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RICE FARMING HOUSEHOLDS IN NORTHWESTERN NIGERIA: STATUS OF FARMLAND OWNERSHIP AND BARRIERS TO ITS ACQUISITION

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ABSTRACT:

A fundamental tactic for reaching Sustainable Development Goals 1 and 2 of eradicating hunger and poverty, respectively and making the nation food self-sufficient is still acquiring farmland for agricultural investment. For this study, which intended to establish the prevalence of current farmland ownership among these households in North-Western Nigeria, 380 rice farming households were chosen using a multi-stage sampling technique. Descriptive statistics, such as frequency counts, percentages, averages, and the likert scale, were used to analyze the data. The result of the analysis revealed that 35.40%, 13.80%, 33.00% and 17.80% of the households, respectively, acquired their farmland through inheritance, purchase, rent and lease. There was a similar distribution of general property rights, except for the case of purchase, where most households (64.70%) hold a title right to their farmlands. The challenge that had the biggest effect on households' capacity of acquiring land throughout the ownership category was determined to be a bureaucratic backlog. Inconsistent regulations, a protracted registration procedure, and a high registration price for land titles for inheritance and purchase came next. However, a little variation exists between long registration process, and a high registration cost, with the latter more severe in the purchase. In decreasing order of relevance, length of the registration process for rent and lease, inconsistent policies, and high registration costs were mentioned. The weak land market is without a doubt the structure with the worst ranking. Reinforcement of the rural land governance systems is therefore recommended.

Keywords: Land acquisition; Property Right; Ownership, Challenges; Rice Households; Nigeria

INTRODUCTION

Absolute and derived interests are the foundation of land ownership in Nigeria (Udoekanem, 2014). The absolute interests are those in land that grant their holders genuine interests in perpetuity (i.e., total property rights), and as a result, they allow for the widest range of ownership decisions regarding the use and management of land. In contrast, the derivative interests are those that have been derived from the larger estates (Udoh, 2003). Land must first

be obtained in some form for rights to be exercised over it. Inheritance, purchase, lease, pledge exchange, and gifting are the main methods of acquiring land in Nigeria (Udoekanem, 2014).

Every human action begins with the land because it is the source of all material wealth. However, over time, control, use, and management of the land have led to the establishment of land property systems that aim to regularly balance the interests of the stakeholders, which include the government, the landowning class, and the landless class. It has been stated that Nigeria's structure evolved through time until 1978, when a single land policy law known as the Land Use Act of 1978 was adopted to bring ownership in the nation into compliance and standardize it. Access to land is nevertheless restricted since families and community leaders continue to exercise control over it. The Land Use Act of 1978's position suggests that the recipients of the community land allocation scheme are not explicitly acknowledged as the legal owners of the land. In the developing world, land, a crucial component of the agricultural system, significantly supports rural lives (Koirala *et al*., 2016). The fundamental objective of Nigerian agricultural policy is self-sufficiency in rice production, and providing the rural poor with access to land for agriculture is crucial for both food security and economic growth.

Without understanding how food shortages and crises are socially produced, with a focus on the resources employed in production, particularly land, the farmers' livelihood cannot be appropriately addressed (Ajibade *et al*., 2019). Answering issues about hunger is related to land power and market economics, i.e., who has control over land and other production inputs. Land has always been a resource tied to survival and power. According to classical economic theory, one of the three major determinants of production is land (Obayelu *et al*., 2017). The availability and use of land have a linkage to food insecurity, poverty and economic development. Hence, land regulation is critical to food production in Nigeria (Ojong and Anam, 2018). Among other factors, land availability for the purpose of production without conditions is directly influenced by the prevailing land tenure system (Adamu, 2014). Land tenure system puts a severe constraint on land that is accessible for all kinds of farmers and this varies with states and communities.

In Nigeria, the traditional land tenure system of ownership is predominant (Akinola and Adeyemo, 2013). The tenure system informs the acquisition of land in Nigeria and this is somehow a complex issue as it defines the rules and conditions guiding the right to hold a piece of land for a particular purpose (Udoekanem, 2014; Ukaejiofo and Nnaemeka, 2014). Low agricultural production however, might not be unconnected with the insecure right to land which is regularly mentioned as one of the barriers to the investment in land management practices in Africa and Nigeria inclusive (Shittu *et al*., 2021). Land tilting as a case is bizarrely tedious and costly to execute. Going with the background of smallholder farmers in Nigeria being resource poor, applying such technology on their farmland becomes difficult especially when they are not sure of what becomes of such land in the absence of property right.

In fact, according to (Hull e*t al*., 2016), 95% of Nigeria's agricultural lands are untitled. As a result, farmers are less able to use their lands as collateral when applying for formal loans from financial institutions (Hull *et al*., 2016). Once more, the inability of farming households to have absolute or non-derivative property interests prevents them from planting cash crops, which in turn reduces their ability to generate

revenue (Odoemelam *et al*., 2013). Promoting sustainable development can therefore be attainable if farmers can have an emotional attachment to the land they cultivate (Deininger, 2003). Due to a dearth in research on the status of land ownership, it is pertinent to understand the farming households' land ownership status and the factors limiting the acquisition of land. The study therefore unraveled the forms of farmland ownership among rice farming households in the study area.

Theoretical Framework

In general, land systems prosper when property rights are well defined. Absolute or non-derivative interests and derivative interests are the two categories of proprietary rights that have been identified in the literature (Udoekanem, 2014). The possessor of an absolute or non-derivative interest has unrestricted access to and usage of the land. The highest level of private decisions about the use and management of property are included in the absolute interest in land, according to another explanation. On the other hand, derivative interests come from superior or larger estates. The derivative right includes, among other things, leaseholds, life interests, mortgages, rents, and pledges. In Nigeria, these two sorts of property rights are recognized.

Land accessibility laws are governed by a diverse legal system that combines statutory, customary, and religious frameworks (Obayelu *et al*., 2017). Politics and power have an impact on how the state tries to enter and interfere with the legal pluralism; these attempts are occasionally greeted with abrasive rejection from the customary authority (Aryeetey, 2007). Power and politics have a big impact on a country's ability to feed its people. This study uses a combination of power, human right, and access theory to gain a comprehensive understanding of the relationships between land tenure, accountability, and agricultural production.

Due to the unequal authority of those in charge of land governance, land reforms by land tenure system have a negative impact on the poor and marginalized groups. Over time, this interference affects food production and the majority's access to land. The institutional framework of the reform provides easier access to loans and land for some persons with means and authority. Therefore, those in positions of authority can affect who has access to property and their transaction costs in the reform-making and implementation processes may be cheap. Others, primarily the poor, who have little to no influence over decisions about access to land by those in charge of administering the land tenure, find it much more difficult to access land (Narh *et al*., 2016). Land as a factor of production is connected to productivity, poverty and food security. Regional and individual poverty are both aspects of poverty that interact with one another (Zhou *et al*., 2019).

Farmers' access to credit and land they need for better agricultural practices may be hampered by a lack of land ownership. Extreme climate-related catastrophes, stalled agricultural productivity, increasing poverty, and rapid population expansion have all put strain on the structures of land allocation and tenure that now exist in emerging nations. In many developing nations, the research revealed a high correlation between rural poverty, agricultural productivity, and land distribution (Zulfiqar *et al*., 2016). Recent years have seen an increase in interest in land policies in emerging nations. The primary justification, which cannot be emphasized enough, is that it is widely acknowledged that raising smallholder production is essential for long-term, inclusive growth.

METHODOLOGY

Study Area

One of Nigeria's six geopolitical zones, the north-western region includes the following states: Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara. However, only three states of Sokoto, Kebbi, and Zamfara were the locations of the study. The 102,741 km^2 of territory that makes up the designated territories is predominantly inhabited by the Hausa and Fulani people (NBS, 2012). As of 2024, it had an estimated population of 17,659,797 people, growing at a 3.5% annual rate (NBS, 2016; NPC, 2006). Figure 1 displays a map of the study region.

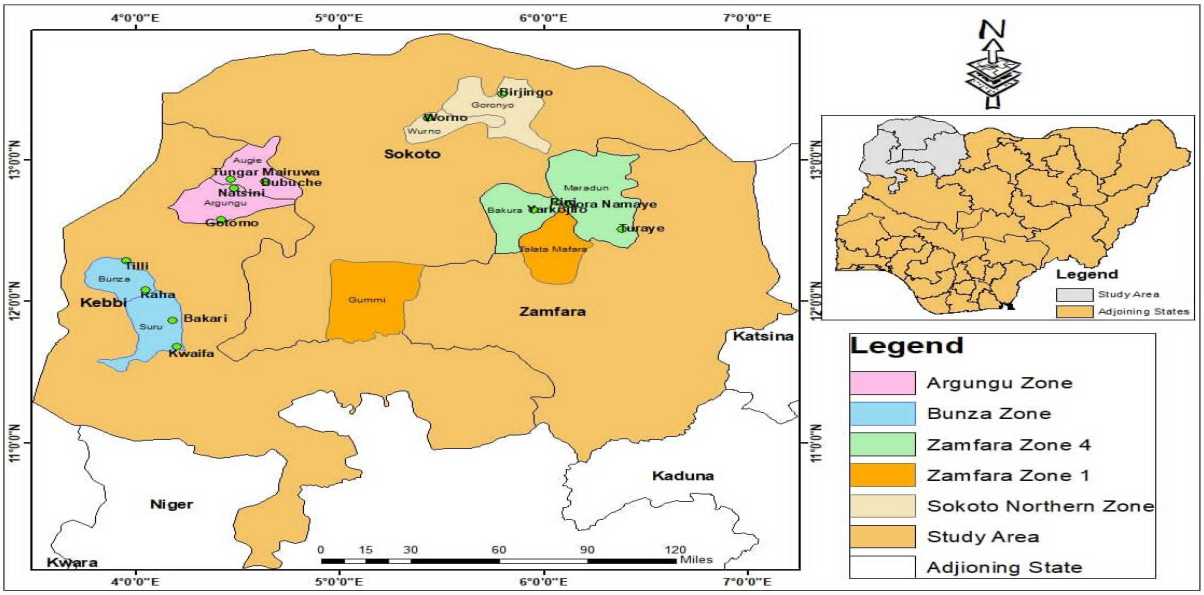

Figure 1: Map of the study area
Source: Department of Geography, Usmanu Danfodiyo University Sokoto (2023)

Sampling Procedure

In the three States of Sokoto, Kebbi, and Zamfara, rice farming households were chosen using a multistage sampling technique. In the first phase, two of the four existing Agricultural Development Programme (ADP) zones in the States of Kebbi and Zamfara, as well as one zone in Sokoto State, were purposefully sampled. The selection was made based on each state's predominant rice production, agrarian nature, and unequal size of the zones. Having a strong representation in the States was a result of this. Following this, two blocks in each of the chosen zones were purposefully selected. In the second, considering the blocks generating the most rice, two villages were then selected at random from each of the two blocks. Due to differences in the number of rice-farming households between States and villages, households were proportionately selected in the fourth stage, yielding a sample size of 380 rice-farming households. However, only 370 surveys were found to be suitable for analysis during the data cleaning process.

Data Collection

The study made use of primary data that was gathered via a semi-structured questionnaire created to extract pertinent details on the socioeconomic features of the households, the

status and prevalence of their land ownership, and the bottleneck to their land acquisition.

Analytical Techniques

Descriptive statistics in the form of frequency distribution, percentages and mean descriptive statistical tools such as frequency distribution, percentages and mean were employed in expressing the characteristics of the households, and consequently, identifying the forms of farmland ownership and their prevalence. The Likert scale was used to identify the challenges of the rice farming households to farmland ownership and was presented graphically on a bar chart.

Likert scale

Following the work of (Obalola *et al*., 2021; Obalola and Ayinde, 2018), the used scale format and the computations was employed to identify the most pressing challenges to farmland acquisition and use in order of importance. The ordered scale and its measure are presented in Table 1.

Table 1. The Ordered Likert Scale and its Measure

Scale Items	Measure
Very important (VI)	5
Important (I)	4
Not sure (NS)	3
Not important (NI)	2
Not very important (NVI)	1

Source: Adopted from Obalola *et al*. (2021)

However, the weighted score (WS) and mean score (MS) were computed thus;

$$Weighted\ score = \sum VI_f * S_{VI} + * I_f + S_I + NS_f + S_{NS} + NI_f + S_{NI} + NVI_f + S_{NVI} \quad (1)$$

$$Mean\ Score = {Weighted\ score}/{Sample\ size} \quad (2)$$

Where,
f = frequency observed from the scale item
S = ordered value of the scale item

RESULTS AND DISCUSSION

Socioeconomic Characteristics of the Rice Farming Household

The socioeconomic attributes of the farming households are summarized in Table 2. As observed from the data, males predominated as household heads in rice farming. This situation may be explained by the fact that growing rice is laborious and takes more strength than women are often able to offer (Kehinde *et al*., 2022; Kehinde *et al*., 2021; Aboaba *et al*., 2019). The study found that most households with rice farmers were married. Farmers who are single make up the minority everywhere. This has the implication that individuals who have children will likely have access to inexpensive agricultural family labor, which will help with the timely completion of farm operations and, as a result, boost output at a lower rate (Obalola and Ayinde, 2018). Only one household in each category, except for purchases, reported having experienced divorce, making it a rare occurrence among households.

Most household heads in Table 2 had no formal schooling. A little over 26% of the heads had completed their primary education. Only a few of the household heads reported having completed secondary and/or tertiary education, with the latter not being reported for the inheritance category. The results are anticipated to shed light on their level of proficiency, their capacity for allocation, and their awareness of contemporary technological advancements. The study area is situated in a Nigerian state with

limited educational options; therefore the results are not shocking. It backs up the conclusions of (Aboaba *et al*., 2019; Obalola and Ayinde, 2018; Tsoho and Salau, 2012).

Majority of the household heads are primarily farmers, according to the findings, and no secondary occupations have been mentioned. Some households did, however, mention having other jobs. This includes trading, which appears to be done by households across all four types of ownership that have been identified. Nevertheless, in the purchase, rent, and leasehold categories, respectively, 11.8%, 2.5%, and 1.5% of the households were made up of civil servants. Other occupations associated with the households include crafts and fishing, with the former being reported in all categories except leasehold and purchase for the latter. The representation that was seen is not out of line with the reality that the household heads' primary occupations were farming. This is congruent with the findings of Aboaba *et al*. (2019).

Table 2 also demonstrated that most households are members of an association. A closer examination revealed that, except for leasehold, where the majority (53.0%) of its households belongs to the farmers group, cooperative groups are the most common association form among households in all ownership categories. However, some households did not belong to either of the two associations mentioned. Farming households had access to an extension agent, although the frequency still needs to be improved. All of the categories can be reached using this. Inferentially, the household typically receives assistance regarding processes that enhance their farming skills and techniques. Regarding the agrarian sector's improvement, extension service is important because it would assist farmers in identifying and resolving production-related issues and informing them of opportunities for growth.

One of the major barriers to production is still access to credit. This has been established by the fact that most of the household does not have access to official financial credit facilities. With no access recorded from households in the leasehold group, about 0.8%, 11.8%, and 1.6% of the households had access to bank facilities for ownership categories based on inheritance, purchase, and rent, respectively. Apparently, households in the purchase category held titles to their farmland, which could be used as collateral to get loans from the bank. As a result, households must rely on friends, family, and, of course, their own personal finances to pay for production. Surprisingly, only a selected few households received credit from the cooperative society despite being members.

In theory, a cooperative society should promote savings, which then opens the door for investment. However, the situation can be attributed to a decline in household saving capacity.

Distribution of Farmland Acquisition, Its Prevalence and Rights amongst the Rice Farming Households

The farmland ownership profiles of the farming households are revealed in Table 3; while Table 4 summarizes the right to the farmlands cultivated by the households.

According to the findings on Table 3, 35.4% of the households had their farmland acquired through inheritance and 33.0% through rental agreements. Following this were households that leased their farmland (17.8%), followed by those that owned their farmland via outright purchase (13.8%). The result agrees with findings from (Kehinde *et al*., 2021; NBS, 2016; Alarima *et al*., 2012).

Table 2. Distribution of the Rice Farming Households by their Socioeconomic Characteristics

	Absolute ownership				Temporary ownership			
	Inheritance		Purchase		Rent		Lease	
Variables	F	%	F	%	F	%	F	%
Sex								
Male	114	87.00	38	74.50	110	90.20	62	93.90
Female	17	13.00	13	25.50	12	9.80	4	6.10
Marital status								
Single	13	9.90	2	3.90	12	9.80	7	10.60
Married	102	77.90	39	76.50	100	82.00	46	69.70
Widowed	15	11.50	10	19.60	9	7.40	12	18.20
Divorced	1	0.80	-	-	1	0.80	1	1.50
Educational level								
No formal education	85	64.90	23	45.10	74	60.70	41	62.10
Primary education	35	26.70	14	27.50	30	24.60	18	27.30
Secondary education	11	8.40	7	13.70	16	13.10	5	7.60
Tertiary education	-	-	7	13.70	2	1.60	2	3.00
Secondary Occupation								
Civil servant	-	-	6	11.80	3	2.50	1	1.50
Artisan	2	1.50	4	7.80	3	2.50	-	-
Fishing	4	3.10	-	-	7	5.70	4	6.10
Trading	18	13.70	3	5.90	8	6.60	14	21.20
None	107	81.70	38	74.50	101	82.80	47	71.20
Membership of association								
Yes	110	84.00	43	84.30	105	86.10	55	83.30
No	21	16.00	8	15.70	17	13.90	11	16.70
Association type								
Cooperative group	67	51.10	25	49.00	63	51.60	21	31.80
Farmers group	43	32.80	18	35.30	42	34.40	35	53.00
None	21	16.00	8	15.70	17	13,90	10	15.20
Extension Access								
Yes	102	77.90	32	62.70	89	73.00	48	72.70
No	29	22.10	19	37.30	33	27.00	18	27.30
Credit access								
Yes	31	23.70	17	33.30	30	24.60	10	15.20
No	100	76.30	34	66.70	92	75.40	56	84.80
Credit source								
Friends and family	43	32.80	15	29.40	30	24.60	24	36.40
Banks	1	0.80	6	11.80	2	1.60	-	-
Cooperative society	21	16.00	7	13.70	17	13.90	6	9.10
Own finance	66	50.40	23	45.10	73	59.80	36	54.50

Source: Field Survey, 2023

Note: F represents frequency; % represents percentage

Table 3. Distribution of the Rice Farming Households by Tenure Type

Farmland ownership category	Frequency	Percentage
Inheritance	131	35.40
Purchase	51	13.80
Rent	122	33.00
Leasehold	66	17.80
Total	370	100.00

Source: Field Survey, 2023

Table 4. Distribution of the Rice Farming Households by Tenure Right

	Absolute ownership				Temporary ownership			
	Inheritance		Purchase		Rent		Lease	
Land Right	F	%	F	%	F	%	F	%
Title	36	27.50	33	64.70	22	18.00	11	16.70
No title	95	72.50	18	35.30	100	82.00	55	83.30
Total	131	100.00	51	100.00	122	100.00	66	100.00

Source: Field Survey, 2023
Note: F represents frequency; % represents percentage

Except for the incidence of purchase, which was relatively higher (64.7%) with only a small portion (27.5%; 18.0% and 16.7%) of the landholding registered under inheritance, rent, and lease, respectively, the patterns of general land tenure and property rights were similar across households. According to Obayelu *et al*. (2017) and FMARD (2016), this is accurate. This implies that they hold the rights to the use, control, and transfer of their farmlands for the free holdings (inheritance and purchase). Despite some of the farms being registered, this is not the case for those who are under rent or lease. Up to the end of the rent or lease term, they only have the legal right to use and control the property. The conclusion shows that land tenure and title are still complicated problems. This backs up the research done by (Obayelu *et al*., 2017).

Rice Output across Farmland Ownership Category

Table 5 reveals that households with absolute ownership exhibit higher productivity compared to those renting or leasing. Among those inheriting land, the majority (62.60%) reported rice outputs ranging between 1001-4000kg, followed by outputs between 4001-8000kg. A smaller percentage (9.90%) had yields less than or equal to 1000kg, indicating a predominantly subsistence-oriented approach. Only 3.10% achieved rice outputs exceeding 12000kg, reflecting limited commercial production. Similar trends were observed among households purchasing land. However, variation was noted in the rent and lease categories, where households reported consistent distribution spreads but lacked outputs exceeding 8000kg. Mean values further elucidate these disparities, with inheritance yielding 3533.5kg on average, representing approximately 78.5% of suggested output levels. Purchase categories showed slightly higher yields (87.4%). This is consistent with the report of (Kamai *et al*., 2020). In contrast, rental and lease categories yielded 52.3% and 45.6%, respectively, reflecting the influence of cultivated varieties, primarily FARO 44 or FARO 52, as depicted in Figure 2.

Table 5. Distribution of the Rice Farming Household by their Output

	Absolute ownership				Temporary ownership			
	Inheritance		Purchase		Rent		Leasehold	
Rice Output in Kg	F	%	F	%	F	%	F	%
≤ 1000	13	9.90	3	5.90	11	9.00	6	9.10
1001 – 4000	82	62.60	26	51.0	97	79.50	58	87.90
4001 – 8000	26	19.80	19	37.30	14	11.50	2	3.00
8001 – 12000	6	4.60	2	3.90	-	-	-	-
> 12000	4	3.10	1	2.00	-	-	-	-
Mean	3533.59		3937.26		2354.92		2054.55	
SD	3002.45		2353.29		1226.24		796.57	

Source: Field Survey, 2023
Note: F represents frequency; % represents percentage, SD represents standard deviation

Recommended yield is 3 – 6 tonnes/ha (Kamai *et al*., 2020)

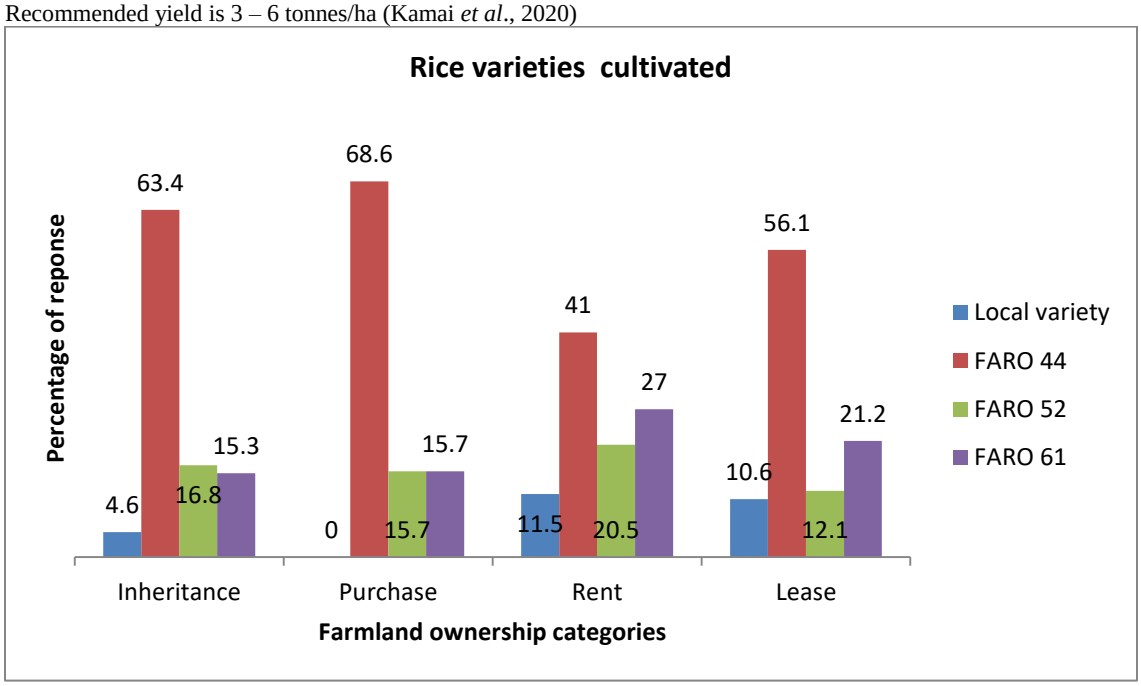

Figure 2. Rice varieties cultivated by households across farmland ownership categories
Source: Field Survey, 2023

Challenges to Farmland Acquisition

Figures 3, 4, 5, and 6 shows the impediments militating against the households' capacity to produce rice in order to obtain the complete control and use rights to farmland.

The major challenges to farmland acquisition confronting rice farming households under inheritance in order severity are bureaucratic bottleneck ($\bar{x}$ = 4.44), inconsistent government policies ($\bar{x}$ = 4.26), long registration procedure ($\bar{x}$ = 4.15), high cost of registration of land title ($\bar{x}$ = 4.14), and weak land market ($\bar{x}$ = 3.87). Farming households identified and ranked bureaucratic bottleneck as the most pressing challenge hindering their ability to acquire land and, subsequently, land titles. This was the choice about every ownership structure that was mentioned. Land acquisition for agricultural investment is still hampered by bureaucracy, which is practiced by approving authorities in communities where land is located. In order to make it easier for people to acquire agricultural land and make the country self-sufficient in food production, this still needs to be addressed. The finding backs up the arguments made by Chikaire *et al.* (2014), Obayelu *et al.* (2017), and Oluwatayo *et al.* (2019) who reported bureaucracy as an impediment to land acquisition for agricultural investment.

The number of steps that must be completed in order to finish the property title registration process is quite a lot especially when compared to other nations, thus making it more challenging to execute. This demonstrates the study area's low level of innovation and inefficiency in the land registration procedure. That undoubtedly led to a longer period of time to register a land title. This supports the stance taken by the World Bank (2017) on the possible ways of limiting the number of steps involved in title registration. The weak land market which ranked 5th can be linked to the challenges in our land market, such as the guaranteed land rights, limited access to financing, and insufficient transparency, openness, and ease of access which had made

the households resort to operating in the informal land market. This supports the conclusions of the report from USAID (2009) and Oluwatayo *et al.* (2019).

For the purchase farming households, bureaucratic bottleneck ($\bar{x}$ = 4.43), and inconsistent policies ($\bar{x}$ = 4.24) were the major challenges affecting farmland acquisition (Figure 4). This is followed by high cost of land registration title ($\bar{x}$ = 4.20), and long registration procedure ($\bar{x}$ = 4.04). As the majority of the households in this area have land titles, they operate under the formal land market. This may help to explain why it wasn't seen as s challenge and hence received the lowest ranking. The policy implications for rice farming households are significant, with the most critical challenge being bureaucratic bottleneck, hindering efficient operations. Inconsistent policies further exacerbate uncertainties, making it crucial for policymakers to provide stability and coherence. Addressing the high cost of land registration is pivotal, as it directly impacts the economic viability of rice farming. Streamlining and expediting the registration procedure are essential measures to alleviate the burden on farmers. This conforms to the findings of Obayelu *et al.* (2017) who reported a tedious condition for the acquisition of agricultural lands. Prioritizing these challenges in a strategic order can enhance policy effectiveness and promote a conductive environment for sustainable rice farming.

Figure 5 indicates the challenges to farmland acquisition by rice farming households under rent. It is worthy to note that long registration processes ($\bar{x}$ = 4.25) ranked second after bureaucratic bottleneck ($\bar{x}$ = 4.31), followed by inconsistent policies ($\bar{x}$ = 4.12), and high cost of land title registration ($\bar{x}$ = 4.03). Land rights are based on the contractual terms of rent and lease, and households in these categories function by combining the legal and informal land markets (Figures 5). The prolonged registration processes, topping the list after bureaucratic bottlenecks, pose a substantial challenge for rice farmers seeking land acquisition. Cumbersome procedures contribute to delays, affecting farmers' timely access to land resources. This corroborates the position of Obayelu *et al.* (2017) who reported that the process of land acquisition is more cumbersome. Inconsistencies in policies add another layer of uncertainty, making planning and investment challenging. The high cost of land title registration compounds financial strain on farmers, limiting their ability to expand operations. Addressing these issues is imperative for streamlining the land acquisition process, ensuring farmers' access to affordable, secure land, and fostering a more conducive environment for sustained growth in the rice farming sector.

Figure 6 showed that bureaucratic bottleneck ($\bar{x}$ = 4.26), long registration procedure ($\bar{x}$ = 4.21), high cost of title registration ($\bar{x}$ = 4.18), and inconsistent policies ($\bar{x}$ = 4.15), were the challenges faced by the rice farming households in their quest to acquiring farmland. Bureaucratic bottlenecks create administrative complexities, hindering operational agility and responsiveness. This is in tandem with the work of Obayelu *et al.* (2017) who observed a high level of lobby in the acquisition of land.

The protracted registration procedures introduce time lags, impeding farmer's ability to promptly secure and utilize land. The high costs associated with title registration strain financial resources, diminishing the economic viability of lease holding. Inconsistent policies compound uncertainties, affecting long-term planning and investment decisions. Collectively, these challenges jeopardize the stability and sustainability of rice farming under leasehold arrangements.

