing T1, T2, T3, T4 and T5 respectively. Crude fiber: 4.01 (%), 4.72 (%), 4.88 (%), 4.96 (%), and 5.00 (%), representing T1, T2, T3, T4 and T5 respectively. Crude protein: 21.67 (%), 21.87 (%), 21.50 (%), 20.55 (%), and 20.42 (%), representing T1, T2, T3, T4 and T5 respectively. Ether extract: 5.22 (%), 4.72 (%), 4.22 (%), 4.06 (%), and 4.00 (%), representing T1, T2, T3, T4 and T5 respectively. Phosphorus: 0.87 (%), 0.86 (%), 0.83(%), 0.85 (%), and 0.85 (%), representing T1, T2, T3, T4 and T5 respectively. Calcium: 1.53 (%), 1.61 (%), 1.60 (%), 1.60 (%), and 1.61 (%), representing T1, T2, T3, T4 and T5 respectively.

Nutrient Retention of Broiler Chickens Fed With Cassava and Plantain Peels Mixture.

The nutrient retention of broiler chickens fed cassava and plantain peels mixture at 0 %, 5 %, 10 %, 15 %, and 20 % respectively are as shown in Table 7. The dry matter as well as crude fiber increased as the inclusion level increases in the feed, though at a significant (P< 0.5) level. Also, crude protein and ether extract increased as the inclusion level increases in the feed. However, nitrogen free extract reduced as the inclusion level increases in the feed.

DISCUSSION.

The result from this study showed that feeding broiler chickens with cassava and plantain peels mixture as partial maize replacement in diet had beneficial effects on body weight gain and nutrient retention. The proximate components meet the nutritional needs of birds according to NRC (2002). The crude fibre and ether extract range also conforms to the report of Teodora *et al*. (2020) in feeding broilers *Hermetia illucens* meal. The calcium (0.98 – 1.10 %) and phosphorus (0.47 – 0.51 %) range in the experimental diet is in line with the reports of Fascina *et al.* (2017); Aduk (2004). Proper feeding is one of the key cardinals of management in livestock production, for animals to perform at their optimum, there is need to furnish them with proper balanced diet which contains all the necessary nutrients (Alagbe and Oluwafemi, 2019). The proximate composition of plantain peels used in this experiment was contrary to the findings of Raymond and Fredrick (2015). These variations could be attributed to differences in processing methods, varieties, stage of growth of the plant as well as anti-nutrients. ADWG and ADFI were not significantly (*P*>0.05) influenced by the dietary inclusion of CPPM. ADFI increased across the treatments though not at a significant (*P*>0.05) level. The result obtained in this study is in agreement with Abubakar and Ohiaege (2011). The increase in the average body weight, feed consumption recorded in birds fed 20 % sun dried cassava and plantain peel is due to the presence of phytochemicals which has been reported to improve palability and flavor of feed (Oluwafemi et al., 2020). Similar reports were recorded by Iheukwumere (2007) who reported that phytochemicals are capable of reducing the entry of pathogenic bacteria in animals, this is reflected on the mortality recorded ($P<0.05$).

Table 7. Shows the result of the nutrient retention. From the result, T1, T2, T3 and T4 were similar ($P<0.5$) for dry matter retention. However, those in T5 recorded significantly ($P<0.5$) different dry matter retention and also having the best retention. CP and CF followed similar pattern with the DM, while EE and NFE followed same pattern, T2 and T4 recorded highest valve respectively. The highest values of weight gain and nutrient retention in T4 and T5 indicated that there was a better utilization of nutrients. This present study cassava and plantain peels mixture (CPPM), showed that the combination have positive impact on the nutrient utilization.

CONCLUSION AND RECOMMENDATIONS.

The increasing cost of conventional ingredients for poultry production is negatively impacting on the gross margin and the affordability of the resultant products. Therefore, the quest for the utilization of cheaper non-conventional alternatives to conventional ingredients still remains a valid objective in poultry production. The results of this study showed that the use of cassava and plantain peels mixture can replace maize up to 20% inclusion level without affecting the feed intake, body weight gain, and nutrient retention. Incorporation of enzymes could further enhance digestibility

Table 3 Proximate composition of sun dried cassava peel.

Parameters	% Composition
Moisture	14.88
Crude fiber	6.11
Crude protein	1.56
Ether extract	1.12
Ash	17.22
Energy (Kcal/kg)	3080.6

T able 4. Proximate composition of sun dried plantain peel.

Parameters	% Composition
Moisture	12.08
Crude fiber	7.70
Crude Protein	4.71
Ether Extract	1.55
Ash	12.51
Energy	2900.1

Table 5. Effect of cassava and plantain peel on growth performance of the broiler chicks

Parameter	T1 0%	T2 5%	T3 10%	T4 15%	T5 20%	SEM
IBW(g)	40.94	40.94	40.88	40.87	40.94	0.01
FBW (g)	1566.66	1585.00	1596.66	1718.33	1723.33	10.2
WG (g)	1525.27	1544.05	1555.78	1672.46	1700.78	9.33
TFI (g)	4162.33	4385.66	4385.66	4309.00	4159.00	7.01
ADWG (g)	27.24	27.57	27.78	29.86	30.37	0.01
ADFI (g)	74.32	78.31	78.31	76.94	76.96	0.03
FCR	2.76	2.92	2.93	2.60	2.49	0.01
MOT	1.33	1.000	0.66	1.00	0.00	0.01

IBW: Initial body weight; FBW: final body weight; FWG: final weight gain; ADWG: Average daily weight gain; TFI: total feed intake; ADFI: Average daily feed intake; FCR: feed conversion ratio; SEM: Standard error of mean

Table 6. Analyzed nutrient composition of experimental diet

Parameter	T1	T2	T3	T4	T5
Crude protein (%)	21.67	21.87	21.50	20.55	20.42
Crude fiber (%)	4.01	4.72	4.88	4.96	5.00
Ether extract (%)	5.22	4.72	4.22	4.06	4.00
Calcium (%)	1.53	1.61	1.60	1.60	1.61
Phosphorus (%)	0.87	0.86	0.83	0.85	0.85
Energy (Kcal/kg)	3100.8	3102.8	3100.6	3100.2	3100.1

Table 7. Nutrient retention of broiler chicken

Parameter (%)	T1	T2	T3	T4	T5	SEM
Dry matter	71.00	72.11	74.61	73.18	85.60	5.02
Crude fibre	49.26	53.91	52.10	54.13	60.22	3.58
Crude protein	54.56	51.08	55.45	57.10	59.10	3.11
Ether extract	41.27	47.23	40.67	41.56	46.34	3.02
NFE	77.22	76.11	75.12^{c}	78.37	70.34	5.77

Means in the same row with same superscripts are significantly difference (P<0.05)
SEM= Standard error of means
NFE= Nitrogen Free Extract

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Journal of Applied Agricultural Research 2022, 10(2): 229-239
ISSN 2006-750X.

BIOSECURITY MEASURES ADOPTED BY POULTRY FARMERS IN RIVERS STATE, NIGERIA

Okafor, B. B. and Tasie, C. M.
Department of Agricultural Science, Faculty of Vocational and Technical Education
Ignatius Ajuru University of Education, Rumuolumeni, Port Harcourt, Rivers State, Nigeria
Author's Contact: tasiechimezie@gmail.com; chimezie.tasie@iaue.edu.ng

ABSTRACT.

This study ascertained the biosecurity measures adopted by poultry farmers in Rivers State, Nigeria. The objectives of the study were to: ascertain the socio - economic characteristics of poultry farmers; identify sources of information on biosecurity measures; ascertain biosecurity measures adopted by poultry farmers; determine factors influencing adoption of biosecurity practices used. A survey research design was employed and multistage sampling technique was used to select ninety (90) poultry farmers for the study. Descriptive statistics and binary logistic regression analysis were used to analyse data and present results for the study. The mean age of respondents was 44 years while farming experience was 16 years. All the respondents had formal education. The majority of the farmers mainly sourced biosecurity information from farmers association or co-poultry farmers (94.4%) and veterinary officers (83.3%). Major bio-security measures used by farmers include: Washing of hands before and after handling poultry birds/products, providing foot-dip with disinfectant, Separation of birds according to age, Proper washing and disinfection of feeding/water troughs, Ensure adequate ventilation for the birds, isolation and quarantine of sick and infected birds etc. Age, cooperative membership, experience in poultry farming, training, farm size, education and access to credit significantly influenced the adoption of biosecurity practices in the study area. Any increase in the level of these variables would increase the level of adoption of biosecurity practices for disease prevention and control in the study area. Based on the findings of the this study, it is recommended that aggressive sensitization of the poultry farmers through seminars, workshops and conferences by relevant authorities on the advantages of adoption of biosecurity measures in their farms and encouraging fellow farmers to do so.

Key words: Adoption, biosecurity measures, poultry farmers, practice, disease outbreak.

INTRODUCTION.

The poultry industry in Nigeria is made up of about 180 million birds and accounts for the second largest chicken population in Africa after South Africa (SAHEL, 2015); producing 650 000 tonnes of eggs and 300 000 tonnes of poultry meat (Central Bank of Nigeria (CBN), 2019 and FAOSTAT, 2017). The Central Bank of Nigeria (CBN, 2019) says the poultry sub-sector is the most commercialized of all Nigeria's agricultural sub-sectors with a current net worth of N1.6 trillion and the sub-sector contributes about

25% of agricultural gross domestic product (GDP) to the Nigerian economy. Poultry production is an important source of animal protein, income generation, employment, industrial raw materials, manure and financial security. Poultry include chicken, turkey, guinea fowl, pigeon, ostriches, quail, peafowl, duck and goose. Poultry refers to chickens kept for the purpose of meat and eggs. Poultry production outnumbers all other forms of livestock production in Nigeria and it thrives well in any part of the country (FAO, 2018). In spite of these important contributions of the poultry industry, Nigerian poultry sector faces high production costs and biosecurity concerns due to inadequate sanitary controls and technical constraints in production, processing and marketing.

The recurrent global disease outbreak in poultry production has made the practice of biosecurity a very essential practice to protect and prevent the poultry birds from intentional and unintentional threat of any disease producing agents on the farms. Alalade *et al*., (2018) defined biosecurity as measures and methods designed and adopted to prevent disease transmission in a poultry farm for improved profitability.

Biosecurity measures in poultry production involve isolation, traffic controlling and sanitation. Isolation means the practice of separating birds from sources of infection. Isolation according to (FAO, 2008) is the practice of keeping different bird species separately, preventing birds from having contact with potential sources of diseases, avoidance of mixing new birds from markets or neighbours with older flocks, quarantining those new birds for some time before joining them to the older flock, quarantining any bird that has gone out for sale or returned from exhibition to join back into the same bird house and preventing wild bird from having contact with the flocks. These are called bio-exclusion and bio-containment that limits the spread of diseases (Kasiiti, 2007). Bio-exclusion is a measure taken to minimize the risk of introduction of pathogens into individual unit of production, while bio-containment is the practices implored to mitigate the spread of diseases agent outside the facility. Traffic Control in poultry production involves provision of fencing, doors and locking of gates, control of human and vehicle within and into the farm, notifying the visitors that flock areas are out of bound for people, control of the movement of machines, animals, equipment and products to and fro the farm (Musiime, 2005). Sanitation can be achieved through effective cleaning, sterilization and disinfection. Sterilization is the act of destruction of all vegetative and spores of microorganisms especially bacteria, fungi, and virus that are highly resistant (Musiimi, 2005). Disinfection is the act of destruction of pathogenic organisms using agro-chemicals called disinfectants. On the other hand, sanitation practically reduces the amount of pathogenic organism and reduces quantity of contaminating organisms to its minimum level such that they pose no disease threat to birds through the practice of regular cleaning of equipment, washing of protective clothing and maintaining personal hygiene that will lead to destruction of disease organisms. It includes hand sanitizing, wearing of clothing exclusively made for the chicken house, using personal protective equipment like overalls, boots, and headwear. Cleaning, disinfection of vehicle, houses and equipment, fumigation of poultry house, frequent washing of hands and feet before and after handling poultry materials (Nyaga 2007). Disinfectants are chemicals that are used for disinfection on inanimate objects only while antiseptic is mild form of disinfectant that is used externally on living tissues to destroy the activities of microorganisms. Sainsbury (2009) reported that limiting diseases spread in poultry farm, involves implementation of effective biosecurity that has a comprehensive range of clear procedure aiming at minimizing the possibility of introduction of undesired pathogen into the poultry production area.

Diseases remain one of the major threats to boosting poultry production in Nigeria (Adewole, 2012). Poultry production enterprises are faced with myriads of diseases problems like Newcastle disease, avian influenza, avian pox, etc. (Usman and Diarra, 2008). Famous among the diseases distressing poultry enterprise in Nigeria is unending outbreaks Newcastle disease (Adene and Oguntade, 2006). Poultry farmers all over the world face endemic disease challenges that threaten poultry health, welfare and the profitability of the poultry enterprise. These diseases can have a substantial economic impact on individual enterprises and on the poultry industry as a whole (Wierup, 2012). The incessant outbreak of diseases in the poultry industry have made the practice of biosecurity an essential practice to protect the poultry industry from bio-risks and threats from any disease producing agents and the prevention and control of these diseases depends on the adoption of biosecurity and best management practices. Therefore, the problem of this study is that operators of poultry enterprise in the study areas are suffering huge losses due to diseases and this has resulted to complete crumble and failure of poultry business in the area. Therefore, it is on this basis that this work was designed to ascertain the level of adoption of biosecurity measures by poultry farmers in Rivers State and the factors influencing the use of biosecurity measures in the State.

METHODOLOGY.

The Study was conducted in Rivers State. The State is made up of 23 Local Government Areas. The state has a population of 5,185,400 people (NPC, 2006) and is located on latitudes 4^{o} 45' North and longitudes 6^{o} 51' East of the equator (RSADP, 2014). Rivers State is bounded on the South by the Atlantic Ocean, to the North by Imo and Abia States, to the East by Akwa Ibom State and to the West by Bayelsa and Delta States (RSADP, 2014**)**. The inland part of the state consists of tropical rainforests and towards the coast the typical Niger Delta environment featuring many mangrove swamps (RSADP, 2009). Agriculture is the primary occupation of the people of Rivers State. Temperature range is between 23-31ºC and vegetation found in the State includes the saline water swamp, Mangrove swamp and the rain forest.

The people in the state are predominantly farmers who engage in food production, livestock production and artisanal fisheries. There are principally three agricultural zones in the state (RSADP, 2014 and Iyagba, 2013). The three Agricultural zones in the state with the accompanying Local Government Areas are as follows:

Survey research design was adopted for the study. The study population consist of all poultry farmers in Rivers State. Multistage sampling technique was adopted for the study. From the three (3) agricultural zones in Rivers State, two (2) Local Government Areas were randomly selected from each of the zones which gave a total number of six (6) L.G.As. Viz: Obio/Akpor, Oyigbo, Degema, Andoni, Emohua and Etche Local Government Areas. A total of 15 poultry farmers were randomly selected from each of the Local Government Areas based on the list of poultry farmers obtained from the State Fadama programme office, which gave rise to ninety (90) poultry farmers used for the study. Both primary and secondary data were used for the study. Primary data were collected with the help of structured questionnaire. Data collected were on socio – economic characteristics of the respondents such as sex, age, educational qualification, farming experience, type of poultry system used and on the individual farmers' awareness and adoption of biosecurity measures.

Both descriptive statistics and binary logistic regression model were used to achieve the stated objectives. The binary logistic regression model is implicitly stated as follows.

$Y = Ln (P/1 – P) =$

$Y = f (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11})$

The functional form is expressed in explicit form as:

$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + \ldots\ldots.. U$

Where:

Y = Dependent binary variable (Adoption of biosecurity measures = 1, Non- adoption = 0)

X_1 = Age (years)

X_2 = Sex (male = 1, female = 0)

X_3 = Marital Status (married = 1, single = 0)

X_4 = Household size (number of persons in the household)

X_5 = Cooperative membership (member = 1, not a member = 0)

X_6 = Poultry experience (number of years in poultry production)

X_7 = Access to training (number of times)

X_8 = Flock size (number of birds)

X_9 = Education (number of years in spent in school)

X_{10} = Extension contact (number of visit)

X_{11} = Credit access (savings = 1, credit access = 0)

b_0 = Constant

$b_1 – b_{11}$ = Regression coefficients

$X_1 – X_{11}$ = Independent variables

Ln = Logarithm

P = Probability of Adoption

RESULTS AND DISCUSSION.

Socio-economic Characteristics of Poultry Farmers in Rivers State.

Table 1 showed the socio-economic characteristics of the poultry farmers in Rivers State. The Table showed that males (62.2%) dominated poultry business in the study area. The reason for this could be that poultry farming is labour intensive and so discourage women from engaging in it. This finding supports earlier findings of Tasie *et al.*, (2020) in Imo State, Alalade *et al*. (2018) in Kwara State who reported in their separate studies that poultry farming is dominated by the male folk. Most of the respondents (44.4%) were between the ages of 41 – 50 years and the mean age of respondents was 44 years

Table 1: The Agricultural Zone in Rivers State

Zones	LGAs	Headquarters.
Zone 1	Eleme, Gokana, khana, Tai, Obio/Akpor, Port Harcourt, Oyigbo, Ogu/Bolo	Bori
Zone 2	Degema, Abua/Odual, Bonny, Andoni, Asari-Toru, Akuku-Toru, Opobo/Nkoro, Okrika.	Andoni
Zone 3	Ikwerre, Emohua, Ahoada East, Ahoada West, Ogba/Egbema/Ndoni, Omuma, Etche	Omuma

Source: RSADP, 2014 and Iyagba, 2013

Table 1: Socio - economic characteristics of poultry farmers

Variables	Freq.	%	Mean
Sex			
Male	56	62.2	
Female	34	37.8	
Total	**90**	**100.0**	
Age			
21 - 30	11	12.2	
31 – 40	13	14.4	44
41 – 50	40	44.4	
51 – 60	18	20.0	
61 - 70	8	8.9	
Total	**90**	**100.0**	
Marital Status			
Single	17	18.9	
Married	58	64.4	
Widow	15	16.7	
Total	**90**	**100.0**	
Level of Educational (Years)			
Primary Education	13	14.4	
Secondary Education	24	26.7	
Tertiary Education	53	58.9	
Total	**90**	**100.0**	
Household Size			
1 – 5	20	22.2	
6 – 10	60	66.7	7
11 – 15	10	11.1	
Total	**90**	**100.0**	
Farming Experience (Years)			
1 - 10	15	16.7	
11 – 20	47	52.2	16
21 – 30	18	20.0	
31 – 40	10	11.1	
Total	**90**	**100.0**	
Cooperative Participation			
Yes	51	56.7	
No	39	43.3	
Total	**90**	**100.0**	
Access to Credit			
Yes	43	47.8	
No	47	52.2	
Total	**90**	**100.0**	
Enterprise Objective			
Commercial	60	66.7	
Family Consumption	6	6.67	
Both	24	6.7	
Total	**90**	**100**	
Flock Size			
1 - 200	53	58.9	
201 – 400	26	26.9	252
401 – 600	7	7.8	
601 – 800	4	4.4	
Total	**90**	**100.0**	
Poultry Management System			
Deep litter system	41	45.6	
Battery cage system	28	31.1	
Both	21	23.3	
Total	**90**	**100.0**	
Training in poultry production			
Yes	58	64.4	
No	32	35.5	
Total	**90**	**100.0**	
Extension visits			
Yes	10	11.1	
No	80	88.9	
Total	**90**	**100.0**	

Source: Field Survey, 2019

The respondents are mainly middle aged farmers who are still active, productive and vibrant and are more likely to adopt innovations faster than others in the other age brackets. Poultry farming is labour intensive and requires younger farmers who can cope with the tedious and rigorous biosecurity practices including disease management. This finding is in consonant with Tasie *et al., (2020) and* Ibekwe *et al. (2015).*

The study revealed that majority (64.4%) of the poultry farmers in the State are married. This means they have family responsibilities and should be committed to the biosecurity practices of their poultry enterprises so as not to reduce their farm income and profits. The table further showed that majority (58.9 %) of the respondents were well educated and are more likely to adopt innovations and biosecurity measures faster than others. High educational attainment is very essential, since practice of biosecurity and disease management requires some level of literacy and technical knowledge and also education enhances the farmers' productivity, accountability and profitability of the farm business. This finding is in agreement with Eze et al. (2017) and Ibekwe et al. (2015).

The result showed also, that the average household size is seven (7) persons. The average household size of the respondents is above national average of 5 persons in Nigeria (NBS, 2009). This large household size implies available labour for the poultry farm. The mean poultry farming experience of farmers in the study area is 16 years. This number is quite reasonable for any significant biosecurity improvement and achievement by the respondents in the study. The survey result as presented in Table 1 also showed that majority of the poultry farmers (56.7%) in the study area belong to cooperative groups. Poultry farmers use the opportunity of being members of cooperative groups to interact and obtain information on how to improve the biosecurity of their farms. According to Ekong (2010), association with cooperative groups helps farmers to satisfy their innate need of solving their problems through collective efforts. Table 1 show also that about 53.3 % of the respondents have no access to farm credit; this may be due to the fact that they are rarely considered as credit worthy because they have no collateral (Yisehak, 2008). The farmers that have access to credit may be due their membership of cooperative groups.

Table 1 further showed that most (66.7%) of the respondents have their enterprise objective as profit making (commercial). With profit motive as their enterprise objective, the poultry farmers would do everything possible to get information and practice biosecurity measures that would help them maximize their profit. This finding is agreement with Maduka, Igbokwe and Atsanda (2016). All the respondents surveyed keep less than 1000 birds in their farms and the mean flock size was 252 birds in the study area. This showed that poultry farmers in Rivers State are micro and small scale poultry farmers. This finding is in line with Agbola (2014).

The result also showed that most (45.6%) of the respondents use deep litter system of poultry management. In the deep litter system, poultry birds have direct contact with their faecal matter. This implies high risk of infection and disease, which will result in high medication costs, increasing the overall cost of production Eze *et al*. (2017). In the battery cage system, the poultry droppings fall on the floor beneath the cages so the poultry birds have no contact with their faecal matter. This helps to reduce health risks and expenditure on drugs (Ayadole, 2016). Table 1 additionally, showed that majority (64.4.7%) of the poultry farmers had training in Livestock production. Also majority (88.9%) of the respondents did not receive any agricultural extension visit/services for the past two years.

Sources of information on biosecurity measures adopted by poultry farmers Rivers State.

Table 2 shows the sources of information on biosecurity measures adopted by poultry farmers in Rivers State. The result showed that farmers association ranked 1st (94.4%) as a source of information on biosecurity measures. Veterinary officers ranked 2nd. Internet and researchers ranked 3rd and 4th as sources of information on biosecurity. Other sources of information on poultry biosecurity practices were news media (5th), books/magazines (6th), seminar/workshops (7th), family and friends (8th), extension workers (9th), ministry of agriculture (10th) and feed and drug sellers (11th). Table 2 shows that poultry farmers in the study area have access to information on biosecurity practices from various sources. Correct and adequate information enhances a farmer's ability to make sound decision on matters regarding biosecurity in his farm (FAO, 2008). Maningas *et al.* (2005) and FAO (2008) opine that effective information, training, awareness and efficient delivery system of relevant information and technology services facilitates the poultry farmers' critical role in decision-making towards enhanced production, processing and marketing of poultry products.

Ascertain biosecurity measures adopted by poultry farmers in Rivers State.

The level of adoption of biosecurity measures by the poultry farmers in the study area is presented in Table 3. The table showed that all the poultry farmers had adopted the biosecurity measures listed above at different levels of adoption. Notwithstanding, only 14 biosecurity measures out of the 27 measures listed recorded 100% positive and significant responses while the other 13 measures recorded various levels of response though positive and significant as presented in the table. Socio – economic factors influencing biosecurity practices in Rivers State

Table 2: Sources of Information on biosecurity measures adopted.