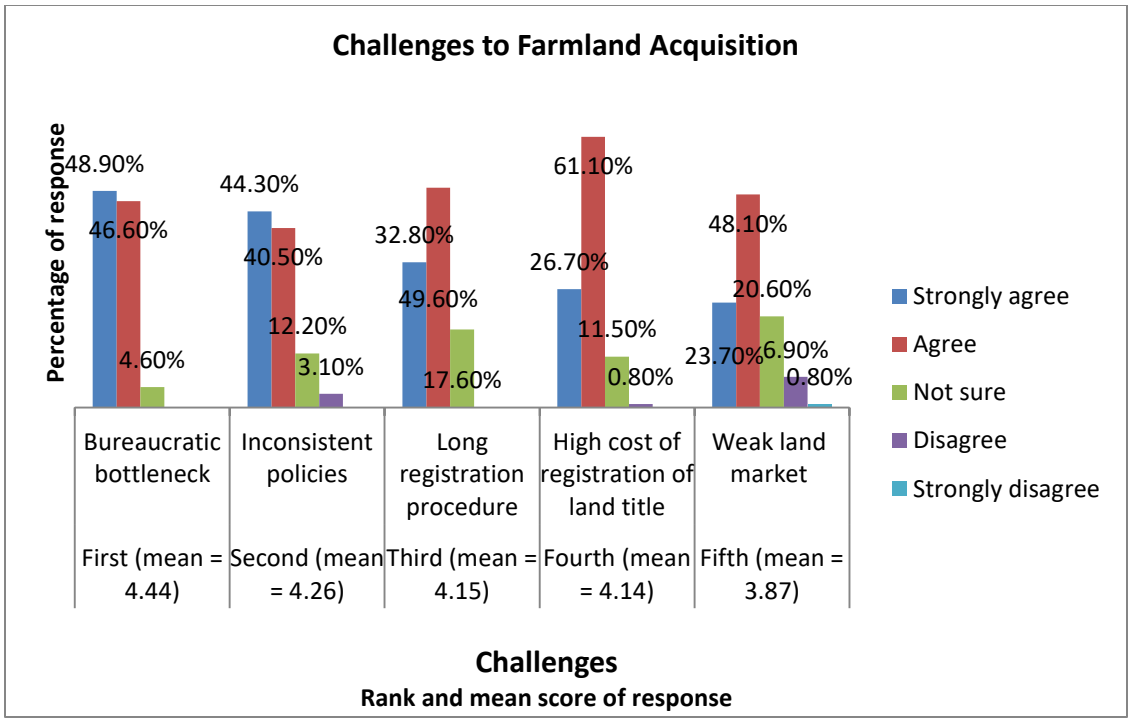

Figure 3. Challenges to farmland acquisition by rice farming households under inheritance
Source: Field Survey, 2023

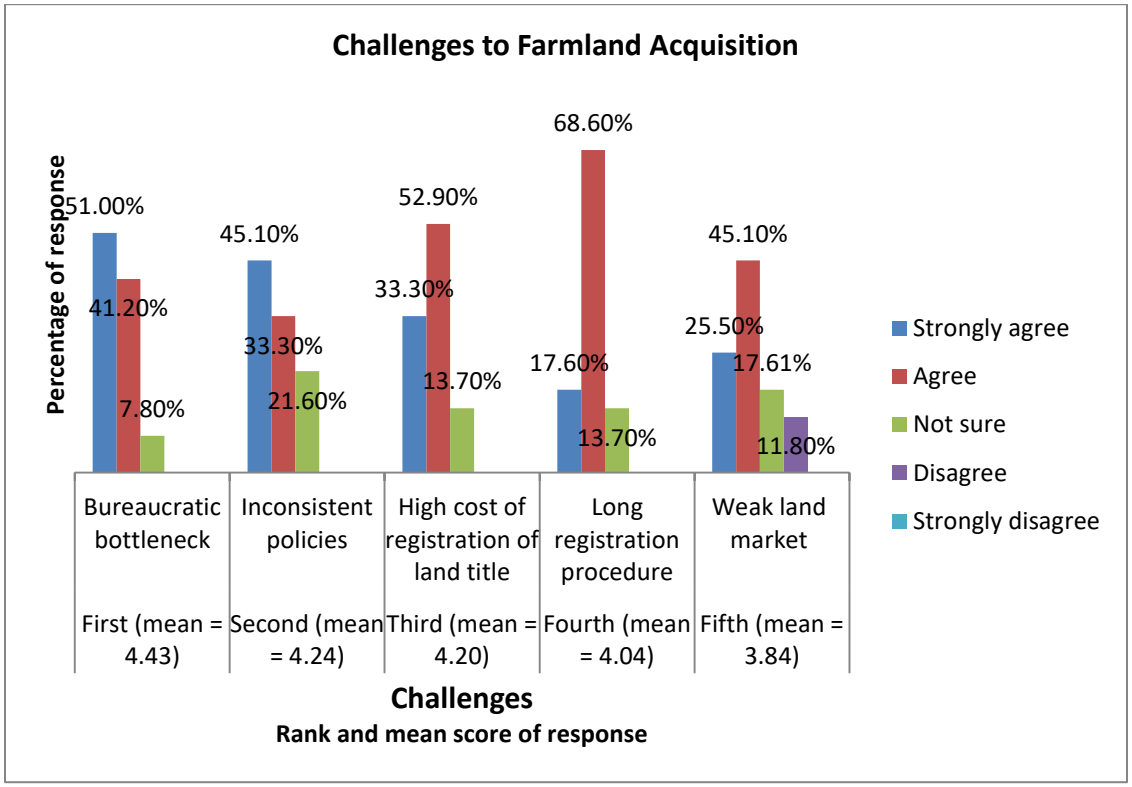

Figure 4. Challenges to farmland acquisition by rice farming households under purchase
Source: Field Survey, 2023

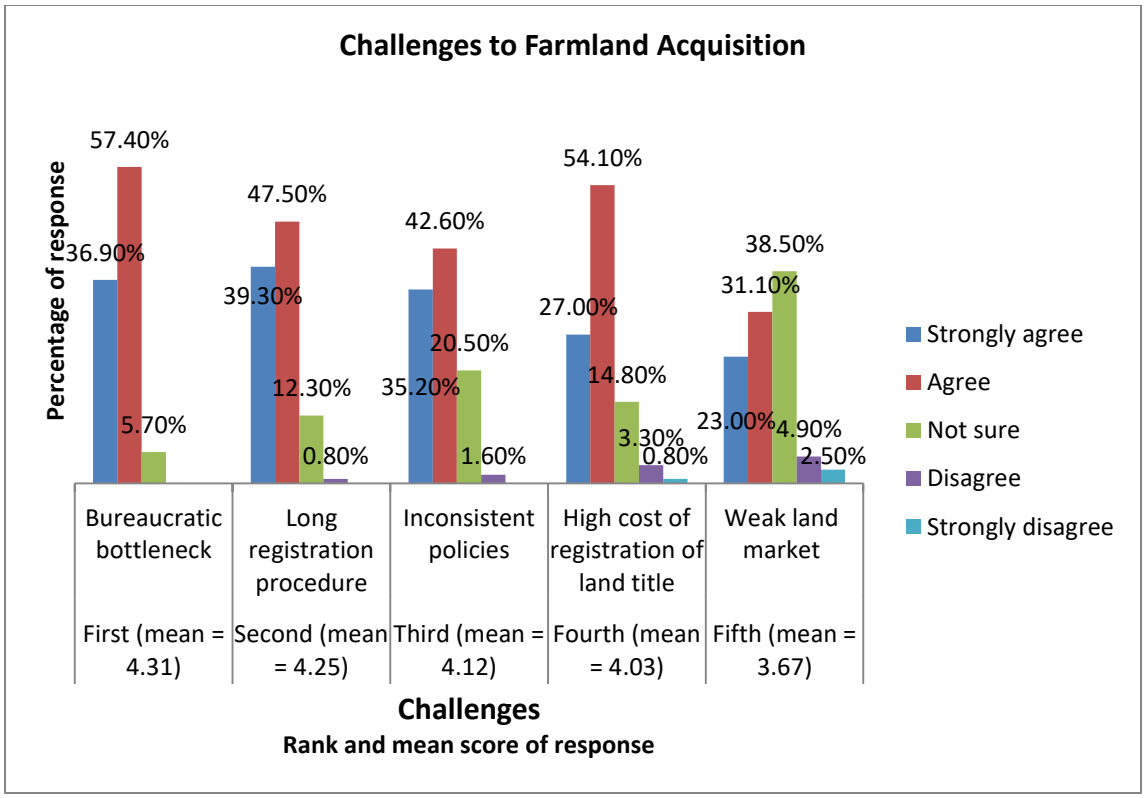

Figure 5. Challenges to farmland acquisition by rice farming households under rent
Source: Field Survey, 2023

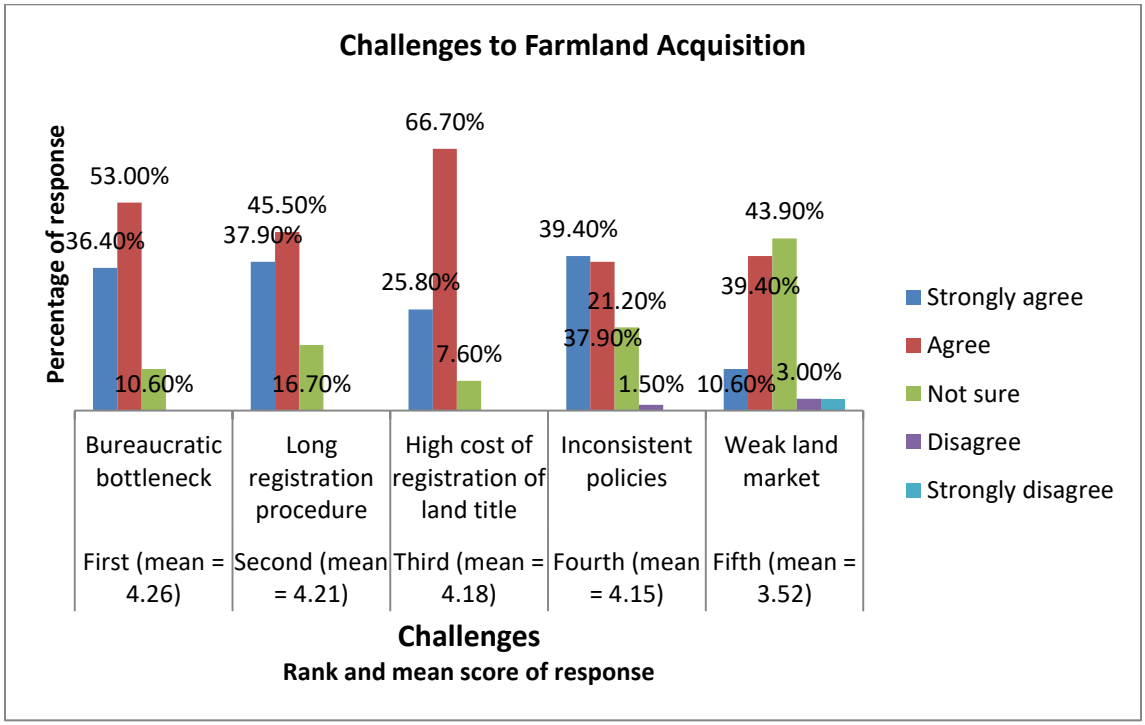

Figure 6. Challenges to farmland acquisition by rice farming households under lease
Source: Field Survey, 2023

CONCLUSION

This study was carried out to unravel existing farmland ownership and their prevalence amongst rice farming households in North-western Nigeria. It was discovered that the two categories of land acquisition; absolute or freehold, which includes personally inherited and/or purchased lands with exclusive use and transfer rights, and temporary, which includes rented or leased land with only use rights are mutually exclusive, exist in the area. If problems with land tenure are addressed by considering issues like bureaucratic bottleneck, inconsistent policies, a protracted registration process, and a high registration fee in order to obtain title to land, there may be significant progress made in producing enough food to sustain Nigeria's future population. Leaving such untreated becomes risky for the future given Nigeria's current food shortage issue.

In order to overcome the highlighted obstacles, the study recommends that rural land governance mechanisms, particularly in northern Nigeria, be strengthened. One technique to employ in order to improve the security of land tenure and property rights and promote medium-to long-term land leasing is the reform of the Land Use Act to address the issues.

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INFLUENCE OF PARTICIPATION IN NATIONAL ROOT CROP RESEARCH INSTITUTE'S (NRCRI'S) CAPACITY BUILDING PROGRAMME ON PRODUCTION OF SWEET POTATO IN SOUTHEAST NIGERIA

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ABSTRACT

The study investigated the influence of National Root Crops Research Institute's capacity building programme on the production sweet potato in South-East Nigeria. The specific objectives were to; ascertain the level of participation in NRCRI's capacity building programme by sweet potato farmers, estimate of the quantity produced and revenue generated by participants and non-participants amongst others. A multi-stage sampling procedure was used to select 180 participants and 180 non-participants. Data were collected using structured questionnaire and analysed using both descriptive and inferential statistics (bivariate regression and Z-test). The sweet potato farmers highly participated in the NRCRI's capacity building programme (grand mean = 2.3). The participants produced an average of 1,545.6kg/ha of sweet potato yields and the generated sum of ₦818,100.00 whereas the non-participants produced an average of 665.8kg/ha of sweet potato and generated the sum ₦359,974.00. Simple linear regression estimates revealed that the coefficient of level of participation (0.147***) was statistically significant at 1% and positively related to sweet potato output. The Z-test result revealed there was a significant difference in output of participant and non-participants at 1%. The study concluded that sweet potato farmers highly participated in the NRCRI's capacity building programme. The study recommends that NRCRI's capacity building programme should be extended to all sweet potato farmers in the study area.

Keywords: Participation, Capacity building, Sweet Potato.

INTRODUCTION

Sweet potato (Ipomoea batatas (L.) Lam) is a member of the morning glory (Convolvulaceae) family, an important stable food in many countries of Sub-Saharan Africa with both domestic and industrial usages. It possesses medicinal properties with great nutritional values, which exceeds those of other tuber crops such as yam, cassava, cocoyam (Law-Ogbomo and Osaigbovo, 2018). The crop has a short growing period of 3-5 months depending on the variety, and this permits the growing of two or three crop cycles in a year. This crop is usually produced by resource challenged farmers. Sweet potato is cultivated globally in eleven countries in an area of 8.106 million ha producing 106.5kg million tons with an average productivity of 13.147tons/ha (Udemezue, 2019). Sweet potato

is one of the most misunderstood major food crops.

According to Udemezue (2019), Nigeria is the second largest producer of sweet potato in the world after China with an annual output of 3.46 million metric tons/year. Nigeria is also one of the largest producers of sweet potato in sub-Saharan Africa with annual production estimated at 4.03 million tons per year with farm size of about 1.7mha and yield of 2.3t/ha (FAO, 2018). Sweet potato is an important food security and early maturity crop that can be intercropped with some crops like yam and maize. It can also be a monocrop based on the intentions of the farmer.

In Nigeria, Sweet potato is the third most important root and tuber crop after cassava and yam. It is planted in all states of the country. Nigeria produces over four million tonnes of sweet potato annually. Its production in Nigeria has increased rapidly in the last 15 years due to the increase in the number of farmers and area of land under sweet potato cultivation (Gehan, 2019). This rapid increase is due to some unique attributes of the crop among which are: its short maturation period of 3-4 months (depending on variety and altitude); its adaptation to marginal soil environments; its low input requirement; the ease of sweet potato field management; its ability to withstand random drought (especially after the first two months of planting), and its high production per unit area.

Its food security role is appreciated more during the early planting season when most staple root and tuber crops are often scarce and very highly priced. Sweet Potato is planted twice in a year at household levels. It is planted between June/July and October/November each year (Law-Ogbomo, and Osaigbovo, 2017). It could be planted solely or intercropped with cereals such as maize, millet, and sorghum. Sweet potato roots are usually available, and the availability of sweet potato in major urban markets during this period often helps to mitigate hunger and moderate the prices of other staple foods (Udemezue, 2019). Despite the importance of the sweet potato in Nigeria as a country, the crop has received so little attention in some States, due to a paucity of information on the factors limiting sweet potato production. Studies have shown that the Southeast states of Nigeria are yet to attain their full potential food security status using sweet potatoes, because farmers have not taken advantages of improved crop varieties and other capacity building programmes provided for them to maximize output and profit (Ejechi, 2020).

Farmers are highly dependent on effective extension services to provide advice on commercial and technical opportunities to improve their livelihoods. Capacity to learn technical and extension skills is critical to success which is influenced by the capacity building methods. The objective of enhancing the capacity of farmers is to intensify, in a sustainable manner, agricultural production using improved agricultural technologies by farmer to improve food security and farm income and raise livelihoods particularly for the small holder (Kroesen and Ndegwah, 2019).

Capacity can be defined as the people, institutions, and practices that enable organizations, institution and countries to achieve their development goals. It encompasses human skills and institutional and organizational structures, procedures, and systems. Capacity building programmes are carried out in order to provide skills and knowledge to its members, staff and partners from government, non-governmental institutions, private sector, and farmers. According to Kumari and Kandhuri (2019), capacity building methods may include conferences, workshops, consultations, study tours, participatory research and extension, on-

job training, demonstration plots, coaching and mentoring. The main sources of information that capacity builders use to support capacity building are training, international NGO project material, general textbooks, workshops, meetings, exposure visits, project/NGO documents, national networks, state/national sources, own research, on-job learning, using Internet and other (e.g. many sources, friends, facilitators, advisers and consultants).

The National Root Crops Research Institute (N.R.C.R.I) Umudike, with support from International Agencies such as the Center for International Potato (CIP), International Institute for Tropical Agriculture (IITA), Technologies for African Agricultural Transformation (TAAT), have severally mounted collaborative capacity building programmes aimed at empowering sweet potato farmers to increase their productivity, improve their livelihoods and income. The programmes have activities which target building the competencies and capabilities of small holder sweet potato farmers to increase their productivity, income and enhance their wellbeing. By these activities, capacity building targets development and improvement of individuals to build existing knowledge and skills. It also deals with the establishment of conditions in which individuals engage in learning and adapting process. The capacity development of sweet potato smallholder farmers is an important input, as most of the farmers come from a background of traditional agriculture. Several small holder sweet potato farmers in Southeast Nigeria have participated in the capacity building programmes implemented by NRCRI Umudike which include pieces of technical training on subject areas about sweet potato, access, use and sharing of sweet potato related information, facilitation of production activities, and coaching/mentorship in technology utilization.

Sweet potato possesses a great potential of serving as a food security crop as it provides an array of foods for humans and animals as well as raw materials for industries (IITA, 2019). It also has potentials for empowering the small holder producers. In Southeast Nigeria, most of the sweet potatoes are produced by smallholder farmers whose outputs are quite below market demands due to low production capacities. To address the attendant domestic food insecurity, it is necessary to close those farms' yield gaps, which are the differences between the actual yields that farmers are making and the yields they could achieve if they were to adopt better agricultural inputs and technologies. In attempts to narrow the yield gaps, the National Root Crops Research Institute (NRCRI) Umudike, which has the mandate for development of root and tuber crops mounted capacity building programmes mentioned above aimed at enhancing sweet potato farmers' productivities. Nevertheless, the influence of the programmes in building the production capacities and technical competencies of sweet potato farmers in Southeast Nigeria has not been determined through an empirical study. This study therefore examined the influence of participation in NRCRI's capacity building programme on output of sweet potato farmers in Southeast Nigeria.

Specific Objectives

i identify the techniques/methods used by NRCRI in the farmers' capacity building programme;
ii ascertain the level of participation in NRCRI'S capacity building programme by sweet potato farmers;
iii estimate of the quantity produced and revenue generated by participants and non-participants;
iv Determine the influence of participation in capacity building programme of NRCRI on output.

Hypothesis

1. There is no significant difference in the output of participants of NRCRI and non-participants in the study area

METHODOLOGY

The South-East Agro-ecological Zone of Nigeria was the main focus of the study. The Zone lies between latitude 6° and 9°E and 4° and 7°N longitude and has a total land mass of 952,400 hectares. The zone has a projected population estimate of 36million and is made up of five states viz: Abia, Anambra, Ebonyi, Enugu and Imo States (Population of Cities in Nigeria, 2023). Three states (Abia, Anambra and Ebonyi state) out of the 5 states in the South-East Geo-Political zone 3 were purposively selected for the study in the first stage because they have received Capacity building Services under Sweet potato programme of NRCRI Umudike and their active involvement in sweet potato farming. For the second stage from the list of participants at NRCRI Umudike sweet potato capacity building programme for each state and the list from sweet potato farmers association from each state out of 150 participant (yearly) from each state that were trained from 2014-2017, 60 participants were randomly selected from a pool of farmers who had passed through the Institute's requisite pre-selection process for participants of the capacity building programme and those who actually benefitted from the capacity building programmes. The processes include: (1) Benchmark survey (sample almost all the sweet potato farmers) (2) Selection based (a) Gender (b) Lack of knowledge of the area of training that is (new entrance). Which gave a total number 180 farmers. The other 180 who did not participate in any of the training programmes were also be selected using the same sampling procedure across the three states.

Data were collected using structured questionnaire and analysed using both descriptive and inferential statistics such as frequencies and percentages for descriptive statistics and bivariate regression and Z-test models for inferential. The variables were measured thus:

Objective i: identify techniques/ methods used by NRCRI in capacity building programmes: This objective was measured using frequency and percentages

Objective ii**:** ascertain the level of participation in NRCRI capacity budling programme in the study area: This objective was measured with mean counts. Data were rate with 3-point Likert scale of Always (3), Rarely (2) and Never (1) with a benchmark mean of 2.0.

Objective iii: to estimate the quantity produced and the income generated by participants and non-participant sweet potato farmers. The quantity produced was measured in Kg/ha while the income generated was measured in Naira.

Objective iv: determine the influence of participation in capacity building programme of NRCRI on output. This was estimated with simple linear/bivariate regression model.

The explicit model is expressed as:

$Y = b_0 + b_1X_1 + e_1$

Where,

Y = Output of sweet potato farmers (Kg)

X = Level of participation in NCRRI's capacity building programme (mean score)

b_1 = Regression coefficient

b_0 = Regression Constant

e_1 = error term

For Significant difference between output of the sweet potato farmers who participated and those who did not participate in the capacity building programme was tested with the use of Z test.

$$Z = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

$n_1 + n_2 - 2$ degrees of freedom

Where:

$\bar{X}_1$ = sample mean of sweet potato production among respondents who participated in the capacity building programme

$\bar{X}_2$ = sample mean of production among respondents who did not participate in capacity building programme

σ^2_1 = standard deviation of production of respondents who participated in the capacity building programme

σ^2_2 = standard deviation of production of respondents who did not participate in the capacity building programme

n_1 = sample size for sample size for participants in the programme

n_2= sample size for non-participants in the programme

RESULTS AND DISCUSSIONS

Techniques/Methods Used by NRCRI in the Farmers' Capacity Building Programme

The result on Table i show the Techniques/methods used by NRCRI in the farmers' capacity building programme in the study area. The result revealed that NRCRI used several methods/techniques in the capacity building programme for sweet potato farmers in the study area. The result revealed that training workshop (81.1%), seminar (80.0%), demo plots (72.8%), group work (71.7%), SPAT (63.9%), group meetings (56.1%) amongst others, were the techniques employed by NRCRI. The result implied that NRCRI made use of a variety of extension teaching techniques in training the participants of sweet potato capacity training programme in the study area.

Level of Participation in NRCRI'S Capacity Building Programme

The result on Table 2 shows the mean rating of the level of participation in NRCRI's Capacity building programme for sweet potato farmers in the study area. The result revealed a grand mean of 2.3 which affirmed that sweet potato farmers highly participated in the National Root Crop Research Institute's Capacity building programme in Southeast Nigeria. The sweet potato farmers highly participated in the activities under technical trainings on subject areas about sweet potato, networking/partnership/corporation with other stakeholders, facilitation of production activities and coaching/mentorship in technology utilization. More so, the report from Focused Group Discussion affirmed the sampled respondents participated highly in the NRCRI's Capacity building programme for sweet potato farmers. However, the participants equally affirmed that they have been able to extend some of the information to their friends and relatives like how to plant sweet potato very well and other technologies on how to increase our production.

The findings implied that the sweet potato farmers highly participated in the NRCRI's Capacity building programme in the study area. In agreement with the findings of this study, Okafor, (2018) affirmed that capacity building (or capacity development) is the process by which individuals and organizations obtain, improve, and retain the skills, knowledge, tools, equipment and other resources needed to do their jobs competently or to a greater capacity. Capacity building is a conceptual approach to development that focuses on understanding the obstacles that inhibit people, governments, international organizations and non-governmental organizations from realizing their developmental goals while enhancing the

abilities that will allow them to achieve measurable and sustainable results.

Kumari and Kandhuri (2019), found capacity building methods may include conferences, workshops, consultations, study tours, participatory research and extension, on-job training, demonstration plots, coaching and mentoring. Capacity strengthening of extension workers, farmers and members of civil society organizations tend to be done as a component of programmes or projects targeted primarily at farmers (Chepkoech, *et al.*, 2020). The capacity building for sweet potato farmers is a crucial factor for sustainable growth of smallholder farmers. It can help to increase the capabilities of a farmers to continue practices learned in an intervention and increase trust in other stakeholders.

Estimate of the Quantity Produced and Revenue Generated by Participants and Non-Participants

The result on Table 3 shows the mean estimate the quantity produced and revenue generated by both participants and non-participants in the study area. The result revealed that the participants an average yield of 1,304.60kg/ha of sweet potato roots and 241.0kg/ha of sweet potato vines while the non-participants produced 573.9kg/ha of sweet potato roots and 91.28kg/ha of sweet potato vines. Furthermore, the participants generated ₦ 652,300.00 on sweet potato roots at ₦500/kg and ₦ 192,800.00 on sweet potato vines at ₦800/kg while their non-participant counterparts generated an average of ₦286, 950.00 on sweet potato root and ₦73, 024.00 on sweet potato vines. More so, the participants produced an average of 1,545.6kg/ha of sweet potato yield and the sum of ₦818, 100.00 whereas the non-participants produced an average of 665.8kg/ha of sweet potato and generated the sum ₦359, 974.00. This result clearly indicates that the participants of NRCRI's capacity building programme produced more yield and generated more income than their non-participant counterparts.

This result is plausible in that the NRCRI's capacity building programmes were targeted at enhancing the technical and managerial efficiencies of sweet potato farmers. In agreement with the study, Okafor, (2018) affirmed that capacity building (or capacity development) is the process by which individuals and organizations obtain, improve, and retain the skills, knowledge, tools, equipment and other resources needed to do their jobs competently or to a greater capacity.

Influence of Participation in Capacity Building programme of NRCRI on Sweet Potato Output.

The result on Table 4 showed the simple linear regression estimate of the effect of farmers' levels of participation in capacity building programme of NRCRI Umudike on the production of sweet potato in the study area. According to the Table, the R-square value was 0.875 indicating that about 87.5% of the variation in the dependent variable (output) was accounted for by the variables included in the model, while others were due to error. The F-test was statistically significant at 1% indicating that the model used was fit for the analysis.

The coefficient of farmers' level of participation was statistically significant at 1% probability level and positively related to sweet potato output. The result implied that an increase in farmers level of participation in the capacity building programme of NRCRI Umudike will lead to a corresponding increase in the output of sweet potato in the study area. This finding is consistent with Nwaobiala, Odoemelam and Dybia (2020) that opined that participation influenced the output of sweet potato output.

S/N	Techniques/methods used	Percentages (n= 180)
1	Training workshop	81.1
2	Seminar	80.0
3	Demo plots	72.8
4	Field trips	35.0
5	Smart phone	64.4
6	Field day	55.0
7	Group meeting	56.1
8	Group work	71.7
9	SPAT	63.9

Table 1: Techniques/methods used by NRCRI in the farmers' capacity building programme

Field survey, 2023

Multiple responses recorded

Table 2: Mean rating of level of participation in NRCRI's capacity building programme by sweet potato farmers

S/N	Level of Participation	Mean
A	Technical trainings on subject areas about sweet potato	
1	Technical knowledge on improved technologies of sweet potato production, processing and value addition	2.71
2	Technical skills in use of improved technologies of sweet potato production, processing and value addition	2.23
3	Farm management practices sweet potato enterprises	2.86
4	Sweet potato Marketing and Financial management	2.74
B	Access, use and sharing of sweet potato related Information	
1	Social media use for access and share of sweet potato information	1.66
2	Access, use of printed resource material on sweet potato	1.71
3	Availability of electronic materials (photo, video etc) on sweet potato	1.63
4	Availability of sweet potato project documents	1.63
C	Networking/partnership/corporation with other stakeholders	
1	Integration into National/local sweet potato networking group	1.37
2	Involvement in sweet potato projects	2.23
3	Membership of national/local association of sweet potato growers	1.73
4	Groups dynamics and conflicts resolution	2.74
5	Linking up with relevant support institutions	2.18
6	Strengthening corporation and linkage capacity	2.86
D	Facilitation of Production Activities	
1	Enrolment/registration into sweet potato group membership	2.28
2	Providing platform form for accessing certain facilities/services	2.18
3	Providing information for accessing inputs	2.23
4	Providing access to recommendations materials for sweet potato	2.28
5	Aiding for accessing fund	2.18
E	Coaching/Mentorship in technology utilization	
1	Conducting farmers through guided tours	2.86
2	Organizing farmer-to –farmer exchange visits to project sites	2.75
3	Guiding farmers in participatory research	3.00
4	Establishment of and skill plots	2.23
5	Guiding farmers through demonstration	2.56
6	Farmers' Small plots adoption techniques (SPATs)	2.61
7	Monitoring and evaluation of farmers' field activities	2.28
	Grand mean	59.72
	Benchmark	2.30

Field Survey, 2023

Table 3: Mean estimate the quantity produced and revenue generated by both participants and non-participants in the study area.

S/N	Products	Mean Unit Price	Participants (n = 180) Yield (Kg/ha)	Revenue (Naira)	Non-participants (n=180) Yield (Kg/ha)	Revenue (Naira)
1	Sweet potato Roots	500	1,304.60	652,300.00	573.9	286,950.00
2	Sweet potato vines	800	241.0	192,800.00	91.28	73,024.00
	Total		1,545.6	818,100.00	665.8	359,974.00

Field survey, 2023

Table 4: Simple linear regression estimate of the effect of farmers' levels of participation in capacity building programme of NRCRI Umudike on the output of sweet potato in the study area.

Parameters	Coefficient	Standard error	t-value
Constant	1349.801	0.0642	11.903***
Level of participation in NRCRI's capacity building programme	0.147	0.108	6.552**
R-square	0.875		
R-adjusted	0.849		
F-ratio	27.609***		

Source: *Computed from Field Survey Data 2023*

Key = *** = significant at 1%

Hypothesis Testing

There is no significant difference between the sweet potato output of participants and non-participants farmers in in the study area.

The Z- test comparative analysis of the difference in the sweet potato output of participants and non- participant farmers in the study area is shown on Table 5. The result of the output of participant and non-participant farmers showed that the mean output of participant farmers was 51085.6kg/ha while non-participant farmers was 24102.98kg/ha. The standard deviation for the participants and non-participant farmers were 2706.09kg and 1519.94kg, respectively. The result shows that the calculated 'Z' was 6.785, which is greater than the 'Z' tabulated of 1.960 and was significant at 1% level of probability. This result implied that participant farmers recorded higher sweet potato yield than their non-participant counterparts in the study area. This can be attributed to effect of NRCRI's training on the participant farmers as they seem to be more technically and managerially competent compared to the non-participant farmers in the study area.

The null hypothesis that states there is no significant difference in farm output of participant and non-participant sweet potato farmers is hereby rejected. We conclude that there was significant difference in the output of participant and non-participant sweet potato farmers at 1% confidence level.

Table 5: Z-test Comparative analysis of the difference in the output of participants and non-participant sweet potato farmers in the study area

Farmers Output (kg)	Mean	Std. Deviation	Df	Z- cal	Z-tab
Participants[a]	51085.6	2706.09			
Non-participants[b]	24102.98	1519.94			
Difference [a-b]	26982.62		358	6.785***	1.96

*** = significant at 1%.

CONCLUSION AND RECOMMENDATIONS

The study provided empirical evidence of the positive influence of participation of National Root Crops Research Institute capacity building programme on the output of sweet potato farmers in South-East Nigeria. National Root Crop Research Institute used several methods/techniques in disseminating the capacity building programme for sweet potato farmers such as training workshop, seminars, group meetings amongst others. Sweet potato farmers highly participated in the National Root Crop Research Institute's Capacity building programme in Southeast Nigeria. Clearly, there were indications that the participants of NRCRI's capacity building programme produced more yield and generated more income than their non-participant counterparts. This result is plausible in that the NRCRI's capacity building programmes were targeted at enhancing the technical and managerial efficiencies of sweet potato farmers.

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

1. NRCRI's capacity building programme should be extended to all sweet potato farmers in the study area. This will encourage increase sweet potato production for both domestic use and export market.
2. Non-participant sweet potato farmers should participate in NRCRI's capacity building programmes. This enhances allocated resource use of input appropriately in order to achieve optimality, to achieve resources and errors in production process.
3. NRCRI's capacity building programme should be extended to other economic root crops within their mandate. This will boost the output of crops like cassava, ginger, turmeric, cocoyam, yam among others, towards increased revenue returns both to the farmers and Government.

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FACTORS INFLUENCING SUBSISTENCE FARMERS' DECISION TO PRACTICE BEEKEEPING IN OGBOMOSO AGRARIAN SETTLEMENTS, SOUTHWEST NIGERIA

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ABSTRACT

This study examined the factors influencing beekeeping among subsistence farmers in Ogbomoso settlements of southwest Nigeria. A total of 80 rural farmers were randomly selected through a multi-stage sampling technique. The findings show that 45% of the respondents were between the ages of 31 and 40 years, and the male made up 90% of those engaged in farming in the area. Respondents who had post-primary education were 52.5% of the sample. Most (61.25%) of the farmers surveyed inherited their farmland, which they used to cultivate permanent crops as well as maize and cassava. The ease of acquiring land (Weighted mean score (WMS) = 4.21), the closeness of cropland to a water source (WMS = 4.25), and efficient pest control (WMS = 2.43) were factors that encouraged farmers to practise apiculture. The coefficients of sex and age from the logit regression analysis were positively significant (p = 0.05), suggesting that increase in age and being male would increase the likelihood of farmers to include beekeeping in their farming activities. Based on the study's findings, it was recommended that younger male farmers should be encouraged to integrate apiculture into their farming practices to increase avenues of income generation.

Keywords: Beekeeping; Ogbomoso; Rural Settlements; Subsistence Agriculture

INTRODUCTION

Beekeeping is a lucrative enterprise that helps stop the conversion of forests in areas with forest margins. It has been used as a technique for diverse land uses and can be combined with farming, hunting, and fishing (Triantomo *et al.* 2016). Beekeeping, a non-timber forest product (NTFP), has received comparatively little attention in some parts of Africa, despite the existence of initiatives focused on forest conservation, improving livelihoods and promoting trade (Ogunjimi *et al.* 2016). Some farmers in Africa engage in subsistence beekeeping, which has great promise as a means of fostering long-term rural development (Babarinde *et al.* 2010). Bees can be managed as a type of animal husbandry, or they can be investigated as wild species inhabiting woods, with their main uses being agricultural pollination and biodiversity preservation. Bees are a key supplier of many products in addition to producing honey. Additionally, beekeeping has the potential to be a strategic component in rural development programs with the ultimate goal of enhancing sustainability among rural

residents due to the abundance of apicultural products that can be obtained from the business, including honey, bee wax, propolis, and royal jelly (Babarinde *et al.* 2012; Heckle *et al.* 2018; Triantomo *et al.* 2016). The low cost of beekeeping as an agricultural endeavour means that farmers can expect to see fair returns on their small investments, which is a key benefit (Babarinde *et al.* 2010, 2015; Gobena, 2020).
The potential for honey to assist rural communities in terms of both economic and social benefits drives the cultivation of honey. Economic benefits are typically quantified in terms of the revenue generated from the many apicultural products. The use of honey as food and other apicultural products as medicines for a variety of maladies, as well as the sociocultural advantages, have been reported (Babarinde *et al.* 2011, 2015; Ononye and Akunne, 2015; Wagner *et al.* 2019). Beekeeping is seen as a practical way to combat poverty by generating employment, especially for the unemployed youth and the underprivileged rural people (Bradbear, 2009; Hilmi *et al.* 2011; Amulen *et al.* 2019). In the developing world, farmers have been raising livestock and growing crops since the beginning of time.

Agricultural extension agents have been bringing cutting-edge methods to boost livestock and crop output for several decades in an effort to improve the financial situation of farmers. Interestingly, reports have consistently indicated the low agricultural output and consequently little profits accruing from farming activities due to the relative subsistence level of production and farmers having no influence over market prices (Wagner *et al.* 2019) Therefore, it is important to take into account alternative methods of improving income generation for farmers particularly those who cultivate tree crops by enhancing their revenue through beekeeping (Adedeji and Aiyeloja, 2014; Fasasi *et al.* 2014; Lorenz and Stark, 2015; Keshlaf, 2017; Kohsaka *et al.* 2017; Mburu *et al.* 2017; Uchiyama *et al.* 2017).

It was anticipated that the rural dwellers would embrace and sustained the ability to keep bees for productions purpose and market the by-products derivable from the enterprise for enhanced revenue. The ecological characteristics of the zone which include abundant apicultural flora, desirable terrain, and reliable water sources, highly support honey bee domestication (Bradbear, 2009; Babarinde *et al.* 2015). It is unfortunate that the desired domestication has not been the case. Therefore, it is necessary to implement contemporary apicultural methods that will encourage bee keeping by farmers. Both the governmental and non-governmental organizations have conducted a number of awareness campaigns at various agricultural events (Ja'far-Furo and Madu, 2016). The Ogbomoso Agricultural Zone is characterized by an ecological nature that makes it suitable for apiculture which is sustainable and compactible with other agricultural practices in the area. The zone's ecological conditions support the health and productivity of bee colonies making it an ideal location for beekeeping activities that can coexist with other farming endeavours. Despite these facts, farmers have not responded favourably to the campaigns; and there has been little or no literature to substantiate the reason for this apathy and non-participation of farmers. The degree of awareness or perception of the farming communities about apiculture as a viable/profitable source of income and the likely factors that restricted its adoption must be assessed in order to actively encourage bee production both rural and urban farming communities. The level of adoption and the choice of expansion strategy of a practice depend on community perception of its usefulness or otherwise (Meijer *et al.* 2015). Given the aforementioned facts, the study aims at identifying the socioeconomic characteristics

of the bee farmers, the types of crops grown and the factors influencing the farmers' decision to participate in beekeeping in the study area.

MATERIALS AND METHODS

Study Area

The study was conducted in Ogbomoso Agricultural Zone in Oyo, southwest Nigeria. The zone is administratively divided into 5 Local Government Areas (LGAs), from which two LGAs, Ogbomoso South and Ogbomoso North, were randomly selected (Fig. 1). The chosen LGAs are located between the latitudes 08°4 and 08°18 and the longitudes 04°11 and 04°19 of the earth, respectively. The average temperature of the area ranges between 21°C and 79°C, Typically, the heat season lasts from January until March. Extreme seasonal variations in monthly rainfall and perceived humidity are experienced in Ogbomoso. The rainy season starts from March and lasts till November. In the rural parts of the Ogbomoso Agricultural Zone, farming predominates as an economic activity, with the traditional farming system being the most widely used.

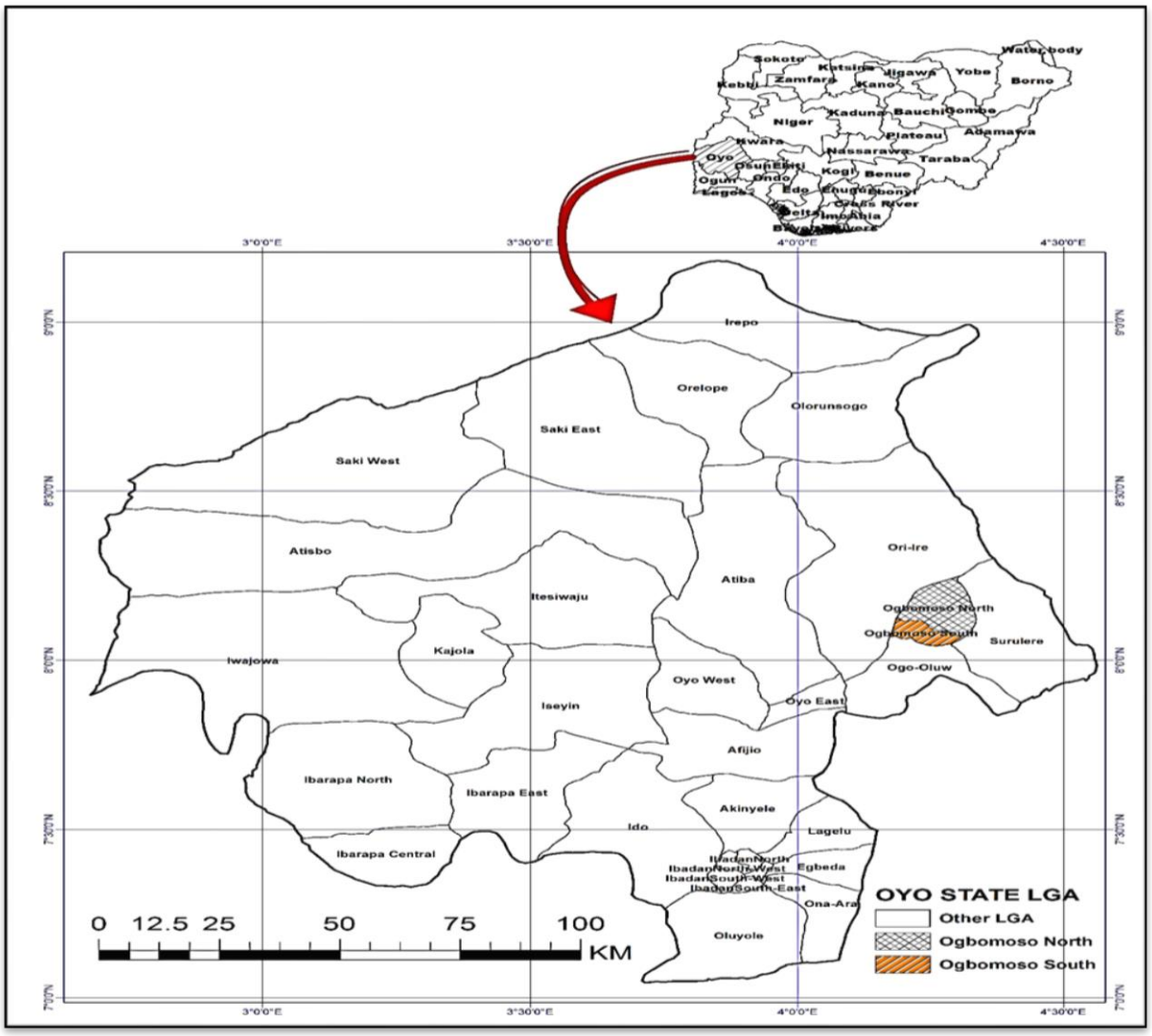

Fig 1. Map of Nigeria showing Oyo State and the two Local Government Areas (Ogbomoso North and Ogbomoso South) where the study was carried out

Sample Selection and Sampling Method

This study used a multi-stage random sampling methodology. Out of the 14 wards in the two LGAs of the research community with active subsistence agricultural operations, 4 wards were randomly chosen for the first stage. The second stage involved the selection of one village from each of the four wards that had been chosen, for a total of four villages. The chosen villages were Aje Ikose (8°08'16"N 4°13'50"E to 8°08'12"N 4°13'58"E) and Atako (8°10'55"N 4°14'34"E to 8°10'48"N 4° 14'42"E), from Ogbomoso North LGA. Ibapon along Odo-Oba (8°07'12"N 4°12'56"E to 8°07' 32"N 4°13'06"E) and Abede (8°10"'N 4°18"'E to 8°15 "N 4°20"E) were also selected from Ogbomoso South LGA.

Finally, a proportionate to size sampling technique was used to select 30% of the farmers in the four selected villages. An average of 20 respondents from the 4 villages totalled 80 respondents for the study. The All Farmers Association of Nigeria (AFAN) list of registered members in each village served as the basis for choosing the respondents. The data were elicited using a semi-structured questionnaire. Illiterate respondents were interviewed in vernacular, that is their local language to ensure their understanding as used by Ewetola *et al. (*2018).

Data Analyses

The Statistical Package for Social Sciences (SPSS) Software, Version 16, was used for all data analyses. The socioeconomic characteristics of the respondents were identified using descriptive statistics such as frequency, mean, and percentage. To demonstrate the association between specific socioeconomic characteristics of the studied farmers and their choice to practice beekeeping, the Logit regression model was used.

Logit Regression model is a dichotomous regression analysis used where there is dichotomous outcome for the dependent variable. In logit regression the outcome is frequently recorded as 0 or 1, where 1 denotes the presence of the desired result and 0 denotes its absence. If *p* is defined as the probability that the outcome is 1, the logistic regression analysis can be written as follows:

$$\hat{p} = \frac{\exp(b_0 + b_1X_1 + b_2X_2 + \ldots + b_pX_p)}{1 + \exp(b_0 + b_1X_1 + b_2X_2 + \ldots + b_pX_p)} \quad 1$$

$\hat{p}$ is the expected probability of the presence of the outcome; X_1 through X_p are distinct independent variables, and b_0 through b_p are the regression coefficients. The logistic regression model can be written differently. In the following form, the result is the expected log of the odds that the outcome is present in equation 2.

$$\ln\left(\frac{\hat{p}}{(1-\hat{p})}\right) = b_0 + b_1X_1 + b_2X_2 + \ldots + b_pX_p \quad 2$$

In assessing the factors affecting participation of rural farmers in beekeeping, the regression equation used is presented in equation 3.

$$Y = b_0 + b_1X_1 + b_2X_2 + \ldots + b_pX_p + e \quad 3\ (3)$$

Where

Y= 1 for Participation in the beekeeping and 0 otherwise and b_0 - b_p are regression coefficients

X_1- age (years)
X_2- sex
X_3- household size
X_4- years of education
X_5- farm size (hectares)
X_6- farm experience (years)
X_7- Marital status
X_8- Secondary occupation
e- error term

RESULTS

Socio-economic Characteristics of the Respondents

Table 1 presents the socioeconomic characteristics of the farmers that were interviewed for this study. In this study, factors such as the farmers' sex, age, marital status, religion, and degree of education were taken into account. Only 10% of the farmers were women, with men making up the vast majority (90%) of them. The biggest percentage of respondents (45%) were between the ages of 31 and 40; the lowest percentage of respondents (10%) were over the age of 50. The average age was about 39 years, an indication that they farmers are in their active age and can withstand the rigours of bee keeping Only 7.50% of the farmers surveyed were single, while the majority of the respondents were married. The two major religions in the study area were Islam and Christianity, with 53.75% of the respondents being Muslims, an indication that religion is not a barrier to beekeeping in the area. The distribution of the sampled farmers' educational backgrounds showed that those with a secondary education were 52.5%, while those with no formal education made up the lowest percentage (8.75%). Just 10% of the farmers had tertiary education, while 28.75% attended only primary school.. This implies that majority of the beekeepers were educated. ,

The distribution of the occupations, crops cultivated, farm sizes, and methods of land acquisition available to the farmers who were interviewed are shown in Table 2. Multiple responses were permitted for the questions about occupation and crops grown, allowing the farmers to include all jobs they held and all the crops they raised. The respondents' most common occupations (93.75%) were farming and working for the government. However, 47.5% of the farmers in rural areas claimed to also be artisans. Mango, cashew, maize, and cassava production were the primary crops produced by the farmers and all the respondents claimed to produce these crops in their respective farmlands this was closely followed by pawpaw cultivation (98.75%). Citrus, which was mentioned by 82.5% of the respondents and was the least popular.

According to the distribution of farmers based on farm sizes, 61.25% of the farmers had between 1.0 and 1.5 hectares of farmland for cultivation. Those with less than 0.4 hectares available for farming operations had the lowest value (5%) overall. The typical farm measured 1.29 hectares. According to the respondents' distribution of land ownership, most (51.25%) of them inherited their farms, while 17.5% of them bought their farms. The value of individuals whose cultivated land was provided to them as a gift was the lowest (1.25%). It was noticed that 20% and 10% of the respondents, respectively, leased and rented out their farmlands.

Factors Influencing the Respondents' Decision to Participate in Beekeeping

Table 3 presents the justifications provided by the farmers that affected their choice to raise bees. The proximity of a water supply on the farms and the pattern of land acquisition were variables mentioned by every respondent in the research region (100%) as motivating them to practice beekeeping. Effective pest control, which reduced the pest infestation on the farm (56.3%) is the third on the list, followed by adequate security (42.5%). However, farmers' access to land in terms of distance (26.3%) received the lowest ranking (1.01 WMS). Table 4 displays the findings of the Logit Regression study. The major variables that influence farmers' decisions to engage in beekeeping were sex and farmers' age. The coefficient of sex and age were significant ($p=0.05$) and positively related to farmers' decision to engage in beekeeping.

Table 1: Socio-economic characteristics of respondents in selected Ogbomoso agrarian settlements, southwestern Nigeria

Socio-economic features	Frequency	Percentages	Mean
Sex			
Female	8	10	
Male	72	90	
Age			
<30	26	32.5	38.91
31-40	36	45	
41-50	10	12.5	
>50	8	10	
Marital Status			
Married	74	92.50	
Single	6	7.50	
Religion			
Christianity	37	46.25	
Islam	43	53.75	
Educational qualification (years)			
Illiterate	7	8.75	
Primary Education	23	28.75	
Secondary Education	42	52.5	
Tertiary Education	8	10	

Table 2: Distribution of farming activities in selected Ogbomoso agrarian settlements, southwestern Nigeria

Farming activities	Frequency	Percentage	Mean value
Occupation			
Farming	75*	93.75	
Civil Service	75*	93.75	
Artisan	38*	47.50	
Crops grown			
Mango	80	100	
Cashew	80	100	
Citrus	66	82.50	
Coconut	80	100	
Pawpaw	79	98.75	
Maize	80	100	
Cassava	80	100	
Farm size (ha)			1.29
0.2-0.4	4	5.00	
0.5-1.0	27	33.75	
1.0-1.5	49	61.25	
Total	80	100	
Source of farmland			
Purchased	14	17.50	
Inherited	41	51.25	
Rented	16	20.00	
Leased	8	10.00	
Gift	1	1.25	

***** Multiple answers allowed

Table 3: Perceived factors and reasons that encouraged beekeeping among the respondents in selected Ogbomoso agrarian settlements, southwestern Nigeria

Factors/Reasons	Frequency	Percentage	Weighted mean score	Rank
Closeness to water	80	100	4.25	1
Land acquisition	80	100	4.25	1
Adequate security	34	42.5	1.91	4
Accessibility to the farm	21	26.3	1.01	5
Effective pest control	45	56.3	2.43	3

Source: Field survey, 2014

Table 4: Presentation of Logit regression analysis for the respondents in selected Ogbomoso agrarian settlements, southwestern Nigeria

Parameters	Coefficient	Standard error	Z
Sex	2.2358**	0.9056	2.47
Educational qualification	-0.0655	0.0890	-0.74
Marital status	-1.7691	1.3522	-1.13
Age	0.1193**	0.0541	2.21
Farming	0.4505	0.6761	0.67
Farm size	-0.1318	0.6352	-0.21
Farm ownership	-0.5846	0.5005	-1.17
Constant	-2.0920	2.1657	-0.97

Note: **: Significant at 5 percent level of probability
Source: Computations from Field survey, 2014
Pseudo = 0.2074 which accounts for 21% probability in the interest of the farmers to keep honeybees.

DISCUSSION

The socioeconomic makeup of the people in any given society has an impact on the adoption of new farming practices (Asfaw and Admassie, 2004; Nnena and Adaeze, 2006). In this study, factors such as the farmers' sex, age, marital status, religion, occupation, method of acquiring land, and educational attainment were taken into account. The gender distribution of the farmers revealed that the male farmers made up the majority of the population, and this had a favourable impact on the farmers' choices. This result is contrary to the assertion, , that female farmers dominated the beekeeping industry in various nations (Hilmi *et al.* 2011), The findings of this research established that male farmers outnumbered their female counterparts. This is corroborated with Mburu *et al.* (2017) report for the Binshanyi District in western Uganda. Also, the number of male beekeepers outnumbered the number of female beekeepers in the Volta and Brong Ahofa regions of Ghana (Boahen, *et al.* 2016) and Districts of Gedeo Zones, southern Ethiopia (Lowder *et al.* 2016). Additionally, a study on the value of honey production in the Lira sub-county of Uganda revealed that beekeeping was predominated by the male gender (Ndyomugyenyi *et al.* 2015). It was also confirmed by Jeil *et al.* (2019) that beekeeping is a male-dominated livelihood activity in Ghana.

The respondents were 38.91 years old on the average. This shows that, in contrast to their older colleagues, the average farmer in the research area was of an active age and had the physical capacity to cultivate fields. These results are in line with those of other researchers (Jiriko, 2015), who noticed that the majority of the farmers in their case studies were young and nimble. In the study area, only Christians and Muslims were present, with around 54% of respondents being devout Muslims. The

Ogbomoso Agricultural Zone's high level of civilization was a significant contributor to the dominance of both religions' adherents over traditional worshipers in the agrarian communities. The average number of years in school was 4.04. Over one-third of the farmers who were surveyed did not meet the national policy on education in Nigeria's minimal basic education criteria for respondents. According to Nigeria's National Policy on Education, the duration of basic education is approximately nine years, divided into three years of junior secondary school and six years of primary education (NPE, 2004). Farmers who do not meet the minimal standards for a basic education may embrace new beekeeping techniques more slowly. Asfaw and Admassie (2004) assert that literacy levels can influence how quickly new agricultural technology are adopted.

Mango, cashew, coconut, pawpaw, maize, and cassava were among the principal crops grown in the research area. The ease of cultivation, the availability of distribution channels, and the fact that the crops were a part of the farmers' food systems were all factors in the cultivation of these crops. These are all apicultural plants that can provide bees with nectar for making honey, pollen for nourishment, or resins for making propolis (Bradbear, 2009; Hilmi *et al.* 2011). The idea behind growing crops on farmers' farmlands was that if apiaries were sited on the farmlands, the honey production would be larger. This is so that the bees might save the energy required to find flowers and use it to make honey instead. Additionally, honeybee pollination of fruit crops might increase yields. Pollination is frequently cited as the primary advantage of the apiculture sector for agricultural production (Calderone, 2012; Traynor, 2015; Otto *et al.* 2016). Additionally, plant-pollinator interactions provide the fundamental underpinning for all other trophic relationships (Otto *et al.* 2016).

According to the distribution of farm sizes, between 1.0 and 1.5 ha were used for agriculture by 61.25% of the respondents. The greatest value was accounted for by this. Those with less than 0.4 hectares available for farming operations had the lowest value (5%) overall. The typical farm measured 1.29 hectares. This suggests that farming in the studied area was done on a small scale. The average size of the farmland in agricultural villages is less than 5 ha. Our findings corroborate Lowder *et al.* (2016) who found that small farms (those with less than 2 ha) account for 12% of all agricultural land worldwide, and HLPE (2013), who found that the average farm size has decreased in Africa and China, with 73% of farms having less than 1 ha, when 81 countries were sampled.

Small-scale farming, in contrast to mechanized farming, typically entails the cultivation of small plots of land for domestic consumption, with the surplus of the harvest frequently sold at local markets. The viability of the farmers' agricultural operations and the returns to them would both increase if apiculture were integrated into subsistence farming. According to the respondents' distribution of land ownership, more than 50% of respondents claimed to have inherited their farms, which had the highest worth, while 17% said they had bought their property. The value of individuals whose cultivated land was provided to them as a gift was the lowest (1.25%). It is noteworthy that 20% and 10% of the respondents, respectively, rented and leased their farmlands. Individual land tenure can be purchased outright from family members or the community in southeast Nigeria (Arua, 1980). The Nigeria Land Use Act of 1978, however, produced a number of different types of tenure. For instance, it might be possible to rent, mortgage, or buy land (Udoekanem *et al.* 2014).

The proximity of a water supply on the farms and the pattern of land acquisition were variables mentioned by all survey participants (100%) as motivating them to undertake beekeeping. Effective pest control, which assisted in reducing the pest infestation on the farm was ranked third on the list of causes. However, the ability of farmers to obtain land had the lowest rank (1.01 WMS). This was the case because the majority of the respondents resided in rural areas close to their farms. Farmers may be eager to expand farming operations due to the accessibility of land acquisition, which could be a major influence dictating farming activity. Considering that the pattern of land administration has an impact on land ownership, respondents who either inherited or bought their farmlands were given the most encouragement to undertake beekeeping (Ireti, 2016). Furthermore, in rural areas, the owners of leased or rented land may abruptly violate the contract and reclaim the property from the residing farmers. Access to land was identified as a key variable influencing smallholder farmers' decisions to start beekeeping businesses in Kenya (Heckle *et al.* 2018).

Bradbear (2009) assert that choosing an apiary site involves taking proximity to a water source into account. In a different study conducted in Tanzania's Manyoni District (Nyunza, 2018), 77% of the participants linked a drop in honey yield to the drying up of water sources. For the honey bees, water is a vital resource that they use for cooling, drinking, and honey production. Another significant issue with beekeeping in small-scale apicultural systems around the world is pest infestation (Oyerinde and Ande, 2009; Rtanieks and Carreck, 2010; Babarinde *et al.* 2012, 2016; Ogunjimi *et al.* 2016; Wakgari and Yigezu, 2021). A major global worry has been the threat of pesticides (mostly fungicides and insecticides) harming the environment and food supplies of bees (Rtanieks and Carreck, 2010; Bonmatin, 2016).

Statistic revealed that both sex and age have coefficient of 2.236 and 0.119, respectively. The two variables are significantly related to farmers' decision to involve in beekeeping at 5% significant level (pseudo R^2=0.2074). The farmers' decision to engage in beekeeping is positively related with the sex of the farmers and significant at 5%. This indicates that a unit increase in the number of male farmers will increase the probability of farmers' decision to engage in beekeeping by 2.23. This implies that more male farmers in the research area will increase the likelihood to practice beekeeping than their female counterparts. Age, on the other hand also had a positive link with farmers' decisions and was significant at 5%. This is an indication that a unit increase in age of farmer will increase the likelihood of farmers to embrace bee farming by 0.119. This means that as the farmers become older, chances of developing interest in beekeeping would increase as well. It suggests that young and inexperienced farmers were less likely to pursue beekeeping relative to the older and more seasoned farmers. Ayansola (2012) in his study of apicultural farmers, found that the proportion of respondents who practiced beekeeping increased for aged farmers

CONCLUSION AND POLICY RECOMMENDATIONS

The main crops grown by the respondents were arable and fruit crops. These plants serve as a source of apicultural resources, boosting the production of honey and other apicultural products. The primary socioeconomic factors influencing farmers' decisions to adopt beekeeping were sex and age. According to a logit regression analysis, as male farmers aged, their interest in beekeeping grew. Motivating the

younger farmers in the research area to include beekeeping in their diverse land-use systems is therefore crucial. It is therefore recommended that the process for purchasing farmland suited for beekeeping needs to be made simpler. Also, younger farmers who are interested in beekeeping should have access to extension services on environmentally responsible beekeeping techniques with a focus on pest management methods. Lastly, in order to promote and facilitate young farmers' involvement in beekeeping, the government should make financing facilities available to them.

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ASSESSING LEVEL OF YOUTH PARTICIPATION IN RICE VALUE CHAIN ACTIVITIES IN THE WESTERN AGRICULTURAL ZONE OF NASARAWA STATE, NIGERIA.

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ABSTRACT

The study assesses the Level of Youth Participation in Rice Value Chain activities in the Western Agricultural Zone of Nasarawa State, Nigeria. The specific objectives of the study were to describe the socioeconomic characteristics of youth entrepreneurs in rice value chain, identify the major types of rice value chain activities (enterprises) undertaken by youths and to determine the level of youth participation in rice value chain enterprises. The study focused on youth participating in activities along the rice value chain. A multistage sampling technique was employed to select 220 respondents for the study. Data was collected using a structured questionnaire and were analysed using descriptive statistics and a 3-point Likert scale to measure the level of participation. The results revealed that majority (60%) of the respondents were male whereas 40% were female with the mean annual income of ₦188,612. The result also revealed the mean household size of 8 persons, mean of 17years farming experience and with the majority (92%) of the respondents being members of the cooperative society while only 8% were non-members. The respondents identified rice milling activity (96%), transportation system enterprise (95%), spraying of herbicide enterprise(93%),land preparation enterprise(89%),paddy parboiling enterprise(86%) as the major rice value chain activities(enterprises) undertaken in the study area. It further shows that most of the respondents participated highly in these value chain activities identified. It was concluded that Paddy parboiling, spraying using insecticide and herbicide, rice milling, and land preparation emerged as the most actively engaged activities with significantly higher mean values than other activities. To enhance more participation of youths in other rice value chain activities, it was recommended that the government and stakeholders should develop targeted interventions and programmes to boost participation in activities with low participation rates also, policymakers should design tailored projects, awareness campaigns, and support mechanisms to overcome specific barriers hindering youth participation in the activities of Rice Value Chain which will help to achieve a fairer and more sustainable development across the entire rice value chain, ultimately fostering a thriving and inclusive agricultural sector.

Keywords: Participation, Rice, Youth, Value chain.

INTRODUCTION

Youth has been defined by many authors and organizations. However, there is no universally accepted definition of youth. The notion of youth varies as much as there are scholars, writers, cultures, and societies. For our study here, "youth" is considered as the state in the

lifetime of an individual whose age is between 18 and 35 years in which his or her young age has accorded on them the advantage to the depositary of energies and innovativeness to undertake societal activities (Nigeria National Youth Policy, 2009) Youth are very important resources for every nation, especially for sustaining agricultural productivity and an important sector for development Francis *et al.*, (2015).

Youth are characterized by optimism, idealism, empowerment, ambition, tradition, self-assurance, commitment, enthusiasm, and teamwork (Watts, 2014). Participation is a social process whereby specific groups with shared needs and living in a defined geographic area actively pursue identification of their needs, take decisions, and establish a mechanism of meeting these needs (Ong'ayo *et al*., 2019).

It is also described as organized efforts aimed at influencing authority over resources and regulatory institutions within a specific context, orderly assemblages, and actions of such efforts, until the moment at which this influence is excluded (Njeru *et.al.,* 2015). Increased youth participation in agriculture holds the promise of tackling the issues posed by aging agricultural demographic and lessening youth unemployment. To realize this goal, it is crucial to secure the engagement and active participation of youth in agriculture by purposefully altering policies, providing training, and implementing promotional efforts that are specifically attuned to the preferences and requirements of the youths. Participation is a key element of any development initiative. The rice value chain represents a typical agricultural commodity value chain encompassing various stages from input acquisition to output utilization, as defined by the Federal Ministry of Agriculture and Rural Development (FMARD) in 2014. Within the rice value chain, participants such as input suppliers, farmers, processors, and traders engage in activities that involves production, transformation, storage, transfer, or marketing, contributing to the product's value at each stage and receiving corresponding revenues. Participation of youth in these rice value chain activities not only has the potential to address the demand and supply gap for rice in Nigerian markets but also to enhance the socioeconomic status of rural communities. Additionally, youth participation in these activities facilitates their training in agriculture.

Numerous government interventions and stakeholders support have been notable in the recent period within the realm of rice production offering potential employment opportunities for rural youth (Agboola *et.al.,* 2021). This stems from its significance in the Nigerian economy and its status as a widely consumed staple food (Bello *et.al,* 2021; Sadiq *et.al,* 2019). Despite that, a significant number of the rural youth remain unemployed. It is in view of the above that this study aims to assess the level of youth participation in rice value chain activities in the western agricultural zone of Nasarawa State.

The specific objectives of this study were to describe the socioeconomic characteristics of youth entrepreneurs in rice value chain, identify the major types of rice value chain enterprises undertaken by youths, and determine the level of youth participation in rice value chain enterprise

METHODOLOGY

The study was conducted in the Western Agricultural Zone of Nasarawa State. The Western Zone comprises of four (4) local government areas namely: Keffi, Karu, Nasarawa and Toto. The zone lies within the guinea savannah climate with annual rainfall ranging between 1000-1500mm. The zone is located between latitude 8˚51' and 8˚53' N of the equator and longitude 7˚50' and 7 ˚51' E of the

Greenwich Meridian. The zone has the mean annual temperature ranging from 23^{o}C – 37^{o}C (Nasarawa State Agricultural Development Programme (NADP), 2017).

Nasarawa State has agriculture as the mainstay of its economy with the production of varieties of cash crops throughout the year. It is predominantly agrarian with much of the population actively involved in farming. The food crops produced within the study area are rice, yam, benniseed, sorghum, melon, cassava, cowpea and maize. Rice occupies a dominant position among arable crops grown in the Western Agricultural Zone of Nasarawa State. Farmers in the western zone cultivate rice as sole crop in the field and or as intercrop with others such as maize and cocoyam. Nasarawa State is one of the major rice producing states in Nigeria where production capacity was estimated at 350,000 metric tons/ha (NADP, 2017).

The population for this study was youth entrepreneurs in rice value chain in the Western Agricultural Zone of Nasarawa State. A multi-stage sampling technique was used to select respondents for this study.

The first stage was the purposive selection of three (3) local government areas out of the four (4) local government areas in the western agricultural zone of the state namely: Keffi, Nasarawa and Karu based on the prominence of rice value chain activities.

The second stage was the purposive selection of four (4) major villages where youths participate in rice value chain activities from each of the three (3) Local Government Areas and in the third stage, a simple random selection of youths participating in rice value chain from twelve (12) villages across the three (3) Local Government Areas was done proportionately. Twenty (20%) percent of the respondents in each of the villages were randomly selected from the population to give a total sample size of two hundred and twenty (220) respondents for the study. Primary data were collected using questionnaire that was administered to the respondents and were analyzed using descriptive statistics (such as percentages, frequency, and ranking) and a 3-point Likert scale was used to measure the level of youth participation.

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Respondents

Gender: The result revealed that majority (60%) of the respondents were male whereas 40% were female which means that the male respondents participate more in rice value chain activities than the female respondents in the study area. The high percentage of male youth in rice value chain activities could be because most activities along the value chain are generally strenuous and women may not be able to participate in the operations.

This result agrees with that of Bello *et.al.* (2014) and Oluwatoyin, (2018) who also revealed that male respondents participate more in rice enterprises.