Information Source	**Frequency**	**Percentage**	**Rank**
Farmers Association	85	94.4	1st
Veterinary officers	75	83.3	2nd
Internet	68	75.6	3rd
Researchers	60	66.7	4th
News media (print and electronic)	56	62.2	5th
Books/ magazines	50	55.6	6th
Seminar/Workshop	40	44.4	7th
Family and Friends	30	33.3	8th
Extension workers	10	11.1	9th
Ministry of Agriculture	9	10.0	10th
Feed/Drug Sellers	5	5.5	11th

Source: Field Survey, 2019 Multiple responses recorded

Table 3: Biosecurity measures adopted by poultry farmers

Biosecurity Measures	Frequency	Percentage
1. Limit non – essential human traffic on the farm	87	96.7
2. Restraining farm workers from visiting other farms	85	94.4
3. Keep other animals out of poultry building	90	100.0
4. Isolation of infected birds	90	100.0
5. Quarantine of new birds	88	97.8
6. Avoid mingling flock with local, wild/migratory birds	85	94.4
7. Examine flocks daily for disease symptoms	90	100.0
8. Keep a record of all farm visitors	90	100.0
9. Keeping birds of different ages separately	89	98.9
10.Selling crates along with eggs	86	95.6
11.No recycling of feed bags	85	94.4
12. Providing foot-dip with disinfectant	90	100.0
13. Separation of birds according to age	90	100.0
14.Proper washing and disinfection of feeding/water troughs	90	100.0
15. Ensure adequate ventilation for the birds	90	100.0
16.Constant cleaning of litter	90	100.0
17. Burying or burning of dead birds	90	100.0
18.Keeping areas around poultry house/feed bins clean to keep rodents away	90	100.0
19.Avoiding overcrowding	87	95.0
20.Ensure adequate floor spacing	87	96.7
21.Adequate feeding and drinking troughs	90	100.0
22.Fumigate poultry house and equipments before stocking	88	97.8
23.Separate transport for eggs and birds	85	94.4
24.Washing hands before and after handling poultry birds/products	90	100.0
25.Adequate light source for the birds	86	95.6
26.Regular vaccination of birds	90	100.0
27.Have only one entrance/exit	80	88.9

Source: Survey data, 2019

Table 4: Socio – economic factors influencing biosecurity practices in Rivers State

Variables	Coefficient	Standard error	Z – value
Constant	63.47 **	31.36	2.95
Age	0.67*	0.05	1.52
Sex	- 0.05	0.03	- 1.10
Marital status	0.18	0.17	1.07
Household size	- 0.35	0.04	- 0.98
Cooperative membership	0.04*	0.02	1.95
Poultry experience	0.03**	0.13	2.30
Formal training	0.27**	0.10	2.70
Flock size	0.34**	0.15	2.27
Educational qualification	0.65*	0.37	1.80
Extension contact	0.21	0.34	0.87
Credit access	0.32*	0.01	1.78
MC Fadden Pseudo R^2	0.685		
Chi^2	10.654		
Log likelihood function	-60.643		

Source: Survey data, 2019 ** Significant a * Significant at 10%

Table 4 shows the result of the regression analysis of the relationship between the Biosecurity Control Score (BCS) and the socio – economic characteristics of the poultry farmers. The Table showed that age, cooperative membership, poultry experience, formal training, farm size, educational qualification and credit significantly influenced the adoption of biosecurity practices in the study area. Any increase in the level of these variables would increase the probability of adoption of biosecurity practices in the study area. The Table shows that the value of R^2 of the regression model was 0.685 which shows that the socio - economic variables included in the model accounted for 68.5% of the variation in the level of poultry farmer's adoption of biosecurity practices in the study area.

CONCLUSION AND RECOMMENDATION.

Poultry farming in the study area is dominated by male farmers and married people. It also showed that these farmers were still in their active and productive ages and most of them were educated. Majority of the poultry farmers in the study area were well experienced in poultry farming, though operated at the micro and small scale levels and are members of farmers groups with profit motive as their farming enterprise objective.

Age, cooperative membership, experience in poultry farming, formal training, farm size, educational qualification and access to credit significantly influenced the adoption of biosecurity practices in the study area. Any increase in the level of these variables would increase the probability of adoption of biosecurity practices in the study area. Therefore, it is recommended that aggressive sensitization of the poultry farmers through seminars, workshops and conferences by relevant authorities on the advantages of actively adopting biosecurity measures on their farms and encouraging fellow farmers to do so, relevant agencies (public and private) need to understand the factors influencing adoption for them to appropriately factor them into policies and decisions that will encourage and motivate smallholder poultry farmers to adopt biosecurity measures in their farms.

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Journal of Applied Agricultural Research 2022, 10(2):240-251
ISSN 2006-750X.

EFFECTS OF DIETARY SOURCES OF RAW LOCAL ROCK PHOSPHATES ON PERFORMANCE OF BROILER CHICKENS.

Samuel Joseph Anzaku[1] and Comfort Dooshima Tuleun[2]
[1]Department of Animal Husbandry Services, Federal Capital Territory Administration, Abuja, Nigeria
[2]Department of Animal Nutrition, College of Animal Science, University of Agriculture Makurdi, Makurdi, Benue State, Nigeria.
Author's Contact: samanzaku@gmail.com; Phone no.+2348035965318.

ABSTRACT.

This study assessed the effect of Raw Rock Phosphate (RRP) on performance of broiler. Two hundred and sixteen (216) birds were used for the study, which was divided into two phases namely; the starter and finisher phase. The study adopted the Complete Randomized Design (CRD). Optimal levels of P and Ca were observed for Dange rock phosphate (15.11% and 38.29%), Dogon-Daji rock phosphate (13.71% and 37.60%), Bondiga rock phosphate (11.80% and 35.90%), except for Shunni rock phosphate which has a very low P and high Ca (5.17% and 43.69%) content. For the starter phase, significant difference ($P<0.05$) existed for daily feed intake (FI), feed conversion ratio (FCR), protein intake (PI) and protein efficiency ratio (PER), while other parameters were not affected across treatment groups. On the other hand, the result obtained showed significant difference ($P<0.05$) for final weight (g/b), weight gain (g/b), daily body weight gains and leg deformity while other parameters were not affected across treatment groups for the finisher phase. Final weights of birds were highest in Bondiga rock phosphate diet and lowest in Shunni rock phosphate diet. However, weight gains of birds in Dange and Dogon-Daji rock phosphate diets were comparable ($P>0.05$) to that of dicalcium phosphate and bone meal diets. This also means that diet containing Dange and Dogon-Daji rock phosphate can compete favourably with dicalcium phosphate and bone meal diets for broiler chickens' production. It is recommended that rock phosphate from these four different sources can be utilized without adverse effect on growth performance of broiler chickens.

Keywords: Raw Rock Phosphate, Bone Meal, Dicalcium phosphate, Broiler.

INTRODUCTION.

Bone meal is the major source of organic calcium and phosphorus use animal feed production. It is widely used in developing countries to supplement both mineral nutrients. However, there are growing concerns over its use particularly in developed countries because of the risk of zoonotic disease transmission through animal feed (Tion *et al.,* 2012). According to the 2018 Poultry Trends Report, Poultry meat remains the most produced meat in terms of metric tonnage, led by United States, China and Brazil. In 2018, estimated 128 million tons of poultry meat was produced. Global demand is expected to hit 1.8 per cent by 2050 with developing country reaching 2.4 per cent. Developing countries might be shutout of the projected market for poultry if alternatives to bone meal are not sourced. Some alternatives to bone meal are: oyster shell, periwinkle shell, limestone, rock phosphate and the imported dicalcium phosphate. Indeed, not much has been done in the area of local alternative sources for these major mineral nutrients.

Wright *et al* (1985) reported large deposits of rock phosphate in some countries in West African namely; Togo, Senegal, Benin Republic and Nigeria. In Nigeria, commercial quantity of rock phosphate was found in Sokoto, Ogun and Imo (Kaankuka, 1990). These rich deposits of rock phosphate in the aforementioned states spell hope for Nigeria and other developing countries. However, high levels of rock phosphate in diets of Livestock for long periods have injurious effects (Veloso *et al.*, 1998a) due to the presence of fluorine.

With recent advances in technology, rock phosphate can be defluorinated to produce soft rock phosphate, which has no harmful effect on livestock. The need to evaluate the impact of locally availably rock phosphate is now more than every important. This study assesses the effects of different raw rock phosphate sources as replacement to bone meal and dicalcium phosphate on the on performance of broiler chickens

MATERIALS AND METHODS.

Ethical Approval.

All the animal experimentation procedures used in this study were approved by the College of Animal Science Postgraduate board of Federal University of Agriculture Makurdi, Benue State. This research work is an excerpt of Samuel Joseph Anzaku's master's thesis.

Study Location.

The experiment was carried out at Abmo'azhe Poultry Farms, New Nyanya, Karu Local Government in Nasarawa State, Nigeria. Karu has a geographic coordinate of 8.9928° N, 7.5725° E with maximum temperature of 35^{0}C and minimum temperature of 17^{0}C.

Experimental Birds.

Two hundred and sixteen (216) day-old broiler chicks purchased from Sayeed Farms in Ibadan, Oyo State were used for the study.

Experimental Design.

A one-week pre-feeding trail was carried out to allow for body weight balancing. The experiment was separated in two phases - starter and finisher phases. Chicks were randomly allocated to six dietary treatments of thirty-six each at the starter broiler phase. Each treatment consisted of three replicate groups of twelve birds per replicate in a Completely Randomized Design. The same birds, replicate groups and design was maintained for the finisher phase of the research.

Sampling of Experimental Materials.

Rock phosphate (the experimental material) was sourced from four different locations in Sokoto State namely; Shunni, Dange, Dogon-Daji and Bodinga. Bone meal and Dicalcium phosphate were purchased from Livestock feed store in Abuja. Other ingredients like maize, soya bean, rice bran, methionine, lysine, premix and salt were bought from nearby market.

Experimental Diet.

Six experimental diets were formulated using bone meal, dicalcium phosphate and raw rock phosphate from four different locations namely; Shunni, Dange, Dogon-Daji and Bodinga in Sokoto State. Dietary treatments were formulated to be essentially isocaloric and isonitrogenous. For the starter phase of the experiment, which lasted for four weeks (28 days), birds were fed formulated diets containing 23% CP and 3128.25 kcal/kg metabolizable energy as shown in Table 1.

The finisher phase lasted also for four weeks (28 days). Table 2. Showed the finisher diets had 20% CP and 3159.69 kcal/kg metabolizable energy.

Table 1: Dietary Composition for Broiler Starter Chicks fed Rock Phosphate from different locations.

Ingredients	Experimental diets					
	T1	T2	T3	T4	T5	T6
Maize	40.22	40.22	40.22	40.22	40.22	40.22
Full Fat Soya	48.38	48.38	48.38	48.38	48.38	48.38
Rice Bran	8.00	8.00	8.00	8.00	8.00	8.00
Dicalcium Phosphate	2.50	-	-	-	-	-
Bone Meal	-	2.50	-	-	-	-
Shunni	-	-	2.50	-	-	-
Dange	-	-	-	2.50	-	-
Dogon-Daji	-	-	-	-	2.50	-
Bodinga	-	-	-	-	-	2.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10	0.10
Vit-Min. Premix*	0.30	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Nutrients						
ME(Kcal/kg)	3128.25	3128.25	3128.25	3128.25	3128.25	3128.25
Crude protein (%)	23.00	23.00	23.00	23.00	23.00	23.00
Crude fibre (%)	4.47	4.47	4.47	4.47	4.47	4.47
Calcium (%)	0.96	1.06	1.01	1.09	1.07	1.03
Phosphorus (%)	0.96	0.92	0.65	0.92	0.98	0.84
Flourine (%)	-	-	0.11	0.10	0.10	0.10
Methionine(%)	0.62	0.62	0.62	0.62	0.62	0.62
Lysine (%)	1.41	1.41	1.40	1.40	1.40	1.40

Metabolizable Energy = 37 x %CP + 81 x %EE +35.5 x %NFE…. (Pauzenga, 1985), Ca: P ratio = Calcium to Phosphorus ratio, Shunni = Rock Phosphate from Shunni, Dange = Rock Phosphate from Dange, Dogon-Daji = Rock Phosphate from Dogon-Daji, Bodinga = Rock Phosphate from Bodinga, ME = Metabolizable Energy, T1-T6 = Means treatment. Premix (BIO-MIX Finisher) supply the following per kg: Vitamin A 80000IU; Vitamin D_3 16000IU; Vitamin E 5000mg; Vitamin K_3 2000mg; Thiamine (B_1) 5000mg; Riboflavin (B_2) 4000mg; Pyridoxine (B_6) 1500mg; Niacin 16000mg; Vitamin B_{12} 1mg; Pantothenic acid 5000mg; Folic acid 5000mg; Biotin 20mg; Choline chloride 200mg; Antioxidant 125mg; Manganese 80mg; Zinc 50mg; Iron 20mg; Copper 5mg; Iodine 12mg; Selenium 200mg; Cobalt 200mg.

Table 2: Dietary Composition for Broiler Finisher Chickens fed Rock Phosphate from different locations.

	Experimental diets					
Ingredients	T1	T2	T3	T4	T5	T6
Maize	50.54	50.54	50.54	50.54	50.54	50.54
Full Fat Soya	38.06	38.06	38.06	38.06	38.06	38.06
Rice Bran	8.00	8.00	8.00	8.00	8.00	8.00
Dicalcium phosphate	2.50	-	-	-	-	-
Bone meal	-	2.50				
Shunni	-	-	2.50	-	-	-
Dange	-	-	-	2.50	-	-
Dogon-Daji	-	-	-	-	2.50	-
Bodinga	-	-	-	-	-	2.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10	0.10
Vit-Min.Premix*	0.30	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Nutrients						
ME(kcal/kg)	3159.69	3159.69	3159.69	3159.69	3159.69	3159.69
Crude protein (%)	20.00	20.00	20.00	20.00	20.00	20.00
Crude fibre (%)	4.25	4.25	4.25	4.25	4.25	4.25
Calcium (%)	0.94	1.04	1.20	1.07	1.05	1.01
Phosphorus (%)	0.95	0.90	0.65	0.90	0.86	0.81
Fluorine (%)	-	-	0.13	0.10	0.10	0.11
Methionine(%)	0.58	0.58	0.58	0.58	0.58	0.58
Lysine (%)	1.20	1.20	1.18	1.20	1.20	1.20

Metabolizable Energy = 37 x %CP + 81 x %EE +35.5 x %NFE…. (Pauzenga, 1985), Ca: P ratio = Calcium to Phosphorus ratio, Shunni = Rock Phosphate from Shunni, Dange = Rock Phosphate from Dange, Dogon-Daji = Rock Phosphate from Dogon-Daji, Bodinga = Rock Phosphate from Bodinga, ME = Metabolizable Energy, T1-T6 = Means treatment. Premix (BIO-MIX Finisher) supply the following per kg: Vitamin A 80000IU; Vitamin D_3 16000IU; Vitamin E 5000mg; Vitamin K_3 2000mg; Thiamine (B_1) 5000mg; Riboflavin (B_2) 4000mg; Pyridoxine (B_6) 1500mg; Niacin 16000mg; Vitamin B_{12} 1mg; Pantothenic acid 5000mg; Folic acid 5000mg; Biotin 20mg; Choline chloride 200mg; Antioxidant 125mg; Manganese 80mg; Zinc 50mg; Iron 20mg; Copper 5mg; Iodine 12mg; Selenium 200mg; Cobalt 200mg.

Chemical Analysis.

Chemical composition of rock phosphate from the four locations in Sokoto was analyzed in a standard laboratory using Energy Dispersive X-ray fluorescence and gravimetric methods at National Geological survey Agency Kaduna.

LOI = (a-b/1) x 100% = H_2O

Where: a = weight of crucible + 1g of the sample before heating

b = weight of crucible + 1g of the sample after heating. The elemental or ionic phosphorus were calculated using atomic numbers and molecular weight.

Performance Traits: The performances of broiler chicks were assessed using the following parameters:

Feed Intake: The weighed quantity of feed was given to the birds such that they were fed free choice each week. At the end of the week, the remaining feed was weighed and recorded. The difference was recorded as the feed intake for the week.

Body weight gain was measured by the difference between the current weight and the previous weight of the chicks on weekly basis.

Feed conversion ratio (FCR): It was calculated as the ratio of feed intake to live weight gain. $FCR = \frac{Feed\ intake\ (g)}{Weight\ gain\ (g)}$

Protein intake = Feed intake × % Crude protein in feed

Protein efficiency ratio was determined as ratio of gain in body weight to the protein consumed. $PER = \frac{Gain\ in\ body\ weight\ (g)}{Protein\ consumed\ (g)}$

Records of mortality was kept throughout the experimental period. Percent mortality was determined by recording each dead bird in each replicate and the total in each treatment was divided by the actual number of birds allocated to each treatment and multiplied by 100.

Data Analysis.

Data collected were subjected to a one-way analysis of variance (ANOVA) using Statistical Package of Social Science (SPSS) computer programme (Version 20.0 of Window 2010 model) and means were separated using the Duncan Multiple Range Test as outlined by Steel and Torrie (1980). Significance was accepted at the 0.5 level of probability.

RESULTS.

Mineral Composition of Raw Rock Phosphate Sources, Bone Meal and Dicalcium Phosphate.

Mineral composition of raw rock phosphate sources, bone meal and dicalcium phosphate is presented in Table 3. The major minerals of concerns are Ca, P, and F. Optimal levels of P and Ca were observed for Dange rock phosphate (15.11% and 38.29%), Dogon-Daji rock phosphate (13.71% and 37.60%), Bondiga rock phosphate (11.80% and 35.90%), except for Shunni rock phosphate which had the least P and highest Ca (5.17% and 43.69%) content. Fluorine content for the respective sources are 4.13%, 3.98%, and 4.37%, with Shunni rock phosphate having the highest value of 5.32%. With the exception of Shunni rock phosphate, values of P and Ca obtained from the various sources are closed to those of bone meal (16.88% and 34.45%) and dicalcium phosphate (18.00% and 33.00%).

Effect of Sources of Raw Rock Phosphate on the Performance of Starter Broiler Chickens.

The effect of sources of raw rock phosphate on the performance of starter broiler chickens is presented in Table 4. Significant difference ($P<0.05$) existed for daily feed intake (FI), feed conversion ratio (FCR), protein intake (PI) and protein efficiency ratio (PER), while other parameters were not affected across treatment groups. Daily FI and protein intake had similar order of significance, and were highest for Dogon-Daji rock phosphate diet and least for Dicalcium phosphate diet in the control group, while other treatment groups fall in between. FCR was superior for Dicalcium phosphate diet (control group) and statistically similar ($P>0.05$) with that of Dange rock phosphate and Dogon-Daji rock phosphate diets, while other treatment groups were inferior. PER values were better and statically similar ($P>0.05$) for bone meal, Shunni, Dange, Dogon-Daji and Bodinga RRP diets, but inferior for Dicalcium Phosphate diet. No mortality and leg deformity were recorded at this phase of the study.

Effect of Sources of Raw Rock Phosphate on the Performance of Finisher Broiler Chickens.

Biological Performance.

The effect of sources of raw rock phosphate on the performance of finisher broiler chickens is presented in Table 5. The result obtained showed significant difference ($P<0.05$) for final weight (g/b), weight gain (g/b), daily body weight gains and leg deformity while other parameters were not affected across treatment groups. Final weights of birds were highest in Bondiga rock phosphate diet and lowest in Shunni rock phosphate diet. However, weight gains of birds in Dange and Dogon-Daji rock phosphate diets were comparable (P>0.05) to that of dicalcium and bone meal diets. Weight gain (g/b) and daily BWG (g/b) virtually followed the same trend as that of the final weight across treatment groups. Mortality recorded in this phase of the study ranged between 0.33 and 1.33.

Bone Characteristics and Mineral Profile.

The effect of sources of raw rock phosphate on the tibia bone characteristics and mineral profile of finisher broiler chickens is presented in Table 6. Leg deformity was high (P<0.05) in the bone meal diet (2.33), while those of Shunni, Dogon-Dagi, and Bondiga rock phosphate diets were similarly (P>0.05) low. Fat free tibia bone weight, bone length, ash percent and ash phosphorus did not significantly (P>0.05) differ across treatment groups while ash weight and ash calcium varied significantly (P<0.05) among treatment groups.

DISCUSSION.

Mineral Composition of Raw Rock Phosphate, Bone Meal and Dicalcium Phosphate.

Mineral analysis of the various rock phosphate sources, bone meal and dicalcium phosphate in this study revealed optimal levels of calcium (Ca), phosphorus (P) and fluorine (F) except for Shunni rock phosphate with extremely high Ca, F and low P. Mean values of Ca and F for Dange rock, Dogon-Daji rock phosphate, Bondiga rock phosphate and Shunni rock phosphate obtained in this study is higher than the values of 34.64% and 3.65% for Ca and P reported by Kaankuka (1990) for rock phosphate. However, the corresponding values of P in the present study are lower than the value of 16.98% reported by Kaankuka (1990) for rock phosphate. The differences in values obtained between the two studies could be due to differences in geographical locations of the rock phosphates. The Ca (34.45%), P (16.88%) and F (0.34%) levels of bone meal in this study is comparable to the corresponding values of 37.11%, 16.10%, and 0.34% by Kaankuka (1990).

Although, prolong use of high levels of raw rock phosphate (RRP) in diets of livestock have injurious effects (Veloso *et al.*, 1998a) due to the presence of high level of fluorine, the numerous elements contained in RRP such as Manganese, Aluminium, Sulphur, Potassium etc. has been shown to reduce Fluorine toxicity in rat (NRC, 1980). This probably explained why the various sources of RRP were successfully utilized for feeding birds in this study. Fluorine is readily absorbed and binds to calcium in bone as fluorapatite (Garzillo *et al.,* 1997). This may impair the biodynamics of bone metabolism resulting in poor bone mineralization. The intake of high levels of F from sodium fluoride (NaF) added to experimental diets in a study by Abdelhamid and Dorra (1992) was shown to increased glycemia in broiler chicks. They added that intake of fluorine at levels over 40 mg per day limited productive performance of the chick and restricted bone mineralization.

Effect of Sources of Raw Rock Phosphate on the Performance of Starter Broiler Chicks.

A significant difference in daily feed intake existed among treatment groups, with birds fed Dogon-Daji rock phosphate (T5) having the highest mean score (68.38), and least (62.30) in the control group (T1). Mean values for other treatment groups fell in-between and were similar (P>0.05) to both T1 and T5. The trend of variation in mean values of FI obtained in this study showed that the sources of rock phosphate used did not seem to have a pronounced effect on FI. This could probably be due to adequacy in amount and ratio of calcium and phosphorus from the various sources. The finding is in harmony with the report of Moreki *et al*. (2011). The feed intake value of 62.30g to 68.38g obtained in this study is comparable to the values of 61.29g to 62.57g reported by Iyayi *et al*. (2006), but higher than the corresponding values of 34.64g to 39.93g and 51.10g to 58.20g observed by Tion *et al*., (2012) and Thomas *et al*., (2007) from the same class of chicks. The high feed intake value obtained in this study could be due to the adequacy and balanced of other mineral elements of the raw rock phosphate used (Thomas *et al*., 2007). Also, differences in strain of birds, environmental effect as affected by location and season, physical/chemical properties of the feed and age of birds as at the time of commencement of the feeding trial may have accounted for the differences in feed intake.

Final weight, weight gain, and daily body weight did not differ (P>0.05) across treatment groups. It has been reported that the metabolism and utilization of calcium and phosphorus is influenced by the ratio of the two elements, and their bioavailability to animals (Waldroup, 1997). The similarity in weight parameters observed in this study is an indication of efficient absorption and adequate utilization of the elements in the diets. Insufficient supply of one or both minerals, when the deficiency or excess of one of them interferes with homeostasis of the second one (Kebread and Vitti, 2005), results in reduced growth rate. That the growth rate of birds in the various rock phosphate sources was similar with the control group could be due to sufficient supply of calcium and phosphorus (Hurwitz *et al*., 1995). The daily body weight gain value of 34.39g to 36.45g observed in this study is higher than the corresponding values of 19.14g to 20.86g and 21.82g to 23.14g reported by Iyayi *et al*. (2006) and Tion *et al*. (2012). This difference is expected due to difference in the age of birds as at commencement of feeding trial and duration of the feeding trial (chick phase). Birds in this trial stage lasted for 3 weeks (i.e 8-28 days), while those of Iyayi *et al*. (2006) and Tion *et al*., (2012) lasted for 4 weeks (0-28 days).

The FCR varied significantly among treatments, with dicalcium phosphate in the control group (T1) having a better feed utilization value (1.74), which showed that they exhibited a better utilization of the feed nutrients than other treatment groups. This is probably due to the high biological quality of bone meal (Waldroup, 1997) over other sources. The FCR value of 1.74 to 1.94 in this study compares favourably with the value of 1.83 to 1.96 reported by Tion *et al*. (2012) when limestone sources were used in place of Bone meal. These values also fell within the recommended range of 2 to 5 for chickens (Oluyemi and Roberts, 2000) showing the proficiency of the raw rock phosphate to support performance. This is suggestive of the adequacy of the test rock phosphate sources in commercial broiler production.