Annual Income: The result of the analysis of income level of the respondents in the study area shows the mean annual income of ₦188,612 with a greater proportion (46%) of them having annual income of between ₦40,000 to ₦160,000, 36% within ₦161,000 to ₦281, 000, 15% within ₦282,000 to ₦402,000 while only 2% earned above ₦402,000. This implies that youth participating in rice value chain activities earn reasonable income which could be due to their subsistent level of activities.

Household Size: The result revealed the mean household size of 8 persons with majority (52 %) of the respondents having a household size of between 1-5, 46% had between 6-10 and only

2% had between 11-15 persons. Indicating that the majority (98%) of the respondents had small (52%) and medium (46%) families and this enable them to have access free family labor. This result agreed with that of Samarpitha *et.al.*, (2016) who also reported that 95.55% of the farmers belonged to small and medium-sized families.

Farming Experience: The result in Table 1 revealed the mean of 17years farming experience with the majority (55%) of respondents having between 11-20 years' experience in farming, 25% had between 1-10years and 20% had above 20 years' experience. This indicates that most of the farmers had long years 'of experience in rice value chain activities which is expected to increase the ability of the farmers to participate in the activities of rice value chain. The result of these findings agrees with that of Effiong *et.al.*, (2015) which showed that majority of the farmers are well experienced with at least 10 years' experience.

Membership of Cooperative Society: The result shows that majority (92%) of the respondents were members of the cooperative society while only 8% were non-members. This means that most of respondents are members of a cooperative society which often serve as a source of loan/credit and also a source where those engaging in rice value chain activities interact, provide meaningful insights and knowledge.

Types of Rice Value Chain Enterprise (activities) Undertaken by the Respondents

The result in Table 2 shows the percentage distribution of the major types of rice value chain activities undertaken by the youth in the study area. The result shows that majority (96%) of the respondents were involved in the rice milling activity,95% were involved in transportation system enterprise,93% were involved in spraying of herbicide enterprise,89% were involved in land preparation enterprise,86% were involved in paddy parboiling enterprise. This implies that almost all the respondents participated in these activities.

Additionally, it revealed that 47% of the respondents were involved in one-stop agro inputs shop enterprise,42% were also found to be involved in destoning and packaging,21% in advisory services, 11% involved in rice seed production enterprise, 4% in mechanized rice harvesting and threshing and only 2% of the respondent were involved in rice flour production. This implies that there were various profitable activities within the rice value chain for youth participation in the study area.

This finding is in line with Adesiji *et.al*., (2022) who in their study also identified rice cultivation, rice processing and transportation as the activities undertaken by the respondents in the study area.

Level of Participation along Rice Value Chain Activities

Table 3 revealed the level of participation of youths in rice value chain activities which was measured using a 3-point Likert Scale of High (1), Moderate (2) and Low (3). The table shows the average mean score of the activities participated by the youth to be 2 with the minimum mean of 1.0 and maximum of 2.99. It further shows that mean score less than 2 is regarded as Low participation in rice value chain activities whereas mean score equal to or greater than 2 is regarded as High participation. According to the result, the activity with the highest mean were Paddy parboiling (2.99). Spraying using insecticide and herbicide (2.98), Rice milling (2.92) and Land Preparation (2.85) were ranked1st, 2nd, 3rd and 4threspectively. This

implies that most of the respondents participated highly in these value chain activities identified. Furthermore, the result revealed the respondents' level of participation the following activities: Transportation System (1.96), Rice destoning and Packaging (1.90),One stop agro input shop (1.26), Rice seed Production (1.24),Advisory services (1.21), Youth resources and training centres(1.02), Mechanized rice harvesting and threshing (1.01) and Rice flour production (1.00). These activities were found to have a low level of participation along the rice value chain. This finding is in line with Okeke *et.al.,* (2021) who in their study also reported high participation in rice production and processing activities by the youth

Table 1: Distribution of the respondents according to their socio-economic characteristics

Factor	Frequency	Percentage	Mean
Gender			
Male	133	60	
Female	87	40	
Annual income			
< 40,000	0	0	
40,000-160,000	102	46.3	₦188,612
161,000-281,000	80	36.3	
282,000-402,000	34	15.4	
Above 402,000	4	2	
Household size(Number)			8 persons
1-5	114	52	
6-10	101	46	
11-15	5	2	
Farming experience (Years)			17 Years
1-10	54	24.5	
11-20	120	54.5	
Above 20	46	20.9	
Membership of cooperative society			
Members	202	92	
Non-members	8	8	

Source: Field survey, 2021

Table 2: Distribution of Respondents based on the types of Rice Value Chain Enterprise undertaken.

Variables	Frequency	Percentage
Rice milling	212	96
Transportation system	208	95
Spraying using herbicide and insecticide	205	93
Land preparation	196	89
Paddy parboiling	188	86
One-stop agro inputs shop	103	47
Rice destoning and packaging	93	42
Advisory Services	46	21
Rice seed production	24	11
Mechanized rice harvesting and threshing	8	4
Rice flour production	4	2
Youth resources and training centres	3	1

Source: Field survey, 2021 multiple responses

Table: 3 Distribution of the Respondents level of participation in rice value chain activities

Variables	Frequency	Mean scores	Participation level	Ranking
Paddy parboiling	188	2.99	High	1st
Spraying using herbicide and insecticide	205	2.98	High	2nd
Rice milling	212	2.92	High	3rd
Land preparation	196	2.85	High	4th
Transportation system	208	1.96	Low	5th
Rice destoning and Packaging	93	1.90	Low	6th
One stop agro input shop	103	1.26	Low	7th
Rice seed production	24	1.24	Low	8th
Advisory services	46	1.21	Low	9th
Youth resources and training centers	3	1.02	Low	10th
Mechanized rice harvesting and threshing	8	1.01	Low	11th
Rice flour production	4	1.00	Low	12th

Mean =2, Minimum=1.00 and Maximum=2.99
< 2=Low Participation
≥2=High Participation
Source: Field survey, 2021 Multiple Responses

CONCLUSION

In conclusion, the study indicates a clear hierarchy in the level of participation among respondents in various activities along the rice value chain. Paddy parboiling, spraying using insecticide and herbicide, rice milling, and land preparation emerged as the most actively engaged activities with significantly higher mean values. Conversely, activities such as transportation system, rice destoning and packaging, on-stop agro input shop, rice seed production, advisory services, youth resources and training centers, mechanized rice harvesting and threshing, and rice flour production demonstrated a notably lower level of participation. This insight underscores the importance of focusing interventions and strategies on enhancing involvement in these less engaged aspects of the rice value chain to promote overall sector development.

RECOMMENDATIONS

Based on the findings of this study, it was recommended that;

i. The government and stakeholders should develop targeted interventions and programmes to boost participation in activities with low participation rates.

ii. Policymakers should design tailored projects, awareness campaigns, and support mechanisms to overcome specific barriers hindering youth participation in the activities of Rice Value Chain. This will help achieve a fairer and more sustainable development across the entire rice value chain, ultimately fostering a thriving and inclusive agricultural sector.

CONFLICT OF INTEREST

The authors of this manuscript declare that there are no conflicts of interest regarding its publication.

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EVALUATION OF E-EXTENSION APPLICATIONS IN NORTH-CENTRAL NIGERIA: UTILIZATION, COMPETENCE, AND CONSTRAINTS

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ABSTRACT

The study evaluates the utilization of e-extension applications among public extension workers in North-Central Nigeria. A sample of 219 respondents was selected using a multi-stage sampling technique, and primary data were collected through a Google-scripted questionnaire. The findings reveal that smartphones, WhatsApp, and Facebook are highly available e-extension tools, whereas GIS, application software, and data centers/databases are the least available. Extension workers exhibit high competence in using desktop computers, WhatsApp, and the Internet but low competence in GIS and data center/database operations. The most utilized e-extension tools include Internet services, WhatsApp, and mobile phones, while data centers and GIS are least utilized. Major constraints to effective utilization of e-extension tools include lack of government support, high costs, and poor electricity supply. Socioeconomic characteristics significantly affect the level of utilization of e-extension tools. The study recommends that training programs be tailored towards e-extension tools and that the government provides reliable data centers accessible to public extension workers.

Keywords: e-extension, Nigerian agriculture, technology adoption, socioeconomic factors
JEL code: O33 - Technological Change: Choices and Consequences; Diffusion Processes

INTRODUCTION

The global population is anticipated to reach 10.9 billion by 2100, with Nigeria's population doubling to 400 million by 2050 (UN 2019; UNFPA 2022). This demographic surge necessitates a significant boost in agricultural production to meet the growing food demand. Currently, Nigeria faces a substantial rice production deficit, with only 57% of the 6.7 million metric tons demanded annually being produced domestically (FAO 2023). Nigeria's agricultural landscape is predominantly characterized by small-scale farmers who rely heavily on indigenous knowledge (Mgbaka *et al*., 2015; Ameyaw *et al*., 2018).

Technological advancements disseminated by extension workers are crucial for transforming agricultural production systems and enhancing food security. The Agricultural Policy of Nigeria underscores the importance of agricultural extension services in improving rural living standards through self-reliance and empowerment (FMA&RD 2016). Effective agricultural extension services can break the cycle of poverty and low productivity among smallholders by facilitating technology transfer

and fostering the adoption of agricultural innovations (Daniel *et al*., 2021).

Given the impending population boom and rising food inflation, there is an urgent need for a comprehensive agricultural extension system. e-extension, or cyber extension, augments traditional approaches by leveraging digital interactive multimedia and online networks for efficient agricultural technology dissemination (Tata & McNamara 2018). This integration can enhance extension delivery services, bridge knowledge gaps, and facilitate social networking between extension workers and farmers (Gonte 2018; Olagunju 2021).

However, for these benefits to be realized, extension workers must possess the necessary skills to effectively utilize e-extension tools. Factors influencing the adoption and utilization of e-extension tools among extension officers include institutional, infrastructural, and socio-economic considerations (Azumah *et al*., 2018; Nyarko & Kozári 2021).

E-agriculture encompasses various e-technologies and data integration methods aimed at enhancing agricultural productivity. In Nigeria, the development of e-agriculture has seen the introduction of e-extension tools designed to improve extension delivery services (Nyarko & Kozári 2021). Studies have highlighted the socio-economic characteristics of extension workers, the availability and competence in using e-agricultural tools, and the level of utilization of these tools. Constraints to effective utilization include lack of government support, high costs, and inadequate infrastructure (Azumah *et al*., 2018; Olagunju 2021).

The utilization of e-extension tools in agricultural services has been increasingly recognized for its potential to enhance agricultural productivity and efficiency. Various studies have explored the impact of socioeconomic characteristics on the adoption and utilization of these tools. Ibezim and Osondu (2014) found that socioeconomic characteristics significantly influence the utilization and compliance with Information and Communication Technologies (ICTs) in agricultural extension services. They identified educational background, income level, and access to training as critical determinants in the effective use of ICTs by extension workers.

Contrastingly, Iniobong *et al*. (2021) indicated that the utilization of Computer-Based Internet Technologies (CBIT) was not significantly influenced by personal characteristics of the respondents. Their study suggested no significant disparity in CBIT utilization levels between field extension personnel (FEP) and supervisory extension personnel (SEP), highlighting the complexity and variability in the factors influencing ICT adoption in different contexts and regions.

Gonte (2018) investigated the impact of e-extension tools on agricultural productivity, finding that their use led to significant improvements in crop yields and farming practices. The study recommended that governments and stakeholders invest in training programs and infrastructure development to promote the widespread adoption of e-extension tools.

Theoretical Framework

The Technology Acceptance Model (TAM) posits that perceived usefulness and perceived ease of use are key determinants of technology adoption (Davis, 1989). According to TAM, extension workers are more likely to adopt e-extension tools if they believe these tools will enhance their job performance and are easy to use.

The Task-Technology Fit (TTF) model suggests that the alignment between task requirements

and technological capabilities influences the utilization of technology (Goodhue & Thompson, 1995). In the context of e-extension, the fit between the extension tasks (e.g., information dissemination, farmer training) and the capabilities of e-extension tools (e.g., internet services, mobile applications) is crucial for effective utilization.

The Perceived Characteristics of Innovation Theory (PCIT) by Rogers (2003) outlines five attributes that influence the adoption of innovations: relative advantage, compatibility, complexity, trial ability, and observability. For e-extension tools, these attributes can help explain the variation in adoption rates among extension workers.

Statement of the Problem

The Nigerian agricultural extension system faces significant challenges, including inadequate extension worker-to-farmer ratios, poor transportation infrastructure, and limited dissemination resources (FMARD, 2016; Apantaku *et al*., 2016). The current extension worker-to-farmer ratio is 1:3000, far below the World Bank's recommended ratio of 1:1500 (World Bank, 2011; Sennuga & Fadiji 2020).

e-Extension tools offer a promising solution to enhance the efficacy of extension workers. However, significant government and stakeholder interventions are required to promote their widespread utilization. Existing studies have explored aspects of e-extension adoption but do not cover the entire North-Central Nigeria region or the full spectrum of extension worker's roles viza vis different categories of extension workers, highlighting the need for further research.

This study aims to fill this void by assessing the utilization of e-extension applications in North-Central Nigeria, examining the availability and competence in using these tools, and identifying constraints to their effective utilization.

Objectives of the Study

The specific objectives of this study are to:

1. Describe the socio-economic characteristics of public extension workers in the study area.
2. Ascertain the available e-extension tools for utilization by public extension workers in North-Central Nigeria.
3. Examine the level of competence in using e-extension tools among public extension workers.
4. Evaluate the level of utilization of e-extension tools by respondents in North-Central Nigeria.
5. Determine how respondents' socio-economic characteristics influence the utilization of agricultural e-extension tools.
6. Identify the constraints to the effective utilization of e-agricultural extension tools among respondents.

METHODOLOGY

Study Area

The study was conducted in North-Central Nigeria, a region comprising several states with diverse agricultural practices and varying levels of technological infrastructure.

Population and Sampling

The population for this study included all categories of public extension workers in North-Central Nigeria. A multi-stage sampling technique was employed to select 219 respondents from the region which was determined using Taro Yamane formula with a 0.05 level of error tolerance. The sampling process involved selecting three states of Nassarawa, Niger states and FCT, and random

selection of respondents from various categories of extension workers and based on their involvement in agricultural extension services.

Data Collection and Analysis

Primary data were collected using a structured questionnaire administered through Google Forms. The questionnaire comprised sections on socio-economic characteristics, availability of e-extension tools, competence in using these tools, utilization levels, and constraints faced. Descriptive statistics, including means and standard deviations, were used to analyze the data. Inferential statistics, such as regression analysis, were employed to determine the influence of socio-economic characteristics on the utilization of e-extension tools.

RESULTS AND DISCUSSIONS

Socio-Economic Characteristics of Respondents

The socio-economic characteristics of the respondents, as outlined in Table 1, provide critical insights into the demographic profile and educational background of public extension workers in North-Central Nigeria. The predominance of male respondents (72.6%) reflects a gender imbalance in the sector, which could have implications for gender-specific agricultural extension strategies. The high level of tertiary education (65.3%) among extension workers indicates a well-educated workforce capable of understanding and implementing advanced agricultural technologies. This educational background is crucial for the effective dissemination of complex e-extension tools and methodologies (Adekunle, 2020).

The average age of 41 years suggests a workforce with substantial experience but also highlights the need for continuous training to keep up with rapidly evolving technologies. With an average of 15 years of experience, these extension workers are likely to have developed strong relationships with the farming communities they serve, which can facilitate the acceptance and adoption of new technologies. However, the sector should also focus on attracting younger professionals to ensure long-term sustainability and innovation in extension services (Adekunle, 2020).

Availability of E-Extension Tools

Table 2 illustrates the availability of various e-extension tools among public extension workers. The high availability of smartphones (mean = 4.56), WhatsApp (mean = 4.44), and Facebook (mean = 4.32) underscores the widespread penetration of mobile and social media technologies in the region. These tools are relatively affordable and user-friendly, making them accessible even in areas with limited infrastructure (Agboh, 2015).

The lower availability of more specialized tools like GIS (mean = 2.76) and data centers/databases (mean = 2.22) indicates a gap in advanced technological resources, which could limit the scope and efficiency of extension services. Bridging this gap requires targeted investments and policy interventions to equip extension workers with the necessary tools to enhance agricultural productivity (Agboh, 2015).

Competence in Using E-Extension Tools

The competence levels in using e-extension tools, as shown in Table 3, highlight areas of strength and weakness among extension workers. High competence in using desktop computers (mean = 4.45), WhatsApp (mean = 4.30), smartphones (mean = 4.28), and Internet services (mean = 4.18) suggests that extension workers are well-versed in basic and commonly used technologies (Aker & Mbiti, 2010). However, the low competence in using GIS (mean = 2.84) and data centers/databases (mean

= 2.60) reveals a significant skills gap in more advanced technological applications. Addressing this gap through specialized training programs can empower extension workers to leverage these tools for better data management and decision-making in agricultural practices (Aker & Mbiti, 2010).

Utilization Level of e-Extension Tools

The competence levels in using e-extension tools, as shown in Table 3, highlight areas of strength and weakness among extension workers. High competence in using desktop computers (mean = 4.45), WhatsApp (mean = 4.30), smartphones (mean = 4.28), and Internet services (mean = 4.18) suggests that extension workers are well-versed in basic and commonly used technologies (Aker & Mbiti, 2010).
However, the low competence in using GIS (mean = 2.1) and data centers/databases (mean = 2.60) reveals a significant skills gap in more advanced technological applications. Addressing this gap through specialized training programs can empower extension workers to leverage these tools for better data management and decision-making in agricultural practices (Aker & Mbiti, 2010).

The low utilization of GIS (mean = 2.1) and data centers/databases (mean = 2.2) highlights the need for enhanced training and resource allocation to promote the adoption of these advanced tools. Increasing the utilization of such technologies can significantly improve the efficiency and effectiveness of extension services (Bello-Bravo et al., 2013).

Effect of Respondents' Socioeconomic Characteristics on Utilization

Table 5 shows the impact of respondents' socioeconomic characteristics on their utilization level of e-extension tools. The Chi-square statistic indicated statistical significance at the 1% level, rejecting the null hypothesis and suggesting that socioeconomic characteristics significantly influence e-extension tool utilization.

This finding aligns with Ibezim and Osondu (2014), who reported significant impacts of socioeconomic characteristics on ICT utilization in agricultural extension. However, it contrasts with Iniobong *et al*. (2021), who found no significant influence of personal characteristics on CBIT utilization.
The positive correlation between higher education levels and e-extension tool utilization suggests that more educated extension workers are better equipped to adopt and effectively use these technologies. However, the negative impact of ICT training indicates a possible mismatch between the training content and the practical needs of extension workers, underscoring the need for more tailored training programs (Asa & Prakash, 2018).

The pseudo-R-square value of 0.1024 indicates that the model explains 10.24% of the variance in e-extension tool utilization levels. The positive and significant odds ratio for years of schooling suggests that higher education levels increase the likelihood of utilizing e-extension tools. This finding is consistent with Wawire *et al*. (2017) and Subhrajyoti *et al*. (2019), who highlighted the positive impact of education on technology adoption.
Higher annual income also positively affects e-extension tool utilization, reflecting the economic advantages of higher incomes in adopting new technologies. However, the negative impact of ICT training suggests that the training received may not align with the practical needs of extension workers, indicating a potential misalignment between training content and on-the-ground requirements.

Constraints to Utilization of E-Extension Tools

Major constraints to the effective utilization of e-extension tools are outlined in Table 6. The lack of government support (mean = 4.60), high costs (mean = 4.50), inadequate internet access (mean = 4.32), and poor electricity supply (mean = 4.25) are identified as significant barriers (Fadairo *et al*., 2015).

Addressing these constraints through policy interventions, improved infrastructure, and targeted training programs is crucial for enhancing the effectiveness of e-extension services. Ensuring reliable internet access and electricity supply, particularly in rural areas, can significantly improve the utilization of e-extension tools and contribute to agricultural development (Fadairo *et al*., 2015).

Table 1: Socio-Economic Characteristics of Respondents

Characteristic	Frequency	Percentage
Gender (Male)	159	72.6%
Gender (Female)	60	27.4%
Education (Tertiary)	143	65.3%
Education (Secondary)	76	34.7%
Average Age (Years)		41
Average Experience (Years)		15

Source: Field Survey (2023)

Table 2: Availability of E-Extension Tools

E-Extension Tool	Mean Availability	Standard Deviation
Smartphones	4.56	0.82
WhatsApp	4.44	0.91
Facebook	4.32	1.04
Desktop Computers	4.10	1.23
GIS	2.76	1.89
Application Software	2.54	1.67
Data Centers/Databases	2.22	1.92

Source: Field Survey (2023)

Table 3: Competence in Using E-Extension Tools

E-Extension Tool	Mean Competence	Standard Deviation
Desktop Computers	4.45	0.99
WhatsApp	4.30	1.11
Smartphones	4.28	1.12
Internet Services	4.18	1.19
GIS	2.84	1.86
Data Centers/Databases	2.60	1.75

Source: Field Survey (2023)

Table 6: Utilization Level of e-Extension Tools

e-Extension tools	Very low (1)	Low (2)	Moderate (3)	High (4)	Very high (5)	Mean
Internet service	5	3	18	60	132	4.4
WhatsApp	9	29	39	56	85	3.8
Mobile phone	29	38	57	47	47	3.2
Facebook	33	51	84	38	12	3.1
Desktop	33	43	78	38	26	2.9
Printer	22	64	80	37	15	2.8
Website	36	45	89	34	14	2.7
CD/Flash drive	30	76	73	28	11	2.6
Video camera	27	103	47	34	7	2.5
Communication satellite	32	06	49	32	9	2.4
Zoom/video conferencing	33	107	41	30	7	2.4
Network infrastructure	37	93	52	27	9	2.4
Instagram	47	68	72	23	8	2.4
Application software	36	98	63	12	9	2.3
Digital camera	37	106	39	32	4	2.3
Data center/Data base	59	70	73	10	6	2.2
Laptop	59	70	73	10	6	2.2
GIS	41	114	48	11	4	2.1

Source: Field Survey (2023)

High: Mean Score 3.1 – 5.0; Moderate: Mean Score 2.3 – 3.0; Low: Mean Score 0.0 - 2.2

Table 5: Effect of respondent's socioeconomic characteristics on their level of utilization of e-extension tools

Parameters	Odds Ratio	Std. Err.	Z	P>|z|
Constant	0.10	0.16	-1.4	0.16
Sex	0.52	0.19	-1.8**	0.07
Age	1.03	0.02	1.11	0.27
Years of schooling	1.17	0.08	2.26*	0.02
Extension working experience	0.99	0.02	-0.29	0.77
Annual income	1.00	0.00	1.94**	0.05
Household size	0.93	0.04	-1.71**	0.09
ICT training	0.40	0.13	-2.73*	0.01

Source: Field work (2023)

*, ** statistical significance at 5% and 10% levels, respectively

Table 6: Constraints to Utilization of E-Extension Tools

Constraint	Mean Impact	Standard Deviation
Lack of Government Support	4.60	0.91
High Costs	4.50	0.95
Inadequate Internet Access	4.32	1.10
Poor Electricity Supply	4.25	1.15
Lack of Training	4.20	1.18
Inadequate Infrastructure	4.10	1.22

Source: Field Survey (2023)

CONCLUSION

The study reveals a high level of utilization of e-extension tools such as Internet services, smartphones, Whats App, and Facebook among public extension workers in the study area. Factors such as educational background, income level, and ICT training significantly influence the adoption and utilization of these tools. However, challenges such as inadequate government support, poor electricity supply, and high costs of digital facilities hinder the effective utilization of e-extension tools. Addressing these challenges through policy interventions, improved infrastructure, and targeted training programs can enhance the effectiveness of e-extension services, thereby contributing to agricultural development and productivity.

RECOMMENDATIONS

1. Training Programs: Tailored training programs should be developed to enhance the competence of extension workers in using advanced e-extension tools such as GIS and data centers.
2. Government Support: Increased government support is crucial for the provision of necessary infrastructure and resources to facilitate the effective use of e-extension tools.
3. Infrastructure Development: Investments should be made in developing reliable internet access and electricity supply, particularly in rural areas, to support the utilization of e-extension tools.
4. Cost Management: Strategies to reduce the costs associated with e-extension tools should be explored to make them more accessible to extension workers.

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DETERMINATION OF PHYSICAL AND FRICTIONAL PROPERTIES OF TWO VARIETIES OF CASTOR SEEDS

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ABSTRACT

This study investigated some physical and frictional properties of castor seed for two varieties at 10 % moisture content wet basis. The axial dimensions length, width, and thickness of the two varieties of Castor Seeds were measured using a digital Vanier caliper. The result for the large castor seed were in the range of 15.11 - 19.37 mm, 12.04 – 14.32 mm, and 6.65 – 7.86 mm, respectively. While that of small castor seed were in the range of 11.11 – 17.29 mm, 8.74 – 12.32 mm, and 5.13 – 7.26 mm, respectively. The coefficients of variation for these dimensions are 6.25, 4.21, 3.57 for large seeded variety and 8.87, 6.52, and 6.71 for small castor seeds. The geometric mean diameter were in the range of 10.961 – 12.713 mm; averaging 11.872 mm for large seed castor and 7.927 – 11.240 mm; averaging 10.936 mm for small castor seed. The coefficient of static friction values obtained for the large castor seeds ranged from 0.20 – 0.21, 0.25 – 0.26 and 0.20 – 0.21 on the surfaces of glass, plywood and aluminum respectively and for small castor seeds, the values ranged from 0.23 – 0.24, 0.29 – 0.30, and 0.24 – 0.25 for the three surfaces respectively. The angle of repose (Ɵ) were such that the large seeds recorded values that ranged from 24.7^o – 26.57^o, 29.97^o – 35.38^o and 29.45^o – 34.77^o on the surfaces of glass, plywood and aluminum respectively, while for the small castor seeds, the values ranged from 27.83^o – 29.87^o, 31.76^o – 34.99^o and 28.28^o – 32.95^o on the three surfaces respectively. *These generated experimental data can be used for Engineering design purposes.*

Keywords: Angle of repose, Castor oil seeds, Coefficient of static friction, Geometric mean diameter, One thousand seed weight, Seed length, Thickness and width.

INTRODUCTION

Castor plant (*Ricinus communis L.*) is a specie of flowering plant in the spurge family, *Euphorbiaceae*. Although the plant is native to the Ethiopian region of tropical East Africa, it has become naturalized in both tropical and warm temperate regions throughout the world. The castor crop is very attractive to industries because of the under listed characteristics. It is resistant to drought, requires low soil fertility and contains valuable oil properties. The crop produces satisfactory yields after a short period of time, of about 140 to 160 days and could be handled as perennial or annual for regular supply of seed to the industry. Being a hardy crop, it rarely fails, and can be grown under irrigation

and rain fed. Therefore, it can be grown twice in a year. It requires one hoe weeding to harvest, especially for the annual species (Gana *et al*., 2013). It grows naturally over a wide range of geographical regions and tolerates variety of physical and climatic regimes. The seeds contain between 40 and 60% oil which is rich in triglycerides, containing mainly ricinolein (Wikipedia, 2011).

Economic Importance of Castor

Castor seed is toxic due to presence of ricin and is regarded as the most poisonous plant in the world (Wikipedia, 2011). However, despite the toxicity, it has a wide variety of uses. The oil and its derivatives are used in the production of paints, varnishes, lacquers, adhesives, artificial leather, candles, carbon paper, lubricants and greases, hydraulic fluids, germicides, insecticides and as raw material in the manufacturing of various chemicals such as sebacic and undecylenic acids used in the production of plasticizer and nylon (Oyeyemi *et al.*, 2007). It is, also, used in the production of bio-diesel and its toxin provides the castor oil plant with some degree of natural protection from insect pests (Wikipedia, 2011).

In Nigeria, there is no available statistics regarding the level of production, but experts observed that the plant grow well in the North-Eastern States of Yobe, Borno, Adamawa and Gombe, because of their Sahelian weather and prolonged dry season. There are many vernacular names for castor bean indicating its common occurrence; locally the plant is known in Nigeria by such names as “Zurman” (Hausa), “Laraa” (Yoruba). “Ogilisi” (Igbo), “Kpamfinigulu” (Nupe), “Jongo” (Tiv), and “Era ogi” (Bini) (Sani and Sule, 2007). Nigeria spends 400 to 600 million dollars annually in importation of castor oil despite the abundant land, good ecological and climatic conditions which are favourable to castor production (Oyeyemi *et al.*, 2007).

Justification for the Study

In spite of the economic potential of Castor Seed, the processing operations are predominantly done manually. These operations are time consuming and laborious, inherent unhygienic conditions and poor or unsatisfactory output like high castor seed breakages as a result of shelling. The knowledge of physical and frictional properties of Castor Seeds like any other agricultural material is of paramount importance in order to facilitate the design and development of equipment for harvesting, shelling, conveying, cleaning, delivering, separation, packing, storing, drying, mechanical oil expelling and processing of the products (Davies, 2010).

Engineering Properties

Engineering properties among others to be discussed in this work would include Physical and Frictional properties of Castor Seeds. Lack of basic engineering properties of plant material is an identified problem in the development of new equipment for processing and method of sowing the crop (Mohsenin, 1980). In general, engineering properties of agricultural materials constitute the design parameters for the construction of an efficient handling, processing and storage equipment for agricultural materials.

Physical Properties

Shape, size, volume, density, surface area, porosity and appearance are some of the physical characteristics which are important in solving problems involving the design of specific machine for food material handling.

Due to the irregular nature of the shapes and sizes of agricultural products, coefficient of

variation (CV) may be used to characterize the quality of dispersion of the measured parameters about their means. Low CVs indicate more uniform dispersion (Eke *et al.*, 2007).

The objective of this study was to determine the physical and frictional properties of two varieties of castor seeds at 10-% moisture content (wet basis) in the design of agricultural processing machine.

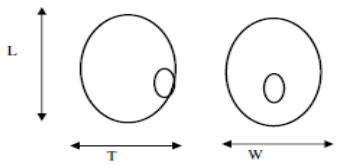

Fig 1: Characteristic dimensions of Castor oil seed: Length (L); Width (W) and Thickness (T).
(Source: Mpotokwane *et al*., (2008)

Table 1. Comparison of Physical parameters of Castor Seed with other Seeds

Property	Seeds and pods				
	Castor seed	Chickpea split (*ciceraetium* L)	Jackbean seed (canavaliaensifiormis)	Bambara groundnut	African breadfruits
D1	9.420	6.250	18.662	18.90	11.91
D2	5.621	5.310	13.141	15.70	5.69
D3	4.270	2.910	10.224	14.40	4.64
AMD	6.435	4.823	14.009	16.33	7.41
GMD	6.089	-	13.563	16.23	57.10
SMD	6.249	-	13.780	16.28	7.06
EQD	6.258	-	13.784	-	-
W100	116.17	69.50	1.591	-	-
Volume	12.60	0.005	1.324	-	-
Sphericity	0.650	-	0.727	85.86	57.10
Aspect ratio	0.947	-	0.706	0.831	0.478
Particle density	9.288	-	1.190	0.755	0.979
Surface area	123.178	-	-	-	-

Ghadge *et al.*, (2008); Eke *et al.*, (2007)

D_{1-3} = Diameter of the Castor seed; AMD = Arithmetic mean diameter; GMD = Geometric mean diameter; SMD = Square mean diameter; EQD = Equivalent mean diameter; W1000 = 1000 seed weight.

MATERIALS AND METHOD

Material Collection

Five (5) kilogrammes each of two different varieties of shelled Castor oil seeds accession Alaja Ogbomosho (Large seed) and accession Obollo - Afor (Small seed) were purchased from National Cereals Research Institute Badeggi in Niger State and Obollo - Afor Market in Enugu State, respectively.

Material Preparation

The Castor Seeds were sun–dried to safe moisture content of about 10 % (wb). This is to prevent fungal attack (Dash *et al.*, 2008; Olatunde, 2011; Mahbobeh *et al*., 2011; Adedeji, 2012).

Moisture Content Adjustment

The moisture content of the sample was adjusted to 10 % (wb) (Oluwole *et al*., 2007; Olatunde, 2011). Each sample weighing 50g was sealed in separate polythene bags with the calculated amount of distilled water that changed the moisture content to the desired level. The

quantity of distil water that was added in order to adjust the moisture was calculated using equation 1; below:

$$M = W_s\left(\frac{M_1 - M_2}{100 - M_1}\right) \quad (1)$$

Where:

W_s = weight of sample (kg)

M = weight of distilled water that will be added (kg)

M_1 = initial moisture content (%)

M_2 = Final moisture content (%)

(Davies and Zibokere, 2011)

After addition of the required distilled water, the samples were kept in a refrigerator at a temperature of 5 ºC for seven days to enable the moisture to distribute uniformly.

Equipment

The equipment used for this research were;

a. Cylinder container of known volume and electronic weighing balance: Used to determine bulk density, true density and porosity.

b. Digital Vanier caliper: It was used to determine major (L), intermediate (W), minor (T) diameters, while geometric mean diameter, sphericity and surface area were calculated using relevant and appropriate equations of the selected samples (Mahbobeh *et al.*, 2011).

c. Friction device (tilting table): It was used to determine coefficient of static friction on three surfaces (Plywood, Aluminium and Glass).

d. Topless and bottomless cylinder of known volume: It was used to determine the angle of repose using three surfaces (Plywood, Aluminium and Glass).

Determination of Physical Properties of Castor Oil Seeds

Determination of Size

The geometric mean diameter of a castor oil seed was determined by measuring the dimension of the principal diameter on three axes – major (L), intermediate (W) and minor (T) – for 50 seed that was randomly selected. Digital Vanier calliper was used to determine these dimensions. The geometric mean diameter (Dg) was calculated using equation 2.

$$D_g = (LWT)^{1/3} \quad (2)$$

Determination of Sphericity of Castor Oil Seed

The sphericity was calculated by using the relationship in equation 3 (Davies, 2010).

$$\varphi = \frac{D_g}{L} \quad (3)$$

Where; φ = sphericity.

Determination of Volume and Surface area of Castor Oil Seeds

The volume of the sample was determined using equation 4.

$$V = \pi\frac{(LWT)^{1/3}}{6} \quad (4)$$

Where;

V = volume (m^3)

Equation 5 was used to determine the surface area:

$$S = \pi\left(D_g\right)^2 \quad (5)$$

Where;

S = Surface area (mm^2)

Determination of 1000 Seed Weight

To determine the 1000 seed weight, 1000 seeds was randomly selected from the samples and the weight was determined using the weighing balance. The mean value of three replicates of each variety was recorded.

Determination of True Density of Castor Oil Seeds

The seed volume and true density S_t, as a function of moisture content, was determined by liquid displacement method (Adejumo *et al.*, 2007; Davies and Zebokere, 2011). Castor Seed absorbs water so toluene was used for the experiment and a small metal weight of 2 mg

was used as a sinker. Toluene was poured into a 250 mL capacity measuring cylinder and the level was noted. The metal weight was immersed in toluene noting the final level to which the toluene rose. The two major varieties of the Castor oil seeds used for the experiment are shown in Plates 1 and 2.

Plate 1. Large Castor Oil Seeds used for the Experiment

Plate 2. Small Castor Oil Seeds used for the Experiment

The difference between the final and the initial toluene levels gave the volume metal weight. The seed was tied with a light inextensible string to the sinker and both immersed in toluene. The difference between the final and initial toluene levels for the both seeds and the metal weight was obtained. The volume of the seed was calculated by subtracting the volume of the metal from the difference. The procedure was followed for the two varieties of seeds. The mass of the each seed was obtained using an electronic weighing balance. The true density of castor seed was evaluated using eqn. 6:

$\rho_T = \frac{m}{v}$ Eke *et al.*, 2007 (6)

Where;

ρ_T = true density (kg/m^3)

m = mass of the sample (kg)

v = volume (m^3)

Determination of Bulk Density and Percentage Porosity

The bulk density(ρ_B) in kg/m^3 is the ratio of the mass of sample of the castor oil seeds to its volume. Equation 7 was used to determine the bulk density using a container of 0.6 m (60 mm) height and 0.5 m diameter. The container was filled with the sample from a height of about 0.3 m; the container and the top was marked (Karababa, 2006). No additional manual compaction was done. The electronic balance was then used to weigh the sample:

$\rho_B = \frac{m_2 - m_1}{v}$ (7)

Where:

m_2 = Mass of cylinder plus seeds (g)

m_1 = mass of empty cylinder (g)

v = volume of the cylinder (cm^3)

The porosity (g) of the bulk seed was computed from the values of the true density (S_t) and bulk density(ρ_B) of the seeds by using equation 8;

$\varepsilon = \frac{\rho_T - \rho_B}{\rho_T}$ x 100 (8)

Determination of Frictional properties of Castor Oil Seeds.

Determination of coefficient of friction

The static coefficient of friction (μ) of castor oil seeds were determined on three surfaces namely:

aluminium, plywood and glass. A topless and bottomless material box of 150 mm x 150 mm x 40 mm was filled with sample and placed on adjustable tilting table onto which the material to be tested was fastened. The box was placed on one side of the surface and raised slightly so that it will not be touching the material. A screw jack was used to gently tilt the table until friction force between the seeds and the material was overcome by the gravity and moves down the slope. The angle of inclination was read from the graduated protractor attached to the tilting table. The mean value of five replicates was recorded accordingly (Alonge and Adebulugbe, 2005).

Measurements of Angle of Repose of Castor Oil Seeds

Angle of repose (θ) was determined using an open ended cylinder of (5cm diameter and 40cm height). The cylinder was placed at the centre of a circular plate of 80 cm; it was filled with castor oil seeds. The cylinder was lifted slowly until the seeds form a cone on the circular plate. The diameter and height of the cone was measured and recorded and the angle of repose was calculated. The procedure was replicated five times using the three different surfaces (aluminium, plywood and glass). These surfaces were used because they are common materials used for handling processes (Juana *et al*., 2008). Equation 9 was used to calculate the angle of repose (Dash *et al*., 2008).

$$\theta = tan^{-1}\left(\frac{2H}{D}\right) \quad (9)$$

Where:

θ = angle of repose;
H = the angle of the cone (cm); and
D = diameter of the cone (cm)

Table 2. Physical Properties of Castor oil seed at 10 % mc on wet basis – (Large seeded castor)

Physical Property & Symbol	Unit	No. Of Obvs	Mean Value	Minimum Value	Maximum Value	SD	CV
Length, L	Mm	50	17.28	15.11	19.37	1.08	6.25
Width, W	Mm	50	13.24	12.04	14.32	0.56	4.21
Thickness, T	Mm	50	7.31	6.65	7.86	0.26	3.57
Geometric Mean Diameter,	Mm	50	11.87	10.96	12.71	0.47	3.95
Sphericity	%	50	68.84	64.87	74.91	2.30	3.35
Specific surface area	cm^2	50	443.55	377.49	507.81	34.94	7.88
1000 Mass, m	G	6	748.33	730	760	12.11	1.62
Porosity, ρ	%	6	98.08	97.82	98.45	0.24	0.24
True density, ρ	g cm^-	6	2.64×10^{-4}	2.63×10^{-4}	2.67×10^{-4}	2.810×10^{-6}	-
Bulk density, ρ	g cm^-	6	4.6×10^{-6}	4.4×10^{-6}	4.9×10^{-6}	1.751×10^{-7}	-
Unit volume, V_u	cm^3	5	2.96	2.8	3.0	8.9×10^{-2}	3.02
Coefficient of Static Friction, μ							
Glass	Value	10	20.3	20	21	0.48	2.38
Plywood	Value	10	25.2	25	26	0.42	1.67
Aluminium	Value	10	20.2	20	21	0.42	2.09
Static Angle of Repose, θ_s							
Glass	^{o}	5	25.65	24.7	26.57	0.69	2.71
Plywood	^{o}	5	32.68	29.97	35.38	2.22	6.78
Aluminium	^{o}	5	33.12	29.45	34.77	2.11	6.36

Table 3. Physical Properties of Castor oil seed at 10 % mc on wet basis - Small seeded castor

Physical Property & Symbol	Unit	No. Of Obvs	Mean Value	Minimum Value	Maximum Value	SD	CV
Length, L	Mm	50	14.72	11.11	17.29	1.31	8.87
Width, W	Mm	50	11.48	8.74	12.32	0.75	6.52
Thickness, T	Mm	50	6.66	5.13	7.26	0.45	6.71
Geometric Mean Diameter, Dg	Mm	50	10.39	7.93	11.24	0.69	6.71
Sphericity	%	50	70.78	64.65	77.75	2.69	3.81
Specific surface area	cm^2	50	341.07	197.44	396.95	43.36	12.71
1000 Mass, m	G	6	553	540	561	7.69	1.39
True density, ρ	g cm^{-3}	6	0.45	0.45	0.45	$5.38 \times 10^{-}$	8.53
Bulk density, ρ	g cm^{-3}	6	-0.69	4.6×10^{-8}	4.9×10^{-8}	$1.65 \times 10^{-}$	
Porosity, ρ	%	6	98.73	98.5	98.9	0.16	1.65
Unit volume, V_u	cm^3	5	1.04	1.0	1.2	0.09	8.60
Coefficient of Static Friction, μ							
Glass	Value	10	23.7	23	24	0.48	2.04
Plywood	Value	10	29.2	29	30	0.42	1.44
Aluminium	Value	10	24.2	24	25	0.42	1.74
StaticAngle of Repose, θ_s							
Glass	^{o}	5	29.07	27.83	29.87	0.79	2.72
Plywood	^{o}	5	32.96	31.76	34.99	1.29	3.92
Aluminium	^{o}	5	31.53	28.28	32.95	1.92	6.08

RESULT AND DISCUSSIONS

The results obtained from the determination of the physical properties of the two varieties of castor oil seeds were presented in Tables 2, and 3. Table 2 showed the summarized physical parameter values of the large sized castor oil seeds while Table 3 had values for the small seeded product. These physical parameters studied included: size, sphericity, volume and surface area, 1000 seed weight, true density, bulk density and percentage porosity; others include frictional properties such as coefficient of friction and angle of repose, investigated at 10 % moisture content wet basis.

Axial Dimensions

The axial dimensions (length, width, and thickness) of the Large Castor oil seeds are in the range of 15.11 - 19.37 mm, 12.04 – 14.32 mm, and 6.65 – 7.86 mm, respectively, with the average values of 17.277 mm, 13.243 mm and 7.313 mm respectively. The coefficients of variation for these dimensions are 6.25, 4.21, 3.57 respectively. While the axial dimensions (length, width, and thickness) of the Small Castor oil seeds are in the range of 11.11 - 17.29 mm, 8.74 – 12.32 mm, and 5.13 – 7.26 mm, respectively, with the average values of 14.724 mm, 11.479 mm and 6.658 mm, respectively. The coefficients of variation for these dimensions are 8.87, 6.52, and 6.71. The coefficients of variation for large seed castor 6.25, 4.21, 3.57 represents a good measure of agreeable data as obtained in the experiment when compared with the coefficient of variation 3.8, 3.8 and 3.2 as obtained by Danbaba *et al.* (2011). If the Castor Seed data generated in this study are compared with other seed and pods presented in Table 1, the length, width and thickness are closely related to jackbean seed, bambara groundnut and twice that of chickpea

split. The geometric mean diameter for the large Castor seed was in the range of 10.961 – 12.713 mm with mean value of 11.872 mm. Sphericity was 64.874 – 74.913 %, 1000 mass was 730 – 760 g, and surface area was in the range of 377.491 – 507.811 cm^2.

While the geometric mean diameter for the small Castor seed was in the range of 7.927 - 11.24 mm with mean value of 10.396 mm. Sphericity was 64.650 – 77.747 %, 1000 mass was 540– 561 g and surface area was in the range of 197.435 – 396.953 cm^2. The sphericity of the castor seed which is (65 %) is lower than that of jack bean seed (73 %) and bambara nut (86 %) when compared with the values in Table 1. Judging by the criteria given by Bal and Mishra (1988) and Garnayak *et al.* (2008), which considered grain as spherical when the sphericity value is more than 0.80 and 0.70, respectively, as cited by Dash *et al*. (2008); Castor oil seeds as in this study can be referred to as nearly elliptical with mean sphericity of 70.75 %. These generated data can be used as base information in the design of cleaning, grading and separating machines

Unit volume, True Density, Bulk Density, and Porosity

The unit volume, true density, bulk density, and porosity are in the range of 2.80 – 3.00 cm^3, 2.63 x 10^{-4} – 2.67 x 10^{-4} g cm^{-3}, 4.4 x 10^{-6} – 4.9 x 10^{-6} g cm^{-3}, and 97.82 – 98.45 %, respectively for the Large Castor oil seeds. While for the Small Castor oil seeds, the values were 1.0 – 1.2 cm^3, 0.44797 – 0.44809 g cm^{-3}, 4.6 x 10^{8} – 4.9 x 10^{-8} g cm^{-3}, and 98.5 – 98.9% for the respective parameters.

The high value of porosity suggests that their aeration during deep bed drying would be better than those with low value. An increase in porosity with moisture content were reported by Nimkar and Chattopadhyay (2001) for green grain, Aydin (2002) for hazel nuts, Davies and Zibokere (2011) for cowpea, and Seyed *et al*. (2011) for castor seed.

For the large seed used for this study, one thousand seed mass ranged between 730 – 760 g with a mean value of 748.33 g. Specific surface areas investigated were in the range of 377.49 – 507.81 cm^2, averaging 443.55 cm^2. The small seed has its one thousand seed mass values that ranged from 540 – 561 g with a mean value of 553 g and Specific surface areas investigated were in the range of 197.44 – 396.95 cm^2 with a mean value of 341.07 cm^2.

Coefficient of Static Friction and Static Angle of Repose

For the three surfaces of glass, plywood and aluminium, the coefficient of static friction values were 0.20, 0.25, and 0.20, respectively, with the plywood recording higher values in both sizes of the castor oil seed. Coefficient of static friction against glass, ply wood, and aluminium revealed that they were in the range of 0.20–0.21, 0.25–0.26, and 0.20–0.21, respectively, for large seeds and for small seeds, the values ranged from 0.23–0.24 for glass surface, 0.29–0.30 for the plywood surface, and 0.24–0.25 for the aluminium surface. The values obtained for plywood were highest while glass sheet gave the lowest values. The differences observed on the values of coefficient of static friction against plywood and other surfaces can largely be attributed to differences in their surface smoothness.

The angle of repose values were such that the large seeds recorded values that ranged from 24.7°–26.57°, 29.97° – 35.38° and 29.45° – 34.77° on surfaces of glass, plywood and aluminium, respectively, while for the small castor oil seeds, the values ranged from 27.83° -29.87°,31.76°– 34.99° and 28.28°–32.95° on surfaces of glass, plywood and aluminium, respectively. In both seed sizes, the plywood appeared to have produced the highest repose angle. This is

because the surface of the seeds tends to encourage inter particulate cohesion by virtue of the roughness leading to higher values of static angle of repose.

From Tables 2 and 3 the summary of generated data for the physical properties of castor oil seeds at 10 % moisture content on wet basis made one observation noticeable. From these Tables, it can be deduced that the variations that existed in the replications of the experiment are negligible and are within the acceptable level. This followed the conclusions reached by Isiaka *et al*. (2006) that the acceptance range of coefficient of variation (CV) must be ≤ 14 % and this holds true in all the cases.

CONCLUSION

The mean, major, intermediate, minor, and geometric mean diameter, sphericity, surface area, 1000-seed unit mass, for the two Castor Seed varieties were different at 10 % moisture content wet basis. While the mean porosity, true and bulk densities and angle of repose investigated for the two varieties were also different at 10 % moisture content wet basis. The coefficient of static friction of Castor seed was determined for three different surfaces, glass, aluminium and plywood. Plywood surface was observed to have higher coefficient of static friction for the two varieties while glass sheet gave the lowest values. These generated data can be used as base information in the design of cleaning, grading and separating machines for castor seed.

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EFFECT OF TILLAGE AND SOWING DATE ON YIELD OF PEARL MILLET [*Pennisetum glaucum* (L.) R.Br.] VARIETIES IN SEMI-ARID AREA OF NIGERIA

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ABSTRACT

Field trials were conducted during the 2018 and 2019 rainy seasons to compare and identify appropriate tillage method for high millet yield and to compare the effects of different sowing dates on millet varieties. The trials were carried out at Wasai village, Minjibir Local Government Area, Kano State, of the Sudan Savanna ecological zone (lat. $12^{o}8^{'}$N; long. 8^{o}39'E). The experiment consisted of six tillage methods, three sowing dates and two millet varieties. The experiment was laid out in a split-split-plot arrangement in a Randomized Complete Block Design (RCBD) with four replications. Tillage methods [T_1: Zero Tillage (ZT) (Paraquat at 1.0 kg a.i.ha^{-1} followed by Primextra at 1.0 kg a.i.ha^{-1} pre-emergence followed by 2,4-D at 1.5 kg a.i ha^{-1} post emergence), T_2: Minimum Tillage (MT) (Light hoe weeding followed by atrazine at 1.0 kg a.i.ha^{-1}pre-emergence followed by 2,4-D at 1.5 kg a.i ha^{-1} post emergence), T_3: MT (Paraquat at 1.0 kg a.i.ha^{-1} followed by Primextra at 1.0 kg a.i.ha^{-1} pre-emergence followed by light hoe weeding at 4 WAS), T_4: MT (Ridging followed by supplementary hoe weeding), T_5: Conventional Tillage (CT) (Single harrowing followed by ridging followed by Primextra at 1.0 kg a.i.ha^{-1} pre-emergence followed by supplementary hoe weeding), T_6: CT (Double harrowing followed by ridging followed by Primextra at 1.0 kg a.i.ha^{-1} pre-emergence followed by supplementary hoe weeding)] were assigned to the main plot. Sowing Dates [Early June (1^{st} - 10^{th}), Mid June (11^{th} – 20^{th}) and Late June (21^{st} - 30^{th})] were assigned to the sub-plot. Millet varieties (LCICMV-1 and LCICMV-3) occupied the sub-sub plot. The result of the trials indicated significant effect ($p \leq 0.05$) of tillage methods and sowing dates on yield characters and yield in both years. Varieties also differed significantly in yield characters and yield in both years. T_5 had significant effect and scored highest on more yield characters. LCICMV-3 sown within early June significantly recorded highest yield variables. It could be concluded that farmers in the study areas should sow LCICMV-3 early in June after T_5.

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INTRODUCTION

Cereals are universally important food crops, among which Millet is one of the most important in the world (Siddig *et al*., 2013). Pearl millet [*Pennisetum glaucum* (L) R. Br.] belongs to the family Poaceae. It is believed to have originated in West Africa (Van Oosterm *et al.*,

2002). It is planted as grain and fodder crop across a wide range of environments around the world (Raemaeker, 2001). Pearl millet is an important drought-hardy coarse grain crop that provides staple food for the poor in a short period. It flourishes satisfactorily and can be cultivated under rainfall as low as 200 to 250 mm (Bidinger and Hash, 2003), which makes it one of the most reliable cereals in the rainfed regions of arid and semi-arid tropics although average yields are usually very low. Generally, soils are tilled to provide a more suitable structure for plant growth and development. At any level of field management, different pearl millet varieties have different performance level. Lal (1989) asserted that emphasis in crop production should be placed on appropriate and efficient tillage method, for higher productivity. Sowing is an important factor influencing growth and yield of crops (Nafziger, 1994). The sowing date plays vital role in improving its growth and increasing the yield (Farrell *et al*., 2003). Timely sowing of millet ensures sufficient time for root development and vegetative growth for optimum harvesting (Amodu *et al*., 2005). Timely sowing ensures sufficient time for optimum harvesting of available soil nutrients and radiant energy (Soler *et al*., 2007).

In sahelian locations, manipulation of sowing dates in millet cultivation offers flexibility owing to the narrowness of the optimum time of sowing as conditioned by erratic onset of the rains and shorter raining season. Millet is grown in over 40 countries, predominantly in Africa and Asia, as a staple food grain and source of feed, fodder, fuel and construction material in the hottest, driest, semi-arid and arid regions where rainfed agriculture is practiced. In Africa, its uses are diverse and range from baby food to bread. In Nigeria, the grain is used primarily for human consumption. It is processed into "tuwo" "kunu" and "akamu" (Remison, 2005). The culm is used for fencing, thatching, roofing and fodder for livestock (Uzoma *et al.*, 2010). Millet grains may be cooked as rice, or may be ground into flour to make cake and bread. The grains are also used to produce malt, and in Nigeria the malted seed is an important source of beer (Remison, 2005). It is proving to be superior feed for poultry, pigs, cattle, fish and other livestock. As a food source, it is non-glutinous and non-acid forming so it is smoothing and easy to digest (Oelke *et al*., 2011).

There has been no sustainable rise in productivity of rainfed pearl millet mainly because of soil-moisture deficiency, usually at critical stages of growth. There is a need to focus our research efforts on how the productivity potential can be best achieved to overcome the effect of moisture stress, which is mainly responsible for reduction in the productivity of rainfed pearl millet. The average national grain yield of millet stood at 0.85 t ha^{-1} in 2016 as against 1.3 t ha^{-1} in 2012 (FAOSTAT, 2017; 2018). Nema *et al*. (2008) reported beneficial effect of various tillage practices on the moisture conservation and crop yields under dryland condition. Among several agronomic advantages that tillage operations offer to a crop, moisture conservation is of utmost importance.

The soils of the pearl millet growing regions being mostly light in texture embody low moisture holding capacity. Efforts have been made to augment the soil-moisture retentivity by adopting various tillage practices (Sinha, 2015). Although for most situations conventional tillage methods have been the major tillage operations for crop production, they are now expensive operations in terms of work rate and fuel consumption (Ecclestone, 2004). The costs, as well as the environmental concerns have led farmers and researchers to adopt alternative tillage methods (Ecclestone, 2001). For these reasons, there is a considerable attention and emphasis on the shift to the conservation tillage methods, i.e., reduced tillage, minimum tillage and no-tillage methods.

Time of sowing is an important agronomic factor which causes substantial increase or decrease in yield. To date, the challenge for cereal growers is to find the most suitable date between sowing too early and sowing too late (Nielson *et al*., 2002). In Niger Republic, the length of the growing period is mainly a function of the date of the first rains (Sivakumar 1988) and varies widely from year to year. However, due to the erratic rainfall pattern in the Sahelian regions, the first rain suitable for planting is often followed by several dry days that cause high seedling mortality and require the farmers to replant.

The optimum planting date range for pearl millet is only 10–14 days, which is a major constraint to using soil tillage with animal traction (Grema and Odo, 1998). The fact that pearl millet has a large early season root-to-shoot ratio, tolerates high soil temperatures (Bidinger and Hash, 2004), and tolerates sand blasting (Buerkert and Stern, 1995; Buerkert *et al*., 2000; Michels *et al*., 1995a,b) makes early planting a viable option. A significant reduction in grain yield has been shown to occur with delayed sowing for a wide range of climatic conditions (Dahlke *et al*., 1993). With the fluctuation of rainfall pattern in the savannah agro ecological zone of Nigeria caused by climate change, the traditional or long period when rain is believed to have established have been fluctuating and the period when rainfall is received is becoming shortened and cannot be predicted.

In view of the above, this study was designed to evaluate the yield of millet varieties to different tillage practices and sowing date in semi-arid area of Nigeria.

MATERIALS AND METHODS

Field trials were conducted during 2018 and 2019 rainy seasons at the Institute for Agricultural Research farm, Wasai village, Minjibir Local Government Area, Kano state located in the Sudan savannah ecological zone (latitude 12^{o} 8' N; longitude 8^{o} 39' E).

The treatments consisted of six tillage methods:

T-1: Zero tillage (Paraquat at 1.0 kg a.i.ha^{-1} followed by Primextra @ 1.0 kg a.i.ha-^{1} pre-emergence followed by 2,4-D @ 1.5 kg a.i ha^{-1}post emergence)'

T-2: Minimum tillage (Light hoe weeding followed by atrazine at 1.0 kg a.i.ha^{-1}pre-emergence followed by 2,4-D @ 1.5 kg a.i ha^{-1} post emergence)

T-3: Minimum tillage (Paraquat at 1.0 kg a.i.ha^{-1} followed by Primextra @ 1.0 kg a.i.ha-^{1} pre-emergence followed by light hoe weeding post emergence.)

T-4: Minimum tillage (Ridging followed by supplementary hoe weedings),

T-5: Conventional tillage (Single harrowing followed by ridging followed by Primextra @ 1.0 kg a.i.ha-^{1} pre-emergence followed by supplementary hoe weeding),

T-6: Conventional tillage (Double harrowing followed by ridging followed by Primextra @ 1.0 kg a.i.ha-^{1} pre-emergence followed by supplementary hoe weeding,

Three Sowing Dates: Early June (1^{st} – 10^{th}): 6^{th} June 2018, 2^{nd} June 2019. Mid June (11^{th} – 20^{th}): 16^{th} June 2018, 12^{th} June 2019. Late June (21^{st} – 30^{th}): 26^{th} June 2018, 22^{nd} June 2019 and two varieties of millet: LCICMV-1 and LCICMV-3. All sowings were at intervals of 10 days from the beginning of the rainy season in the two years of study. The experiment was laid out in a Split-Split Plot Design (SSPD) with four replications. Tillage methods were assigned to the main plots, while the sowing dates and millet varieties were allocated to the sub and the sub-sub plots, respectively.

Sowing was manually done at inter-row and intra-row spacing's of 75cm x 25cm. recommended fertilizer rates of 60 kg N, 30 kg P_2O_5 and 30 kg of K_2O were applied. Weeding was done as per treatment to eliminate weed competition in the respective plots. Two pre-

emergence herbicides were used; Atrazine and Primextra applied by the use of garden plastic hand operated manual pressure pump sprayer. The panicles were harvested at physiological maturity stage from the net plot by the use of sickle packed and labeled as per plots for easy identification and then sun dried to constant weight. After drying, manual threshing was done to separate the grains from the chaff.

Data on the weather conditions at were obtained from IITA Meteorological station at Wasai village. The meteorological data collected included rainfall, temperature and relative humidity.

Prior to sowing, soil samples were taken by random sampling from the experimental site at 0-15 cm and 15-30 cm depth, air dried at room temperature, ground, sieved using 2 mm siever and then subjected to routine analysis using standard laboratory analytical procedure to determine physical and chemical properties (Oladoye, 2015) Crop yield data collected are: Number of panicles, 1000-seed weight (g), grain yield (kg ha^{-1}), stover yield (kg ha^{-1}), harvest index (%) and threshing percentage (%). All data collected were statistically analysed using GENSTAT 17^{th} edition. Significant treatment means were compared using Students Newman Keuls (SNK).

RESULTS AND DISCUSSION

The results of the physical and chemical properties of the soils at the experimental site in 2018 and 2019 rainy seasons are presented in Table 1. The results of the soil analysis showed that pearl millet is tolerant to acidic soils for high grain and stover yields. Dewey *et al*. (2012) stated that pearl millet appeared to be more tolerant to sandy and acidic soils than other summer grain crops in the southeastern United States. In 2018 the soil potassium contents was moderate at top and high at sub soil level and in 2019 the soil potassium contents was generally low. Egharevba *et al*. (1984) showed that millet does not give good response to application of potassium but may improve the vigour of young plants (Pieri, 1986). The micronutrients are however required in trace amount. The soil in the location was classified as sandy loam. This is in conformity with the report of Arnon (1972) who stated that pearl millet is adapted to poor sandy soil on which it produces reasonable yield relative to most other arable crops that would fail to produce good yields.

The meteorological data of the experimental site in 2018 and 2019 rainy seasons are presented in Table 2. Highest rainfall figures of 616.2 mm and 605.7 mm in 2018 and 2019 rainy seasons were recorded at the site. Erratic rainfall was experienced during the early season as evident by the lower rainfall figures received in June. The peak rainfall of 329.2mm and 221.3 mm was received in August at Wasai. It is evident from the study that the rainfall figures contributed to the yield of the crop in the two seasons.

Number of Panicles ha^{-1}

Table 3 shows the effect of tillage and sowing date on number of panicles ha^{-1} of millet varieties during 2018 and 2019 rainy seasons. The result in both years though statistically similar in 2018 showed that conventional tillage (T_5) recorded the highest number of panicles ha^{-1} (46,988 and 34,888). This high panicle number was produced as a result of high numbers of effective tillers. Verma *et al*. (2017) observed a significant increase in yield and yield attributes viz., effective tillers $plant^{-1}$, grain yield, straw yield and biological yield under conventional / minimum tillage as compared to zero tillage.

Millets sown early recorded the highest number of panicles ha^{-1} except in 2018 which had its highest number of panicles on millets sown in late June. The low panicle number recorded on millets planted in early June at Wasai in 2018

was as a result of poor seedling emergence caused by drought. LCICMV-3 recorded highest number of panicles ha^{-1} in 2019 which is a consequence of its high tailoring ability.

1000-Seed Weight (g)

Table 3 also shows the effect of tillage and sowing date on 1000-seed weight (g) of millet varieties in the 2018 and 2019 rainy seasons at Wasai. Findings from the study showed that conventional tillage (T_5) had the highest thousand seed weight (6.6 g) in 2019. The higher seed weight observed may be due to favourable soil and ambient plant environment so obtained under the influence of tillage thereby increased the photosynthesis process and accumulation of photosynthates in grains.

The heaviest seed recorded in early June at the location and years of study is in line with the findings of Killi and Altunbay (2005) who observed that seed weight was significantly affected by the sowing date. Results in 2018 showed that millets sown early recorded the heaviest seeds of 9.44g, while in 2019; millets sown early on 2nd June 2019 recorded the highest thousand seed weight of 8.3g respectively. However, Amanullah *et al*. (2015) reported that millet crop planted on 20th June had the highest thousand grain weight (12.3 g) in Peshawar, Pakistan while Shinggu and Gani (2012) reported that finger millet seeded on 9th July had the highest 1000-seed weight of 2.91g in northern Nigeria. Leila (2008) observed highest thousand grain weights (13.9 g) when pearl millet was sown on 3rd May.

Findings from the study also indicated that LCICMV-3 resulted in greater 1000-seed weight compared to LCICMV-1. This may be due to varietal differences in grain size.

Grain Yield (kg ha^{-1})

Table 4 shows the effect of tillage and sowing date on grain yield (kg ha^{-1}) of millet varieties at Wasai during the 2018 and 2019 rainy seasons. Conventional tillage (T_5) produced the highest grain yield of 1,686.4 kg ha^{-1} in 2019 at Wasai. Verma *et al.* (2017) observed a significant increase in grain yield under conventional tillage + ridging as compared to zero tillage. This increase in yield could be attributed to improvement in growth attributes under the influence of tillage treatment through increased availability of soil moisture and nutrients, which favorably influenced physiological processes of the plants leading to storage and buildup of food material. Minimum tillage (T_2) recorded the lowest grain yield in the location similar to zero tillage. The low yields observed could be ascribed to the compacted soil condition and effects caused by weeds which were not eliminated by the post emergence herbicides applied as evident by high weed count. Significant improvement in grain yield under T_4 treatment seems to be an outcome of increased dry matter accumulation right from early stages of crop growth till harvest due to favorable soil and plant environment so obtained under the influence of tillage practices. Poor crop growth and yield so obtained under zero tillage practice further explains these contentions. It can also be safely assumed that increased availability of nutrients to the crop in the presence of ample moisture might have helped in the increased synthesis of growth substances and naturally occurring phyto-hormones probably the auxin, which ultimately helped in increased effective tillers $plant^{-1}$. Increased moisture availability due to the impact of ridging coincided with flower primordial initiation stage, which might have helped in increased flowering, fertilization and grain formation resulting in higher yields. This finding corroborates results of Usman *et al*. (2014) who reported similar effects of ridging in pearl millet.

Table 1. Physical and Chemical Properties of Soils of the Experimental Site at Wasai in 2018 and 2019 Rainy Seasons at 0-15 and 15-30 cm Soil Depths.