The result of Protein Efficiency Ratio (PER) differed significantly (P<0.05) among the dietary treatment groups. The mean values 2.23 to 2.66 recorded in this study are higher than the average values of 1.90 reported by Aduku (1993) for broiler chicks. The significant difference in PER observed in this study could be indicative of a differential rate of conversion of dietary protein into flesh between Dicalcuim Phosphate and other treatment groups. That this did not adversely affected weight gains of birds fed Dicalcium Phosphate, might be due the superiority and balanced mineral profile of the Dicalcium Phosphate (Thomas *et al*., 2007). Also, the fluorine content of the raw rock phosphate sources may have posed a factor inhibiting the utilization of protein in the broiler chicken.

Incidence of leg deformity was absence across treatment groups which signified a balanced diet (Long *et al*., 1984b), normal homeostasis and bone mineralization (Shafey *et al*., 1990, Hurwitz *et al*., 1995). Also, a balance in Ca:P ratio in the diet (Table 6) (1.0:1 to 1.5:1) (NRC, 1994) could best explain efficient absorption of Ca and P and thus, adequate bone mineralization which resulted in absence of bone disorder**.**

No mortality was recorded across treatment groups. Lack of mortality observed in this study could be due to the proficient ratio of Ca:P from the various sources. This confers the ability of the various rock phosphate sources to support survivability. McCormick *et al*. (1980) indicated that most of the heat-induced mortality could be alleviated by manipulating the Ca:P ratio of the diet.

Fluorine has been reported to be a constant constituent of bones and teeth, with optimal amount beneficial in the development of caries-resistance and prevention of excess demineralization of bone (NRC, 1984). This probably explained the absence of skeletal disorder across treatment groups. Also skeletal disorders are associated with dietary imbalances and deficiencies (Williams *et al*., 2000; Whitehead *et al*., 2004) which interfere with homeostasis and bone mineralization (Shafey *et al*., 1990). The absence of skeletal disorder in this study is an indication of bioavailability and balance in the Ca:P ratio (1.0:1 to 1.5:1) among the various rock phosphate sources. This complied with the recommendation of between 1.0:1 and 2.2:1 by Scott *et al*. (1982) and 1.0:1 and 1.5:1 by NRC (1994).

Effect of Sources of Raw Rock Phosphate on the Performance of Finisher Broiler Chickens. Biological Performance.

Results for daily feed intake (FI) were not significantly affected across treatment groups. This implied that sources of rock phosphate used in this study did not impose any factor restricting feed intake. This is probably due to the balance in terms of quality and ratio of Ca and P among other minerals. This finding is in line with report of Smith *et al*. (2003) who found that adequate dietary levels and ratios of calcium and phosphorus had no effect on feed consumption of broiler chickens. The daily FI values of 103.86g - 123.02g obtained in this study is lower than the corresponding values of 164g – 174.28g, and 148.60g – 163.80g reported by Makinde *et al*. (2008) and Tion *et al*. (2012) for the same breeds of birds. This might be due to differences in environmental factors between the two locations.

Daily body weight gain which signifies the growth rate of birds was highest for Bodinga Rock Phosphate (T6) and least for Shunni Rock Phosphate (T3). The lower weight gains recorded for birds fed diet containing Shunni rock phosphate (T3) could be due to the low P content and high Fluorine content of the rock phosphate. This report is in accordance with the report of AAFCO (2003) which stated that high Fluorine level has a negative effect on productive performance. The cumulative effect of fluorine (Waldroup, 1997) may have resulted in the lower weight gains recorded in this study. It has been reported by Loosli (1973) that inorganic calcium and phosphorus supplement in feeds is utilized if Ca:P ratio is satisfactory, and if specific factors do not interfere with absorption. Such factors are the bioavailability of elements, age and physiological state of the animals (Waldroup, 1997). Although, the daily FI is similar across treatment groups, differences in growth rate can best be explained by the relative bioavailability of Ca and P from the various sources and their influence in homeostasis and utilization of feed nutrients. This probably explained the higher weight gain recorded in T6. The daily body weight gains values of 38.68g to 55.66g recorded in this study is superior to the values of 16.29g to 24.43g reported by Iyayi *et al*. (2006) but inferior to the values of 61.19 to 73.86 reported by Tion *et al*. (2012).

FCR was not significantly affected across treatment group. This indicated adequate phosphorus availability from the various rock phosphate sources, and efficient usage by the birds. This agreed with the postulation of Rodehutscord (2009) that response criteria are the first step to measure the availability of phosphorus in a feed sample. It is significant that the proportion of Ca:P did not impair the utilization of the various nutrients in the test diets. The FCR of 2.22 to 3.03 obtained in the study compared favourably with the value of 2.85 to 3.25 observed by Iyayi *et al*. (2006) for same class of birds, and fell within the normal range of 2 to 5 recommended for chickens by Oluyemi and Robert (2000).

Protein efficiency ratio (PER) showed no significant difference ($P>0.05$) among dietary treatments. The mean value of 1.71 to 2.28 recorded in this study is comparable to the value of 1.55 to 2.10 reported by Tion *et al*. (2012). The lack of significant difference across treatment groups is an indication of adequate conversion of dietary protein into flesh by the birds at this phase of the study. The fluorine content of the RRP did not adversely affect the utilization of protein for growth.

Mortality occurred across treatment groups, with mean value which ranged from 0.33 to 1.33. Mortality recorded in this study may not be connected with the sources of rock phosphate. Heat stress might be the major cause of mortality since this study was carried out in hot dry season (February – April). This is in consonance with the findings of Ubosi (1988) who reported that performance of birds is adversely affected by high environmental temperatures in the semi-arid zones of Nigeria during the hot season, and may cause death (Dafwang, 2009).

Table 3: Mineral Composition of Raw Rock Phosphate, Bone meal and Dicalcium Phosphate.

Minerals	Dange rock phosphate (%)	Dogon - Daji rock phosphate (%)	Bodinga rock phosphate (%)	Shunni rock phosphate (%)	Bone meal (%)	Dicalcium Phosphate (%)
Phosphorus pentoxide (P_2O_5)	34.6	31.40	27.02	13.5	-	-
Phosphorus (P)	15.11	13.71	11.80	5.17	16.88	18.00
Silicon oxide (SiO_2)	6.27	5.40	10.04	5.77	-	-
Aluminium oxide (Al_2O_3)	3.08	2.07	2.80	1.40	-	-
Sulphur trioxide (SO_3)	0.58	0.78	0.70	0.60	-	-
Potassium oxide(K_2O)	0.02	-	0.04	-	-	-
Calcium oxide (CaO)	53.61	52.64	50.26	61.17	-	-
Calcium (Ca)	38.29	37.60	35.90	43.69	34.45	33.00
Titanium dioxide (TiO_2)	0.40	0.27	0.39	0.34	-	-
Vanadium oxide (V_2O_5)	0.06	0.03	0.05	0.04	-	-
Manganese oxide (MnO)	0.95	0.97	0.82	0.89	-	-
Magnesium (Mg)	-	-	-	-	0.45	-
Iron oxide (Fe_2O_3)	2.89	2.09	2.31	9.14	-	-
Fluorine (F)	4.13	3.98	4.37	5.32	0.34	-
Indium oxide (In_2O_3)	0.40	0.59	0.49	0.38	-	-
Barium oxide (BaO)	0.18	0.06	0.20	0.16	-	-
Mercury II oxide (HgO)	0.69	0.71	0.50	1.10	-	-

The analysis was done at National Geosciences' Research Laboratories Center, Kaduna.

Table 4: Effect of sources of raw rock phosphate on the performance of starter broiler chickens

	Experimental diets						
Parameters	T1	T2	T3	T4	T5	T6	SEM
Average initial weight (g/b)	141.67	141.67	141.67	141.67	138.89	145.83	0.92^{ns}
Average final weight (g/b)	894.44	863.89	873.61	905.55	938.89	883.34	10.68^{ns}
Average weight gain (g/b)	752.78	722.22	731.94	763.89	800.00	737.50	11.16^{ns}
Daily body weight gain (g/b)	35.85	34.39	34.86	36.38	38.09	36.45	0.51^{ns}
Daily feed intake (g/b)	62.30^{b}	66.93^{ab}	66.99^{ab}	64.68^{ab}	68.38^{a}	67.52^{ab}	0.75*
Feed conversion ratio	1.74^{b}	1.94^{a}	1.92^{a}	1.78^{ab}	1.79^{ab}	1.92^{a}	0.26*
Protein intake (g/b)	14.33^{b}	15.39^{ab}	15.40^{ab}	14.87^{ab}	15.73^{a}	15.53^{ab}	0.17*
Protein efficiency ratio (BWG/PI)	2.66^{a}	2.23^{b}	2.27^{b}	2.45^{ab}	2.42^{ab}	2.26^{b}	0.04*
Mortality (%)	0	0	0	0	0	0	--
Leg Deformity(%)	0	0	0	0	0	0	--

SEM = Standard Error of Means, ns = Not Significant Difference (P>0.05), abc = Means on the same row with different superscripts are significantly different (P<0.05), * = Significantly different (P<0.05), T1 = Dicalcium phosphate, T2 = Bone meal, T3 = Shunni rock phosphate, T4 = Dange rock phosphate, T5 = Dogon-Daji rock phosphate, T6 = Bondiga rock phosphate, Av = Average, Wt =Weight, % = Percent, g/b = Gramme per bird

Table 5: Effect of sources of raw rock phosphate on the performance of finisher broiler chickens.

	Experimental diets						
Parameters	T1	T2	T3	T4	T5	T6	SEM
Average initial weight (g/b)	894.44	863.89	873.61	905.55	938.89	883.34	10.67^{ns}
Average final weight (g/b)	2108.89^{bc}	2288.38^{ab}	1956.67^{c}	2226.67^{abc}	2172.73^{abc}	2441.92^{a}	47.08*
Average weight gain (g/b)	1214.44^{bc}	1424.49^{ab}	1083.06^{c}	1321.11^{abc}	1233.84^{bc}	1558.58^{a}	46.16*
Daily body weight gain (g/b)	43.37^{bc}	50.88^{ab}	38.68^{c}	47.18^{abc}	44.07^{bc}	55.66^{a}	1.64*
Daily feed intake (g/b)	103.86	116.07	113.39	117.46	107.84	123.02	2.87^{ns}
Feed conversion ratio	2.38	2.28	3.03	2.50	2.48	2.22	0.11^{ns}
Protein intake (g/b)	20.77	22.55	22.67	22.82	21.57	24.61	0.56^{ns}
Protein efficiency ratio (BWG/PI)	2.16	2.19	1.71	2.00	2.07	2.28	0.08^{ns}
Mortality (%)	0.67	0.33	0.67	0.67	1.33	0.33	0.20^{ns}

SEM = Standard Error of Means, ns = Not Significant Difference (P>0.05, abc = Means on the same row with different superscripts are significantly different (P<0.05), * = Significantly different (P<0.05), T1 = Dicalcium phosphate, T2 = Bone meal, T3 = Shunni rock phosphate, T4 = Dange rock phosphate, T5 = Dogon-Daji rock phosphate, T6 = Bondiga rock phosphate, Av = Average, Wt =Weight, % = Percent, g/b = Gramme per bird

Table 6: Effect of sources of raw rock phosphate on the tibia bone characteristics and mineral profile of finisher broiler chickens

	Experimental diets						
Parameters	T1	T2	T3	T4	T5	T6	SEM
Leg Deformity (%)	1.00^{bc}	2.33^{a}	0.67^{c}	2.00^{ab}	0.67^{c}	0.33^{c}	0.22*
Bone length (cm)	10.38	10.40	10.20	10.32	10.35	10.45	0.08^{ns}
Ash weight (g)	5.30^{a}	4.76^{ab}	4.54^{b}	4.69^{ab}	5.21^{a}	5.13^{ab}	0.96*
Ash (%)	39.18	35.42	34.40	35.23	38.75	38.00	0.77^{ns}
Ash Ca (%)	34.00^{a}	28.13^{ab}	24.27^{b}	22.67^{b}	29.13^{ab}	25.07^{b}	1.25*
Ash P (%)	14.93	16.00	14.97	15.17	16.40	17.27	0.39^{ns}
Ca:P ratio	2.27:1	1.80:1	1.62:1	1.50:1	1.80:1	1.50:1	---

SEM=Standard Error of Means, ns=no significant difference (P>0.05), ab= Means on the same row with different superscripts are significantly different (P<0.05)* =significantly different (P<0.05). T1=Dicalcium phosphate, T2=Bone meal, T3= Shunni rock phosphate, T4=Dange rock phosphate, T5=Dogon-Daji rock phosphate, T6= Bondiga rock phosphate, %=Percent, cm= Centimetre, g=gram, Ca= Calcium, P=Phosphorus.

CONCLUSION AND RECOMMENDATIONS.

From the study, utilization of raw rock phosphate sources (Shunni, Dange, Dogon-Daji and Bodinga) as alternative for Dicalcium phosphate and Bone meal in the diet of broiler chickens did not elicit adverse effect on growth performance at the starter phase, however, there was compromised for Shunni at the finisher phase due to high fluorin level. Mineral analysis revealed fluorine range of 3.98% - 5.32%. The study therefore recommend utilization of Dange, Dogon-Daji and Bodinga as suitable alternative source but will require innovative technique for removing the fluorine.

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Journal of Applied Agricultural Research 2022, 10(2): 252-263
ISSN 2006-750X.

EVALUATION OF CATTLE TEMPERAMENT TRAITS IN RELATION TO SOCIABILITY, SAFETY AND FARMER-HERDER CONFLICT

[1]Sunday, H. L., [2]Adedibu, I.I, [3]Tunji, A. O., [4]Kezi, D. M.,
[1]Livestock Department, Agricultural Research Council of Nigeria (ARCN), Mabushi, Abuja.
[2,] Animal Science Department, Ahmadu Bello University, Zaria
[3]National Agricultural Extension Research and Liaisons Services (NAERLS), Zaira
[4] Agricultural Extension Department, Agricultural Research Council of Nigeria (ARCN), Mabushi, Abuja.
Author's Contact: sundaylot5@gmail.com +2347038501030

ABSTRACT.

The study was carried out to explore the phenotypic relationships and dependencies among temperament traits that significantly affect the function of Bunaji cows. Fifty-one (51) multiparous Bunaji cows that were non-pregnant, in their third stage of lactation were used in the study. The cows were tagged and certified clinically fit by animal health personnel. The techniques implored to assess the animals' temperament traits were milking temperament, pen temperament, chute temperament, chute exit score and chute exit speed. The data in the empirical study were analysed using SAS (9.0) version. Computations using means procedure were done to: determine the means and standard error for each trait; and coefficients of variation (CV) to determine the variability in the population sample. Pearson correlation coefficients were computed to determine the degrees of relationship among and between variables for all animals within each temperament group. Significant differences in means were compared using the Duncan Multiple Range Test (DMRT). The results showed that Bunaji cattle were generally perceived as moderately-calm animals. Pen temperament score 1 (very calm) cows had the lowest exit speed than their counterparts. Animals that walked and trot (Scores 1 and 2) exited the chute at a lower speed than the most reactive ones (Scores 3 and 4). Milking temperament Scores 1 and 4 (for very calm and nervous cows) had significant ($P<0.05$ lower milking time than the moderately-calm and very nervous cows (Scores 3 and 5). The correlations between chute temperaments score (CT), chute exit score (CES) and chute exit speed (FS) were highly significant ($P < 0.01$). In concluding, Bunaji cows that were very reactive in pen, chute and milking process, were not sociable, pose latent safety threat and had longer duration of milking respectively. It is therefore recommended that handlers' should have a good understanding of handling temperament traits for their safety; this study should be replicated for other breeds of cattle.

Key words: *Bunaji*, Temperament trait, Handling, reactivity.

INTRODUCTION.

Cattle temperament influence the way to which the animal associate in a group settings (Haskell *et al*, 2014). Cattle temperament varies and comprises of behavioural characteristics like shyness to boldness, exploration, avoidance, activity, sociability, aggressiveness and emotionality such as fearfulness which constitute an important aspect of behavioural genetics (Friedrich *et al*., 2015). It is a trait that has been reviewed to have both safety and economic implications (Burrow, 1997; Turner *et al.*, 2013). Several behavioural techniques of assessing cattle temperament has been developed (Jones, 2013) yet the extent to which temperament traits are quantified by these techniques is not certain from many breeds of animals. The development of these techniques for assessing the temperament of cattle was based on the outcome of observation that allow animals to be described according to different types of behavioral activity (Antanaitis *et al*., 2021).

Prior to this empirical study, a multistage survey study was conducted to evaluate the perception of cattle handlers to temperament trait of Bunaji cattle in Kajuru, Giwa and Sabon-gari Local Government Areas of Kaduna State (MSc. Project). The three L.G.A of the State constituted a total of 12.30% (696) farming families who were into cattle production (Kaduna State Agriculture Structure Survey, 2017). The total of 101 questionnaires constituting 14.50% of its total cattle handlers was randomly administered to respondents in 12 villages of the three LGAs of the State as follows: Kajuru (33); Giwa (38); and Sabon-gari (30) respectively. The handlers were pastoralist, village cattle farmers, veterinary doctors, animal scientist and cattle traders drawn from individual house-holds, village major markets, abattoir, veterinary clinics and farms. The primary data obtained was from ninety-six (96) retrieved structured questionnaires. The data were coded and analysed using IBM SPSS (2017) statistics (Version 25) predictive analysis software. The result showed that the perception varied by the handlers. More so the very wide differences between pastoralist and their counterparts in terms of socio-economic background in respect to formal education could mean a challenge in the understanding of life issues. In view of this the empirical study was necessitated.

In addition, because human-cattle contact cannot be avoided (Adedibu and Musa, 2017), cattle which are difficult to handle, control or manage under resource based competition are not of any priority to cattle handlers especially for herders and more so under limited naturally based resources for grazing and crop farming (Turner *et al*., 2018). The significance of the study therefor seek to ascertain the perception of cattle handlers to temperament traits of Bunaji cattle and equally reveal the impact of temperament traits on handler's safety, animal's sociability and production attributes. The study will also proffer recommendations that are appropriate to the handlers of Bunaji cattle. The main objective of the study was to assess Bunaji cows reared under extensive system of management for temperament traits and explore the phenotypic relationship and dependencies of the traits that significantly affect the function of the animal to handling and milking. The specific objectives are to: evaluate the effect of temperament on exit speed, milking duration the body weight of the animals; determine the relationship between the different handling temperament techniques with body weight, milk yield and milking duration.

MATERIALS AND METHODS.

Experimental site.

The study was carried out at Alhaji Adamu Haruna Farms, along Kaduna–Kachia express way, Kamshi- Iburu, Kajuru Local Government Area of Kaduna State. The farm is located on Latitude 10.303217 and

Longitude 7.831113 *(*Handheld GPS Receiver- GERMIN 78 CSX).

Experimental Animals and Management practice.

Fifty-one (51) multiparous, non-pregnant, lactating cows were used for this study. These cows in their third stage of lactation were sorted from four different herds under the control of different herdsmen on the same geographical location. The animals were tagged and certified clinically. The experiment lasted within a month (May to the beginning of June, 2018), just after the peak of dry season and the onset of rainy season. The experimental cows had access to salt-lick prior to grazing and they have unrestricted access to drinking water. Feeding was via unrestricted grazing under the supervision of herdsmen for about 8 - 9 hours period daily.

Data Collection and Traits Definitions.

Body weight

Body weight was recorded in Kilogram (kg) using a universal weigh band (WEBO animal measure, ref. 240591, manufactured by Kruuse Den, and approved by the Danish Agricultural Association, Denmark).

Milking and milking temperament.

The cows were hand-milked in the morning after the calves were introduced to their dams to stimulate milk let-down, this was done by restraining the calf to the fore- leg of the dam, and restraining the hind leg as well, this was necessary to avoid disruption by the calf, as well as preventing kicks by the dam and in the same vein giving it the impression that the calf is sucking. Milk yield was collected and measured in litres using a plastic calibrated cylinder of 1.00 Litre capacity. The duration of the milking was recorded in seconds with the aid of a digital stop watch. The operation was repeated three more times on weekly basis following the same procedure.

The milking temperament scores were assessed on a five point scale (Gergovska *et al*., 2012) as follows:

1: The cow is very calm if it never shows restlessness, fully calm and obedient during preparation and milking itself, the ideal dairy cow;

2: The cow is calm if it stands calmly on the bedding (the milking place), does not show any restlessness during preparation and milking, but may move frequently, shift their point of gravity from one side onto the other; sometimes slash with the tail; show slight restlessness;

3: The cow is moderately- calm but move a lot, and can sometimes lift a leg during preparation and milking, but without kicking; they often slash with the tail or sometimes look restless;

4: The cow is nervous- they look very restless during preparation and milking; sometime attempt to kick the milk man, move from one foot to another all the time; startle upon reaching an arm to them;

5: The cow is very nervous if it is very restless during preparation and milking, lifts the leg in attempting to kick the milkman, move from one foot to another and slash with the tail, upon reaching towards them they pull back or react.

Pen temperament score.

Pen temperament (PT) assessment methodology was employed to describe cow's response in a smaller group (about 4-5) placed in a pen while an observer tries to approach them. A five point scoring criteria (Gibbons *et al.*, 2009) was used thus:

1: The cow is non- aggressive, if it walks slowly, can be approach closely and is not excited by humans or novel objects;

2: The cow is slightly aggressive, if it runs along fences when being approached or standing in a corner and if humans stay away, may pace around the fence;

3: The cow is moderately aggressive; it runs along fences, heads up, and run if humans move closer and stop before hitting gates or humans;
4: The cow is aggressive; runs, stays in back of group (in case in group), head high and very conscious of humans, may run into fences and gates even with some distance;
5: The cow is very aggressive, if it becomes excited, runs into fences, runs over humans and anything else in its path (Gibbons *et al.*, 2009).

Chute temperament score.

The chute temperament (CT) score was employed to test the strength of response to confinement of an animal inside a chute. The scoring criteria of a five (5) point scale (Woiwode et *al*., 2016) were used thus:
1: Calm; no movement
2: Slightly reactive; slight movement
3: Moderately reactive; squirming and occasionally shaking of the chute
4: Reactive; continually twisting and shaking of the chute
5: Very reactive; roaring, twisting or violently struggle.

Chute exit score and Exit Speed.

The temperament relating to chute exiting was carried out using two methodologies; the subjective (chute exit score-CES) and the objective (chute exit speed- FS) as described by (Lanier and Grandin, 2002; Jones, 2013; Adedibu and Musa, 2017). The subjective techniques classified the gait of the animal as it exit the chute on a four point scoring criteria as follows:
1: The cow walked;
2: the cow trot (the cow walked but in a hurry);
3: The cow ran;
4: The cow jumped out of the chute.
The objective method which is the flight speed incorporated a digital stop watch to record the time where cow exit the chute until it had travel the measured distance of 2.0m (Adedibu and Musa, 2017). The speed was calculated by dividing the measured distance in meters by the reported time in seconds.

Statistical Analysis:

All the data in the experiment were analysed using SAS (9.0) version. Significance level was set at $P < 0.05$. Computation using means procedure was done to: determine the means and standard error for each trait; coefficients of variation (CV) to determine the variability in the population sample. Pearson correlation coefficients were computed to determine the degrees of relationship among all variables (both subjective and objective traits) for all the animals within each temperament groups. Significant differences in means were compared using the Duncan Multiple Range Test (DMRT). The analysis follows the statistical model below.

Statistical Model.

The temperament traits follow the statistical model:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where

$\mathbf{Y_{ij}}$ is the individual's phenotypic value for the trait (body weight, exit speed, milkingduration);
μ is the overall mean;
T_i is the i^{th} effect of the T temperament trait;
e_{ij} is the residual random error, nid $(0, \sigma^2)$
nid $(0, \sigma^2)$: Normally and independently distributed with zero means and constant variance.

RESULTS AND DISCUSSION.

Socio-Economic Characteristics of the Cattle Handlers.

Table 1 shows the socio-economic characteristics of the respondents. The result of the analysis showed that, about 47% (majority) of the respondents were pastoralists, 23% were Animal Scientist and Veterinary doctors, 15% were cattle traders, and 13.5% were village cattle farmers. The obvious reason agrees with AGTR (n. d) that most cattle were in the hands of pastoralist and most breeds were named after their respective tribe and ancestry. The high involvement of male gender (88.50%) means that male predominates in cattle handling within the study areas. The predominance could be attached to cattle size, strength, speed and potential for aggression which requires a thoughtful and confident handling (Handling cattle-NSW, n. d). About 56%, mostly animal scientist, veterinary doctors, cattle traders and village cattle farmers were learned whereas those who have not had the opportunity of obtaining a formal education were mostly herders (39.58%). The low level of involvement in formal learning places the pastoralist at the extreme end of which better understanding of temperament and other issues of life among them could be difficult (Hussein, 2016).

The respondents differ in their years of handling experienced, the cattle herd sizes kept, the sex of the animal reared and the type of handling facility used. The Commonwealth Scientific and Industrial Research Organization (CSIRO, 2020) attested the herd size of cattle ranges from 50 to 1000 heads and mostly in the hands of the pastoralist.

Pastoralist uses such temporary facilities like ropes and curds, veterinarians and animals scientist mostly used permanent handling facilities (chute, weighing crate, crush, forcing pen, dispersal pens, race, and automated milking machine). This also agrees with Charban (2019) that pressure and release forms the central basis to which large animals are handled. The used of this equipment was attributed to the purpose to which the animal was kept as expressed by the respondents (Field Survey, 2018). Perception of Cattle Handlers to Temperament Trait of Bunaji Cattle.

The perceived temperament of *Bunaji* cattle varied among the handlers. The minimum, maximum and overall mean scores of 1, 5 and 3.32 shows that Bunaji cattle were generally perceived to be moderately-reactive by its handlers. The perceptions by handlers below the mean were majorly pastoralists who had non- formal education but had more number of years of handling experience on temporary facilities and on large herd size above 50 cattle number; village cattle farmers who handle Bunaji cattle for draughts. The perception above the mean were mostly animal scientist, veterinary doctors and cattle traders who have had the privilege of obtaining formal education and whose purpose of handling were health related. The values above the means implies that the animal is more reactive, difficult to handle, managed or control in a group setting thereby posing safety threat to the handler and other cattle in the herd (Turner *et al*., 2013). These reactive cattle could vent into crop fields when excited and cause damage as expressed by the respondents. Crop damage has been the major cause of farmer-harder conflicts in the Sudano-Sahelian zone (Turner *et al*., 2018).

Descriptive Statistics of the Body Weight, Milk Yield and Milking Duration of the Bunaji Cows.

The mean, minimum and maximum value of the body weight trait was within normal distribution in the sample population. Majority of the cows yielded their weekly milk below the mean while the milking duration of most cows was higher than the mean. The coefficients of variation (CV) ranged from 16.40% (Body weight) to 30.60% (milking duration) and 40.11% (milk yields).

The result suggests that the trait for body weight was evenly distributed (symmetrical) while milk yield and milking duration were asymmetrical in the population. The average, minimum and maximum milk yield and milking duration implies that majority of the cows took longer duration of 2.348 minutes to release a 1.00 litre of milk**.** This result agrees with Sitkowska *et al*. (2015) who found the average milking speed of 2.60 litres per minutes in a group of Holstein-Friesian cows subjected to automatic milking systems respectively. The CV shows that the size of the standard deviation is 16.40% to 40.11% the total size of the means. This suggested that the CV was good for body weight; within the range of acceptability for milking duration and outside the range of acceptability for milk yield traits for field experiment (Ebrahimi, 2018) as the cows differs more in their respective milk yields.

Summary Statistics for the Distribution of the Animals Based on Temperament Traits.

Table 4 defines the percentage distribution of Bunaji cows based on the subjective and objective assessment of temperament traits. The mean, minimum and maximum values of the traits shows that the values exhibited by majority of the cows were below the mean for milking temperament (MT), chute temperament (CT) and chute exit score temperament (CES) techniques and normally distributed for pen temperament (PT) technique respectively. The coefficients of variation (CV) for these traits ranged from 47.63 % (MT) to 53.74 % (CES).

The result suggests that PT trait was symmetrical; MT, CT and CES were asymmetrical in the study population. Lower temperament scores (scores 1 and 2) for less reactive cows as opposed to higher scores (scores 4 and 5) for more reactive cows denotes that the animal is suitable to be approach, driven, weighed and treated for injury; exhibits minimal danger to the handlers and other cows in the heard (Haskell *et al.,* 2014). The mean MT value reported in this study agrees with the mean values of 2.30 reported for Holstein cows in Japan (Abe *et al.,* 2002). The mean PT score observed in this study was higher than the values of 2.1 to 2.6 for Bunaji and Bunaji x Simmental cross bred bulls reported by Adedibu and Musa (2017). The mean chute exit speed (FS) temperament in this study was in the range category of < 1.9 m/s values that defined the cows to be lowly temperamental against 2.4m/s for the highly temperamental (Burrow, 1991). All the CVs of temperament traits were outside the range of acceptability for field experiment (Ebrahimi, 2018).

Effect of Temperament on the Body Weight, Exit Speed, Milk Yield and Milking Duration.

The effect of temperament on body weight, exit speed, milk yields and milking duration of the Bunaji cows are displayed on Table 5. The results shows that body weight trait was significantly ($P < 0.05$) affected by pen temperament, chute exit score and milking temperament; exit speed was significantly affected by pen temperament score and chute exit scores; while milk yield and duration for milking were significantly affected by milking temperament trait respectively.

The effect of pen temperament shows that very aggressive cows (Score 5) are distinguished from their counterparts by their smaller body weights ($P < 0.05$). These are cows that can jump over fences or barricades; difficult to managed and approached, such animals could scare others to alarm (Haskell *et al.,* 2014).

The effect of chute exit score on body weight and exit speed shows that exit score had had significant ($P < 0.05$) influence on body weight and exit speed. Calm cows that walked (score 1) and trot (score 2) exit the chute at a significant ($P < 0.05$) slower speed than cows that ran (score 3) and jump (score 4). The smaller body weight, tail and body lengths associated with the very reactive cows agrees with Burrow, (1997) and Burdick *et al*., 2011); that faster exit speed in cattle have been associated with lower body weight (Burrow, 1997); and immune responses compared to the calmer cattle (Burdick *et al*., 2011). It is thus recommended that cows that exit the chute at a speed above 3.0m/sec. are extremely dangerous and should be treated with caution.

The effect of milking temperament on body weight, milk yield and milking duration shows that the milking temperament scores were statistically similar ($P > 0.05$) in their milk yield; but the milking duration of the very nervous groups (Score 5) had significantly ($P < 0.05$) longer duration of milking than the very calm groups (score 1). It thus implies that even though the very nervous cows had a good milk yield and body weight, but their high temperament and longer time of milking are undesirable for frequent milking; as this has safety and economic implications (Gray *et al.*, 2012). Several physiological factors such as diseases causing orgarnisms have been linked to behavioral reactivity of cows (Jones, 2013).

Relationship of Temperament Traits with Milk Yield, Duration, Body Weight and Exit Speed.

Table 6 shows the phenotypic correlation between temperament with body weight, milk yield and milking duration of the Bunaji cows. The result showed significant ($P < 0.05$) positive correlated values between pen temperament (PT) score with chute temperament (CT) and chute exit score (CES); highly significant ($P < 0.01$) positively relationship between CT, CES and chute exit speed (FS). Significantly ($P < 0.05$) positive correlated traits were observed between pen temperament (PT) average milk yields (AMY).

The highly significant positive relationships of chute exit score (CES) chute (CT) and Chute exit speed (FS) temperaments suggest that these techniques measured more similar attributes of temperament (Sebastian *et al.*, 2011; Jones, 2013) than moderately correlated values of PT with CS and FS. Therefore individual Bunaji cows classified as reactive in terms of CT are expected to be reactive for CES and FS respectively. Some researchers (Core *et al.*, 2009; Cafe *et al*., 2011) have reported moderate relationship between CT score and FS on a group of Brahman cattle (Core *et al.*, 2009) and Angus cattle (Cafe *et al.*, 2011). The relationship of CES and FS indicate that Bunaji cows which exit the handling chute at a faster speed also required less time to cover the measured distance (Schwartzkopf-Genswein *et al*., 2012) as higher scores meant a faster chute exit. Lighter body weight and flightiness were influenced by the higher scores for reactive cows in the handling chute. High reactivity of cattle has been reported to be associated with faster exit speed, lower body weight (Burrow, 1997); poor growth performance, carcass characteristics, and immune responses (Burdick *et al*., 2011).

Reactive cows that were either nervous during milking or aggressive during handling in chutes would require longer duration of milking. This relationship is not economical to the farmer as the cost associated with milking would be increased (Schick, 2009; Gray, *et al*., 2012). This result agrees with (Louise and Hanne, 2015) that cows that respond strong to social separation were associated with longer milking duration and low milk yield.

CONCLUSION AND RECOMMENDATION.

In concluding, Bunaji cows that were very reactive in pen, chute and milking process were; not sociable, pose latent safety threat and had longer duration of milking respectively. It is therefore recommended that handlers' should have a good understanding of handling temperament traits for their safety; this study should be replicated for other breeds of cattle.

ACKNOWLEDGEMENTS.

I profound gratitude goes to Agricultural Council of Nigeria (ARCN) for funding and support provided. I appreciate Alh. Adamu Haruna Auwal Haruna, Bashiru Haruna and Rashidi Haruna the Farmers who wilfully released their cattle for this study as well as Shadrach Samson and Miracle D. Sunday, for their continued support throughout data collection.

Table 1: Socio- Economic Background of Bunaji Cattle Handlers.

	Parameter	**Anim. Scientist**	**Vet. Doctors**	**Cattle Traders**	**Pasto-ralist**	**Village cattle farmers**	**Total**	**(%)**
a	**Local Government**							
	Kajuru	0.00	0.00	0.00	29 (30.20)	4 (4.17)	33	34.38
	Giwa	6 (6.25)	6 (6.25)	7 (7.29)	9 (9.37)	9 (9.37)	37	38.54
	Sabon Gari	7 (7.29)	3 (3.12)	8 (8.33)	8 (8.33)	0.00	26	27.08
	Total	**13(13.54)**	**9 (9.38)**	**15 (15.63)**	**46 (47.92)**	**13 (13.54)**	**96**	**100.00**
b.	**Sex**							
	Male	11(11.45)	8 (8.33)	14 (14.58)	41 (42.70)	11 (11.45)	85	88.58
	Female	2 (2.08)	1 (1.04)	1 (1.04)	5 (5.21)	2 (2.08)	11	11.46
	Total	**13(13.54)**	**9 (9.38)**	**15 (15.63)**	**46 (47.92)**	**13 (13.54)**	**96**	**(100.00)**
c	**Age (years):**							
	1 - 10.	0.00	0.00	0.00	3 (3.13)	0.00	3	3.13
	11-20.	0.00	0.00	0.00	4 (4.17)	0.00	4	4.17
	21-30.	8 (8.33)	9 (9.37)	6 (6.25)	16 (16.67)	5 (5.21)	44	45.83
	> 30	5 (5.21)	0.00	9 (9.38)	23 (23.96)	8 (8.33)	45	46.88
	Total	**13(13.54)**	**9 (9.38)**	**15 (15.63)**	**46 (47.92)**	**13 (13.54)**	**96**	**(100.00)**
d	**Academic qualification**							
	Non formal	0.00	0.00	3 (3.13)	38 (39.58)	1 (1.04)	42	43.75
	Primary	0.00	0.00	3 (3.13)	4 (4.17)	3 (3.13)	10	10.42
	Secondary	0.00	0.00	3 (3.125)	3 (3.125)	**6 (6.25)**	12	12.50
	Tertiary	13(13.54)	9 (9.37)	6 (6.25)	1 (1.04)	3 (3.12)	32	33.33
	Total	**13(13.54)**	**9 (9.38)**	**15 (15.63)**	**46 (47.92)**	**13 (13.54)**	**96**	**(100.00)**
e.	**Experience (years)**							
	< 1	1 (1.04)	0.00	1 (1.04)	1 (1.04)	3 (3.13)	6	6.25
	1—5.	4 (4.17)	8 (8.33)	2 (2.08)	2 92.08)	4 (4.17)	20	20.83
	6 –10.	5 (5.21)	1(1.04)	4 (4.17)	3 (3.13)	2 (2.08)	15	15.63
	➢ 10	3 (3.12)	0.00	8 (8.33)	40 (41.67)	4 (4.17)	55	57.29
	Total	**13(13.54)**	**9 (9.38)**	**15 (15.63)**	**46 (47.92)**	**13 (13.54)**	**96**	**(100.00)**
f	**Herd size**							
	Nil	3 (3.12)	4 (4.17)	4 (4.17)	1 (1.04)	0.00	12	12.50
	1—5	1 (1.04)	0.00	5 (5.21)	0.00	13 (13.54)	19	19.79
	6—10	1 (1.04)	0.00	1(1.04)	2 (2.08)	0.00	4	4.17
	11—50	4 (4.17)	0.00	4 (4.17)	21 (21.88)	0.00	29	30.21
	51-100.	0.00	1 (1.04)	1 (1.04)	13 (13.49)	0.00	15	15.63
	➢ 100	4 (4.17)	4 (4.17)	0.00	9 (9.38)	0.00	17	17.71
	Total	**13(13.54)**	**9 (9.38)**	**15 (15.63)**	**46 (47.92)**	**13 (13.54)**	**96**	**(100.00)**
g	**Handling facilities**							
	Permanent	1 (1.04)	4 (4.17)	4 (4.17)	0.00	2 (2.08)	11	(11.46)
	Temporary	3 (3.13)	0.00	0.00	42 (43.75)	13 (13.54)	58	(60.42)
	Both	9 (9.38)	5 (5.21)	11 (11.46)	2 (2.08)	0.00	27	(28.13)
	Total	**13(13.54)**	**9 (9.38)**	**15 (15.63)**	**46 (47.92)**	**13 (13.54)**	**96**	**(100.00)**

Values in parenthesis ( ) stands for values in percentages.

Table 2: Perception of Handlers to Temperament Traits in Bunaji Cattle (N= 96)

Category of handlers	**Perceived temperament score** 1	2	3	4	5	**Mean**	**Min.**	**Max.**
Animal Scientists	0	0	7	6	0	3.46	3	4
Veterinary Doctors	0	0	5	4	0	3.44	3	4
Cattle Traders	0	2	6	2	5	3.67	2	5
Pastoralist (herders)	1	18	9	9	9	3.15	1	5
Village cattle farmers	0	5	1	5	2	3.31	2	5
Total	1	25	28	26	16	3.32	1	5

N: number of respondents, 1: Very calm (non- reactive), 2: Calm (slight- reactive), 3: Moderately-calm, 4: Reactive (nervous/ aggressive), 5: Very reactive (nervous or aggressive), Min. minimum, Max.: maximum

Table 3: Descriptive statistics of the body weight, milk yield and milking duration of the Bunaji cows (N = 51)

Trait	Mean ± SE	Min.	Max.	CV (%)
Body weight (Kg)	212.05 ± 4.87	145.30	305.00	16.40
Milk yield (litres.)	0.92 ± 0.05	0.30	1.89	40.11
Milking duration (min.)	2.16 ± 0.09	1.17	3.80	30.60

SE: standard error, Min.: minimum, Max.: maximum, N: number of cows milked, Kg: kilogram, min: minutes.

Table 4: Summary Statistics for the Distribution of Bunaji Cows based on the Subjective Assessment of Temperament (N = 51)

Traits	**Scores** 1	2	3	4	5	**Mean ± SE**	**Min**	**Max.**	**CV (%)**
MT	12 (23.53)	23 (45.10)	10 (19.61)	3 (5.88)	3 (5.88)	2.25 ± 0.15	1	5	47.63
PT	15 (29.41)	9 (17.65)	5 (9.86)	13 (25.49)	9 (17.65)	2.84 ± 0.21	1	5	53.74
CT	12 (25.53)	14 (27.45)	11 (25.17)	5 (9.80)	9 (17.65)	2.71 ± 0.20	1	5	51.89
CES	21 (41.18)	6 (11.76)	14 (27.45)	10 (19.61)	NA	2.25 ± 0.17	1	4	53.10

N: number of observations, SE: standard error, min.: minimum, max.: maximum, CV: coefficient of variation, MT: milking temperament, PT: pen temperament, CT, Chute temperament, CES: chute exit score, values in parenthesis: percentage distribution. Temperament score 1: the animal is very calm, and score 4 (for CES) or 5 (for MT, PT, CT): the animal is very reactive. NA: not applicable, <: Less than.

Table 5: Effect of Temperament on the Body Weight, Exit Speed, Milk Yield and Milking Duration of the Bunaji Cows (N =51)

Temperament score	Pen temperament Bd. Wt (kg)	ES (m/s)	Chute exit score Bd. Wt (kg)	ES (m/s)	Milking temperament Bd. Wt (kg)	MY (ltr.)	MD (min.)
1	217.54^{a}	1.32^{b}	219.14^{ab}	0.77^{c}	230.74^{a}	1.01^{a}	2.03^{b}
2	204.29^{ab}	1.98^{a}	215.44^{ab}	1.33^{c}	199.57^{b}	0.90^{a}	2.15^{ab}
3	207.66^{ab}	1.72^{a}	226.41^{a}	2.09^{b}	203.33^{b}	0.87^{ab}	2.36^{a}
4	226.33^{a}	1.92^{a}	190.25^{b}	3.28^{a}	238.33^{a}	0.93^{a}	2.04^{b}
5	191.43^{c}	2.06^{a}	NA	NA	235.67^{a}	0.93^{a}	2.24^{a}
SEM	4.89	0.17	4.89	0.17	4.89	0.05	0.09

^{abc}: means with different superscript in the same column are significantly different ($P < 0.05$), bd. wt: body weight, kg: kilogram. MY: milk yield, ltr: Litres, min.: minutes, ES: exit speed, m/s: meters per seconds, NA: not applicable, Scores: (1, 2, 3….5): for pen: very calm, calm, moderately reactive, aggressive, and very aggressive, for chute exit score:1-walk, 2- trot, 3- run, 4- jumps. For milking temperament scores; very calm, calm, moderate, nervous and very nervous.

Table 6: Phenotypic correlations between temperament traits with exit speed, milk yield, milking duration and body weight of the Bunaji Cows (N = 51).

	MT	PT	CT	CES	ES	BW	MY	MD
MT	1.00							
PT	0.16	1.00						
CT	0.06	0 .34*	1.00					
CES	0.14	0.26*	0.72**	1.00				
ES	0.17	0.21	0.65**	0.82**	1.00			
BW	0.03	-0.11	-0.37*	-0.27*	-0.17	1.00		
MY	-0.08	0.25*	0.03	0.01	-0.04	0.15	1.00	
MD	0.10	0.18	0.13	0.15	0.19	0.10	0.35*	1.00

*: Significance (P< 0.05), * *: Highly significance (P < 0.01), BW: body weight, MT: milking temperament, PT: pen temperament, CT, Chute temperament, CES: chute exit score, ES: exit speed, MY; average milk yield, MD: average milking duration

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Journal of Applied Agricultural Research 2022, 10(2):264-273
ISSN 2006-750X.

PRODUCTIVE PERFORMANCE AND EGG QUALITY OF LAYER CHICKENS FED GRADED LEVELS OF SORGHUM ICSV400 VARIETY AS REPLACEMENT FOR MAIZE.

*[1]Jama'a, N. A.[2]Jamilu, H., [1]Doma, U. D., [1]Abubakar, M., Bello, K. M. and Balarabe, S.
[1]Department of Animal Production, AbubakarTafawaBalewa University, Bauchi state, Nigeria
[2]Teaching and Research Farm, Faculty of Agriculture, Federal University Dutse, Jigawa State
[3]Department of Animal Science, Ahmadu Bello University, Zaria
Author's Contact: najamaa4u@yahoo.com, Phone no. +2347061097766

ABSTRACT

This experiment was conducted to evaluate the productive performance and egg quality characteristics of layers fed graded levels of sorghum ICSV400 variety based diet during the months of November and December, 2016. Four hundred (400) Isa Brown layers were used for the experiment. They were allotted to the five (16% CP) diets each replicated four times in a completely randomized design. Sorghum ICSV400 variety replaced maize at 0, 25, 50, 75 and 100% for diets 1, 2, 3, 4 and 5 respectively. During the twelve weeks experiment, parameters studied were performance, egg quality characteristics and financial benefit of layer chickens. All the data generated were subjected to analysis of variance. Live weights was not significant among the performance parameters but highly ($P<0.001$) significant on daily feed intake, percent hen day and hen house productions and significant ($P<0.01$) on feed conversion ratios. However, most of the egg quality parameters were not significantly affected by the dietary treatments but highly significant ($P<0.001$) on albumin and yolk lengths as well as albumin index while albumin height and yolk weight were significantly ($P<0.01$) influenced by the diets. Cost benefit analysis indicated higher values on feed intake and dozens of eggs produced in layers fed diet 5 (100% sorghum ICSV400 variety) and also lower value of feed cost (₦/kg), total feed cost (₦) and feed cost per dozen eggs (₦) were obtained. It is concluded that sorghum ICSV400 variety can completely replace the conventional and highly competitive maize in layer chickens diets without compromising performance and egg quality.

Key words: sorghum ICSV400, layers, performance parameters, egg quality parameters

INTRODUCTION.

Maize is the most widely used cereal grain in poultry feeding around the world and is regarded as possessing better nutritional attributes than other cereal grains (Ajaja and Aletor, 2005). Aremu *et al*. (2010) stated that the provision of energy and protein in the diets accounts for about 90% of the total cost of ration production.Pressure on maize, wheat and recently cassava has been on the increase worldwide with emphasis being placed on exports and other diversified uses mostly in flour based foods and ethanol production as well as an alternative source of fuel (FAO, 2016).Sorghum is one of the most widely grown crops in Nigeria and the grains are valuable concentrates in man and livestock feeding (Njike, 1977). It is the fifth most important cereal after wheat, maize, rice and barley in the world over (Bryden *et al.*, 2009). Sorghum grain is an interesting energy ingredient in poultry diets due to its nutritional composition which is very similar to maize. Oluyemi and Roberts (2013) reported thatmetabolizable energy value of maiz and sorghum is 3432Kcal/kg and 3300Kcal/kg respectively. Chicken meat and eggs are the best sources of quality animal protein, which are badly needed by the many millions of people around the world who live in poverty (David, 2010). Eggs are among the few foods classified as "super foods" and they are among the most nutritious foods on the planet. They are loaded with nutrients, some of which are rare in modern diets (Kris, 2017). In poultry nutrition, several varieties of sorghum grains have been tested as a possible substitute for maize based on the similarities in their chemical composition (Rostagno *et al*., 2000). The factor that must be considered when using sorghum grains in poultry ration however is the presence of a phenolic substance called tannin which limits large scale use. Adamu *et al*. (2001) evaluated the performance of broiler chickens under semiarid environment. They used maize, millet and sorghum each at 60% levels of inclusion and observed that the performance did not differ significantly.

As in most grain however, lysine and methionine are still the most limiting amino acids in sorghum (Wu *et al*., 2010). Jama'a *et al.* (2014) substituted sorghum variety ICSV400 in broiler diets for maize up to 100% replacement level using full fat soya bean and observed that ICSV400 can completely replace maize in the diets with better performance in weight gain. Sorghum variety ICSV400 is a pure line cultivar developed at the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) Asia center, Patancheru, AP, India in 1981-1985 through pedigree selection (Tabo *et al*., 1999). There is less demand for this variety of sorghum and its production is gaining popularity among farmers in the study area. ICSV400 has good agronomic qualities such as high yielding and early maturing. It will be good therefore to test it with different protein sources available around the locality to see if they can do well in poultry diets and finding the best combination among them in terms of performance and cost efficiency. Soya bean (*Glycine max*) is the best protein source of plant origin widely used in poultry diets (Olomu, 2011) which is closely followed by groundnut cake. However, the demand for soya bean is by far above the supply due to its numerous uses ranging from human to industrial.

In view of the competitions on the conventional feedstuffs, efforts should be channeled towards finding the alternatives from the non-conventional ones. For this reason, many protein of plant origin such as ground nut cakes, bambara nuts, water melon seed, sunflower seed etc have been used in place of the highly competitive and costly soya beans using maize as a source of energy, all with the aim of reducing cost of production, improving or at least maintaining performance. Thus any effort to substitute the costly feed ingredients like maize and soya bean with cheaper raw materials will significantly reduce the cost of production (Okah, 2004), which will make poultry products more available and affordable to the teeming population of Nigeria.