	2018		2019	
Properties of soil	0 – 15	15 – 30	0 – 15	15 –30
Physical Properties (g kg^{-1})				
Sand	490.7	250.7	767.6	527.2
Silt	349.3	329.3	107.3	343.0
Clay	420.0	420.0	125.2	129.8
Textural class	Sandy clay	Clay	Sandy loam	Sandy loam
Chemical Properties				
pH in water (1:1)	5.56	5.61	7.05	5.48
Total N (g kg^{-1})	0.3	0.2	0.3	0.2
Organic carbon (g kg^{-1})	2.2	1.7	2.2	1.7
Total P (mg kg^{-1})	1.09	3.84	3.90	5.82
Cu (mg kg^{-1})	0.56	2.04	2.37	0.82
Mn (mg kg^{-1})	5.38	5.88	1.90	1.79
Zn (mg kg^{-1})	3.20	2.97	3.08	1.04
Fe (mg kg^{-1})	54.41	108.4	32.54	78.70
Exchangeable bases				
Ca ++ (cmol kg^{-1})	1.75	3.12	0.60	0.94
Mg + (cmol kg^{-1})	0.55	0.22	0.42	0.16
K + (cmol kg^{-1})	0.15	0.90	0.08	0.09
Na + (cmol kg^{-1})	0.03	0.06	0.05	0.02
C.E.C (cmol kg^{-1})	2.539	4.274	1.16	1.21

Analysed at the Centre for Dry-land Agriculture (CDA), Bayero University, Kano-Nigeria.

Table 2. Meteorological Data of the Experimental Site at Wasai in the 2018 and 2019 Rainy Seasons

Months	2018				2019			
	Rainfall	Relative Humidity	Temperature		Rainfall	Relative Humidity	Temperature	
		Max.	Min	Max.		Max.	Min	Max.
	(mm)	(%)	(^oC)	(^oC)		(%)	(^oC)	(^oC)
March	1.20	12.9	15.6	42.1	0.00	10.3	17.6	44.0
April	0.00	13.8	18.4	44.1	0.00	10.3	19.6	43.6
May	29.1	89.7	20.4	43.9	31.6	100	21.2	42.1
June	65.0	100	20.1	41.2	51.5	96.8	20.6	37.9
July	111.9	100	19.8	35.8	218.1	99.5	20.4	36.7
August	329.2	100	19.7	34.1	221.3	100	20.1	33.8
September	72.3	99.4	19.9	36.5	36.7	83.9	21.1	36.8
October	7.50	96.8	15.4	39.4	46.5	99.5	19.6	37.6
Total	616.2				605.7			

Source: IITA Wasai station, Kano. NB: The rainfall data in 2019 was sourced from Danbatta meteorological station.

Table 3. Effect of Tillage and Sowing Date on Number of Panicles ha^{-1} and 1000-Seed Weight (g) of Millet Varieties during 2018 and 2019 Rainy Seasons at Wasai, Nigeria

	Number of Panicles ha^{-1}		1000-Seed Weight (g)	
Treatments	2018	2019	2018	2019
Tillage (T)				
T_1	26216	18722b	7.04	5.0b
T_2	42378	22833ab	7.25	5.5ab
T_3	27660	20555b	7.96	5.8ab
T_4	40879	30777ab	7.75	6.4ab
T_5	46988	34888a	8.21	6.6a
T_6	35158	26610ab	7.92	6.3ab
SE±	6050.5	3274.2	0.451	0.34
P. value	0.152	0.024	0.454	0.033
Sowing Date (SD)				
Early June	27021b	40443a	9.44a	8.3a
Mid June	29298b	20194b	6.12c	4.9b
Late June	53320a	16555b	7.50b	4.7b
SE±	4237.9	2816.5	0.323	0.27
P. value	<.001	<.001	<.001	<.001
Variety (V)				
LCICMV-1	36639	16500b	7.76	5.5b
LCICMV-3	36454	34962a	7.61	6.4a
SE±	2974.8	1834.4	0.205	0.17
P. value	0.965	<.001	0.601	<.001

Means within same treatment column followed by different letters differ significantly using Student - Newman Keuls Test (SNK). T_1 (Zero tillage); T_2 (pre-plant light hoe weeding); T_3 (post emergence light hoe weeding); T_4 (Ridging);T_5 (Single harrowing + ridging);T_6 (Double harrowing + ridging);Early June (1st -10th); Mid June (11th - 20th); Late June (21st - 30th).

Millet planted in early June in 2018 and 2019 recorded the highest grain yield. This is similar to Anderson (1994) who reported that millet sown on the 8th of June was best date for grain yield while Uzoma *et al.* (2010) reported that 17th June was the best planting date with a grain yield of 3371 kg ha^{-1} in northern Nigeria. The lowest grain yield was however recorded by millets sown in late June. Kamara *et al*. (2003) stated planting too late might reduce valuable growing time and crop yield.

The result of this study showed that LCICMV-3 recorded a higher grain yield than LCICMV-1 in the two years of study. In a similar trial, Verma *et al*. (2017) observed that the difference in grain yield so obtained might be due to difference in their genetic potentials, which led to varied assimilation of photosynthates and its translocation to the sink for grain yield formation.

Stover Yield (kg ha^{-1})

The stover yield (kg ha^{-1}) of millet varieties in the 2018 and 2019 rainy seasons at Wasai are presented in Table 4. Conventional tillage (T_5) recorded the highest stover yield of 2741 kg ha^{-1} in 2018 while in 2019 minimum tillage (T_4) produced the highest. The higher stover yield in T_4 could be attributed to less weed competition due to inverted top soil and availability of nutrient and moisture that facilitated nutrient absorption for plant growth and development. Zero tillage (T_1) recorded the lowest stover yield in the two locations due partly to weed competition and less percolation and absorption of water and nutrient that contributed to retarded growth and consequently affected the yield.

Millet seeded in early June produced the highest stover yield (2,680 kg ha^{-1}). Parihar *et al*. (2009) reported highest dry stover yield of 7.54 t ha^{-1} in

India while Abd El-Latief (2011) reported highest dry matter yields of 3.99 t ha^{-1}, 4.49 t ha^{-1} and 2.77 t ha^{-1} for first, second and third forage cuts, respectively when millet was sown on 15th May in Egypt. However, Obeng *et al*. (2012) reported a dry matter yield of (3,240 kg ha^{-1}) when millet was sown on 25th June in the United States of America. LCICMV-3 also outperformed LCICMV-1 in stover yield. Genetic variability accounted largely for the differences in yield as reported by Anonymous (1984).

Harvest Index (%)

Table 5 shows the effect of tillage and sowing date on harvest index (%) of millet varieties in the 2018 and 2019 rainy seasons at Wasai. Though no significant difference was observed among tillage practices, however minimum tillage (T_3) and conventional tillage (T_6) recorded the highest harvest index in 2018 and 2019 wet season. In a similar trial by Sidar (2017) harvest index was significantly highest in minimum tillage.

Millet sown early June in 2018 and 2019 recorded the highest harvest index while millet planted in late June recorded the lowest. Delay in sowing does not only affect yield, but also affects the yield components and other aspects of growth and development. It is generally associated with reduced kernel weight, reduced number of ear per plant, grain number per plant and LAI (Elemo, 1991; Cirilo and Andrade, 1996; Valencia, 1999; Maryam *et al.*, 2013).

LCICMV-3 also recorded higher harvest index compared to LCICMV-1 though no significant difference observed. Verma *et al*. (2017) in a similar trial recorded a highest harvest index of 30% in cultivar MPMH-17.

Table 4. Effect of Tillage and Sowing Date on Grain yield (kg ha^{-1}) and Stover Yield (kg ha^{-1}) of Millet Varieties During 2018 and 2019 Rainy Seasons at Wasai, Nigeria

	Grain yield (kg ha^{-1})		Stover Yield (kg ha^{-1})	
Treatments	2018	2019	2018	2019
Tillage (T)				
T_1	1458	1477.6b	1000b	943b
T_2	1508	1447.5b	1763ab	998b
T_3	1546	1513.6b	1399b	1300ab
T_4	1633	1580.0ab	2027ab	1921a
T_5	1695	1686.4a	2741a	1754ab
T_6	1670	1588.3ab	2157ab	1597ab
SE±	73.5	34.5	281.0	191.7
P. value	0.201	0.002	0.009	0.011
Sowing Date (SD)				
Early June	1791a	1956.6a	2421a	2680a
Mid June	1430b	1356.3b	1303b	781b
Late June	1535b	1333.7b	1820b	796b
SE±	45.6	27.7	184.0	120.9
P. value	<.001	<.001	<.001	<.001
Variety (V)				
LCICMV-1	1571	1436b	1815	969.1b
LCICMV-3	1599	1662a	1881	1868a
SE±	36.7	30.1	94.2	93.39
P. value	0.588	<.001	0.626	<.001

Means within same treatment column followed by different letters differ significantly using Student - Newman Keuls Test (SNK). T_1 (Zero tillage); T_2 (pre-plant light hoe weeding); T_3 (post emergence light hoe weeding); T_4 (Ridging);T_5 (Single harrowing + ridging);T_6 (Double harrowing + ridging);Early June (1st -10th); Mid June (11th - 20th); Late June (21st - 30th).

Threshing Percentage (TH %)

Table 5 also shows the effect of tillage and sowing date on threshing percentage (%) of millet varieties in the 2018 and 2019 rainy seasons at Wasai. The highest threshing percentage observed in minimum tillage (T_3) in 2018 and conventional tillage (T_5) in 2019 though statistically similar was attributed to favourable climatic condition due to high rainfall and plant environment so obtained under the influence of tillage thereby increased the photosynthesis process and accumulation of photosynthates in grains. Millets sown early between 1st and 10th June, recorded the highest threshing percentage (83.1%) which is considered optimum while millets sown in late June, recorded the lowest (29.4%) due to delay in sowing. This result is similar to the findings of Maryam *et al.* (2013) who reported that delay in sowing affects yield and yield components of maize.

Table 5. Effect of Tillage and Sowing Date on Harvest Index (%) and Threshing Percentage (TH%) of Millet Varieties in the 2018 and 2019 Rainy Seasons at Wasai, Nigeria

	Harvest Index (%)		Threshing Percentage (TH %)	
Treatments	2018	2019	2018	2019
Tillage (T)				
T_1	21.4	19.0	48.0	46.8
T_2	18.0	20.0	44.2	39.3
T_3	22.5	17.2	52.2	44.5
T_4	22.3	17.7	50.2	46.0
T_5	19.8	19.3	46.6	44.2
T_6	18.8	21.0	43.2	52.1
SE±	1.47	1.43	3.40	2.75
P. value	0.216	0.459	0.430	0.100
Sowing Date (SD)				
Early June	22.6a	26.8a	53.7a	65.4a
Mid June	18.3b	16.7b	42.2b	41.6b
Late June	20.5ab	13.7b	46.4ab	29.4c
SE±	1.17	1.08	2.56	2.48
P. value	0.042	<.001	0.010	<.001
Variety (V)				
LCICMV-1	20.3	18.5	46.2	45.0
LCICMV-3	20.7	19.5	48.6	46.0
SE±	0.71	1.08	2.07	2.19
P. value	0.678	0.509	0.432	0.738

Means within same treatment column followed by different letters differ significantly using Student - Newman Keuls Test (SNK). T_1 (Zero tillage); T_2 (pre-plant light hoe weeding); T_3 (post emergence light hoe weeding); T_4 (Ridging);T_5 (Single harrowing + ridging);T_6 (Double harrowing + ridging);Early June (1st -10th); Mid June (11th - 20th); Late June (21st - 30th).

CONCLUSION

The results of this study showed that conventional tillage (T_5) produced higher yield attributes for millet compared to other tillage methods. Similarly, millet variety sown in early June between 1st and 10th after the first heavy rains recorded significantly highest yield characters. Furthermore, LCICMV-3 outperformed LCICMV-1 on grain yield and other yield components. It could therefore be concluded that early sowing of LCICMV-3 in soil prepared by single harrowing + ridging and pre-emergence application of primextra followed by supplementary hoe weeding produced high grain yield.

Based on this trial, it is therefore recommended that millet variety LCICMV-3 should be sown early after the first heavy rainfall within the periods of 1st – 10th June in soil prepared by single harrowing + ridging and pre-emergence application of primextra followed by supplementary hoe weeding for high grain and stover yields in sudan savannah ecological zone of Nigeria.

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EFFECTS OF POULTRY MANURE ON SOIL PHYSIOCHEMICAL PROPERTIES, GROWTH AND SEED YIELD OF KENAF VARIETIES IN SAMARU AND KADAWA, NORTHWEST NIGERIA

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ABSTRACT

The effect of poultry manure (PM) applied at different rates on soil physiochemical properties, growth and seed yield of kenaf varieties was studied in Samaru (Northern guinea Savanna) and Kadawa (Sudan Savanna). The treatment consists of three kenaf varieties (Ifeken 400, Ifeken D1 400 and Girin danani) under four rate of poultry manure (0, 2, 4 and 6 t ha^{-1}) factorially combined and laid in a Randomized Complete Block Design and replicated three times at two locations (Samaru and Kadawa). The experiment was conducted during the 2017 wet season at the Research farms of the Institute for Agricultural Research. Poultry manure improved soil N, P, K, Ca, and Mg, in the experiment. the application of poultry manures especially at 6 t ha^{-1} and Girin danani variety resulted in higher growth attributes (plant height, number of leaves, leaf area index and shoot dry weight) and seed yield in both locations. Poultry manure had cumulative effect on soil properties, growth and yield parameters over the period of the experiment. Therefore, the use of 6 t ha^{-1} poultry manure and Girin danani variety should be adopted by kenaf farmers in the Northern guinea and Sudan savanna agroecological zones to enhance the productivity of the crop.

Keywords: Poultry manure, kenaf varieties, physiochemical properties.

INTRODUCTION

The savannah zone of Nigeria is renowned for the cultivation of cereal crops like rice (*Oryza sativa*), maize (*Zea mays*), sorghum (Sorghum spp.), root and tubers; cassava (*Manihot esculenta* Crantz), sweet potato and several vegetable crops. Apart from food crops, the land is also suitable for the cultivation of fibre crops (cotton (Gossypium spp.), sisal (*Agave sisalana*), jute (Corchorus spp.) and kenaf (*Hibiscus cannabinus* L.) which are used in the manufacturing of paper and cord for many years. Of these crops, kenaf, a member of the Malvaceae family, is a multipurpose crop that is fast-growing and can produce a large quantity of biomass in less than eight months; thus, it can sequester carbon (Dauda *et al*., 2013). Besides, materials made from natural fibres are biodegradable, cause no harm to the environment, renewable and cheap (Huda *et al*., 2006) compared to synthetic products.

Kenaf is believed to have its origin in Africa (Western Sudan), occurring as early as 4000 BC, where diversified forms of its species are widely grown (Mostofa *et al.,* 2013, Kobayashi *et al*. 2003 and Cheng *et al*., 2004). It is an erect annual shrub, 1- 4 meters in height, with well-

developed tap root, leaves, straight and slender stems. It has large cream-colored, flowers characterized by a reddish-purple neck. The seeds are cylindrical or kidney-shaped, pubescent, grey in colour. Kenaf is adapted to a wide range of soil types, but it thrives best on well drained, sandy loam soils, rich in humus with a pH of 5 to 7, and it is grown within a wide geographical range (Lat 45^0N-30^oS). It requires ample moisture at its early stage of growth and requires a rainfall of about 600mm distributed over the growing season of 4-5 months (NAERLS, 1993). Kenaf is the most economically important fiber crop after cotton and jute (USDA, 1986). However, in 2015, India and China accounted for 44% and 29% of the world kenaf production (INFO, 2016). Despite its importance, Africa produces a tiny percentage of the global production output, with Bangladesh, India and China accounting for over 90 % of world exports (AAE, 2020) which is grossly inadequate for the packaging of agricultural produce in the continent; hence the agro-based industries in Nigeria rely on the importation of fibre products.

Investigation has indicated that Nigerian savannah soils are largely deficient in major essential nutrients like nitrogen, phosphorus and potassium. Making it necessary to supply and enrich the soil with applied nutrients using inorganic and organic sources. However, the use of inorganic fertilizer is constrained by factors, such as unavailability of the right type at the right time, and at affordable cost, as well as inadequate credit facilities for the farm inputs (Chude, 1999). Hence poultry manure is a better alternative and a necessary option for improved crop production especially in the Northern Guinea and Sudan Savannah Agroecological zones of Nigeria. Poultry manure is relatively cheap, readily available to small holder farmers and improve soil physical properties compared to inorganic fertilizers, similarly the increasing demand for poultry manure was due to its health benefits and risk-free characteristics especially in vegetables and fruits production. Poultry manure has been found to have higher nutrients concentration (Iken and Amusa, 2004). Eifediyi *et al*. (2022) reported in their study that adding poultry manure increase the yield of kenaf. At the same time, Girma *et al*. (2007) stated that inorganic fertilizer improved the quantity of cotton seed but reduced its quality, especially N applied over 90 kg. We hypothesize that poultry manure, a readily available input for smallholder farmers, will improve both the quantity and quality of kenaf seed. The objectives of this study were to determine the effect of poultry manure on soil physical and chemical properties, growth and seed yield of kenaf in the northern guinea and Sudan savanna ecology of Northwest Nigeria.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Institute for Agricultural Research (I.A.R) Farm, Samaru, (Latitude 11^0 11N Longitude $07^{'}$ 38 E, 686m) above sea level in Kaduna State and at Kadawa, (Latitude 11^0 39 N Longitude $08^{'}$ 27 E, 500m) above sea level in Kano State, in the northern Guinea and Sudan savannah ecological zones of Nigeria, respectively during the 2017 wet season (Kowal and Knabe, 1972).

Treatments, Experimental Design and Plot Size

The treatments consisted of four rate of poultry manure (0, 2, 4 and 6tons ha^{-1}) and three varieties of kenaf (Ifeken 400, Ifeken D1 400, and Girin danani). The treatments were factorially combined and laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The gross plot size was 4m x 3 ($12m^2$) while the net plot was 2 x 3 ($6m^2$).

Land Preparation and Fertilizer Application

The experimental field was cleared and harrowed twice, and raised seed beds were constructed according to plot size above. The poultry manure was applied 7 days before planting by mixing the manure thoroughly with the soil with a hoe in each plot as per treatment basis.

Sowing

Seed was sown manually on 26th July, and 2nd August, 2017 wet season at the rate of 3 seeds per hole, at an intra-row spacing of 25cm and inter-row spacing of 50cm. Sowing was done on flat land after harrowing and the plants were thinned to 2 plants per stand at 3 weeks after sowing.

Harvesting

Seed harvest was done when the plants were mature and dry. All the plants within the net plot were harvested by cutting the plant portion with capsules, which were further sundried, beaten with sticks in bags to thresh and winnowed. The seeds collected and cleaned were then weighed.

Soil and Poultry Manure Analyses

Soil samples were randomly collected from a depth of 0 -30 cm from various points at the experimental sites during 2017 wet season prior to planting using 30cm auger. The soil samples were thoroughly mixed, air dried, and sieved using 2 mm mesh sieve and later analyzed for physical and chemical properties. The soil samples and poultry manure were analyzed as described by Carter and Gregorich (2007). Soil pH was measured (soil: water ratio, 1:2) using a glass electrode; Particle-size analysis was done using the hydrometer method (Gee and Or, 2002). Soil organic carbon was determined by the procedure of Walkley and Black using the dichromate wet oxidation method (Nelson and Sommers, 1996). Organic matter was estimated by multiplying carbon (C) by 1.724. Total nitrogen was determined by Micro-Kjeldahl digestion and distillation techniques. Available phosphorus was determined following Bray No 1 (1N NH4F + 0.5N HCl) extractant by vanadomolybdo phosphoric acid method (Kuo, 1996), Textural class was determined using a textural triangle (USDA, 2017) and extraction of exchangeable bases was done by using IN ammonium acetate, exchangeable potassium and sodium were determined by using flame photometry while calcium and magnesium were analysed by atomic absorption spectrophotometry

Growth Parameters

Crop data were collected at three-week intervals for twelve weeks after sowing (WAS). The parameters measured were plant height, number of leaves, leaf area index, and shoot weights. The heights of five randomly tagged plants per plot were determined by measuring the height from the ground level to the main shoot apex of the plant using a meter rule, and the average thereafter recorded. The number of leaves was counted per plant from the five tagged plants from each plot and the average per plot was determined and recorded. The leaf area index was derived from the result of the leaf area and calculated as shown below.

$$LAI = \frac{\text{Total leaf area per plant}}{\text{Area of ground covered}}$$

The shoot dry weight was recorded using a weighing balance. The samples were oven dried to a constant temperature of 70^{o} C in an oven drying machine for 24 hours. A Metler balance (Metler Toledo, model SB16001) was then used for weight determination and the average was computed and recorded as per treatment.

Yield Parameter

The seed yield was determined from the total seed harvest for each net plot. The dried kenaf seeds were weighed and the yield computed on per hectare basis.

Statistical Analysis

The data collected were subjected to statistical analysis of variance (F-test) as described by (Snedecor and Cochran, 1967) to test significance of treatment effects. The treatment means were compared using Duncan's Multiple Range Test (DMRT) (Duncan, 1955).

RESULTS

Physical and Chemical Properties of the Soil of the Experimental Sites

Table 1 shows the results of the physical and chemical properties of soil in the experimental sites. Soil samples from the two experimental sites, Samaru and Kadawa were sandy loam and loamy sand respectively. The soils at both locations have low levels of nitrogen and moderate available phosphorus, organic carbon, calcium, magnesium, potassium, sodium and cation exchange capacity were moderate. The pH was slightly acidic in H_2O at Samaru and moderately acidic in $CaCl_2$ in both locations.

Nutrient Content of Poultry Manure Used for the Experiment

The composition of poultry manure (PM) used in this experiment is presented in Table 2. The organic carbon (OC), total N, P, K, Ca and Mg constituents improve the fertility of experimental soils on decomposition of PM. The PM samples are relatively high in N, K and Ca.

Plant height

The effects of varieties and poultry manure rate on the mean height of kenaf during the 2017 wet season at Samaru and Kadawa is presented in Table 3. A significant difference ($p < 0.05$) between varieties at 3 and 6 weeks after sowing was observed in Samaru. At 3 WAS, Girin danani significantly produced taller plants with a height of 43.78 cm, than Ifeken D1 400 and Ifeken 400 varieties, which produced similar heights of 41.47 and 41.56 cm. At 6 WAS, Ifeken 400 and Girin danani significantly tall plants with a height of 138.73 and 140.41 cm respectively and both significantly produced taller plants than Ifeken D1 400. At Kadawa, no significant difference was observed between varieties on height of kenaf at all sampling periods. Application of poultry manure significantly ($p < 0.05$) influenced the height of kenaf at 3 WAS and 6 WAS at Samaru and across sampling periods in Kadawa. Where the application of 6 t ha^{-1} poultry manure resulted in the highest plant heights of 44.82, 143.56, 52.74, 156.81, 185.44 and 221.28 cm respectively across all sampling periods in both locations, and the least values of 36.57, 132.82, 39.31, 141.92, 162.73 and 178.24 cm were recorded under control treatment across the same period. The interaction between varieties and poultry manure rate on the height of kenaf was not significant throughout the period of study.

Number of Leaves

The effects of varieties and poultry manure rate on the mean number of leaves of kenaf during the 2017 wet season at Samaru and Kadawa is presented in Table 4. Crop variety influenced leaf numbers at 3 WAS in Samaru only, whereas Ifeken D1 400 and Girin danani significantly produced ($p < 0.05$) higher number of leaves than Ifeken 400. Application of poultry manure had significant effect on the number of leaves of kenaf at 3 and 6 WAS in Samaru and 12 WAS in Kadawa. At 3 WAS in Samaru, application of 4

and 6 t ha^{-1} poultry manure produced similar and higher number of leaves (21.0 and 20.84) than the lower rates of 2 and 0 t ha^{-1}, which produce 19.18 and 18.09 number of leaves and also statistically similar. At 6 WAS in this location, the application of 4 t ha^{-1} poultry manure significantly produced higher number of leaves with a mean value of 24.13 than lower rate of 2 and 0 t ha^{-1}, with mean values of 21.86 and 22.47 but was statistically at par with the application of 6 t ha^{-1}, which produced 23.33 number of leaves. At 12 WAS in Kadawa, application of 6 t ha^{-1} poultry manure produced higher number of leaves (32.73) than 2 t ha^{-1}(29.87) but was statistically at par with application of 4 and 0 t ha^{-1} which produced 32.05 and 30.31 number of leaves, while the least number of leaves (29.87) was produced by 2 t ha^{-1} and was statistically at par with 0 t ha^{-1}(control).

Leaf Area Index

The effects of varieties and poultry manure rates on leaf area index of kenaf during the 2017 wet season at Samaru and Kadawa is presented in Table 5. A significant difference was observed on leaf area index of kenaf varieties at 9 and 12 WAS in Samaru, where Ifeken D1 400 produced a higher leaf area index compared with Ifeken 400 and Girin danani varieties which were statistically similar with each other. No significant difference on the leaf area index of kenaf varieties was observed at all sampling periods in Kadawa throughout the sampling period. Application of poultry manure had no significant difference on the leaf area index of Kenaf at all sampling periods in both locations except at 9 WAS in Kadawa, where the application of 6 t ha^{-1} poultry manure produced statistically higher leaf area index than on plots applied with 0 t ha^{-1}; but was statistically at par with plots applied with 2 and 4 t ha^{-1}. The least leaf area index was observed on plots applied with 0 t ha^{-1}. The interaction between varieties and poultry manure on leaf area index of Kenaf was not significant throughout the period of study.

Shoot Dry Weight

The effects of varieties and poultry manure rate on the mean shoot dry weight of kenaf during the 2017 wet season at Samaru and Kadawa is presented in Table 6. No significant difference between varieties was recorded at all sampling periods in all locations. Application of poultry manure significantly influenced shoot dry weight of kenaf at 9 WAS in Samaru, where the application of 4 t ha^{-1} poultry manure produced a significantly higher shoot dry weight than at 0 t ha^{-1}; but statistically at par with plots applied with 2 and 6 t ha^{-1}. The least shoot dry weight was recorded on plots with 0 t ha^{-1} poultry manure application. There was a significant difference on the application of poultry manure on the shoot dry weight of kenaf at all sampling periods in Kadawa. At 3 WAS, the application of 2 t ha^{-1} poultry manure produced significantly higher shoot dry weight than plots with 0 t ha^{-1}; but statistically at par with plots applied that had 4 and 6 t ha^{-1} poultry manure application. However, at 6, 9 and 12 WAS, shoot dry weight of kenaf generally increased with increasing rate of poultry manure from 0 to 6 t ha^{-1}. Shoot dry weight was significantly higher in plots with 6 t ha^{-1} poultry manure than on those with 0 t ha^{-1}. There was no significant difference on shoot dry weight from plots with 6 t ha^{-1} of poultry manure application and those applied with 2 and 4 t ha^{-1}. The lowest shoot dry weight was recorded on plots with 0 t ha^{-1}. The interactions between varieties and poultry manure rate on the mean shoot dry weight of Kenaf was significant at 9 and 12 WAS in Samaru is presented in Table 7. At 9 WAS, the combination of poultry manure rate and varieties had a significantly higher shoot dry weight with Ifeken 400 and 2 t ha^{-1}

poultry manure; and was statistically similar with the variety Girin danani applied with poultry manure at 2 and 4 t ha^{-1}. The lowest shoot dry weight was recorded with Ifeken D1 400 which had 2 t ha^{-1} poultry manure. At 12 WAS, Ifeken 400 applied with 2 t ha^{-1} poultry manure application produced the highest shoot dry weight; but was statistically at par with Girin danani which had poultry manure at 2 and 4 t ha^{-1} poultry manure application and Ifeken D1 400 at 0 t ha^{-1}. The lowest shoot dry weight was recorded with Ifeken 400 at 0 t ha^{-1}.

Seed yield

Effects of varieties and poultry manure rate on seed yield per hectare of kenaf at Samaru and Kadawa during the 2017 wet season is presented in Table 8. There was significant difference between varieties at both locations. At Samaru, Girin danani recorded a significantly higher seed yield than Ifeken 400, but was statistically at par with Ifeken D1 400. The lowest seed yield was recorded with Ifeken 400. At Kadawa, Girin danani recorded the highest significant seed yield over Ifeken 400 and similarly, Ifeken D1 400 significantly recorded higher seed yield compared with Ifeken 400. The application of poultry manures significantly increased seed yield at both locations. At Samaru, the application of 6 t ha^{-1} poultry manure recorded the highest significant seed yield over other treatments. Plots applied with 2 and 4 t ha^{-1}, significantly recorded higher seed yield over plots applied with 0 t ha^{-1}, but were statistically at par with each other. The lowest seed yield was recorded on plots applied with 0 t ha^{-1}. At Kadawa, seed yield of kenaf significantly increased with increasing poultry manure rate from 0 to 6 t ha^{-1}.

Table 1: Soil Physical and Chemical Properties of the Experimental Sites with a Depth of 0 30cm during 2017 wet season for Samaru and Kadawa.

Physical properties	Samaru	Kadawa
clay (g kg^{-1})	160	28
silt (g kg^{-1})	60	202
sand (g kg^{-1})	780	770
Textural class	Sandy Loam	Loamy sand
Chemical properties		
pH (H_2O) 1:2:5	6.29	6.41
pH 0.01m $CaCl_2$	5.76	5.55
Total Nitrogen (g kg^{-1})	0.15	0.13
Available (P) (mg kg^{-1})	10.11	8.52
Organic carbon (g kg^{-1})	1.21	1.45
Exchangeable bases (cmol kg^{-1})		
Calcium	3.15	2.98
Magnesium	1.50	1.30
Potassium	0.53	0.37
Sodium	0.24	0.21
Exchangeable acidity (H + Al)	0.24	0.22
CEC	4.32	4.05

Source: Agronomy Department Analytical laboratory, A.B.U. Zaria.

Table 2: Nutrient content of the poultry manure used in the experiment during 2017 wet season

Nutrient content	Value (g kg^{-1})
Total Nitrogen	11.25
Available Phosphorus	2.50
Potassium	1.21
Calcium	1.42
Magnesium	0.71

Source: Agronomy Department Analytical laboratory, A.B.U. Zaria.

Table 3: Effects of varieties and poultry manure rate on the height of kenaf at Samaru and Kadawa during the 2017 wet season.