Demand for this variety of sorghum (ICSV400) is very minimal as people are not very much aware of it, as such its price will be moderate. However, there is scanty information as to the utilization of this variety of sorghum in poultry diets. Therefore, this study was designed to evaluate the nutritional values of ICSV400 with regards to Poultry rations for possible utilization.

MATERIALS AND METHODS.

Experimental Site

The research was conducted at the poultry section of Teaching and Research Farm, Abubakar Tafawa Balewa University, Bauchi, Bauchi State, Nigeria. The state occupies a land area of about 66,000 square kilometers. Bauchi town is located within Southern Guinea Savannah on latitude 13^0 30' N and longitude 11^0 50' E at an altitude of 690.20 meters above sea level. The climate is characterized by a well-defined rainy season (June-October) and dry season (November-May). The total mean annual rainfall in the state is 700-900 mm for the Northern zone, 690-1031 mm for Central zone and 900-1300 mm for the Western zone (BASDP, 2003). The mean temperature ranges between 19.15 ^{0}C and 38.50 ^{0}C. The highest temperature is observed in the months of March, April and May, while the lowest is in the months of January and December every year. Highest relative humidity of 99% is observed in August and the lowest of 57% in February (Anonymous, 1999).

Experimental Diets.

Five diets of 16% CP (layer marsh) were formulated with sorghum ICSV400 variety replacing maize at 0, 25, 50, 75 and 100% coded as diets 1, 2, 3, 4 and 5 respectively (Table 1). Each of the diet was replicated four times in a completely randomized design with 20 layers in each replicate.

Experimental Birds and Management.

Four hundred (400) Isa brown point of lay were used for the experiment. The birds were flushed using the experimental diets for one week. There after they were divided in to five groups and each group was further divided in to four sub groups of twenty birds as replicates. The experimental diets (Table 1) were fed the birds for 12 weeks. During the period, water and the diets were given *adlibtum* and all sanitary measures were adhered to.

Data Collection and Analysis

Records of initial weights, feed intake and number of eggs laid were taken to measure layers performance parameters such as daily feed intake (DFI), hen day production (HDP), hen house production (HHP) as well as feed conversion ratio (FCR) as presented in Table 2. Similarly, both internal and external egg quality parameters like egg weight, egg length, egg width, albumin length, yolk length, albumin length, yolk height, yolk weight, albumin weight, shell weight, shell thickness, yolk index (YI), albumin index (AI) and yolk albumin index ratios (YAI) were obtained on weekly basis by selecting 4 eggs from each of the replicate (Table 3). Data generated were subjected to analysis using analysis of variance technique (Steel and Torrie, 1980) Means with significant difference were separated using Duncan multiple range test. Equations used in calculating the various parameters above are shown below.

$$\%HDP = \frac{total\ eggs\ produced}{number\ of\ live\ birds}\ x\ 100 \text{ ----- } (1)$$

$$\%HHP = \frac{total\ eggs\ produced}{initial\ number\ of\ birds\ housed}\ x\ 100\text{- } (2)$$

$$FCR\ layers = \frac{feed\ intake\ (kg)}{dozens\ of\ eggs\ produced}\ x\ 100\text{–}(3)$$

$$YI = \frac{yolk\ height}{yolk\ diameter}\ x\ 100 \text{ ------------------- } (4)$$

$$AI = \frac{albumen\ height}{albumen\ diameter}\ x\ 100 \text{ ------------- } (5)$$

$$YAR = \frac{yolk\ weight}{albumen\ weight}\ x\ 100\text{-------------- } (6)$$

RESULTS AND DISCUSSION.

The initial weights of layers used in the experiment were similar statistically and ranged from 1.65-1.74 kg as shown in Table 2. This is within the range given by Poultry CRC (2014) that at 18-20 weeks of age layers should weigh 1.68-1.72 kg. Daily feed intake (DFI) was significantly affected by the dietary treatments with the values varying between 111.00 and 123.00 g. The values obtained were within the range (120-150 g) given by Olomu (1995). Feed consumption and number of eggs laid increased with the increase in levels of sorghum variety ICSV400. As sorghum is generally lower in metabolizable energy (ME) than maize, the ME decreases as the inclusion levels increased and the birds tend to eat more to meet their energy requirement. This pattern is similar to the report of Salissou (2009) that feed intake and egg production tend to be greater in layers fed sorghum based diets. This however differ from the report of Prochaska *et al.* (1996) who found similar feed consumption among layers fed sorghum based diets.

The highest percent hen day production was observed in birds on diet 5 (100% ICSV400) which was significantly different from the remaining diets. This finding is not in conformity with the findings of Narkhede *et al.* (1981), Thakur *et al.* (1985) and Rama Rao *et al*. (1995) that egg production remained unaffected with sorghum in diet. In those experiments, sorghum was used at a single level to replace maize part per part. However, the result obtained in this research agreed with the reports of Gowda *et al.* (1984) that egg production did not decrease when layers were fed diets with sorghum at 32 to 50 % of their diets or when sorghum was the sole cereal in the diet (Ambula *et al.*, 2003; Partharathy *et al.*, 2005). Similarly, this result is close to the findings of Issa *et al.* (2007) that 57 % egg production for layers fed sorghum compared to 47% from birds fed a corn-based diet, but is higher than that of Ezeogwu *et al.* (2003) for layers fed graded levels of garcinia kola seed meal. Henhouse percent egg production (HHPP) was also better on diet 5 (100 % ICSV400) and significantly ($P<0.001$) differ with the rest of the 4 diets. This may be attributed to the higher feed intake experienced on the diet and the result is also better than some of the reported works like Isika *et al.* (2006) who fed layers with palm oil and animal fats and found 67.8-73.3 % as HHPP. Feed conversion ratio (FCR) was better (1.71) on diet 1 (control) and the lowest on diet 5 (100% ICSV400) which differ significantly ($P<0.01$) among the 5 treatments. This result did not agree with the reports of Salissou (2009) of non-significant differences in average egg weight and feed conversion ratio among birds fed corn and sorghum based diets and that of Narkhede *et al.* (1981); Thakur *et al.* (1985) and Rama Rao *et al.* (1995) of non-significant effect in FCR by including sorghum in the diets of layers. The mortality of 5 birds obtained during the period of the research was within the range (20-25 % per year) reported by FAO (1997).

The values for egg weight (52.59-53.65 %) did not differ statistically across the 5 diets. This result was not in agreement with the result of Issa *et al.* (2007) who reported higher egg weight for birds fed sorghum diet in comparison with those fed corn based diets but it agreed with that of Freitas *et al.* (2014) that egg production and egg weights were not influenced by white or red sorghum based diets. In the same vein, Narkhede *et al.* (1981) and Gowda *et al.* (1984) reported no differences in egg weight of layers fed sorghum based diets. The values of egg length (54.27-54.84 cm) and egg width (41.64-41.91 cm) were close to the values of 51.10-52.80 and 40.50-41.30cm obtained by Oke *et al.* (2014) for egg length and width respectively.

Significant increase in albumen and egg weight in layers fed sorghum based diets was also reported by Prochaska *et al.* (1996). Albumen length was significantly (P<0.001) influenced by the dietary treatments. Highest value (72.46 cm) was observed on diet 5 (100 % ICSV400) and the least (69.58 cm) on diet 1 (control). These values are higher than the proportion for fresh egg (32 % yolk, 58 % albumen and 10 % shell) given by Poultry site, 2014. However, the high values obtained in this research indicated the high quality of the eggs. This is because albumen has a major influence on the overall internal quality of an egg. It is a major determinant of internal egg quality as reported by Oke *et al.* (2014). Higher haugh unit, which is an indicator of egg quality, is obtained in eggs with large proportion of thick white or albumen (Nonga *et al.*, 2010). Albumen height (9.57-9.93, P<0.01) and albumen index (13.30-14.23 %, P<0.001) were affected significantly by the dietary treatments. However, albumen weight (31.32-32.11 g) and yolk albumen ratio (0.43-0.44) were not influenced by the dietary treatments. Albumen weight and albumen ratio are very important from nutrition point of view (Bain, 2005) and cholesterol content (Abdullahi *et al.*, 2000). Yolk length (40.03-40.95 cm, P<0.001) and yolk weight (13.35-13.82 g, P<0.01) were influenced significantly while no significant differences were found in yolk index (44.78-45.43 %). Although shell weight (6.28-6.39 g) and shell thickness (0.47-0.5 mm) were not affected by the dietary treatments, the values increased with the increase in sorghum inclusion levels. This contradicts the report of Narkhede *et al.* (1981) that shell thicknesses reduce with sorghum levels in the diet. This however coincided with the finding of Adamu (2014) who found non significant difference in egg weight and shell thickness in layers fed sorghum based diets.

The shell thickness of 0.47-0.50 mm is a little above the value (0.33mm) given by Chineke (2001) which is considered too thin with the risk of breakage and ease of entry by micro-organism. Egg shell is a good indicator of egg external quality. Thick and strong shells are usually the most marketable (Melesse *et al.*, 2010). Report by Issa *et al.* (2007) showed that sorghum can be used as the sole energy source in layer diets without compromising performance. Similarly, Reddy *et al*. (2005) reported that maize can be replaced by sorghum in poultry feed rations without affecting body weight and egg production performance of laying birds, and quality traits of eggs produced by layer birds fed sorghum based diets were also comparable to that of maize based diets except yolk color.

Total feed intake increased with increased levels of sorghum in the diets. This may be attributed to the reduced metabolisable energy as the level of sorghum increased in the diets. This is in line with the report of Ani and Okeke (2003) that birds eat to meet their energy requirements, so low metabolisable energy in a diet leads to more consumption. Feed cost naira per kg was higher on diet 1 (control, 100 % maize). This may be due to the fact that weight to weight, ICSV400 is heavier than maize. This means that a bag of 100 measures of ICSV400 is heavier than the same measures of maize. Another reason was that ICSV400 is not very popular and its demand is minimal which affects its price. This finding agreed with the report of Reddy *et al.* (2005) who stated that feed cost per production of an egg was lower in sorghum diets compared to control (maize based diets). As total feed intake and feed cost are the determinants of total feed cost, total feed cost (₦) increased as the levels of ICSV400 increased in the diets. This is due to the high feed intake obtained on diet 5. Dozens of egg produced was higher (5.81) on diet 5 (100 %

ICSV400) and the least on diet 1 (5.19). However, it increased with the increased levels of ICSV400 in the diets. Feed cost naira per dozen seems to be higher (₦ 156.20) on diet 1 (control) and lower on diet 5 (100 % ICSV400).

CONCLUSION.

From the results obtained in this study, it was concluded that, based on the nutritive values, ICSV400 sorghum variety is suitable and safe as an energy source in poultry diets and itcan completely (100%) replace maize in layers diets with concomitant reduction in feed cost.

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Table 1: Ingredients and percentage compositions of sorghum ICSV400 variety based diets fed to layers

	Diets				
Ingredients%	**1(0%)**	**2(25%)**	**3(50%)**	**4(75%)**	**5(100%)**
Maize	47.83	35.87	23.92	11.96	0.00
ICSV400	0.00	11.96	23.92	35.87	47.83
FFSB	19.37	19.37	19.37	19.37	19.37
Wheat offal	20.00	20.00	20.00	20.00	20.00
Fish meal	2.00	2.00	2.00	2.00	2.00
Lime stone	7.00	7.00	7.00	7.00	7.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Salt	0.25	0.25	0.25	0.25	0.25
*Premix	0.25	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20	0.20
Lysine	0.10	0.10	0.10	0.10	0.10
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated analysis					
Crude Protein (%)	16.93	17.05	17.17	17.29	17.41
ME (kcal/kg)	2712	2686	2681	2665	2649
Crude Fiber (%)	3.75	3.75	3.75	3.75	3.75
Ether Extract (%)	6.19	6.07	5.95	5.83	5.72
Calcium (%)	3.70	3.70	3.70	3.71	3.71
Phosphorus (%)	0.61	0.64	0.66	0.69	0.72
Methionine (%)	0.48	0.47	0.46	0.45	0.44
Lysine (%)	0.96	0.97	0.98	1.00	1.01

*Vitamin-mineral Premix contains the following per 2.5 kg: Vitamin A 10,000 IU, Vit. D3 2,000,000IU, Vit E 12,000mg, Vit K3 2,000mg, Vit B1 1,500mg, Vit B2 4,000mg, Vit B6 1,500mg, Niacin 15,000mg, Vit B12 10mcg, Pantothenic acid 5,000mg, Folic acid 500mg, Biotin 20mcg, Cholinechloride 100,000mg, Manganese 75,000mg, Zinc 50,000mg, Iron 20,000mg, Copper 5,000mg, Iodine 1,000mg, Selenium 200mg, Cobalt 5000mg, Antioxidant 125,000mg.

Table 2: Performance of layer chickens fed dietary levels of sorghum ICSV400 variety as replacement for maize

	Diets						
Parameters	**1(0%)**	**2(25%)**	**3(50%)**	**4(75%)**	**5(100%)**	**SEM**	**LS**
Live weight (kg)	1.70	1.74	1.69	1.65	1.66	0.04	NS
Daily feed intake (g)	111.00^{e}	115.00^{d}	117.00^{c}	121.50^{b}	123.00^{a}	0.03	***
Hen day production (%)	79.32^{b}	80.91^{ab}	83.70^{ab}	81.96^{ab}	85.61^{a}	1.11	***
Hen house production (%)	79.30^{b}	79.89^{ab}	82.61^{ab}	81.95^{ab}	84.52^{a}	1.10	***
Feed conversion ratio	1.71^{b}	1.75^{ab}	1.72^{ab}	1.80^{a}	1.77^{ab}	0.02	**
Number died	1	2	0	1	1	-	-

NS = not significant, SEM = standard error of means, LS = level of significance, ** (P <0.01) and *** (P <0.001).
a,b,c,d and e = means in the same row bearing the same superscripts are statistically similar

Table 3: Egg Quality parameters of layer chickens fed dietary levels of sorghum ICSV400 variety.

	Diets						
Parameters	**1(0%)**	**2(25%)**	**3(50%)**	**4(75%)**	**5(100%)**	**SEM**	**LS**
Egg weight (g)	52.59	53.65	52.80	52.83	53.32	2.57	NS
Egg length (cm)	54.27	54.82	54.64	54.70	54.84	1.19	NS
Egg width (cm)	41.74	41.91	41.73	41.64	41.72	0.77	NS
Albumen length (cm)	69.58^{b}	70.35^{b}	71.23^{ab}	70.91^{ab}	72.46^{a}	0.37	***
Yolk length (cm)	40.03^{c}	40.36^{bc}	40.64^{ab}	40.34^{bc}	40.95^{a}	0.12	***
Albumen height (cm)	9.81^{ab}	9.93^{a}	9.87^{a}	9.88^{a}	9.57^{b}	0.08	**
Yolk height (cm)	18.11	18.29	18.36	18.30	18.32	0.51	NS
Yolk weight (g)	13.35^{b}	13.66^{ab}	13.73^{a}	13.48^{ab}	13.82^{a}	0.09	**
Albumen weight (g)	31.32	32.11	31.43	31.64	31.77	2.01	NS
Shell weight (g)	6.39	6.34	6.30	6.29	6.28	0.40	NS
Shell thickness (mm)	0.47	0.48	0.49	0.47	0.50	0.07	NS
Yolk index (%)	45.31	45.38	45.26	45.43	44.78	1.43	NS
Albumen index (%)	14.20^{a}	14.23^{a}	13.94^{ab}	14.06^{a}	13.30^{b}	0.14	***
Yolk/ Albumin ratio	0.43	0.43	0.44	0.43	0.44	0.03	NS

NS = not significant, SEM = standard error mean, LS = level of significance, ** = (P <0.01) and *** = (P <0.001), a, b, c = means in the same row with the same superscripts are statistically similar.

Table 4: Production cost analysis of egg production withsorghumICSV400 variety based diets.

	Diets				
Parameters	**1(0%)**	**2(25%)**	**3(50%)**	**4(75%)**	**5(100%)**
Total feed intake (kg)	8.88	9.20	9.36	9.72	9.84
Feed cost (₦ /kg)	91.29	90.63	89.98	89.32	88.66
Total feed cost (₦)	810.66	833.80	842.21	868.19	872.41
Dozens of egg produced	5.19	5.39	5.48	5.68	5.81
Feed cost/dozen (₦)	156.20	154.69	153.69	152.85	150.16

Journal of Applied Agricultural Research 2022, 10(2):274-289
ISSN 2006-750X.

INTERACTIONS OF PACKAGING MEDIA AND STORAGE PERIOD ON QUALITY OF '*Dambun nama'* FROM MEAT OF BROILER CHICKENS FED DIETS CONTAINING '*Zogale*' (*Moringa oleifera*) AND '*Sabara*' (*Guiera senegalensis*) LEAF MEALS

Balarabe[1*], S., Jibir[2], M., Duru[1], S., Abdu[1], S. B. and Jama'a[3], N. A.
[1]Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria, [2]Department of Animal Science, Usmanu Danfodiyo University, Sokoto, Nigeria, [3]Department of Animal Production, Abubakar Tafawa Balewa University, Bauchi, Nigeria,
Author Contact:safiyyahbala251@gmail.com, Tel: +2347033643525

ABSTRACT.

The study was conducted to evaluate storage quality of *dambun nama* prepared from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* (MOL) and *Guiera senegalensis* (GSL) leaf meals. The experiments were carried out at the Research Farm, Department of Animal Science and at the Department of Veterinary Microbiology, Ahmadu Bello University, Zaria. A total of two hundred and forty (240) day old broiler chicks of Cobb 500 strain were used for each of the two experiments (MOL and GSL) concurrently. In Experiment 1a, two hundred and forty (240) day old broiler chicks were allotted into four graded levels of MOL at 0, 7, 14 and 21% to serve as treatments MOL1, MOL2, MOL3 and MOL4, respectively. The birds were replicated three (3) times with 20 chicks per replicate in a Completely Randomized Design. In Experiment 1b, MOL was substituted with GSL for GSL1, GSL2, GSL3 and GSL4. The two experiments lasted for 8 weeks. The results revealed that *dambun nama* (meat floss) processed from meat of broiler chicken fed diets containing graded levels of MOL and GSL for up to 21% can be stored for 12 weeks without significant changes in quality of the product. All the packaging media (FPP, WNP, PCP and DCP) had lower counts of both fungi and bacteria; with PCP and WNP being more effective. For instance, plastic container packs (PCP) had lower total microbial counts ranging from 0.0 to 2.0 cfu/g x 10^5 at higher (8 to 12) weeks of storage than the other media. However, the packaging media were more effective in suppressing fungal than bacterial activities in storing *dambun nama* at various weeks. It is recommended that MOL and GSL be included in broiler chicken diets up to 21% for processing and storage of *dambun nama* for improved keeping quality. It is also suggested that *dambun nama* from meat of broiler chickens fed diets containing graded levels of MOL and GSL should be stored above the 12- week period for further investigations.

Key words**:** *Dambun nama, storage, packaging media*

INTRODUCTION.

Poultry occupies a unique position in the livestock sub-sector of the Nigerian economy because they are good converters of feed, and the best solution to Nigeria's protein intake particularly from animal origin is to increase poultry production (Zahraddeen *et al.*, 2006;

Udedibie *et al.*, 2007; Zahraddeen *et al.*, 2010). Broiler chicken meat is one of the nutritious meats consumed as component of human diets. It is an excellent source of high quality protein and also contains large amount of minerals and essential vitamins, as well as fats (Ojewola and Onwuka, 2001).

Processing of meat products aids in the production of value added varieties and conventional meat products to meet the current life style requirements, and offers better utilization of different carcasses, cuts and edible by products with different flavours and increases the shelf life of the products (Anjeneyulu *et al*., 2007). Processing of meat facilitates incorporation of non-meat ingredients for quality and economy. It also helps in preservation, transportation, distribution and marketing to larger populations (Anjeneyulu *et al*., 2007).

Dambun nama is a dried meat product produced mainly by Hausas and Fulanis in Northern part of Nigeria (Ogunsola and Omojola, 2008; Eke *et al*., 2013). The meat floss is processed by cooking, pounding and then fried with addition of spices (Bube, 2003). Due to its low moisture content, meat floss can be kept without refrigeration and will not drastically change at room temperature for long storage period of time (Huda *et al.*, 2012). Most meat floss come from beef, mutton or camel, however, the use of meat from poultry and fish is becoming popular among consumers (Eke *et al*., 2013).

The main objection to consumption of locally processed meat products lies with the poor sanitary conditions (Ahemen and Zahraddeen, 2010) that are associated with the production and handling processes (Balarabe *et al.*, 2016a). The methods of meat preservation are major challenges among meat consumers, handlers and entrepreneurs. Handling and storage methods are primarily concerned with minimizing microbial contamination and retarding microbial growth (Benjakul *et al.*, 1999; Balarabe, 2021). In Nigeria, meat processing is still in its technological infancy because the processing methods that have been in use for the past generations are yet to be standardized or modernized to cope with increasing consumer demand (Igene and Mohammed, 1983; Balarabe *et al*., 2016a; Balarabe, 2021). The major problem with traditional meat processing industries is lack of standardization required of the finished products (Abubakar *et al*., 2011). Therefore, processing method varies depending on the processor and the quality of the finished products (Farouk *et al*., 1992). Balarabe *et al*. (2016b; 2016c) reported that standardization of production processes of meat products improved shelf life and keeping quality.

However, the local meat industry in the country is still traditional and the production processes are usually done in an un-hygienic manner which results in product adulteration and contaminations (Balarabe, 2021). Local meat products processed in this manner are prone to microbial contamination resulting in quality deterioration in storage and source of infection to consumers (Bube, 2003). There is the need to standardize the production processes of these local meat products in order to enhance their shelf-life and production of wholesome meat products. It is also important to explore the use of local materials that have the potential of enhancing meat quality in storage quality.

However, natural antioxidants especially of plant source have greater application for consumer acceptability, palatability and increase shelf life of meat products and could improve the nutritional quality of the product too (Oshibanjo *et al,*. 2019). *Moringa oleifera* and *Guiera senegalenses* are among such plants. This, therefore, triggered the current interest for using natural plants as ingredients in the feed of broiler chickens and further processing of the chicken meat into meat floss, to reduce lipid oxidative degradation, which deteriorates the quality of meat and reduces its shelf life. There is limited report on the bioactive constituents of *Moringa oleifera* and *Guiera senegalensis* leaves and their impact on broiler meat antioxidant status (Hassan *et al.* 2016). Previous studies using *Moringa oleifera* and *Guiera senegalensis* leaves were reported to have some positive effects on storage of meat floss (*Dambun nama*) (Balarabe *et al.*, 2016c, 2016d; Salisu, 2017). These earlier studies were mostly on the suppression of microbial (fungal and bacterial) activities. Balarabe *et al.* (2016b, 2016c) used leaf powder at 3.0g/100ml of water in cooking of beef, mutton, chevon, camel and broiler chicken meat to process *dambun nama* and examined their effects on shelf-life and storage quality over a 5 - week period. Furthermore, Salisu (2017) investigated the inclusion levels of 2.0, 3.0 and 4.0g/100 ml of water in cooking of beef to process *dambun nama* on the shelf-life and storage quality for up to 12 week period.

However, the limitation of the earlier studies was in the manner of incorporation of these leaf extracts (*Moringa* and *Guiera*), which were only used during cooking processes of meat to process meat floss (*dambun nama*), but not used as dietary components in feed of broiler chickens, and subsequent evaluation of the raw meat and processed *dambun nama* products. Therefore, there is the need to investigate the effects of dietary utilization of these leaf meals in broiler chickens diet and processing of the raw meat into *dambun nama* for assessment of shelf life and quality. Therefore, this study was designed to evaluate the effects packaging media and storage of *dambun nama* processed from meat of broiler chicken fed dietary levels of *Moringa oliefera* and *Guiera senegalensis* leaf meals.

MATERIALS AND METHODS.

Study Area.

The study was conducted at the Department of Animal Science, Faculty of Agriculture, and at the General Microbiology Laboratory, Department of Microbiology, Faculty of Life Sciences, Ahmadu Bello University, Zaria. Samaru is located in the Northern Guinea Savannah Ecological Zone of Nigeria. It is on latitude 11^o 19ˈ North, longitude 7^o, 37ˈ45 East and at an altitude of 610 meters above sea level (Ovimaps, 2019). The temperature ranges between 26^0 and 40^o, depending on the season while the relative humidity during the dry and wet seasons ranged between 21% and 72%, respectively (IAR, 2019). The wet season in Samaru range between May and October with annual rainfall of about 1500mm.

Sourcing and Processing Of *Moringa Oleifera* and *Guiera Senegalensis* Leaf Meals.

Fresh leaves of *Moringa oleifera* and *Guiera senegalensis* were sourced in Samaru and Sabon Gari markets of Sabon Gari Local Government Area, Kaduna State, and were shade-dried for 3 days (72hrs). The dried leaves were ground into powder form using a hammer mill at Labar Feed Mill, Samaru to produce the desired leaf meals of the test plants.

Analysis for Chemical Composition.

The leaf powder of *Moringa* (*Moringa oleifera*) and *Sabara* (*Guiera senegalensis*) used in the study were taken to Biochemical Laboratory, Department of Animal Science for analysis of chemical composition using the standard method described by (AOAC, 2005). The analyses were done to obtain the nutrient composition (dry matter, crude protein, crude fibre, ash and nitrogen free extract) of the diet. Protein was determined by Kjedahl procedure, Ether extract was determined by subjecting the samples to petroleum ether extraction at 60-80^{o}C using the Soxhlet extraction apparatus. Dry matter was determined by oven drying the samples at 100°C over a 12-hour period. Crude fiber was determined by boiling the sample under reflux in a weak sulphuric acid (0.255N H_2SO_4), then in a weak sodium hydroxide (0.312N NaOH) for 1 hour. The residues (fibrous material) were dried and weigh. The ash content was determined by igniting a weighted sample in a muffle furnace at 500°C. The nitrogen free extract (NFE) was obtained by the difference after the percentage of other fractions has been subtracted from 100% (Table1).

Experimental Design and Management of Birds.

Two experiments were conducted separately for *Moringa oleifera* and *Guiera senegalensis.* The studies were conducted concurrently, where two hundred and forty (240) day old broiler chicks of Cobb 500 strain for each of the two experiments.

In the first experiment, the birds were allotted into four different dietary treatments comprising of a control (MOL1; 0) and different proportions of *Moringa oleifera* (7.0, 14.0 and 21.0% of diet to serve as treatments MOL2, MOL3 and MOL4, respectively (Tables 2 and 3) and the treatments were replicated three (3) times with 20 chicks per replicate in a completely randomized design. The trial lasted for 8 weeks (0 – 4 weeks starter phase and 5 – 8 weeks finisher phase).

Two hundred and forty (240) day old broiler chicks of cobb 500 strain were also used for the second experiment involving *Guiera senegalensis* and the birds were allotted into four different dietary treatments comprising of a control (GSL1; 0) and different proportions of *Guiera senegalensis* (7.0, 14.0 and 21.0% of diet to serve as treatments GSL2, GSL3 and GSL4 respectively) and the treatments were replicated four (3) times with 20 chicks per replicate in a completely randomized design (CRD) (Tables 4 and 5). The trial also lasted for 8 weeks (0 – 4 weeks starter phase and 5 – 8 weeks finisher phase).

Feed and clean water were given *ad libitum* to the birds throughout the experimental period. The birds were vaccinated against Newcastle and Gumboro diseases (at 2nd and 3rd weeks) as recommended by the Veterinary Teaching Hospital (VTH) of Ahmadu Bello University, Zaria. Other standard methods such as fumigation, sanitation and prophylactic medications were carried out to ensure healthy birds throughout the experiment.

Preparation of *Dambun nama*

Fresh broiler chicken meat was cut into pieces of approximately 4 cm by 2.5 cm dimensions and washed with water, mixed with spices (ginger, pepper, onion, cloves, garlic, seasoning cubes, thyme, salt, curry) in the ratio of 6g of spice to 100g of meat. Water was added to the meat samples and cooked for about 35 minutes at 100°C. Cooking was done in different aluminium pots for each of the treatments to avoid mixed up, and procedures were the same across all the treatment groups. The cooked meat was then pounded into shreds using a mortar and pestle. Pounding was intense and consistent until the meat strands disengaged and were beaten into shreds. This was then shallow-fried using groundnut oil in a stainless steel pot to obtain *dambun nama*, which is usually brownish in colour (Bube 2003; Kalla *et al*., 2005), and mixture of spices used in the preparation is shown in Table 6.

Effects of storage and packaging method on shelf- life of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oliefera and Guiera senegalensis* leaf meals.

Table 1: Chemical composition of *Moringa oleifera* and *Guiera senegalensis* leaf meals.

Parameters	**Moringa (*Moringa oleifera*)**	**Sabara (*Guiera senegalensis*)**
Dry Matter (%)	88.51	87.04
Crude Protein (%)	19.25	19.52
Crude Fibre (%)	8.71	9.15
Fat (%)	3.11	2.97
Nitrogen Free Extract (%)	60.93	60.07
Ash (%)	8.00	5.18
Ca (%)	0.11	0.23
Mg(%)	0.97	0.87
K (%)	1.45	0.55
Na (%)	0.99	0.52
P (%)	0.33	0.09
Fe (mg/kg)	1867.75	1254.08
Mn (mg/kg)	244.08	577.67
Cu (mg/kg)	108.08	98.17
Zn (mg/kg)	111.08	132.74

Table 2: Composition (Kg) of broiler starter diet containing graded levels of *Moringa oleifera* Leaf meal (0 – 4 weeks)

Ingredients	**MOL 1**	**MOL 2**	**MOL 3**	**MOL 4**
Maize	50.00	46.00	43.00	41.00
FSBM	15.00	15.00	15.00	15.00
MOL	**0.00**	**7.00**	**14.00**	**21.00**
Maize offal	3.50	3.50	3.50	3.50
GNC	27.00	24.00	20.00	15.00
Bone Meal	3.00	3.00	3.00	3.00
Limestone	0.50	0.50	0.40	0.40
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.35	0.35
Common salt	0.25	0.25	0.25	0.25
Vit. Premix*	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis				
ME (Kcal/kg)	2011	2901	2902	2900
Crude Protein (%)	23.11	23.32	23.28	23.13
Crude Fibre (%)	4.61	4.81	4.91	5.00
Ether Extract (%)	6.45	6.55	6.63	6.62
Calcium (%)	1.34	1.34	1.31	1.31
Phosphorus (%)	0.63	0.63	0.62	0.62
Lysine (%)	1.21	1.18	1.20	1.17
Methionine (%)	0.56	0.54	0.52	0.51

*Bio-mix broiler starter premix per 2.5kg of diet: Vit A, 10,000 I.U; Vit D_3, 2,000 I.U; Vit E, 23,000mg; Vit K_3, 2000mg; Vit B1,(thiamine) 1,800; Vit B_2(riboflavin), 5,500mg; Niacin, 27,500; Panthonenic acid, 7,500; Vit B6(pyridoxine),3000mg; Vit B_{12}, 15.00; Folic acid, 750.00mg; Biotin H_2, 60.00mg; Cholin Chloride, 300,000mg; Cobalt, 200mg; Copper,3000mg; Iodine, 3,000mg; Iron, 1,000mg; Manganese, 40,000.00mg; Selenium, 40,000mg; Zinc, 200mg; Antioxidant,1,250mg . GNC= Groundnut cake, FSBM= Full fat soya bean meal, M.E= Metabolisable energy, MOL= *Moringa oleifera* Leaf Meal

Table 3: Composition (Kg) of broiler finisher diet containing graded levels of *Moringa oleifera* leaf meal (5- 8 weeks)

Ingredients	MOL 1	MOL 2	MOL 3	MOL 4
Maize	55.00	51.00	48.00	44.00
FSBM	10.00	10.00	10.00	10.00
MOL	**0.00**	**7.00**	**14.00**	**21.00**
Maize offal	8.50	8.50	8.50	8.50
GNC	22.00	19.00	15.00	12.00
Bone Meal	3.00	3.00	3.00	3.00
Limestone	0.40	0.40	0.40	0.40
Methionine	0.25	0.25	0.25	0.25
Lysine	0.35	0.35	0.35	0.35
Common salt	0.25	0.25	0.25	0.25
Vit. Premix*	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis				
ME (Kcal/kg)	2972	2963	2963	2954
Crude Protein (%)	20.08	20.29	20.15	20.26
Crude Fibre (%)	4.63	4.83	4.93	5.13
Ether Extract (%)	5.63	5.73	5.81	5.91
Calcium (%)	1.29	1.29	1.29	1.29
Phosphorus (%)	0.60	0.60	0.59	0.59
Lysine (%)	1.13	1.10	1.05	1.01
Methionine (%)	0.53	0.51	0.49	0.48

*Bio-mix broiler starter premix per 2.5kg of diet: Vit A, 10,000 I.U; Vit D_3, 2,000 I.U; Vit E, 23,000mg; Vit K_3, 2000mg; Vit B1,(thiamine) 1,800; Vit B_2(riboflavin), 5,500mg; Niacin, 27,500; Panthonenic acid, 7,500; Vit B6(pyridoxine),3000mg; Vit B_{12}, 15.00; Folic acid, 750.00mg; Biotin H_2, 60.00mg; Cholin Chloride, 00,000mg; Cobalt, 200mg; Copper,3000mg; Iodine, 3,000mg; Iron, 1,000mg; Manganese, 40,000.00mg; Selenium, 40,000mg; Zinc, 200mg; Antioxidant,1,250mg , GNC= Groundnut cake, FSBM= Full fat soya bean meal. M.E= Metabolisable energy, MOL= *Moringa oleifera* Leaf Meal

Table 4: Composition (Kg) of broiler starter diet containing graded levels of *Guiera senegalensis* Leaf meal (0 – 4 weeks)

Ingredients	GSL 1	GSL 2	GSL 3	GSL 4
Maize	50.00	46.00	43.00	41.00
FSBM	15.00	15.00	15.00	15.00
GSL	**0.00**	**7.00**	**14.00**	**21.00**
Maize offal	3.50	3.50	3.50	3.50
GNC	27.00	24.00	20.00	15.00
Bone Meal	3.00	3.00	3.00	3.00
Limestone	0.50	0.50	0.40	0.40
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.35	0.35
Common salt	0.25	0.25	0.25	0.25
Vit. Premix*	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis				
ME (Kcal/kg)	2911	2901	2903	2900
Crude Protein (%)	23.11	23.32	23.28	23.13
Crude Fibre (%)	4.61	4.81	4.91	5.00
Ether Extract (%)	6.45	6.55	6.63	6.71
Calcium (%)	1.34	1.34	1.31	1.31
Phosphorus (%)	0.63	0.63	0.62	0.62
Lysine (%)	1.21	1.18	1.20	1.17
Methionine (%)	0.56	0.54	0.52	0.51

*Bio-mix broiler starter premix per 2.5kg of diet: Vit A, 10,000 I.U; Vit D_3, 2,000 I.U; Vit E, 23,000mg; Vit K_3, 2000mg; Vit B1,(thiamine) 1,800; Vit B_2(riboflavin), 5,500mg; Niacin, 27,500; Panthonenic acid, 7,500; Vit B6(pyridoxine),3000mg; Vit B_{12}, 15.00; Folic acid, 750.00mg; Biotin H_2, 60.00mg; Cholin Chloride, 300,000mg; Cobalt, 200mg; Copper,3000mg; Iodine, 3,000mg; Iron, 1,000mg; Manganese, 40,000.00mg; Selenium, 40,000mg; Zinc, 200mg; Antioxidant,1,250mg . GNC= Groundnut cake, FSBM= Full fat soya bean meal, M.E= Metabolisable energy, GSL= *Guiera senegalensis* Leaf Meal

Table 5: Composition (Kg) of broiler finisher diet containing graded levels of *Guiera senegalensis Leaf* meal (5- 8 weeks)

Ingredients	**GSL 1**	**GSL 2**	**GSL 3**	**GSL 4**
Maize	55.00	51.00	48.00	44.00
FSBM	10.00	10.00	10.00	10.00
GSL	**0.00**	**7.00**	**14.00**	**21.00**
Maize offal	8.50	8.50	8.50	8.50
GNC	22.00	19.00	15.00	12.00
Bone Meal	3.00	3.00	3.00	3.00
Limestone	0.40	0.40	0.40	0.40
Methionine	0.25	0.25	0.25	0.25
Lysine	0.35	0.35	0.35	0.35
Common salt	0.25	0.25	0.25	0.25
Vit. Premix*	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis				
ME (Kcal/kg)	2972	2963	2963	2954
Crude Protein (%)	20.08	20.29	20.15	20.26
Crude Fibre (%)	4.63	4.83	4.93	5.13
Ether Extract (%)	5.63	5.73	5.81	5.91
Calcium (%)	1.29	1.29	1.29	1.29
Phosphorus (%)	0.60	0.60	0.59	0.59
Lysine (%)	1.13	1.10	1.05	1.01
Methionine (%)	0.53	0.51	0.48	0.48

*Bio-mix broiler starter premix per 2.5kg of diet: Vit A, 10,000 I.U; Vit D_3, 2,000 I.U; Vit E, 23,000mg; Vit K_3, 2000mg; Vit B1,(thiamine) 1,800; Vit B_2(riboflavin), 5,500mg; Niacin, 27,500; Panthonenic acid, 7,500; Vit B6(pyridoxine),3000mg; Vit B_{12}, 15.00; Folic acid, 750.00mg; Biotin H_2, 60.00mg; Cholin Chloride, 300,000mg; Cobalt, 200mg; Copper,3000mg; Iodine, 3,000mg; Iron, 1,000mg; Manganese, 40,000.00mg; Selenium, 40,000mg; Zinc, 200mg; Antioxidant,1,250mg , GNC= Groundnut cake, FSBM= Full fat soya bean meal, M.E= Metabolisable energy, GSL= *Guiera senegalensis* Leaf Meal

Table 6: Composition of spices used in processing of *Damnub nama*

Ingredients	Hausa	Scientific/Botanical	Quantity (g/100g)
Table salt	Gishiri	*Sodium Chloride*	10.00
Seasoning cube	Dunkule		15.00
Thyme	Tyme	*Thymus vulgaris*	8.00
Curry	Curry	*Murraya koenigii* (L) *Spreng*	8.00
Onion	Albasa	*Allium cepa* L. *var. cepa*	30.00
Red pepper	Borkono	*Piper nigrum L.*	20.00
Garlic	Tafarnuwa	*Allium sativum L.*	2.00
Cloves	Kanumfari	*Syzgium aromaticum*	2.00
Ginger	Chitta	*Zangiber officinale Rosc*.	5.00
Total			100

Botanical names according to Rehm and Espig (1991)

Dambun nama from meat of broiler chickens fed dietary inclusion levels of *Moringa oleifera* (MOL1, MOL2, MOL3, and MOL4) and *Guiera senegalensis* (GSL1, GSL2, GSL3, and GSL4) leaf meals were appropriately packaged and stored in four (4) different packaging materials each, previously described by Balarabe *et al*. (2016b). The materials were Foil Paper Packaging (FPP), Wrapped Newspaper Packaging (WNP), Plastic Container Packaging (PCP) and Disposable Container Packaging (DCP) to give a total of eight (8) products. The products were stored and monitored for shelf-life stability at 0, 4, 8 and 12-week intervals. The analysis of total counts (bacterial and fungal counts) was carried out (at 0, 4, 8 and 12 weeks) at the General Microbiology Laboratory, Department of Microbiology, Faculty of Life Sciences, Ahmadu Bello University, Zaria. The microbial analyses were conducted as follows:-

Fungal Counts: This was determined by the methods of AOAC (2005) by plaiting 0.1ml of the representative sample on potato dextrose agar which was incubated at 25ºC for 5 days. Fungal colonies were then counted and averaged, which was expressed as total number of colonies counted multiplied by the dilution factor and volume of inoculum to give the colony forming unit per gramme (cfu/gm x 10^5).

Bacterial Counts: The total aerobic mesophilic count (cfu/g x 10^5) was determined as per the procedures of AOAC (2005) and Beyene and Seifu (2005). Total aerobic mesophilic counts were made by plating dilutions of samples on plate count agar and incubated aerobically at 37ºC for 24 hours. After incubation, bacterial colonies were counted and averaged, which was expressed as total number of colonies counted multiplied by dilution factor and volume of inoculum thereby giving the colony forming unit per gramme (cfu/gm x 10^5).

Data Analysis

Data obtained from the experiments were subjected to the analysis of variance (ANOVA) using the general linear model procedure of Statistical Analysis System (SAS, 2008). Significant means ($P<0.05$) were separated using Duncan's Multiple Range Test (DMRT) in the SAS version 9.0 package

RESULTS.

Data on interactions of packaging media and storage of *dambun nama* from meat of broiler chickens fed diets containing graded levels of MOL are presented in Fig 1. The results showed that FPP had the least (19 x 10^5cfu/g) microbial counts among the packaging media in the control group (MOL1), followed by PCP (32 x 10^5cfu/g), WNP (39 x 10^5cfu/g) and DCP (40 x 10^5cfu/g) having the highest total counts. DCP had the least total counts (17 x 10^5cfu/g) and FPP had the highest total counts (45 x 10^5cfu/g) in MOL2 (14%).
At 14% inclusion level (MOL3), WNP had the highest total microbial counts of 54 x 10^5cfu/g, and PCP had having the least total microbial counts of 21 x 10^5cfu/g. WNP had the lowest total microbial counts (16 x 10^5cfu/g) in *dambun nama* from MOL4 (21%), followed by PCP (25 x 10^5cfu/g), DCP (26 x 10^5cfu/g) and FPP (43 x 10^5cfu/g) throughout the 12 weeks storage period of *dambun nama* (Fig.1).

Fig 2 shows data on the effects of packaging media and storage period on total microbial load (fungal and bacterial) of *dambun nama* processed from meat of broiler chickens fed diets containing graded levels of GSL. The results showed that FPP (44 x 10^5cfu/g) had the least total microbial counts, followed by PCP (47 x 10^5cfu/g), WNP (53 x 10^5cfu/g) and DCP (69.0 x 10^5 cfu/g) which had the highest total microbial counts across the four packaging media in GSL1 (0%). In GSL2 (7%), PCP (12.0 x 10^5cfu/g) and FPP (13.0 x 10^5cfu/g) had the least counts than WNP (18.0 x 10^5cfu/g) and DCP (23.0 x 10^5cfu/g). FPP had the highest counts (32.0 x 10^5cfu/g) in GSL3, and WNP had the least counts of 20.0 x 10^5cfu/g. GSL4 recorded lower values of total counts in FPP and WNP (18.0 x 10^5cfu/g), where DCP (38.0 x 10^5cfu/g) recorded the highest counts among the packaging media (Fig 2)

The interactions of packaging media and types of *dambun nama* (Treatments) from meat of broiler chickens fed diets containing graded levels of MOL and GSL on total microbial load (bacteria and fungi) as presented in Fig 3. The results revealed that there were both low and high total counts among many of the factors considered. There were high interactions between FPP x MOL2, FPP x MOL4, WNP x MOL3 and DCP x MOL3; values being 45.0, 43.0, 54.0 and 50.0 x 10^5cfu/g, respectively. There were also interactions among the treatments; these were FPP x MOL1, WNP x MOL4, PCP x MOL3 and DCP x MOL2, values being; 19.0, 16.0, 21.0, and 17.0 x 10^5cfu/g, respectively (Fig 3). However, the results also revealed that the interactions between FPP x GSL1, WNP x GSL1, PCP x GSL1 and DCP x GSL1 were 44.0, 53.0, 47.0 and 69.0 x 10^5cfu/g, respectively. Other interactions with low values were between FPP x GSL2, WNP x GSL2/GSL4, PCP x GSL2 and DCP x GSL2; values being 13.0, 18.0, 12.0 and 23.0 x 10^5cfu/g, respectively (Fig 3).

Data on interaction effects of packaging media and types of *dambun nama* (Treatments) on total bacterial counts are depicted in Fig 4. The results showed that interactions of *dambun nama* from meat of broiler chickens fed diets containing MOL levels and packaging media were high in terms of total bacterial counts; between FPP x MOL2, WNP x MOL3, PCP x MOL1 and DCP x MOL3; values being 43.0, 36.0, 32.0 and 35.0 x 10^5cfu/g, respectively. Similarly, there were low interactions between FPP x MOL1, WNP x MOL4, PCP x MOL2 and DCP x MOL2, values being 15.0, 14.0, 10.0 and 11.0 x 10^5cfu/g. However, the interactions (Fig 4) of meat floss processed from GSL and packaging media on total bacterial counts showed both high and low interactions. For instance, the low interaction is between FPP x GSL2, WNP x GSL2, PCP x GSL2 and DCP x GSL2 with values of 8.0, 11.0, 8.0 and 13.0 x 10^5cfu/g, respectively. Similarly, the high interactions were between FPP x GSL1, WNP x GSL1, PCP x GSL1 and DCP x GSL1; values being 34.0, 42.0, 39.0 and 43.0 x 10^5cfu/g, respectively (Fig 4).

Fig 5 shows data on interactions between packaging media and types of *dambun nama* (meat floss) on total fungal counts. The results showed that there were high interactions among MOL treatments and packaging media were FPP x MOL4, WNP x MOL1/MOL3, PCP x MOL2 and DCP x MOL3; values being 18.0, 18.0, 25.0 and 15.0 x 10^5cfu/g. Conversely, there were low interactions were between FPP x MOL3, WNP x MOL4, PCP x MOL1 and DCP x MOL4, values being 0.0, 2.0, 0.0 and 1.0 x 10^5cfu/g, respectively (Fig 5). Furthermore, the results also showed that there were high values among the interactions between GSL and packaging media studied. For instance, the interaction between FPP x GSL1, WNP x GSL3, PCP x GSL1 and DCP x GSL1; values being 10.0, 20.0, 8.0 and 26.0 x 10^5cfu/g, respectively. Similarly, there were low interactions among the treatments. For example, interaction between FPP x GSL3/GSL4, WNP x GSL4, PCP x GSL3/GSL4 and DCP x GSL4; values being 1.0/1.0, 6.0, 2.0/2.0 and 4.0 x 10^5cfu/g, respectively (Fig 5).