	Plant Height (cm)							
	Samaru				Kadawa			
Treatment	3WAS	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Variety (V)								
Ifeken 400	41.47b	140.41a	168.05	180.02	48.28	151.59	174.92	201.02
Ifeken D1 400	41.56b	137.12b	164.15	178.40	45.92	151.91	176.52	202.72
Girin danani	43.78a	138.73ab	162.88	175.55	45.03	152.71	174.68	198.11
SE±	0.681	0.980	3.375	4.490	1.231	3.983	3.888	4.463
Poultry manure (t ha^{-1})								
0	36.57b	132.82c	160.42	172.80	39.31c	141.92b	162.73c	178.24b
2	43.87a	138.18b	161.73	174.00	45.62b	154.37ab	171.22bc	186.08b
4	43.82a	140.45ab	165.42	177.74	47.97b	155.17ab	182.11ab	216.86a
6	44.82a	143.56a	172.53	187.39	52.74a	156.81a	185.44a	221.28a
SE±	0.787	1.132	3.897	5.185	1.422	4.599	4.490	5.154
Interaction								
V x M	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT.
WAS = Weeks after sowing
NS = Not significant
** = significant at 1%

Table 4: Effects of varieties and poultry manure rate on the number of leaves of kenaf at Samaru and Kadawa during the 2017 wet season

	Number of Leaves							
	Samaru				Kadawa			
Treatment	3WAS	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Variety (V)								
Ifeken 400	18.76b	23.01	26.58	30.55	18.75	22.99	27.10	31.38
Ifeken D1 400	20.97a	23.17	26.28	30.78	19.20	23.09	27.25	31.48
Girin danani	20.06a	22.67	25.85	30.75	18.64	23.51	26.65	30.87
SE±	0.393	0.467	0.518	0.676	0.573	0.611	0.677	0.707
Poultry manure(tha^{1})								
0	18.69b	22.47b	26.34	30.65	17.96	22.69	26.49	30.31ab
2	19.18b	21.86b	25.01	29.31	18.91	22.54	25.69	29.87b
4	20.84a	24.13a	26.90	31.67	18.69	23.35	27.73	32.05ab
6	21.03a	23.33ab	26.70	31.16	19.91	24.21	28.11	32.73a
SE±	0.456	0.540	0.599	0.781	0.661	0.705	0.782	0.817
Interaction								
V x M	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5 % level using DMRT.
WAS = Weeks after Sowing
NS = Not significant

Table 5: Effects of varieties and poultry manure rate on the leaf area index of kenaf at Samaru and Kadawa during the 2017 wet season

	Leaf area index							
	Samaru				Kadawa			
Treatment	3WAS	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Variety (V)								
Ifeken 400	0.290	0.997	1.304b	1.643b	0.259	0.711	1.549	2.017
Ifeken D1 400	0.195	1.548	1.633a	2.001a	0.243	0.671	1.524	2.239
Girin danani	0.225	1.891	1.308b	1.526b	0.228	0.650	1.379	2.199
SE±	0.038	0.070	0.079	0.099	0.054	0.058	0.117	0.141
Poultry manure (t ha^{-1})								
0	0.307	1.025	1.416	1.720	0.225	0.630	1.124b	2.064
2	0.225	0.967	1.358	1.725	0.218	0.695	1.521ab	2.011
4	0.206	1.135	1.428	1.766	0.257	0.632	1.513ab	2.149
6	0.209	1.061	2.451	1.677	0.273	0.752	1.779a	2.381
SE±	0.045	0.081	0.091	0.114	0.020	0.059	0.135	0.163
Interaction								
V x M	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT.
WAS = Weeks after Sowing
NS = Not significant

Table 6: Effects of varieties and poultry manure rate on the shoot dry weight of kenaf at Samaru and Kadawa during the 2017 wet season

	Shoot dry weight (g)							
	Samaru				Kadawa			
Treatment	3WAS	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Variety								
Ifeken 400	11.24	15.95	23.94	25.68	11.48	14.99	18.96	23.69
Ifeken D1 400	11.56	16.12	20.99	24.43	11.30	15.24	18.21	22.63
Girin danani	10.98	16.82	23.25	25.58	11.30	14.75	18.78	23.69
SE±	0.549	0.859	0.698	0.815	0.168	0.427	0.474	0.993
Poultry manure (t ha^{-1})								
0	10.87	14.82	20.35b	23.89	10.94b	12.47c	15.33c	20.37b
2	11.14	17.20	23.29a	26.86	11.61a	14.11bc	18.97b	22.85ab
4	11.84	17.03	23.35a	26.12	11.39ab	15.29b	19.52ab	24.38a
6	11.19	16.13	22.51ab	23.97	11.51ab	18.11a	20.72a	25.81a
SE±	0.634	0.992	0.806	0.942	0.194	0.569	0.548	1.147
Interaction								
V x M	NS	NS	**	**	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT.
WAS = Weeks after Sowing
** = significant at 1%
NS = Not significant

Table 7: Interaction between varieties and poultry manure rate on shoot dry weight of kenaf at 9 and 12WAS at Samaru during the 2017 wet season

	9 WAS			
Treatment	Poultry manure (t ha^{-1})			
Variety (V)	0	2	4	6
Ifeken 400	19.41cd	27.35a	22.87bc	22.84bc
Ifeken D1 400	22.33bc	15.97d	23.37bc	22.29bc
Girin danani	19.31cd	26.45ab	23.92a-c	22.42bc
SE± 1.398				

	12 WAS			
Treatment	Poultry Manure (t ha^{-1})			
Variety (V)	0	2	4	6
Ifeken 400	21.39d	31.63a	26.86bc	23.59b-d
Ifeken D1 400	26.93a-c	21.92cd	25.31b-d	23.58b-d
Girin danani	23.34b-d	27.20ab	26.98ab	24.76b-d
SE± 1.631				

Means followed by the same letters do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT)

Table 8: Effects of varieties and poultry manure rate on seed yield per hectare of kenaf at Samaru and Kadawa during the 2017 wet season.

	Seed yield per hectare (kg ha^{-1})	
Treatment	Samaru	Kadawa
Variety		
Ifeken 400	199.6b	209.9c
Ifeken D1 400	203.2ab	217.2b
Girin danani	209.7a	226.5a
SE±	2.744	1.106
Poultry manure (t ha^{-1})		
0	180.1c	187.0d
2	204.6b	206.9c
4	205.5b	227.5b
6	226.6a	250.0a
SE±	3.169	1.277
Interaction		
V x M	NS	NS

Means followed by the same do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).
NS = Not significant

DISCUSSION

The textural class of the soil in Samaru and Kadawa were Sandy loam and loamy Sandy respectively. The pH 6.29 and 6.41 of soils at Samaru and Kadawa were within the range required for the growth of kenaf. The physical and chemical property of the soil in the experimental sites also shows that the cation exchange capacity (useful indicator of soil fertility) for the soils at both locations was moderate. This is in line with the studies of Hazleton and Murphy (2007) who stated that cation exchange capacity is an essential soil property that influences nutrient availability, soil pH and soil reaction to fertilizers which are all

important determinants of crop growth and development. Samples of poultry Manure used in the experiments had slightly varying values of OC, N, P, K, Ca and Mg. On decomposition of organic matter and mineralization of organic nutrients, their release should have benefited the experimental soils that were low in organic matter, nitrogen and phosphorus.

The organic matter (OM) should also have benefited the soil physical properties. The organic matter component of PM decomposed and nutrients were released to soil. Hence the finding that PM increased soil N, P, K, Ca, and Mg significantly. The increases in soil fertility is consistent with findings of previous studies that amendment of soil using poultry manure improved soil OM, N, P, K, Ca and Mg (Kingery *et al*., 1993; Adeniyan and Ojeniyi, 2005; Akanni *et al*., 2005; Adenawoola and Adejoro, 2005). The increased availability of nutrients in soil due to application of the manure expectedly led to increased uptake of N, P, K, Ca, and Mg. The finding that PM significantly increased growth and seed yield of kenaf is attributable to improved soil physical and chemical properties.

The positive response of growth components such as (plant height, number of leaves, leaf area index and shoot dry weight) to poultry manure application from 2 to 6 t ha^{-1} at both locations could be attributed to the beneficial role of manure in providing soil nitrogen, phosphorus, potassium and other essential nutrients, which in turn improved growth and development of the plants during the trial. This is in consonance with the findings of Adekunle *et al*. (2014) who reported that the application of manure from 10-20 t ha^{-1} significantly increased the growth attributes of kenaf. The interaction between varieties and poultry manure was significant on shoot dry weight, where the combination of Ifeken 400 and 2 t ha^{-1} poultry manure produced higher shoot dry weight in Samaru. This could be probably due to the morphology of the variety and its ability to utilize the nutrients supplied by the poultry manure for rapid growth and development. This is in agreement with the findings of Mubarak (2014) who reported that higher shoot dry weight was obtained in Clemson spineless variety of okra as a result of the morphology of this variety which was taller than Ex Samaru 4 and it contributes to the weight of the variety (Clemson spineless).

Seed yield ha^{-1} was observed to increase significantly with the application of 6 t ha^{-1} of poultry manure at both locations. This could be due to the appreciable amount of essential nutrients in the poultry manure (N, P, K, Ca and Mg) and the favorable weather conditions during the 2017 wet season that favored the quick decomposition of the manure. This result conforms to earlier findings by Atif *et al*. (2015) who reported a higher yield of jute mallow when poultry manure was applied. The significant differences recorded among the three kenaf varieties in terms of their growth and yield such as plant height, number of leaves, shoot dry weight and fiber yield of kenaf is attributed to differences in the genetic composition of the varieties used. This is in line with the study of Akinfasoye *et al*. (1997) who reported that the differences in yield parameters of crops are attributed to the cultivars grown and their genetic make-up.

Girin danani produced higher seed yield than Ifeken 400 and Ifeken D1 400 at both locations. Apart from the genetic composition of the variety which plays an important role in the potential yield of the crop, the differences in the rate of nutrient absorption and utilization among the three varieties and environmental variations could greatly influence the yield of kenaf. This result agrees with the finding of Williams, (2004).

CONCLUSION

The application of 6 t ha^{-1} poultry manure and Girin danani variety resulted in higher growth and seed yield in both locations as a result of the appreciable amount of essential nutrients in the poultry manure (N, P, K, Ca and Mg) release in the soil, and suitable soil type, pH and cation exchange capacity which thus helps to improve the growth and development of the crop.

RECOMMENDATION

Therefore, the use of 6 t ha^{-1} poultry manure and Girin danani variety should be adopted by kenaf farmers in the Northern guinea and Sudan savanna agroecological zones to enhance the soil physiochemical properties, growth and seed yield of the crop.

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IN-VITRO EVALUATION OF ANTI-NUTRIENT, ANTI-OXIDANT AND PROXIMATE PROPERTIES OF CABBAGE *(Brassica oleracea)* SPECIES IN JOS, PLATEAU STATE, NIGERIA

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ABSTRACT

A study was carried out to determine anti-nutrient and antioxidant; and compare the proximate properties of 3 *Brassica oleracea* varieties (green, red and Chinese) cabbage, respectively. Fresh samples of the 3 *Brassica oleracea peviridis*, (green cabbage, GC), *Brassica oleracea rupetris* (red cabbage, RC) and *Brassica oleracea rupa* (Chinese cabbage, CC) were collected from Bukuru market of Jos South LGA (9° 45' *54.93"N ; 8° 51*' 34.96"E*)* , Gwol market of Barikin ladi LGA (9°34′N 8°55′E; 9.567°N 8.917°E) and Qui market of Riyom LGA (9°38′00″N 8°46′00″E.). The samples were identified, processed, and analyzed for proximate composition, anti-nutrient and antioxidant scavenging activity. The proximate analysis result showed that CC had more dietary nutritional properties such as high crude protein and high crude fiber while *GC* had more mineral properties such as ash, phosphorus, nitrogen free extract and metabolizable energy. The anti-nutrient analysis showed that both *CC* and *RC* have higher concentration of phytic acid, tannin and oxalate compared to *GC*. Also, the antioxidant analysis showed that *GC* had the highest antioxidant scavenging activity. Therefore, out of the 3 *Brassica oleracea* species, Green cabbage (*Brassica oleracea peviridis*) consisted of the highest mineral properties, lesser anti-nutrient compounds and highest antioxidant scavenging activity. This made Brassica *oleracea peviridis* (green cabbage) the most suitable variety for both human and animal consumption.

Keywords: Cabbage species, Anti-Nutrient, Anti-Oxidant, Proximate, Jos-Nigeria

INTRODUCTION

Cabbage *(Brassica oleracea)* is one of the most important vegetables grown worldwide because it is highly nutritious and rich in vitamin C, fiber, and vitamin K. It belongs to the family *Cruciferae*, which includes broccoli (*Brassica oleracea var. italica*), cauliflower (*Brassica*

oleracea var. botrytis), and kale (*Brassica oleracea, variety acephala*). Vegetables have a wide area of application and nutritional values. Each however, requires certain minimum quality of nutrition because the principle of nutrition for all animals is anchored on the whole content of balanced diet (Hall, 1998). *Brassica oleracea* is a plant of *Brassicacea (or Cruciferae) family*. It is a herbaceous, biennial and dicotyledonous flowering plant with leaves forming a characteristic compact cluster. The most commonly grown varieties of *B. oleracea* on Jos, Plateau are the green, red and Chinese cabbage, respectively in order of their demand. The favorable climatic condition of the Jos Plateau contributes immensely to the commercial and subsistence production of these (three) varieties (Osagie, 1998).

Brassica oleracea has both nutritional and medicinal benefits. The nutritional benefits among others include it's been a rich source of nutrients such as minerals (Ca, K, P, Fe, Mg and Zn), vitamins such as B-complex vitamins and ascorbic acid, carbohydrates, fats, proteins and water (Rosa, 1997). The medicinal health benefits are a function of the nutritional properties some of which include lower risk of heart attack, birth defects, lung cancer, obesity and intestinal un-comfortability (Osagie, 1998).

Several studies have indicated that vegetables such as cabbage have good nutritive value and potential for use as livestock feed (Wadhwa *et al.,* 2006; Tobias *et al.,* 2010; Wadhwa *et al.,* 2013). Cabbage may be fed freshly chopped or processed, such as when dried, composited in feed. Vegetables such as cabbage could also be transformed into value-added products (Laufenberg *et al.,* 2003). This non-conventional feed is highly sought after in arid regions, especially as maintenance feed during the dry season. Cabbage and cauliflower (*Brassica oleracea*) leaves have been reported to serve as excellent sources of nutrients for ruminants and can economize the production of animals (Wadhwa *et al.,* 2006). Also, Mekasha *et al*. (2002) have confirmed that cabbage contains 86 - 140 g dry matter (DM)/kg, 137 - 280 g crude protein (CP)/kg DM, 9 - 17 g ether extract (EE)/kg DM and 186 g crude fiber (CF)/kg DM. In addition, 10.2 MJ metabolizable energy (ME)/kg DM, an 80.4% *in vitro* dry matter digestibility (Mekasha *et al*., 2002) and 84% total digestible nutrients (NRC, 2007) were reported for cabbage, making it a good source of nutrients for ruminants.

However, *Brassica oleracea* varieties also contain corresponding high amounts of anti-nutrients such as S-methyl-L-cysteine, sulfoxide and glucosinolates that depress intake by ruminants (Barry *et al*., 1984; Barry, 2013). Phytic acid, cyanides, oxalates, tannins and glycosides have also been discovered in New Zealand which makes some of the mineral nutrients bio-unavailable due to process of chelation. Prolonged bio-unavailability of essential nutrients can result in metabolic derangement and may consequently lead to dietary deficiency diseases (Chipman, 1978). Liver is one of the largest delicate and complex organs in the body with enormous functions among which is osmo-regulation, detoxification and metabolism. Some of the normal roles of the liver may be altered if tissue injury occurs at specific sites (Berg, 2002). This is the case with prolonged use of the immuno-suppressive plant extract of *Brassica oleracea* for nutritional and medicinal purposes.

Due to its antioxidant, anti-inflammatory and antibacterial properties, cabbage has widespread use in traditional medicine, in alleviation of symptoms associated with gastrointestinal disorders (gastritis, peptic and duodenal ulcers, irritable bowel syndrome) as well as in treatment of minor cuts and wounds and mastitis (Samec, 2011). Fresh cabbage juice, prepared either separately or mixed with other vegetables such as carrot and celery, is often included in many commercial weight-loss diets (Samec, 2011),

diets that improve the bioavailable content of non-heme iron (Chiplonkar *et al.*, 1999), as well as alternative therapies for cancer patients (Maritess *et al.,* 2005). Clinical research has shown positive effects of cabbage consumption in healing peptic ulcers (Cheney, 1949), and facilitating the reduction of serum low-density lipoprotein (LDL) levels (Suido *et al.,* 2002). There are many reports about the phenolic substances and antioxidant activity of cabbage, many of them have focused on the Chinese cabbage or the red cabbage (Ahmadiani *et al.,* 2014). Seong *et al.,* (2016) studied the antioxidant capacities and polyphenolics of Chinese cabbage leaves, Watanabe *et al.,* (2011) investigated the polyphenol content and antioxidant activity of orange colored Chinese cabbage. Mizgier *et al.* (2016) reported the characterization of phenolic compounds and antioxidant properties of red cabbage. Leja *et al.* (2010) found phenolic compounds as the major antioxidant in red cabbage. Nonetheless, the systematic analysis of phytochemicals in cabbages and the comparisons between the different cabbage varieties were limited.

Chemical components analysis has shown that the main constituents of cabbage are carbohydrates, comprising nearly 90% of the dry weight, where approximately one third is dietary fiber and two thirds are low-molecular-weight carbohydrates. Other characteristic components are glucosinolates (Wennberg *et al.,* 2006). Interest in the role of free radical scavenging-antioxidants in human health has prompted research in the fields of horticulture and food science to assess the antioxidant phytochemicals in fruits and vegetables. Some studies have been conducted to quantify the phenolic compounds, carotenoids, vitamin C, and antioxidant potential Nilsson *et al.* (2006) and Kusznierewicz *et al.* (2008). The antioxidant properties were tested in many studies by using different approaches (Liu *et al.*, 2008; Zanfini *et al.*, 2010). The content of antioxidants depends on many factors, especially cultivars, stage of maturity and growing conditions (Hart and Scott, 1995). These antioxidants exist in nature in combination, and in combination they certainly cooperate on total antioxidant activity. The functional quality and antioxidant constituents of cabbage heads are strongly influenced by environmental factors and genetics.

The Ferric Reducing Antioxidant Power (FRAP), Trolox Equivalent Antioxidant Capacity (TEAC) and free radical scavenging activity (such as 2,2-Diphenyl-1-picrylhydrazyl (DPPH) assays are the three most frequently used for assessing the antioxidant activities (Magalhaes *et al.*, 2008).

The absence of antioxidant in dietary foods and vegetables is the primary cause of oxidative stress build-up in the body which has been the root cause of the development and progression of several diseases by damaging vital molecules in animal cells including DNA and proteins which are responsible for many body processes (Kasote *et al.,* 2013)

MATERIALS AND METHOD

Study Area/Study Location

The experiment was conducted in the toxicology laboratory of the National Veterinary Research Institute NVRI Vom, Plateau State, Nigeria . Vom,

Collection and Preparation of Plant Material

Fresh samples of each of the 3 commonly grown varieties of *Brassica oleraceape viridis, Brassica oleracea rupetris,* and *Brassica oleracea nepa* (green, red, and Chinese cabbage) respectively were collected from Bukuru market, Jos south L.G.A, Gwol market, Barikin ladi L.G.A and Qui market, Riyom L.G.A. The samples were identified by a botanist in Federal

College Forestry, Jos, Plateau State and processed according to (Thompson, 2003), and was then taken to the biochemistry laboratory of National Veterinary Institute (N.V.R.I) Vom, Jos, Plateau State, Nigeria for analysis according to Association of Official Analytical Chemists (AOAC), 1990).

Proximate Analysis

Proximate composition (moisture, ash, fat, protein, crude fiber and carbohydrate of *Brassica oleracea spp* was determined using the method of AOAC (1990).

Determination of Moisture Content

A crucible was thoroughly washed and dried in the oven at 100 °C for 30 min and allowed to cool inside a desiccator. After cooling, it was weighed and recorded as W_1. 1 gram of the sample was poured into crucible and weighed, and recorded as W_2. Then, the sample, plus the crucible, was placed in an oven at 100 °C for 2 hr, cooled in a desiccator and weighed for 30 min. The process was repeated until a constant weight (W_3) was obtained. The values obtained were used to calculate the percentage of moisture content.

Determination of Crude Fiber

1 g of the sample was hydrolyzed in a beaker with petroleum ether after which it was refluxed for 30 min with 200 ml of a solution containing 1.25% H_2SO_4 per 100 ml of solution. The solution was filtered through Whatman filter paper. After filtration, the sample was washed in a boiled water until the sample was no longer acidic. The residue was transferred through filter crucible and dried at 100 °C for 2 hr. The percentage crude fiber was thus calculated from the weight after drying and the weight of the sample using the formula below:

% Crude Fiber = $((W_2 – W_3) / W_1) X 100$
Where:
W_1 = sample weight (1 g)
W_2 = crucible weight with fiber and ashes, after drying in an oven at 130 °C for 90 minutes
W_3 = crucible weight with ashes, after muffle at 550 °C for three hours

Determination of Ash Content

1 g of the sample was weighed into a previously ignited and weighed crucible. The crucible and content were ignited in a preheated muffle furnace at 650 °C for 2 hr. The crucible was cooled in a desiccator to a constant weight, weighed and percentage ash content was calculated using the fulmar below:
Ash Content (%)=(Wsample$W$ash)×100
Where:
Wash = weight of the ash residue after combustion
Wsample = weight of the original sample

Crude Fat Determination

This was done by Soxhlet extraction method. 250 ml clean flask was dried in an oven at 105-110 °C for about 30 mi. 1 g of the dried sample was weighed accurately into labelled thimble then corresponding labelled cooled boiling flask was weighed. The boiling flask was filled with 100 mls of petroleum ether (Boiling point 40-60 °C). Extraction thimble was plugged lightly with cotton wool while the Soxhlet extractor apparatus was assembled and reflux for 3 hours. The thimble was removed with care and petroleum ether collected on the top container of the set up and drained into flask for re-use. When the flask was free of petroleum ether, it was removed and dried at 105-110 °C for 1 hr. The flask was transferred from the oven into a desiccator and allowed to cool, and then weighed. The weight obtained were used to calculate the percentage fat.

Determination of Protein

This was done by Kjeldahl method, which remains the most popular method of protein determination.

(a) Protein digestion: 1 g of sample was weighed into a Kjeldahl flask. 5 g of anhydrous sodium sulfate was added. This was followed with the addition of 1 g of copper sulfate and 1 tablet of Kjeldahl catalyst. Into the mixture, 25 ml of concentrated sulfuric acid and 5 glass beads were introduced. In the fume cupboard, heating was done gently at first and then increased in heat with occasional shaking till solution assumed a green color. The black particle that showed at the tip and neck of the flask was cooled and washed with the distilled water. Reheating was done gently at first until the green color disappeared and then allowed to cool. After the cooling, the digest was transferred with several washings into a 250 ml volumetric flask and filled to the mark with distilled water. Distillation was done using distillation apparatus.

(b) Protein distillation: The distillation apparatus was steamed for about 15 min before usage. Under the condenser, 100 ml conical flask containing 5 ml of boric acid indicator was placed such that the condenser tip was under the liquid. 5 ml of the digest was pipette into the body of apparatus through a small funnel aperture; the digest was washed down with distilled water followed by 5 ml of 60% NaOH solution. The mixture was steamed thoroughly for 5-7 minutes to collect enough ammonium sulfate. Then receiving flask and the condensed water were removed. Titration of the solution was made in the receiving flask using (0.1 M) sulfuric acid and calculation of the nitrogen content was done.

Determination of Carbohydrate

The total carbohydrate content of the sample was obtained from the relation; percentage carbohydrate = 100% - (moisture + ash + fat + crude fiber + protein) %

Anti-nutritional Analysis

Oxalate determination

In the determination of total oxalate, 1 g of the sample, 75 cm^3 of 15 N H_2SO_4 was added. The solution was carefully stirred intermittently with a magnetic stirrer for 1 hr and filtered using What-man No. 1 filter paper. 25 cm^3 of the filtrate was then collected and titrated against 0.1 N $KMnO_4$ solution until a faint pink color appeared that persisted for 30 sec (Umar *et al.,* 2007).

Phytate Determination

For determination of phytate, 4 g of the sample were soaked in 100 cm^3 of 2% HCl for 5 hrs and filtered. To 25 cm^3 of the filtrate, 5 cm^3 of 0.3% ammonium thiocyanate solution was added. The mixture was then titrated with iron (III) chloride solution until a brownish-yellow color that persisted for 5 min was obtained (Reddy*et al.,* 1999).

Tannin Determination

The tannin content was determined using Folin Denis reagent, in that method, a standard calibration curve was prepared and the Absorbance (A) against concentration of tannins at specific wave length was estimated as follows: Suitable aliquots of the tannin-containing extract (initially: 0.05, 0.2 and 0.5 cm3) were pipetted in test tubes, the volume was made up to 1.00 cm3 with distilled water, then 2.5 cm3 of sodium carbonate reagent were added. The tubes were shaken and the absorbance was recorded at 72 5nm after 40 min. The amount of tannin was calculated as

tannic acid equivalent from the standard curve (Abdel *et al.,* 2007).

Antioxidant Analysis

2, 2-Diphenyl-1-picrylhydrazyl (DPPH) Assay was used for this analysis which is popular in natural product antioxidant studies (Liu *et al.,* 2008).

Study Design

The data obtained was expressed in replicates of mean + standard error of the means (mean + SEM). Significant differences between means was determined by the student t-test (Bailey, 1992). The value of $p<0.05$ was regarded as significant for statistical comparison in all cases. Graph Pad Prism, Version 5.0, San Diego, CA (source???) was the statistical package used.

RESULT

The result in Table 1 showed that the moisture content in the Chinese cabbage was higher though not significant (P>0.05) compared to green and red cabbage with 7.13±3.43 in Chinese cabbage, red cabbage 6.33±0.00 and green cabbage 5.25±0.00. The crude protein C.P showed that Chinese cabbage had the highest C.P with 5.67±1.16 though not significant (P>0.05), while green cabbage 5.47±0.90 and red cabbage 5.11±0.20 with (P> 0.05) The crude fiber (C.F) showed that the Chinese cabbage contained the highest C.F with 11.80±3.11, red cabbage 7.06±2.54 and green cabbage 7.00±3.04 with (P>0.05) which indicate there is no significant difference between them. Lipid showed that the red cabbage has the highest 2.15±0.00, green 0.40±0.00 and Chinese cabbage 0.10±0.00 with (P<0.05) which indicate there is significant difference between them. The Ash content showed that green cabbage has the highest with 6.15±0.00, red cabbage 5.10±0.17 and Chinese cabbage 2.25±0.00 with (P<0.05) indicating there is significant difference between them. The nitrogen free extract NFE showed that the green cabbage has the highest with 9.35±1.11 and red cabbage 8.26±2.20, Chinese cabbage 6.37±2.27 with (P>0.05) which indicate there is no significant difference between them. The metabolizable energy M.E was seen to be high in the green cabbage with 62.9±22.40, red cabbage has 56.85±31.42 and Chinese cabbage 48.4±2.71 with (P>0.05) which indicate that there is no significant difference between them. Calcium showed that there was significant difference between the 3 varieties with (P<0.05) Chinese cabbage having the highest with 0.33±0.00. Phosphorus also showed that there was significant difference between the 3 varieties with (P<0.05) green cabbage having the highest 0.05±0.00, Chinese cabbage having 0.04±0.00 and red cabbage having 0.02±0.01.

The result in Table 2 showed that the amount of phytic acid in Chinese cabbage was higher 18.26±1.32 than red cabbage 15.88±0.75 and green cabbage being the lowest 10.12±1.52 with (P>0.05) which indicate there is no significant difference between them. Tannins was seen to be in high concentration in the red cabbage 2.63±0.41 compared to Chinese cabbage 2.55±0.35 and green cabbage being the lowest 1.72±0.54 with (P>0.05) indicating that there was no significant difference between them. Lastly oxalate was seen to be in high concentration in the Chinese cabbage 220.00±5.74 compared to red cabbage 130.00±3.48 and green cabbage been the lowest 112.50±4.56 with (P<0.05) which indicate there is significant difference.

Using vitamin C at 2 mg/ml as a standard antioxidant in DPPH assay according to Liu et al., (2008), the result was expressed in various concentration levels and assed for scavenging radicals. At 200 ml, Chinese cabbage has the highest 28.66±2.88 and green cabbage having the lowest 24.33±9.81 with (P>0.05) which indicate no significant difference between them.

Table 1. Proximate composition of *B. oleracea* species (Green, Red and Chinese) cabbage

Sample	Green cabbage	Red cabbage	Chinese cabbage	P-value
Moisture	5.25±0.00	6.33±0.00	7.13±3.43	0.541
C.P	5.47±0.90	5.11±0.20	5.67±1.16	0.736
C.F	7.00±3.04	7.06±2.54	11.80±3.11	0.147
Lipid	0.40±0.00	2.15±0.00	0.10±0.00	0.020
Ash	6.15±0.00	5.10±0.17	2.25±0.00	0.000
N.F.E	9.35±1.11	8.26±2.20	6.37±2.27	0.242
M.E	62.9±22.40	56.85±31.42	48.4±2.71	0.739
Calcium	0.33±0.00	0.76±0.00	2.28±0.49	0.000
Phosphorus	0.05±0.00	0.02±0.01	0.04±0.00	0.017

Table 2: Anti-nutrient analysis on *B. oleracea* species (Green, Red and Chinese) cabbage

Anti-Nutrient (mg/100g)	Green cabbage	Red cabbage	Chinese cabbage	P-values
Phytic acid	10.12 ± 1.52	15.88 ± 0.75	18.26 ± 1.32	0.108
Tannins	1.72 ± 0.54	2.63 ± 0.41	2.55 ± 0.35	0.678
Oxalate	112.50 ± 4.56	130.00 ± 3.48	220.00 ± 5.74	0.009

Table 3: Antioxidant analysis on *B. oleracea* species (Green, Red and Chinese) cabbage using DPPH assay

Average /µg/ml/2mg/ml Std Vit. C	Green cabbage	Red cabbage	Chinese cabbage	P- value
200 ml	24.33±9.81	26.66±2.88	28.33±6.65	0.791
150 ml	20.33±8.8	25.33±4.50	26.33±6.35	0.517
100 ml	19.33±1.15	24.66±5.50	25.00±5.00	0.276
75 ml	16.33±2.30	22.66±4.04	17.66±4.04	0.150
50 ml	14.33±1.15	20.33±8.08	10.00±0.00	0.092
25 ml	14.66±8.08	7.66±4.04	8.33±2.88	0.298
15 ml	9.33±1.15	6.66±2.88	4.33±1.15	0.050
5 ml	7.33±2.51	3.33±0.59	3.00±0.00	0.021

At 150ml also Chinese cabbage has the highest 26.33±6.35, Red cabbage having 25.33±4.50 and green cabbage having the lowest 20.33±8.80 with (P>0.05) which indicate there is no significant difference between them. At 100ml, there is also no significant difference between them (P>0.05 with Chinese cabbage having the highest 25.00±5.00, red cabbage having 24.66±5.50 and green cabbage having the lowest value 19.33±1.15. At 75ml, red cabbage having the highest value of 22.66±4.04 and green cabbage having the lowest value 16.33±2.30 with (P>0.05) which indicate there is no significant difference between them. At 50 ml, red cabbage has the highest value with 20.33±8.08, green cabbage having 14.33±1.15 and Chinese cabbage having the lowest with 10.00±0.00 with (P>0.05) which indicate no significant difference between them. At 25ml, green cabbage has the highest value of 14.66±8.08 and Chinese cabbage 8.33±2.88 and red cabbage having the lowest value of 7.66±4.04 with a (P>0.05) which indicate there is no significant difference between them. At 15ml green cabbage was seen to have the highest value of 9.33±1.15 and red cabbage has 6.66±2.88 and Chinese cabbage has the lowest with (P<0.05) which indicate there is significant

difference between the 3 varieties. At 5 ml, there is also a significant difference between the 3 varieties with green cabbage having the highest value of 7.33±2.51 and red cabbage having 3.33±0.59, Chinese cabbage having the lowest value of 3.00±0.00 ($P<0.05$).

DISCUSSION

The result in Table 1 showed that moisture content in *Brassica oleracea rupa* (chinese cabbage) was higher compared to *B. oleracea rupetris* and *B. oleracea peviridis* (red and green) cabbage of which there was no significant difference between them (Tunde, 1998). High moisture content above 15% in fruit and vegetables was reported by Rumeza *et al.* (2006) to favor microbial activity during storage. There was no significant difference between the crude fiber (CF), crude protein (CP), ash, nitrogen free extract (NFE), metabolizable energy (ME), phosphorus and calcium with ($P>0.05$). this research disagrees with the study of Mohammed and Luka, (2013) who stated that there was significant difference between the proximate parameters of the 3 varieties of *Brassica oleracea species* (green, red and Chinese) cabbage in his study. This could be attributed to the location and environmental factors such as Temperature, humidity, rainfall, soil nutrient and soil pH in which the samples were obtained from (Bernacchia *et al.,* 2016). Soil pH is part of the main factor governing the solubility and bioavailability of soil element leading to accumulation of nutrient in plant (Dewangan *et al.,* 2023). The age and stage of harvesting the Brassica species could also influence the nutrient availability of the plant (Bohinc *et al.,* 2012).