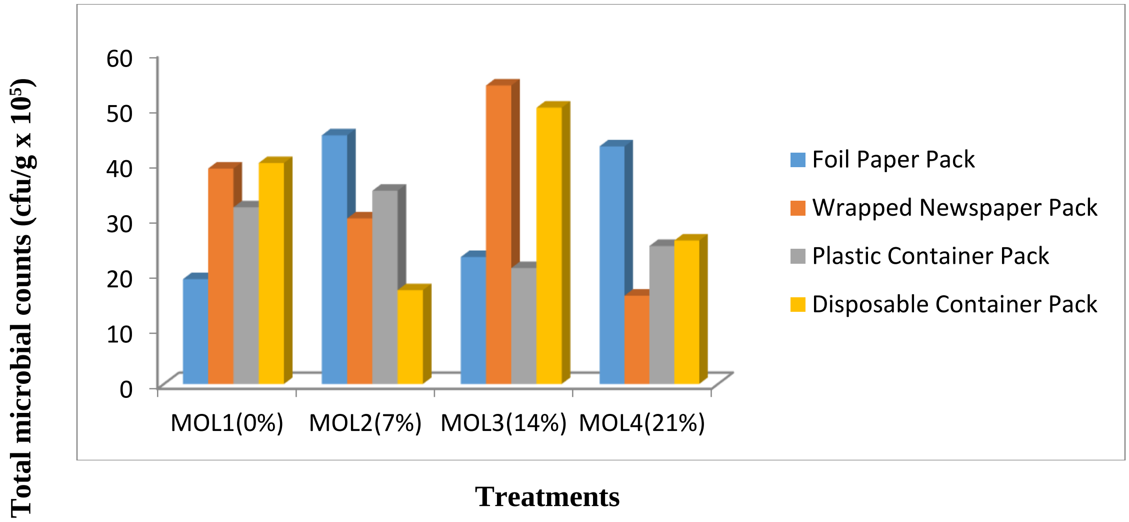

Fig 1: Overall Effects of packaging media and treatments on total microbial counts (cfu/g x 10^5) of *dambun nama* from broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal (MOL)

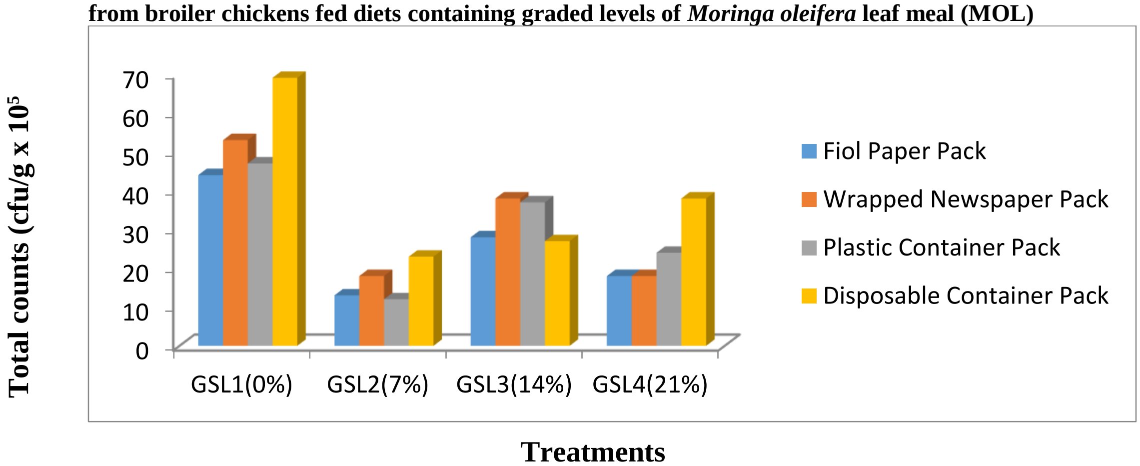

Fig 2: Overall effects of packaging media and treatment groups on total counts (cfu/g x 10^5) of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

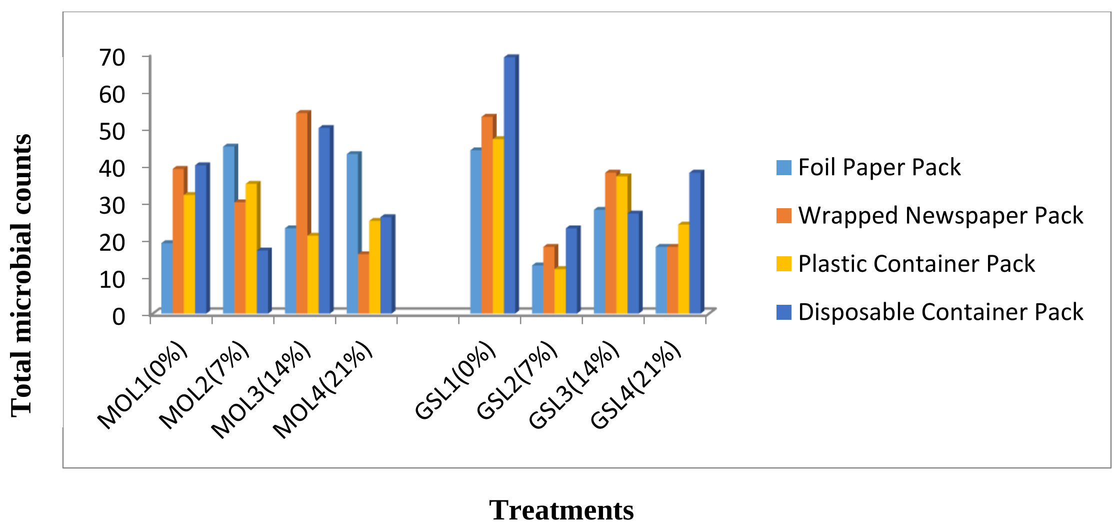

Fig. 3: Effects of types of *dambun nama* from *Moringa oleifera* (MOL) and *Guiera senegalensis* (GSL) leaf meals and packaging media on total microbial load (cfu/g x 10^5)

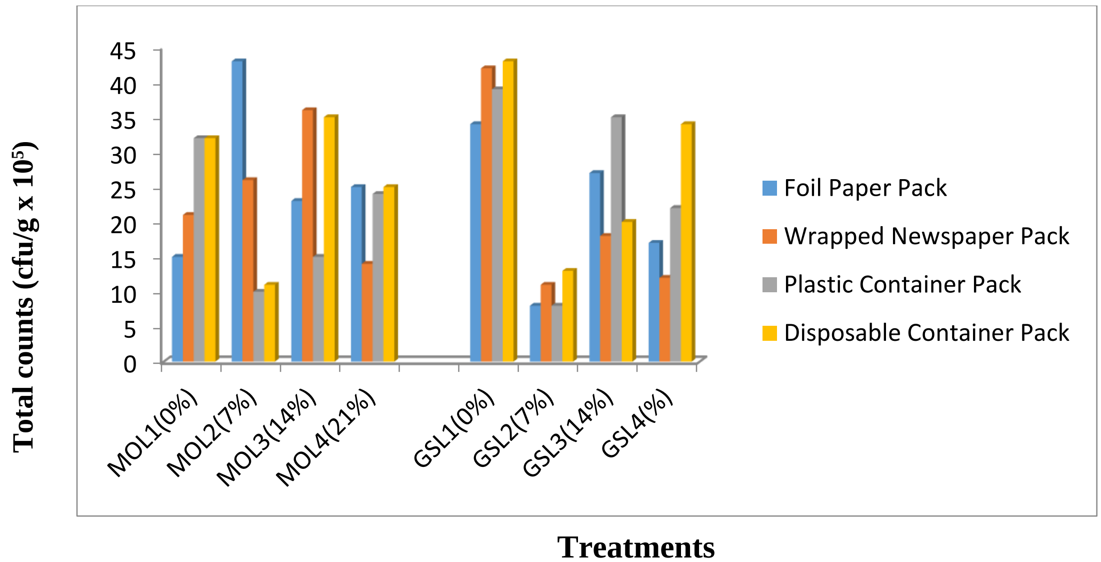

Fig 4: Effects of types of *dambun nama* from meat of broiler chickens fed diets containing *Moringa oleifera* (MOL) and *Guiera senegalensis* (GSL) leaf meals and packaging media on total bacterial load (cfu/g x 10^5)

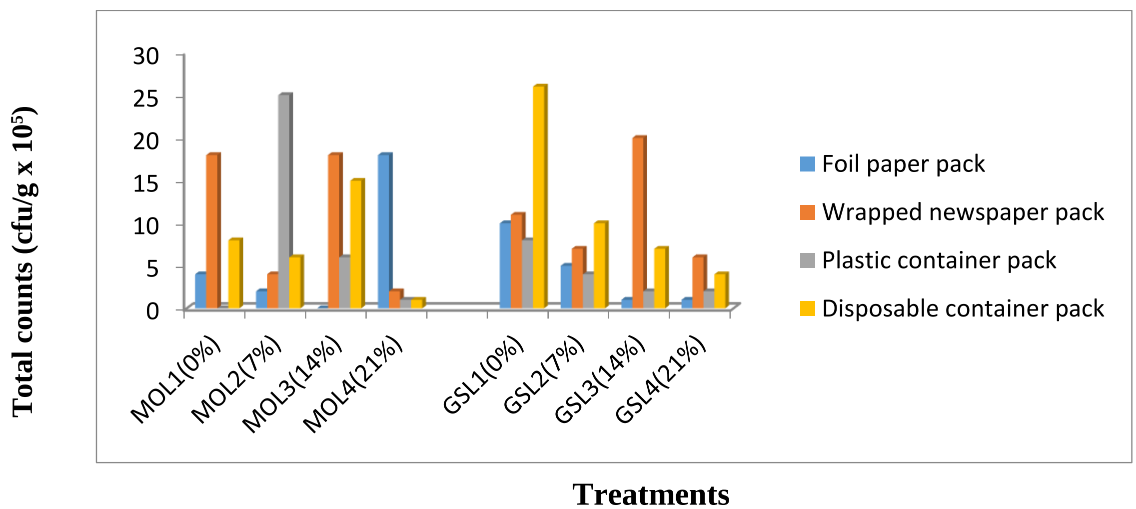

Fig 5: Effects of types of *dambun nama* from meat of broiler chickens fed diets containing *Moringa oleifera* and *Guiera senegalensis* leaf meals and packaging media on total fungal load (cfu/g x 10^5)

DISCUSSION.

The results showed that total fungal and bacterial counts increases and decreases as the level of MOL increases across the treatment groups. Conversely, the total fungal and bacterial counts decrease as the level of GSL was increased increases. This showed that the combined effects of total microbial load of meat floss decreases as the concentration of the plant leaves was increased. There were very high and low interaction effects of total microbial counts among the treatment groups and packaging media for *Moringa oleifera* leaf meal (MOL) and *Guiera senegalensis* leaf meal (GSL). However, the high interaction was observed between FPP x MOL2, DCP x MOL1, WNP x MOL3, and PCP x MOL2 for MOL and DCP x GSL1, WNP x GSL1, PCP x GSL1 and FPP x GSL1 for GSL, respectively. Lower interactions on total counts were observed between FPP x

MOL1, WNP x MOL4, PCP x MOL3 and DCP x MOL2 for MOL and FPP x GSL2, WNP x GSL2/GSL4, PCP x GSL2 and DCP x GSL2 for GSL, respectively. Some of these interaction effects gave an excellent results; having lower total counts in packaging media investigated. Balarabe *et al*. (2016d) reported positive interaction effects on treated beefs *dambun nama* processed from *Moringa oleifera* and *Guiera senegalensis* leaf extracts and packaging media on reduction of total microbial counts. These authors reported that the positive interaction effect was probably as a result of treated beef *dambun nama* from the two leaf extracts. Higher values were obtained when un-treated *dambun nama* was packaged in the various packaging media studied (Balarabe *et al*., 2016d). These authors further stated that the difference in the total counts may be attributed to treatment of *dambun nama* with *Moringa oleifera* (MOE) and *Guiera senegalensis* (GSE) leaf extracts.

From this study, it can be observed that total microbial counts in *dambun nama* of *Moringa oleifera* leaf meal (MOL) and GSL (*Guiera senegalensis* leaf meal) decreases as the inclusion level was increased across the treatment groups and packaging media, respectively. *Guiera senegalensis* leaf meal (GSL) had high level of effect in suppressing microbial counts than *Moringa oleifera* leaf meal (MOL), but the two plant leaves might have a promising effect in inhibiting microbial growth, especially the fungal activities, prolonged shelf life and keeping quality of the product. Salisu (2017) reported that *Guiera senegalensis* leaf extracts had more efficacy in suppressing bacterial counts than *Moringa oleifera* leaf extract in beef *dambun nama*. Similarly, the different packaging media used in the present study (FPP, PCP, WNP and DCP) had the capacity of storing meat floss for up to 12 weeks of storage without showing any deterioration trait. The values obtained for the microbial counts did not exceed the limit specified by International Commission of Microbiological Standards for Foods (ICMSF, 2014). Solberg *et al.* (1986) reported that bacterial count exceeding 10^5/g or coliform count higher than 10^2/g in delicatessen food products are indicative of dangerous contaminations.

Similarly, the low interaction effects observed in the present study with respect to packaging media and storage period of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal (MOL) and *Guiera senegalensis* leaf meal (GSL) might be probably due to the active antioxidant nature of the two plant leaves and the enclosed nature of the packaging materials which prevented further contamination from the environment. This agrees with the report of Wang *et al.* (2004) who indicated that the shelf life of poultry products depends on several factors particularly initial bacterial loads, storage temperature and the gaseous environment around the product.

There were positive high and low interaction values between treatment groups of MOL and packaging media on total bacterial counts stored at 12 weeks. The result shows that low interaction values were observed in FPP x MOL1 (15.0 x 10^5cfu/g), DCP x MOL2 (11.0 x 10^5cfu/g), PCP x MOL2 (10.0 x 10^5cfu/g), WNP x MOL4 (14.0 x 10^5cfu/g). Conversely, high interactions were observed between FPP x MOL2, WNP x MOL3, PCP x MOL1, and DCP x MOL3. It can be observed that MOL4 (21%) and MOL2 (7%) had better interactive value among the four treatment groups in terms of low total bacterial counts across the packaging media. Similarly, WNP had low values among the packaging media and across the treatment groups studied. However, the interactions of *dambun nama* from GSL and packaging media on total bacterial counts showed both high and low values of microbial counts. Low interactions were observed between FPP x GSL2, WNP x GSL2/GSL4, PCP x GSL2 and DCP x GSL2, and high interactions were between FPP x GSL1, WNP x GSL1, PCP x GSL1 and DCP x GSL1, respectively. This shows that GSL2 (7%) and GSL4 (21%) interacted best among the treatments and between the packaging media on week of storage for up to 12 weeks, as observed in MOL. At higher inclusion of GSL, WNP had the least interactive value among the packaging media. It can be observed that GSL is more effective than MOL, especially at 7% inclusion level in terms of bacterial growth. And bacterial load decreases as the inclusion of both MOL and GSL is increased. The high and low values of bacterial counts observed from the packaging media across the treatment groups could be as a result of temperature changes, moisture and the different types of packaging materials used, and also opening and closing of the packaging media in the process of microbial count during storage period in the laboratory which might have exposed the stored product to the environment. Brewer and Wu (1993) reported that micro-organisms are primarily responsible for deleterious effects to meat tissue if the meat product has been temperature abused in any manner. Microbial contaminants of meat are derived from the air environment of the abattoir, the slaughter slabs and knives, the hides and hooves, the gastro-intestinal tract of the animal, the wash water and from poor hygienic practices (Johnson *et al*., 1983).

Interaction between FPP x MOL4, WNP x MOL1/MOL3, PCP x MOL2, and DCP x MOL3 was high, while FPP x MOL3, WNP x MOL4, PCP x MOL4 and DCP x MOL4 had low interaction effect on total fungal counts for *Moringa oleifera* leaf meal, respectively. However, *dambun nama* from GSL, there were high interactions between FPP x GSL1, WNP x GSL4, PCP x GSL1 and DCP GSL1 than interactions between FPP x GSL2/GSL3, WNP x GSL4, PCP x GSL3/GSL4 and DCP x GSL4; with lower values of interactions.

Furthermore, it can be observed that the two plant leaf meals (GSL and MOL) had higher interaction values between packaging media and storage period at 12 weeks. This indicates that the efficacy of the two meals to improve keeping quality with high chances of increasing shelf life of the products. The packaging media proved effective in preventing further contaminations and deterioration. This is in line with the reports of Haruna (2014) and Balarabe *et al.* (2016d). Similarly, Salisu (2017) reported that *Guiera senegalensis* leaf extract had more suppressive effects on bacterial growth than *Moringa oleifera* leaf extract as opposed to the findings of the present study. Siddhuraju and Becker (2003) reported that *Moringa* leaves are good sources of natural antioxidant and thus, enhance shelf life of fat containing foods due to the presence of various types of antioxidants like ascorbic acids, flavonoids, phenolic and carotenoids.

Furthermore, the different packaging media used in this study (FPP, PCP, WNP and DCP) had the capacity of storing meat floss for up to 12 weeks of storage period without any deleterious effect of microbial counts which did not exceed the recommendations reported by ICMSF (2014). Similarly, Solberg *et al.* (1986) reported that bacterial count exceeding 10^5/g or coliform count higher than 10^2/g in delicatessen food products are indicative of dangerous contaminations.

CONCLUSION.

The study concludes that incorporation of MOL and GSL in the diet of broiler chickens up to 21% had no deleterious effects on the storage quality of *dambun nama* from meat of broiler chickens. The packaging media studied (FPP, WNP, PCP and DCP) had suppressive and differential effects on microbial growth/ multiplications, with PCP and WNP being more superior. It is recommended that MOL and GSL be included in broiler chicken diets up to 21% for processing and storage of *dambun nama* above the 12- week period for improved keeping quality.

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FISHERIES AND AQUACULTURE PRODUCTION

Journal of Applied Agricultural Research 2022, 10(2): 291-298
ISSN 2006-750X.

EFFECTS OF CULTURE MEDIUM BACKGROUND COLOURS ON THE GROWTH PERFORMANCE OF *Clarias gariepinus* (Burchell, 1822) FINGERLINGS.

Mohammed Sabo[1] and Kolle Mallah[2]
[1]Department of Fisheries and Aquaculture, Federal University Gashua, PMB 1005, Nguru Road, Yobe State, Nigeria.
[2]Department of Fisheries and Aquaculture, Federal University Gashua.
Author's Contact: smdamagum@gmail.com. Phone no: +2348066028703.

ABSTRACT.

This research on background colour of culture media on *Clarias gariepinus* fingerling growth performance was carried out at Fisheries Research Farm of the Department of Fisheries and Aquaculture, Federal University Gashua, Yobe State, Nigeria. The Study duration was 8 weeks and fish samples were procured from Aqua Venture Fish Farm Limited Kano, Nigeria. The fish were acclimatization and deprived of feed for 24hrs before the commencement of the experiment. The tanks are; Black, Red, Green and Yellow which were tagged as BC, RC, GC, and YC respectively. The fingerlings were randomly distributed into 12 plastic bowls of 15 fingerlings / 45 litres each in triplicates. During the experiment fish were fed to apparent satiation at 5% body weight per day on the 40% crude protein commercial diet. Fish survival rate was recorded on daily basis whilst the growth parameters were measured weekly. The best growth performance (weight gain, and specific growth rate) was achieved under fingerlings in the black background. Percentage survival rate of the fish was significantly (P< 0.05) affected by the tanks background colour. The fish reared in black background had the highest percent survival rate among the experimenter fish. Water quality parameters were not affected by the treatments. All the water quality parameters were within the recommended ranges for *C. gariepinus* culture. The result clearly suggests that *C. gariepinus* should be reared at 15 fingerlings / 45Litres of water in tank culture systems with black backgrounds whereas, the use of yellow tank should be avoided in *C. gariepinus* culture.

Key Words: *Clarias gariepinus,* fingerlings, backgrounds, growth, performance.

INTRODUCTION.

Aquaculture refers to the breeding, rearing and harvesting of Aquatic plants and Animals in all types of water bodies including ponds, rivers, lakes and the Seas (NOAA fisheries, 2011). Fish farming being an integral subset of Aquaculture is significantly important for sustainable production of fish for human nutritional needs. Fish provides a relatively cheap sources of animal protein when compared to terrestrial animals (NOAA fisheries, 2011). Over the years, fish has remained an integral source of quality protein consumed by the world's population (FAO, 2013). Therefore, to sustainably meet the increasing demand for fish in view of its health benefits and the declining catch of the natural waters, intensity and technology advancement in aquaculture cannot be overemphasized. Available space and adequate water for exchange are two factors which could greatly affect the productivity of aquaculture in relation to the target species, hence, must be optimally utilized (FAO, 2013).

The African aquaculture has been dominated by the farming of the *Clariid* fishes of which the African sharp tooth catfish (*Clarias gariepinus*) is one of the most popular and of great economic importance as food fish (Adewumi and Olaleye, 2011). The species, *Clarias gariepinus* command good price in Nigerian markets partly because it's tasty flesh and devoid of sharp bones (FAO, 2013). The fish is hardy, exhibiting great tolerance for high stocking density even in low oxygen waters, has good growth rate, efficient food utilization and great nutritional profile in addition to its medicinal value (Debneth, 2011). Many environmental, nutritional and genetic parameters have been studied in an attempt to improve performance of fish and increase aquaculture production, notable among these are studies on welfare requirement within the culture system (Okomoda *et al.*, 2016). Tanks used for aquaculture activities are made of various materials including plastics tanks, concrete tanks/ponds, glass and fiber glass, bowls (Opiyo, 2010).

Background colour of farming media is an environmental factor that can influence a variety of parameters including growth, improvement of feeding performance and feed intake. Careful selection of rearing units/materials with appropriate colours can lead to increase successes in aquaculture particularly in fish fingerling stage (Rotllant et *al.*, 2012). Most teleost fishes are visual feeders in larval stage, nonetheless, the visual system is not well-developed in most fish larvae and fingerlings which may result in decreased food intake, reduced growth and raised mortality (Barcellos *et al.*, 2009). A suitable tank colour makes it possible to create a contrast between the food (prey) and the tank wall, thereby increasing the chance of food capture by the fish (Tamazouzt *et al*., 2010). This might also help reduce food consumption, feeding costs, prevent environmental pollution, thereby creating contrast between food particles and tank wall. However, the behaviour of the fish may be affected by the tank colour and lead to diminished growth (Barcellos *et al*., 2009). This research is intended to investigate the effect of culture meduim background colours on growth performance of the experimenter fish *(Clarias gariepinus).*

MATERIALS AND METHODS.

The Study Area.

This research was carried out at Fisheries research farm of the Department of Fisheries and Aquaculture Federal University Gashua, Yobe State, Nigeria. Yobe State is located in the North-eastern part of Nigeria and borders four Nigerian states as well as the republic of Niger. It has a population of 3.4 million. Yobe is located on latitude 12.187141N, longitude 11.706829E and an altitude of 189.9N (Canback and Global income distribution data base, 2015).

Physiochemical Parameters.

All the physiochemical parameters monitored during the study were taken twice, morning time (8:00 hour) and evening time (17:00 hour). These parameters include temperature, dissolved oxygen and ph.

Experimental Design.

Two hundred and twenty (220) *C. gariepinus* fingerlings were used for this experiment. All the fish for this experiment were collected in well aerated black (50 litres) Jerican from Aqua Venture Fish farm Nigeria limited Kano. The tanks are; Black, Red, Green and Yellow which were tagged as BC, RC, GC, and YC respectively. The fish were kept for 7 days in the hatchery for acclimatization purpose and deprived of feed for 24hrs before the commencement of the experiment. The fingerlings were randomly distributed into 12 plastic bowls of 45 liters each in triplicates for eight weeks feeding trial.

Experimental Sampling and Measurement.

Fish survival/mortality rates were recorded on daily basis whilst the growth parameters were measured weekly. In each of the experimental tanks, fish weight, length and feed intake were measured in addition to water quality parameters. During the experiment fish were fed to apparent satiation at 5% body weight per day; twice daily at 8-hour interval (at 09:00h and 17:00h) on the 40% crude protein commercial diet.

Water Quality Monitoring.

Water quality in the tanks (bowls) were maintained by siphoning out the bottom debris (faecal matters, uneaten food) twice a day, (before feeding in the morning and in the evening) and the water level re-adjusted by refilling with clean water. After every 3 days, water in the tanks were completely changed. Water temperature and pH were recorded daily at 08:00h using mercury thermometer and pH meter respectively. Dissolved oxygen (DO), was measured twice (morning and evening) with using oxygen meter (model DO 200).

Fingerling Growth Response.

Survival rates were determined by counting the remaining fish in the tanks on each sampling date.

The weight measurements were used to determine the specific growth rate (SGR% day 1), feed conversion ratio (FCR), weight gain and relative condition factor of the fingerlings.

Calculations on the growth performance were done as follows: -

Specific growth rate (SGR) = $\frac{\text{Ln final weight - Ln initial weight}}{\text{Experimental period}} \times 100$

W_O = initial weight (g)

Wt = Final weight (g) and

t= time (days)

Feed conversion ratio (FCR) = $\frac{\text{weight of dry feed given per treatment}}{\text{wet weight gain of fish in that treatment (g)}} \times 100$

Percent weight gain = $\frac{(\text{final weight of fish – initial weight of fish})}{\text{initial weight of fish (g)}} \times 100$

Percent survival = $\frac{\text{Initial number of fingerlings in the tank– No of dead fingerlings}}{\text{Initial number of fingerlings in the tank}} \times 100$

According to (Jhingran, 1992)

Data Analysis: Results were analyzed using SPSS statistical package version 23 IBM and mean scores were established. One way analysis of variance (ANOVA) was used to analyze the result and LSD was used to separate the mean at 95 degree of confidence.

RESULTS AND DISCUSSION.

Water Quality Parameters

Water temperature range between (17.66 ± 0.29 - 26.94 ± 0.13) morning and evening. The experimental water temperature falls within the acceptable range of temperature requirement for catfish culture in fresh water. The ranges agree with the work of Karakatsouli *et al.* (2017) on the culture of *Heterobranchus species* and *Heteroclarias Hybrid* in pond water culture. The water pH ranges from (8.38 ± 0.03 to 9.18 ± 0.06) was within the range suggested by Khan *et al.* (2014) and the dissolved oxygen recorded in this study was (8.58 ±0.01 – 9.30 ± 0.09) which agreed with the study of Karakatsouli *et al.* (2017).

GROWTH PERFORMANCE.

The results on growth performance of experimental fish of this study is shown in Table 1. The percentage weight gained for each treatment were 1488.42 ± 0.56 g, 1336.78 ± 1.12 g, 1316 ± 0.39 g and 1186.26 ± 2.43 g, for black, green, yellow and red backgrounds as can be observed on (plate: 111 and 1V) respectively. But treatment with black background had the highest mean weight gain of 26.65 ± 0.32 g (Plate: 1) while red background had the least (23.58 ± 0.21 g) (Plate: 2).

The result on Table 1 below further showed that, mean weight gained varied among each treatment under black background had the highest mean weight gain follow by treatment in red and yellow backgrounds which showed no significant different (P < 0.05) but differs from treatments in black and green backgrounds.

Plate: 1 *C. gariepinus* raised in Black tank BC 2

Plate: 11 *Clarias gariepinus* raised in Red tank RC 1

Plate: 111 *Clarias gariepinus* raised in Green tank GC 2

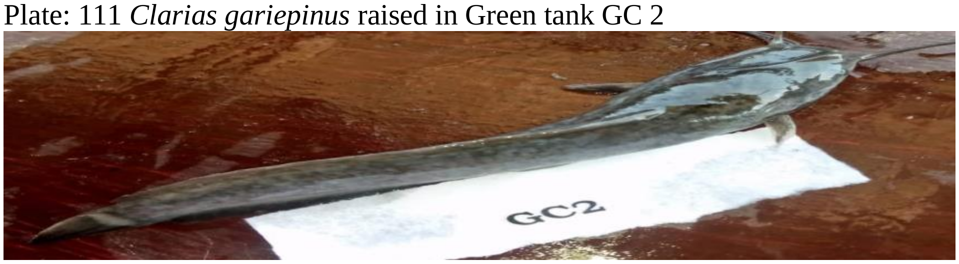

Plate: 1V *Clarias gariepinus* raised in Yellow tank YC 2

Table 1: Growth response and nutrient utilization of *C. gariepinus* fingerlings cultured in different rearing tanks.

Parameters	Black	Red	Green	Yellow
IMW (g)	1.81±0.01	1.95±0.01	1.84±0.00	1.72±0.11
FMW (g)	28.84±0.08	25.74±0.21	26.71±0.17	25.63±0.31
MFI (g)	37.27±0.23^{a}	28.71±0.11^{b}	27.58±0.06^{c}	28.33±0.17^{b}
FCR	1.09±0.01^{d}	1.24±0.01^{a}	1.12±0.01^{b}	1.18±0.01^{c}
PWG	1488.42±0.56^{a}	1186.26±2.43^{d}	1336.78±1.12^{b}	1316.23±0.39^{c}
SGR(%/day)	5.91±0.01^{a}	4.61±0.01^{d}	4.78±0.32^{c}	4.82±0.01^{b}

Means in each row with different superscripts shows significance (P<0.05) difference.
IMW= Initial Mean Weight, FMW= Final Mean Weight, MFI= Mean Feed Intake, FCR= Feed Conversion Ratio, PWG= Percentage Weight Gain, SGR= Specific Growth Rate, SR= Survival Rate.

Growth performance of *C. gariepinus* largely depends on several factors including food quality, energy content of the diet, its physiological status, reproductive state, environment, stocking density and water quality such as temperature, pH, dissolved oxygen and background colour (Ekokotu and Nwachi, 2014).

Background colour has effects the FCR, where 1.09±0.01 as recorded in black backgrounds signifying higher efficiency. However, this agreed with the findings of Tamazouzt *et al*. (2000); Duray *et al*. (,2005); Papotsoglou *et al*. (2005), who reported higher FCR in blue backgrounds indicating lower feed efficiency. Naas *et al*. (2008) reported black tanks enhance sighting of prey by contrast with background hence easier detection of prey their assertion supported this finding. Martin and Peterson (2009) also suggested that larval growth and food consumption were better in black background than in light backgrounds. In contrast Bardocz *et al.* (2010), submitted that *C. gariepinus in* green and black backgrounds did not have any effect on their growth performance but they attained a darker skin colour.

Also, mean feed intake (MFI), feed conversion ratio (FCR), percentage weight gain (PWG) and survival rate (SR) were significantly (P < 0.05) higher in treatment with black background (37.27 ± 0.23, 1.37 ± 0.01, 1488.42 ± 0.56 and 99.00 ± 0.58) while poor performance was recorded in background with green colour in respect to MFI but treatment with red and yellow background colour had the least value for PWG (1186.26 ± 2.43) and SR (79.67 ± 1.76) respectively.

The high growth in black backgrounds could be attributed to low stress levels. This is justified by the findings of Volpato and Barreto (2011), who recorded that black background reduces stress in C. *gariepinus* by inhabitation of plasma cortisol level when fish are subjected to confinement stress.

Fish reared on the clear background had low growth rates than fish reared in other background colours. This could be attributed to diversion of energy towards aggressive behaviour exhibited by fish reared in cleared backgrounds which tend to be positively phototactics as seen on Plate 1V, (Merighe *et al*., 2004). A similar condition was reported on larval striped bass (*Morone saxitilis*) and mud crab (*Scylla serrate*) by Naas *et al*. (2008) which was possibly attributed to lots of energy which could have been channeled to growth was consumed in aggressive behaviour (Ellis *et al*. 2012). Differences in growth variables among the background colours in this study could also be related to response in stress factors. Increased stress may have contributed to reduced growth of the fish reared in other background (Red, Green and Yellow) (Papoustsoglou *et al*. (2005).

On the other hand, background colour significantly affects the percentage survival of the fish. High percentage survival (99.00 ± 0.58) was recorded in black backgrounds. This contradicts the findings of Karakatsouli *et al*. (2017) who recorded no significance effect of background colour on White Sea bream (*Dilodus sargus*). Martinez-Cardenas and Purser (2009) reported that, survival of potbellied sea horses (*Hipocampus abdominalis*) was not affected by any of the tank colours (clear, white, yellow, red, blue and black). White seabream survival was lower in dark coloured tanks because of insufficient prey contrasts against white wall (Karakatsouli *et al*., 2017). Pedreire and Sipauba-Tavares (2001) also reported higher percent survival of Tambaqui larvae (*colossomma macropomun*) in darker backgrounds (65.5%) compared to lighter backgrounds (9.4%). The observation was in line with the present study which showed that *C. gariepinus* fingerlings were more likely to be feeding in black tank hence high survival. Naas *et al*. (2008) suggested that white tanks might reduce survival of fish larvae because the larvae tend to accumulate on the walls and this increase the risk of mortality by abrasion and could be the reason for low survival in red, green and yellow backgrounds.

Similar observations were made by Martin-Robichaud (2009) who reported that positive phototactic fish orientate towards the reflective surface which could be air/water interface with nature overhead illumination under natural conditions. In yellow tank, the low survival could be as a result of difficulty in food perception against the black background which led to starvation hence low survival of the fish. There was a significant difference in FCR among different treatments. (1.09±0.01, 1.24±0.01, 1.12±0.01and 1.18±0.01) in black, red, green and yellow tanks respectively Hassan Akbarian *et al*. (2012) studied the effect of tank colour on growth performance and body composition in common carp and reported that blue tank provided a better condition for growth factors and protein contact compered to white and black tanks. It may be because more physiological compatibility of fish with this colour.

CONCLUSION.

The result from this study indicated that tank background colour considerably influence the growth performance and survival of *C. gariepinus* in tank fingerlings production. It was observed that tank with black background had the best growth performance when compared with other background colours (Red, Green and Yellow). Thus it can be concluded that black colour is the most suitable background for tank culture of *C. gariepinus* fingerlings.

RECOMMENDATIONS.

The study therefore recommends the use of black background tanks for the culture of *C. gariepinus* fingerlings relative to other background colours used in this study. Further research should be conducted to examine the effect of other background colours on the nutrients quality and general consumer acceptability of *C. gariepinus*.

DECLARATIONS.

Corresponding Author's email:
smdamagum@gmail.com Phone:
+2348066028703

Consent to publish

Not applicable.

Author's contributions

Both authors participated equally in the design, draft and manuscript preparation.

Competing Interests.

We the authors declared that there is no competing interests.

ACKNOWLEDGEMENT.

We sincerely acknowledged the contributions of Dr. Ashley D.S and Mr. Abdulrahman A. both of the Department of Fisheries and Aquaculture Federal University Gashua, who had substantially contributed in the area of data analysis/interpretation.

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Journal of Applied Agricultural Research 2022, 10(2): 299-304
ISSN 2006-750X.

MORPHOMETRIC RELATIONSHIP BETWEEN *Atya gabonensis* AND *Macrobrchium felicinum* FRESHWATER PRAWN FROM LOWER RIVER BENUE, MAKURDI, NIGERIA

*[1]Obetta C., [2]R.A. Obande, [2]S. G. Solomon, [2]J. O. Cheikyula, [1]J.O. Apochi, [1]N. Yusuf and [3]A. Yusuf.
[1]Agricultural Research Council of Nigeria, P.M.B 5026, Wuse Abuja.
[2]Department of Fisheries and Aquaculture, University of Agriculture, P.M.B.2373 Makurdi.
[3]Department of Biology, Ahmadu Bello University, Zaria, Nigeria.
Author's Contact: okworcharity@yahoo.com Tel No: +2348026596729

ABSTRACT.

A comparative morphometric relationship study between Atya gabonensis and Macrobrachium felicinum in the lower River Benue, Makurdi was carried out. A total of 1489 freshwater prawn was collected, comprising 784 males and 373 females A. gabonensis and 69 males and 263 females M. felicinum species. Prawns were identified using taxonomic keys, 14 and 19 morphometric characters were measured for A. gabonensis and M. felicinum respectively. This study revealed that A. gabonensis morphometric characters were strongly positively related with a percentage variance (69.01%) in the PCA biplot (component 1) compared to a lower coefficient of correlation values observed for M. felicinum with a lower percentage variance (27.16%). Atya gabonensis males had highest body weight and morphometric measurements compared to all other groups. Moreover, males' morphometric measurements are higher than females. Conclusively, A. gabonensis body weight and morphometric measurements were significantly higher than M. felicinum, however, both species could be good aquaculture (prawn) candidates and all male production is therefore recommended.

INTRODUCTION.

Despite the importance of prawns in the provision of quality protein, foreign exchange earnings and employment generation, their culture is still in its infant stage in Nigeria. There are many species of prawns which are found across the various water bodies in Nigeria belonging to family Atyidae, Alphedae, Hippolytidae, and Palaemonidae, which include good candidates for aquaculture (Powel, 1982). Powell (1983) mentioned three important species of freshwater prawn that dominate Nigerian inland water as *Macrobranchium felicinum*, *M. vollenhovenii* and *M. macrobranchion*. *Atya gabonensis* was also reported to be harvested in a small scale in northern Nigeria (Obande, 2006).

The major challenges limiting the culture development of these prawns in Nigeria is scarcity of post larvae for stocking grow-out ponds (Anyanwu *et al*., 2012). This is due to insufficient knowledge on the biology of Nigerian indigenous prawns. The biology of these prawns has not been fully document, knowledge on their biology is *sine qua non* for their successful culture. Hence, this study is designed to provide necessary information on the morphometrics of *M. felicinum* and *A. gabonensis* in the Lower River Benue, Makurdi.

MATERIALS AND METHODS.

Study Area.

The Lower River Benue, Makurdi (Figure 1) is located on latitude 7˚ 55' and 7 56' North of equator and longitude 8˚20' and 8˚ 40' East of the Greenwich meridian. River Benue originates from Adamawa hills and flows from the Southern part of Cameroon through Makurdi and Southwards to Lokoja where it forms a confluence with River Niger. At bank full, the river is about 129,000 hectares with as much as 25m difference between high and low water levels.

Sample Collection, Identification and Morphological Measurements of Prawn.

A total of 1489 prawns were collected by the help of fishermen and transported in ice box to the laboratory for further studies. Identification to species level was by keys of Powell (1982). The sexes were determined with the aid of specific morphological features that were peculiar to male and females of the prawns, such as appendix masculina, reproductive chamber and nubs on the first abdominal segment as demonstrated by Anetekhai (1990). Total body weight (g) was taken using a top loading electronic Metler balance (Model 59174). Morphological measurements were carried out according to the method described by Adete *et al*. (2013), TL = Total Length, CL = Carapace length, CD = Carapace diameter, RL = Rostral length, AL = Abdomen length, TSL = Telson length, UL = Uropod length, PH = Height of Pleuron of 2nd abdominal segment, PW = Width of pleuron of 2nd abdominal segment, LM = Length of merus of 3rd walking leg, RC = Length of carpus of 3rd walking leg, RP = Length of palm of 3rd walking leg, RF = Length of finger of 3rd walking leg, LRM = Length of Right merus of second walking leg; LRC = Length of Right carpus of second walking leg; LRP = Length of right palm of second walking leg; LRF = Length of right finger of second walking leg. LLM = Length of left merus of second walking leg; LLC = Length of left carpus of second walking leg; LRP = Length of right left palm of second walking leg; LRF = Length of left finger of second walking leg for M were measured.

Data Analysis.

Multivariate analysis principal component analysis (PCA)) was used to establish morphometric relationships across species using PAST statistical software, students't-test and analysis of variance was used to compare morphometrics between sexes using SPSS IBM version 24.

RESULTS.

Macrobrachium felicinum and *A. gabonensis* collected from Lower River Benue, all measured morphometric characters were strongly positively related to each other with the exception of DRS and CD in *M. felicinum* (Fig. 2a, 3a). From the PCA biplot, component 1 attributes showed a higher percentage variance (69.01%), with majority of morphometrical parameters clustering in quadrant 2 and 3 (Fig 2a), while coefficient of correlation (r) from PCA loadings indicates strong positive relationships among morphometric characters of *A. gabonensis* (Fig. 2b). Fig. 3a shows a PCA biplot of *M. felicinum* morphometric characters relationships, using component 1 (27.16% variance) and component 2 (13.40% variance), all morphometric characters clustered in second and third biplot quadrant indicating relationship amongst characters; W, TL, CL, LRM, LRC, LRF, PH and LLC showed strong positive correlation while CD and DRS had no relationship with other characters (Fig 3b). The male and female of

M. felicinum and *A. gabonensis* prawn morphometric characters are presented in Fig. 4a to 4c respectively, body weight and other morphometric characters differed between male and female in both species. *A. gabonensis* male morphometric characters were significantly higher compared to *A. gabonensis* female and *M. felicinum* male and female.

DISCUSSION.

Morphometric studies have been proven valuable in providing insight into several factors that may confirm the analytical results such as sexual dimorphism, timing of sampling, and allometric growth (Chen *et al.*, 2015). Morphometric findings have been widely employed for taxonomic purposes in the freshwater prawn (Mariappan and Balasundaram, 2004). In this present study, variation in the morphometric relationships obtained between the male and female within and between species may have resulted from variation in food, population density, environmental conditions and genetic makeup of the species (Mariappan and Balasundaram, 2004). Also, there is a great sexual dimorphism between sex within and between the two species.

In general, it was found that the morphometrics and weight parameter used, allowed discrimination between male and female prawn species and this gives advantage to males as observed that male grow faster from sampled population of both species, this corroborates the findings of Tizkar *et al*. (2017) and Torres *et al.* (2014). Furthermore, it can be suggested that all male prawn production is more advantageous than female production. Finally, genetic analyses are required to better understand the processes of dispersal involved in the variation in body shape among populations of the freshwater prawn.

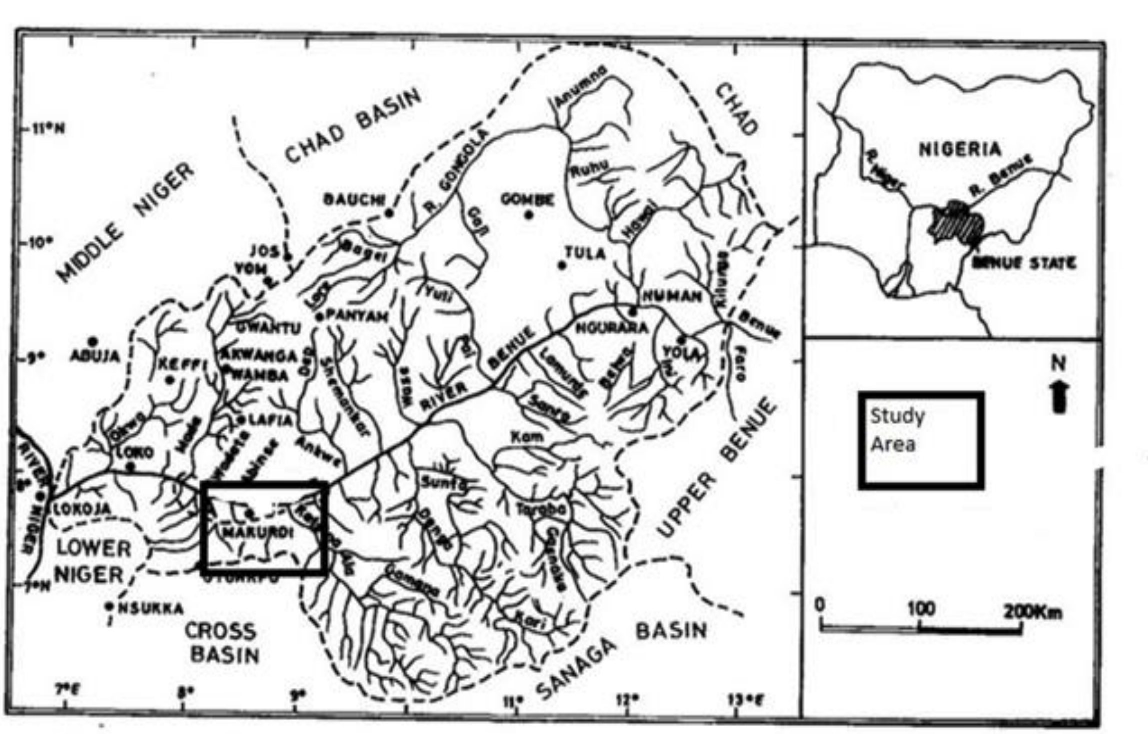

Fig 1: Map of Lower River Benue showing Makurdi, the sampling site. Source: Wikipidia.com (2015)

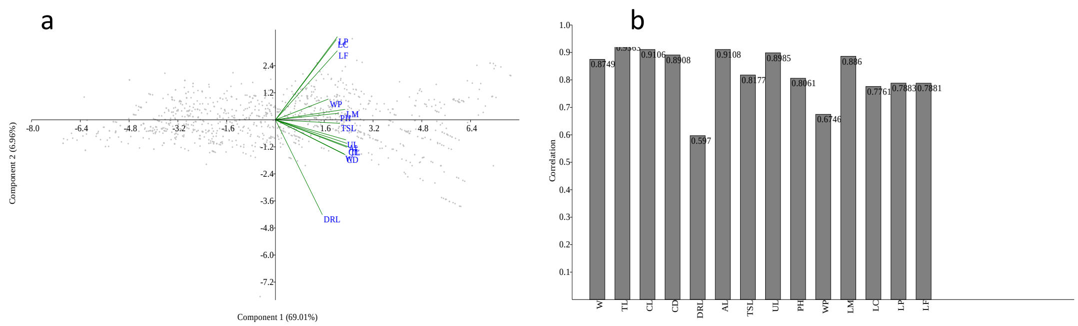

Fig. 2 Principal component Analysis (a) biplot and (b) loadings of morphometric parameters from *A. gabonensis* collected from Lower River Benue, Makurdi

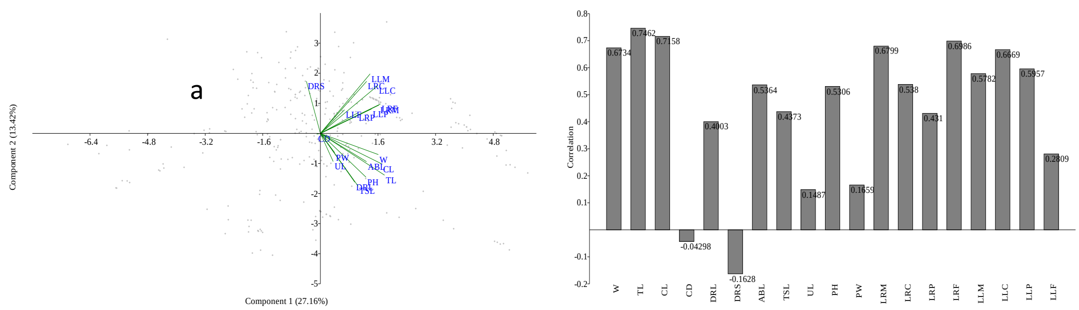

Fig. 3 Principal component Analysis (a) biplot and (b) loadings of morphometric parameters from *M. felicinum* collected from Lower River Benue, Makurdi.

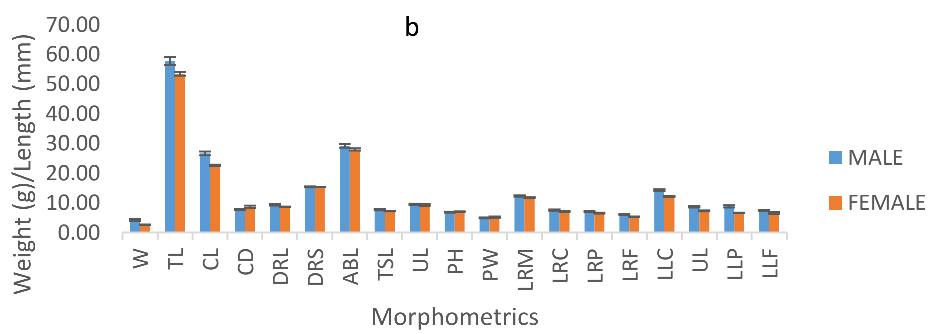

Fig 4a. Morphometric parameters of male and female *M. felicinum* collected from Lower River Benue, Makurdi (W, TL and CL differed significantly)

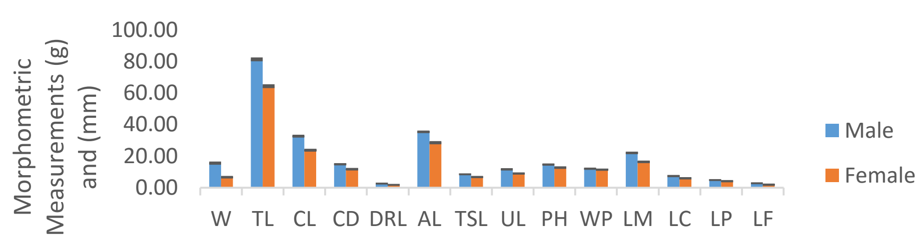

Fig 4b. Morphometric parameters of male and female *A.gabonensis* collected from Lower River Benue, Makurdi (all morphometrics differed significantly (P<0.05))

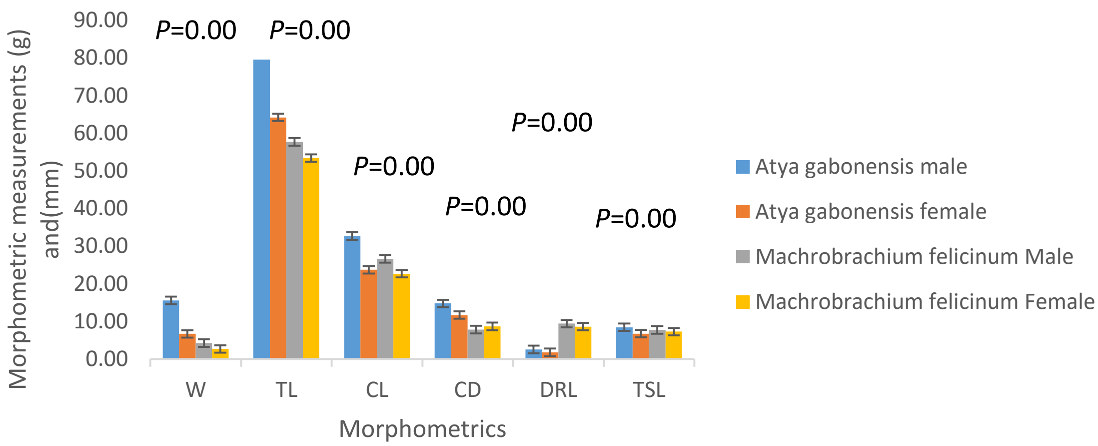

Fig 4c. Morphometric parameters of male and female *A.gabonensis* and *M. felicinum* collected from Lower River Benue, Makurdi

CONCLUSION.

Atya gabonensis body weight, TL, CL, CD, RL, AL, TSL, UL, PH, PW, were significantly higher than *M. felicinum*. Male *A.gabonensis* and *M. felicinum* grew faster than the female species. However, both species could be good aquaculture candidates. Moreover, all male production is therefore recommended.

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