The result in Table 2 showed a high level of phytic acid in *B. oleracea rupa* (Chinese cabbage) compared to *B. oleracea rupetris* and *B. oleracea peviridis* (red and green cabbage) with ($P>0.05$) indicating that there is no significant difference between them. Tannin was also observed to be higher in both *B. oleracea rupa* and *B. oleracea rupetris* (Chinese and red cabbage) with ($P>0.05$) indicating no significant difference between them. This result agrees with the study of Mohammed and Luka, (2020) that both phytic acid and tannin were observed to be in high concentration in both *B. oleracea rupa* and *B. oleracea rupetris* (Chinese and red cabbage). Oxalate on the other hand was observed to be significantly low in the green cabbage *B. oleracea peviridis* compared to the Chinese and red cabbage (*B. oleracea rupa* and *B. oleracea rupetris*) with ($P<0.05$).

The result in table 3 showed the scavenging activities of free radicals using DPPH assay at different level of concentrations using vitamin C as a standard (Malencic *et al.,* 2000). This result is in line with Ayushi *et al.,* (2017) who stated that *B. oleracea* leave exhibited high scavenging activity at IC_{50} (20µg/ml). At 15ml and 5ml there was significant difference between the three varieties of *B. oleracea* with green cabbage showing a high level of scavenging activity. This agrees with the study of Agarwal *et al*. (2017) that maximum DPPH scavenging activities were found in aqueous extract of *B. oleracae peviridis* (green cabbage).

CONCLUSION

B. oleracae rupa (Chinese cabbage) was found to contain more dietary nutritional properties such as high crude protein and crude fiber while *B. oleracae peviridis* (green cabbage) has more vitamins and mineral properties such as ash, phosphorus, nitrogen free extract (NFE) and metabolizable energy (ME). The anti-nutrient analysis showed that both *B. oleracea rupa* and *B. oleracea rupetris* (chinese and red cabbage) have higher concentration of phytic acid, Tannin and Oxalate than *B. oleracae peviridis* (green

cabbage) while the Antioxidant analysis showed the green cabbage (*B. oleracae peviridis)* has the highest scavenging activities making green cabbage the most suitable variety for both animal and human consumption among the 3 varieties of *B. oleracae*s pecies.

RECOMMENDATIONS

Brassica oleracea peviridis (green cabbage) could be used as feed supplement to feed animals conveniently. Further research should be carried out on how to improve the dietary nutrient such as crude protein, and crude fiber of *Brassica oleracea peviridis* (green cabbage). Method and techniques on how to lower the Anti-nutrient should be adopted to reduce the risk factor of chronic health disorder associated with plant Anti-nutrient.

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PHOSPHORUS-DEFICIENCY IN SAVANNA SOILS: A CONCISE REVIEW ON TWO SITES IN SUDAN AND NORTHERN GUINEA AGRO-ECOLOGICAL ZONES OF NIGERIA

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ABSTRACT

Phosphorus (P), the second most critical plant growth nutrient element, is usually not readily available in tropical soils. The paper provides a concise examination of the status of phosphorus deficiency in savanna soils, focusing specifically on a location within each of Sudan and northern Guinea savannah agro-ecological zones of Nigeria. The paper also discusses the significance of phosphorus on agricultural productivity, vis-à-vis exploring the factors contributing to phosphorus deficiency in these particular locations, and potentially offers insights into potential solutions or management strategies to address this issue. By concentrating on these specific locations, the paper aims to provide a targeted analysis that can inform local agricultural practices and policies related to soil fertility management.

Keywords: Minjibir, Northern Guinea savanna, P-deficiency Samaru, Sudan savannah

INTRODUCTION

Phosphorus (P) is a general term used whenever a particular chemical P form is not referred but it also refers to the element. Total P content of a soil or plant material is, for example, usually expressed in a percent of P. Fertiliser analyses are, however, mostly reported as a percent of phosphate or oxide form (*i.e.*, P_2O_5). The phosphate form (P_2O_5) is a chemical that is produced in the fertiliser analysis process but does not exist in either soils or fertilisers as reported in a work of Busman *et al*. (2008) . Like some other nutrient elements, the availability of P for plant growth is very limited. This is especially in calcareous soils, the reason being that most of the P is fixed with a concomitant very low rate of recovery. Vance *et al.* (2000) reported that P is the most important macronutrient after nitrogen (N) that is very essential for the continued existence and stability of life. This nutrient element (P) is also often the most limiting for crop and forage production. Its critical role in a crop plant is to store and transfer photosynthetically-produced energy for use in the processes of growth and production, as highlighted by Panhwar *et al.* (2011). Similar to such nutrients as N, K and Mg, however, P is also "mobile", a term used for nutrients that are easily translocated within plants. Such other nutrients as Fe, Zn, Ca and B, are referred to as immobile, as they don't move around the plant system.

Phosphorus is highly vulnerable to fixation by sesquioxides and mineral P fertilisers may, on the other hand, not be readily available and/or affordable to smallholder farmers of the

Nigeria's agro-ecologies. About thirty years ago, concerns were raised on noxious nutrient exports from sub-Saharan Africa. Export of stimulant crops alone was reported to deplete about 50,000 tons of P from the region in the year 2007. This was rated one-fifth of annual P use. Some researchers observed this to have amounted to a doubled P exports against a stagnant P fertiliser use of over two decades. Over three decades of ceaseless harvests, without a commensurate replenishing fertiliser application, a depletion of 75 kg P ha^{-1} from 200 million ha of cultivated land was bitterly estimated in 37 African countries. This was equivalent to no less than 3.3 kg P ha^{-1} yr^{-1} as reported in some studies which was, consequently, forecasted to a hike of 6 kg P ha^{-1} yr^{-1} in the nearest 2020s unless a 7% increase in growth of fertiliser P use is achieved per year. This poses a serious threat which necessitates urgent attention with a view to juxtaposing the menace. Only moderate P quantities, however, are required to defeat P deficiencies and effectively satisfy crops' needs in the savanna. The importance of studying the trend of this nutrient element may, therefore, not be over-measured. This paper sought to concisely review swift trend in phosphorus and its deficiency in Nigeria with reference to a selected location in each of Sudan and northern Guinea savanna agro-ecologies of Nigeria.

Adequate level of P also enhances, amongst others, root growth and general plant growth and stimulate tillering/branching and early flowering (Gabasawa, 2011; Gabasawa *et al*., 2017, 2018). It also hastens crops' maturity (Panhwar *et al.*, 2011; USDA Soil Survey Staff, 2014). It is also important for many such other functions as metabolic activities, especially the synthesis of protein (Panhwar *et al.*, 2011). Phosphorus is an integral component of adenosine triphosphate (ATP) and adenosine diphosphate (ADP) molecules, phospholipids and nucleic acids, which are significantly available in cellular membranes, and provide the essential compounds for plants' and animals' photosynthesis and respiration respectively. Many other elementary and principal roles of P exist in diverse physiological processes of plants, including the utilisation of sugar and starch; and energy transfer. Aside from this critical metabolic role, P is still also an indispensable structural component of many molecules, such as the earlier mentioned nucleic acids, which are the building blocks of genes and chromosomes in the nucleus of cells (Rai *et al.*, 2013). Under the same *pH* level, studies have indicated that soils with higher clay contents have an elevated P fixing capacity compared to soils with higher sand separates (Bainbridge *et al.*, 1995) and that organic matter immensely contributes to P availability in soils as reported by Owusu-Bennoah and Acquaye (1989), amongst other researchers.

A study conducted in northeast France, aimed at evaluating soils' phosphate-fixing capacity by isotopic exchange techniques, revealed that there was a tremendously significant correlation between *pH*, the quantities of P fixed, exchangeable cations, clay content and soluble phosphate (Morel *et al*., 1989). Also, Owusu-Bennoah and Acquaye, (1989) similarly studied the characteristics of phosphate-sorption of some soils in Ghana to find that the sorption maxima were highly correlated with the soil properties in the order of Al_2O_3 > clay content > free Fe_2O_3 > organic C. Plant available P soil tests are used in the determination of soils' current P status globally to estimate fertiliser P requirements for precision agricultural yields. A normal soil P management approach is, therefore, to (i) determine the exact soil 'available' P level using a predefined soil test extractant, and (ii) compute the soil P deficit from the difference between a known critical level applicable to that particular crop, usually established using field trial calibration studies, against the available P level

obtained from soil P-test. This deficit is then converted into a mass of nutrients required per unit area by multiplying the same with a conversion factor that reflects the soil properties dictating the P-sorption and the depth of incorporation of the fertiliser P, referred to as the P requirement factor (PRF). Thus:

$$Field\ P\ requirement\ (kg/ha) = (optimum\ soil - measured\ soil\ P)\ x\ PRF\ \ldots.(eqn.1.1)$$

Therefore, PRF can be defined as a soil specific factor representing the P quantity needed per hectare for a unit P rate increase for a given soil test and that allows for the P fixation effect on the recovery of an added P (Henry and Smith, 2004). Hence, for a particular soil P-test, PRF has been shown to widely differ across diverse soils due to P sorption differences in soils as also stated by Henry and Smith (2004). However, the determination of PRF, for a particular soil is laborious as it involves: (i) a 6-week incubation experiment, (ii) the P extraction process, and (iii) plotting the P amount recovered in the extraction solution and the added P (Johnston *et al.*, 2014; Henry and Smith 2004). A linear regression function generally results from this relationship, the inverse of which slope is the PRF for the given soil. The PRF is a characteristic that varies widely across different soils for a particular soil P-test. In some studies, like Johnston *et al*. (2014), a range in PRF values varied amongst soils and corresponding extraction methods so also level of P sorption was strongly related to 2:1 clay minerals and clay content as observed by Poswa (2016).

Phosphorus Deficiency of Savanna Soils

Deficiency of phosphorus is a plant disorder that is markedly associated with an insufficient P supply, not to be confused with N-deficiency. Phosphorus, in this context, refers to the salt of monohydrogen (HPO_4^{2-}) and dihydrogen ($H_2PO_4^-$) phosphates. These are readily interconvertible anions which are also the predominant species that are determined by the solution or soil *pH*. Phosphorus deficiency symptoms in plants include poor growth and bluish/greenish colouration of leaves but not yellowing. The oldest leaves are first affected. Phosphorus deficiency could be corrected through the application of P-based fertilisers (Heinrich, 2000). Low inherent nutrient reserves, high P fixation, noxious erosion, frequent moisture stress problems, low soil biodiversity and high acidity with aluminium toxicity are amongst the main factors militating against soil fertility and sustainable agriculture in the tropics as opined by Cardoso and Kuyper (2006), amongst many other scientists. Hence, a lot of tropical soils are vulnerably very fragile thereby limiting their food production efficiency.

Generally, P is one of the most important nutrient elements that determine plant growth and in most savanna soils it exists in forms that are largely unavailable for plant uptake (Zafar *et al*., 2011). This unavailability results from low content of crystalline clays (*e.g.*, bentonites), high content of low specific surface area minerals (*e.g.*, kaolinite) as well as oxides and hydroxides of aluminium and iron (*i.e.*, sesquioxides) thereby rendering a large proportion of soil P unavailable for plant uptake (Nwoke *et al*., 2004). Variable charge minerals such as aluminosilicates are also major components of most savanna soils that make P unavailable to plants. Tsado *et al*. (2012) reported that most savanna soils of Nigeria consist of these variable charges dominated by Oxisols, Ultisols, and Alfisols soil orders. According to Nwoke *et al*. (2004), P can be as low as 2 mg kg^{-1} in the savanna soils of Nigeria thus, making it to be one of the most limiting nutrients in those soils. Kamara *et al*. (2008) reported that P levels were lower than critical values of 7 mg kg^{-1} (Mehlich-3 extractable P) in 92% and 93% of the fields surveyed in the northern Guinea savanna and the Sudan savanna

agro-ecologies of Nigeria, respectively. According to a report by Kwari (2005), mean soil P levels range from 1.50 to 2.51 mg kg^{-1} in dry savanna of Nigeria and from 3.68 to 4.70 mg kg^{-1} in the moist savanna. Earlier, Mokwunye (1979) reported that the P content of some savanna soils was about 100 to 400 mg P kg^{-1}. Albeit, Uyovbisere (1979) later reported that less than 10% of the quantities are said to be inactive or in labile forms (*i.e.*, Al-P, Fe-P and Ca-P) depending on the factors in a given location (Gabasawa, 2021).

Phosphorus deficiency affects an area estimated at more than 2 x 10^9 hectares (Fairhust *et al.*, 1999) in almost all crops and hence its effect on declining crop production (Nto, 1995). Overcoming P deficiency in savanna soils is one of the major challenges that smallholder farmers are facing. Therefore, improved P acquisition is essential in order to improve crop yields in extremely low-P conditions (Xiurong *et al*., 2011). Fortunately, however, only some moderate P quantities are needed to reverse P deficiencies and satisfy crop needs in the savanna soils effectively (Agboola and Obigbesan, 1974; Uyovbisere and Lombin, 1991). The amount of fertiliser P to be applied will be reduced when the soil has high initial P content and, consequently, the P in soil could be more judiciously utilised (Nto, 1995).

Phosphorus Trend of Minjibir and Samaru

A result of P fractionation studies conducted by Gabasawa (2021) on soils of two agro-ecological locations of Nigeria (Figure 2a and Figure 2b) is presented in Figure 1. It indicates that, aluminium-bound (Al-P, 3.0 mg kg^{-1}) and iron-bound P (Fe-P, 5.0 mg kg^{-1}) were lower in Sudan savanna (SS) soil of Minjibir (Figure 2a), compared to that of northern Guinea savanna (NGS) of Samaru (Figure 2b) with 4.0 and 7.0 mg kg^{-1}. However, all other P fractions, including the easily available (*i.e.*, saloid-) P forms (Sarkar *et al*., 2014), were relatively higher in the NGS Samaru soil (Figure 1). A recent study by Ahmed *et al*. (2018) revealed that despite a low $NaHCO_3$-extractable P, 2-3 mg P kg^{-1} was realised in soils of central Sudan. Also, many crops showed an unpredictable response to P fertilisation as also earlier reported by Dawelbeit *et al*. (2010). A limit of 5 mg P kg^{-1} was, however, set by The Soil Science Society of America between sufficiency and deficiency of soil P (Olsen and Sommers, 1982).

Also, in a study by Nishigaki *et al*. (2018), ammonium-oxalate extractable Al (Al_o) was suggested to have possibly caused an accumulation of Al-P. Also, ammonium-oxalate extractable Fe (Fe_o) and sodium dithionite extractable Fe (Fe_d) were observed to generally be responsible for high Fe-P ($NaOH\text{-}P_i$) and residual P contents, respectively (Nishigaki *et al*. (2018). The Al_o played a role in organic P and Al-P accumulation in three Tanzanian geological groups (Lair *et al*., 2009; Nishigaki *et al*., 2018). There was, therefore, an observed diversity and abundance of soil P forms that greatly differed between sites with different soil-related geological conditions. Values of Fe_o/Fe_d within a range of 0.3–0.8 are considered high (Lair *et al*. 2009). There was, therefore, a similarly observed high Fe_o/Fe_d values for both [Minjibir (0.26) and Samaru (0.29)] locations. This, generally, indicated a relative less predominance of such crystalline forms of Fe as goethite and haematite (Agbenin, 2003). The Fe_o/Fe_d is indicative of the degree of crystallinity of Fe oxides (Lair *et al*. 2009). Similarly, Minjibir (Figure 2a) in the Sudan savanna (SS) had the highest sodium-pyrophosphate extractable Al (Al_p) of 2500.0 mg kg^{-1} compared to the 166.0 mg kg^{-1} observed for Samaru (Figure 2b) in the northern Guinea savanna (NGS). Also, the values for Na-pyrophosphate oxides of Fe and Mn (Fe_P and Mn_P) were higher in NGS (634.7 and 16.5 mg kg^{-}

[1], respectively) than in the SS (235.3 and mg kg[-1], respectively). The sodium citrate-sodium bicarbonate-sodium dithionite (C-B-D)-extractable Al_d, Fe_d and Mn_d were predominantly the highest in the NGS (150.0, 2479.2 and 137.0 mg kg^{-1}, respectively) than in the SS (84.0, 1929.8 and 21.0 mg kg^{-1}, respectively) as depicted in Figure 3.

Variations of the two agro-ecological locations, in terms of soil texture and climatic conditions, notably precipitation, may in part be the reason behind the observed disparity in terms of preponderance of the metal oxide fractions. For example, soil water from precipitation may turn an insoluble ferric (Fe^{3+}) into a more soluble ferrous (Fe^{2+}) iron form, which is prone to leaching. Solid phase $Fe(OH)_3$ precipitates out of soil solution. Also, fresh $Fe(OH)_3$ precipitates is reported as having overwhelming P sorption capacities. They can also result in reduced soluble P levels by orders of magnitude in a few minutes as observed by Moore and Reddy (1994) and Graetz and Nair (2000). It may have also co-migrated with clays or may be due to differences in soil organic matter contents of the sites.

Phosphate sorption, by iron (Fe) and aluminium (Al) oxides and amorphous materials in soils, is a major factor that contributes to a reduced effectiveness of added phosphates, which necessitates larger fertiliser P applications before achieving a good crop yield (Warren, 1994). Roles of amorphous Al and Fe oxides on P sorption have been well recorded (Janardhanan, 2007). An active amorphous Al per mole can adsorb almost twice as much P as an active amorphous Fe (Darke and Walbridge, 2000). This, for example, suggests the soil in the NGS Samaru to relatively be more vulnerable to higher capacity for P-fixation than that of SS Minjibir. This is basically because aluminium oxides have been reported to be much more effective in adsorbing phosphates in soils when compared to iron oxides (Borggaard, 1986).

The amorphous form of both Al and Fe were, however, reported to be important predictors of soil P-sorption capacity in peaty, clayey and sandy soils (Borggaard *et al*., 1990; Freese *et al*., 1992). Amorphous Al and Fe correlated well with the soil organic matter in a study by Darke and Walbridge (2000).

Soil Al, Fe and Mn Fractions in the Surface Soils of the Nigeria's Sudan and Northern Guinea Savannas Experimental Sites

The result of Al, Fe and Mn fractionation reported by Gabasawa (2021, as presented in Figure 3, indicates that the ammonium-oxalate extractable Al (Al_o) for the SS Minjibir (997.0 mg kg^{-1}) was higher than that observed for the NGS Samaru (805.50 mg kg^{-1}). Conversely, the Fe_o and Mn_o were observed to be higher in the NGS Samaru (714.0 and 63.7 mg kg^{-1}, respectively) than Minjibir (503.9 and 25.8 mg kg^{-1}) locations.

Phosphorus Sorption Characteristics 0f Surface Soils in the Nigeria's Sudan and Northern Guinea Savannas Experimental Sites

The result of P sorption studies for the surface soils of the two experimental sites, also reported by Gabasawa (2021), is presented in Table 1. The experimental soils were observed to substantially differ in their P sorption characteristics. Thus, it indicated that the NGS Samaru soil had a relatively higher integral P sorption capacity when compared to SS Minjibir soil. The P remaining in the soil solution comparatively differed after spiking the experimental soils with the same quantity of P (Table 1). Among the most essential factors that determine rate of P diffusion in soils is P concentration in the solution. There must, therefore, be an adequate quantity of P in the soil solution prior to its judicious movement from the solution to root tips of plants. A given quantity of

applied P in dissimilar soils will result in different quantities of soil P, as soils differ in their P sorption capacity characteristics.

A considerably higher P sorption index (PSI) was observed in soils of Minjibir when compared to the Samaru locations. This was further stressed by the relatively lower P in solution observed in the Minjibir soil (Table 1). This clearly indicated that soil in Minjibir was of a higher P buffering capacity (Moody and Bolland, 1999). Phosphate sorption index, being a reliable standard of soil P sorption potential (Bruland and Richardson, 2004) has reaffirmed the P sorption observed for the soil. Furthermore, the higher extractable amorphous (*i.e.*, NH_4-oxalate extractable) Al and Fe recorded for Minjibir soil were also corroborative of the different P sorption capacities observed for soils of the two locations. This is because the amorphous Al and Fe have been reported to closely predict PSI (Darke and Walbridge, 2000; Bruland and Richardson, 2004).

Comparison between P application effects on two different soils, having different sorption capacities, is as such, very bothersome. A logical resolution to this problem is, however, to make comparisons on the basis P concentration remaining in soil solution not on the added quantity.

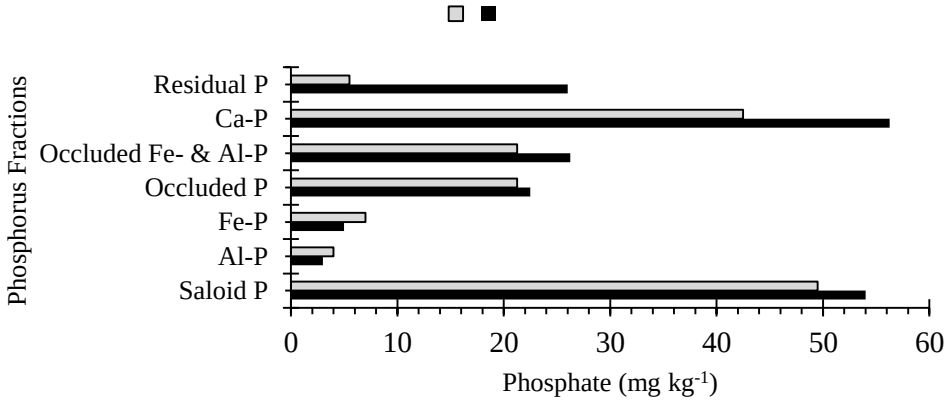

Figure 1. Phosphorus fractions of soils of Nigeria's Sudan and northern Guinea savannas experimental sites

Figure 2a. Minjibir, Sudan savanna agro-ecology, Nigeria

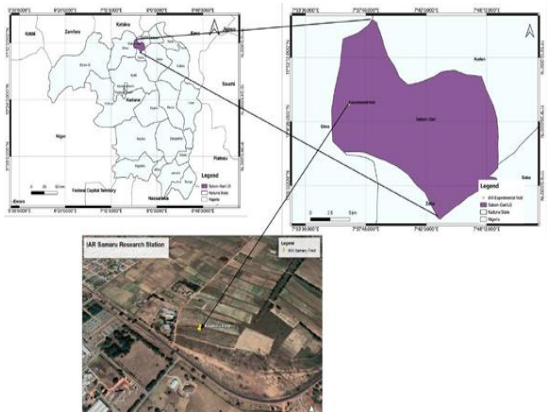

Figure 2b. Samaru, northern Guinea savanna agro-agro-ecology, Nigeria

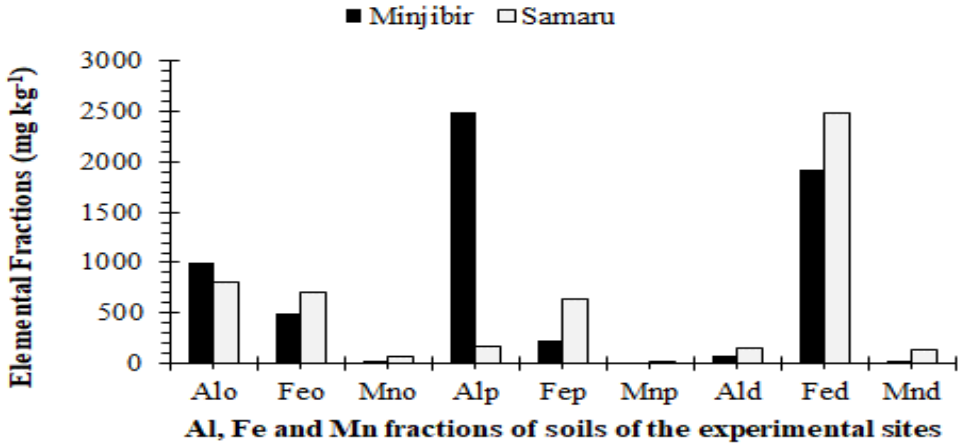

Figure 3: Al, Fe and Mn fractions of soils of Nigeria's Sudan and northern Guinea savannas experimental sites

Table1. Phosphorus sorption studies result of the surface soils of Minjibir and Samaru savannah experimental sites

S/No.	Quantity of P added (mg P kg^{-1} soil)	Minjibir (Sudan Savanna)			Samaru (Northern Guinea Savanna)		
		P in soln. (mg kg^{-1})	P sorbed	PSI	P in soln. (mg kg^{-1})	P sorbed	PSI
1	Control	0.01	- 0.09	0.05	0.28	- 0.28	0.18
2	0.00	0.07	32.68	-27.59	2.43	30.90	-50.29
3	30.00	0.64	60.22	-315.81	3.55	63.12	-140.34
4	90.00	2.72	72.81	167.64	9.34	90.66	-3069.30
5	300.00	4.27	90.64	143.78	52.97	80.36	110.99
6	600.00	5.33	113.41	156.15	57.36	109.30	144.08
7	1000.00	6.35	136.47	169.96	69.98	130.02	153.89

soln. = Solution; PSI = Phosphorus sorption index

The interrelationship between the quantity of P added to a soil and that remained in the solution phase is best portrayed by developing the P-sorption isotherm of that particular soil. The amount of P sorbed in this study (Gabasawa 2021), was observed to gradually increase with an increased P application to soils of both locations. A similar increase in P sorption with increased solution P was also variously reported in studies of Naseri *et al*. (2010) and Hossain *et al*. (2012).

Phosphorus (P) sorption, commonly defined as phosphorus buffering capacity (PBC), which is the capacity of soil to moderate solution-P concentration changes when it is removed from or added to the soil (Ozanne, 1980), is a crucial phenomenon. It describes soil P partitioning between the sorbed and solution P phases. Soil PBC has critical implications for management of P fertiliser from both environmental and productivity perspectives. It (PBC) affects P-sorption extent and precipitation reactions that decrease fertiliser P availability (Moody and Bolland, 1999), thereby influencing the P fertiliser quantity required to improve the availability of fertiliser P for plant growth and development (Dear *et al*., 1992; Burkitt *et al*., 2001; Burkitt *et al*., 2008; Burkitt *et al*., 2010). A PBC estimate is also needed for certain soil P tests so as to adjust critical soil test concentrations for different soil types (Moody and Bolland, 1999). The use of PBC, in addition

to improving P fertiliser accuracy of recommendations, may also prevent excessive application of P fertiliser and off-site movement of P, a major cause of eutrophication and algal blooms in waterways (Sharpley *et al*., 1987). Phosphorus sorption index is needed to accurately predict PBC (Dear *et al*., 1992).

CONCLUSION

Low quantities of total and available P in soils makes it necessary for P availability investigations. Besides, judicious reclamation of P-deficient soils, such as those found in the savanna zones of Nigeria, and elsewhere, remains one of the cardinal questions awaiting answers. Addressing phosphorus deficiency in savannah soils of Sudan (Minjibir) and the Northern Guinea savannah (Samaru) agro-ecological zones of Nigeria is crucial for sustainable agriculture and food security. By understanding the unique challenges posed by phosphorus deficiency in these regions and employing appropriate management practices, farmers can improve soil fertility, enhance crop productivity, and ensure long-term agricultural sustainability.

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PHYTOCHEMICAL SCREENING AND CYTOTOXIC ACTIVITY OF HYDROETHANOLIC EXTRACT OF RED-VEINED PIE PLANT (*Rheum emodi*)

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ABSTRACT

The hydroethanolic extract of the Rheum emodi was prepared and was subjected to phytochemical screening in other to monitor the active phytoconstituents. Quantitative analysis of the total phenolic content of the extract was determined by the Folin–Ciocalteu method. Cell cytotoxicity of Rheum emodi was checked against macrophage cell line by MTT assay. It was observed that Rheum emodi extract consists of mixture of phytochemicals which include: Phenols, flavonoids, tannins, terpenoids and alkaloids. However, saponins were found to be absent in the hydroethanolic extract. It was found that hydroethanolic extract of Rheum emodi has total phenols 248.22 ± 2.3 mg gallic acid/g. The cytotoxicity increases with increase in the concentration of the extract of Rheum emodi and CC_{50} of extract was found to be 525.73 ± 3µg/ml at 72 hrs. It is known that higher the CC_{50} value, safer is the drug. Therefore, Rheum emodi extract can be a used for the treatment of several immunosuppressive diseases.

Keywords: phytochemical, Cytotoxic, hydroethanolic, extract, Rheum emodi

INTRODUCTION

Red-veined pie Plant (*Rheum emodi*) is the popular medicinal plant widely used in system of medicine, it is utilised in several pharmaceutical industries due to its extremely valued therapeutic properties which are antimicrobial, antiulcer as well as anti-fungal (Daniyal*et al*., 2019). Roots and rhizomes of this plant contain secondary metabolites like anthraquinone (emodin, aleo-emodin, rhein, chrysophanol, physcion), stilbene (piceatannol, resvertrol) which are employed in the cure of several type of cancers and other illnesses such as migraine, jaundice, asthma, headache, paralysis, and hepatic diseases etc (Singh *et al*., 2017; Daniyal*et al*., 2019). *Rheum emodi* displayed a nephron protective activity against gentamicin, potassium dichromate, and cadmium chloride induced nephrotoxicity in rats (Alam *et al*., 2005). *R. emodi* possess an immuno-enhancing effect through the release of numerous cytokines. Administration of *Rheum* extract caused a dose dependent upsurge in the secretion of NO (nitric oxide) and cytokines TNF-α, IL-12 and a decrease in IL-10 in

macrophage cell lines (Singh *et al*., 2017). The secretion of TNF-α and IL-12 induces generation and proliferation of Th-1 cells which in turn produces Natural Killer and cytotoxic T-cells. On the other hand, the decreased levels of IL-10 switch off the Th-2 immune system and directs the cell towards Th-1 immune response only (Daniyal *et al*., 2019). Methanolic extract of *Rheum* possesses antifungal activities against *Candida albicans*, *Cryptococcus neoformans*, *Aspergillus fumigates* and *Trichophyton mentagrophytes* (Agarwal *et al*., 2000) and antimicrobial activity against *Pseudomonas aeruginosa* and *Bacillus megaterium* (Ahmad and Salam, 2015). Ethanolic extract of *R.emodi* exhibit gastroprotective and anti-oxidant activities (Kaur *et al*., 2012).The aim of the present study was to determine the phytochemical composition and cytotoxic potential of *Rheum emodi* on *RAW* macrophage cell line.

MATERIALS AND METHODS

Plant Materials

The roots of *Rheum emodi* Wall. ex Meissn was obtained from Java botanical garden, It was identified in Horticulture unit, Agricultural Technology department Federal college of Agricultural produce Technology Kano. The plant specimens were washed thoroughly with water, dried at room temperature grind into powdered and was stored in a tight container.

Preparation of the Extract

Dried powdered roots of *Rheum emodi* was dissolved in 70% ethanol, where the hydro-ethanol extract was prepared by Soxhlet apparatus. About 250 ml of 70% ethanol was added to 100g dried powdered form of *Rheum emodi* in a round bottom flask. The extract was concentrated under vacuum in a rotary evaporator method adopted according to Srinivasarao *et al.*, 2015. The residues obtained was lyophilized and stored at –4°C for further use.

Phytochemical Screening of Plant Extracts

Qualitative tests was done to monitor the numerous phyto constituents such as alkaloids, saponins, tannins, phenols, terpenes, flavonoids and glycosides all methods were adopted from Tiwari *et al*., 2011.

Test for Alkaloids

Hager's Test

The extract was formed by dissolving diluted hydrochloric acid (HCl) followed by 2-4 drops of Hager's reagent i.e. saturated picric acid solution was then added into the filtrate. The observation of yellow precipitates indicates of alkaloids in the extract.

Test for Phenols

Ferric Chloride Test

3-4 drops of Ferric chloride solution were added to the *Rheum* extract. The green color showed the presence of phenols.

Tests of Flavonoids

Alkaline Reagent Test

The extract was treated with 3 drops of Sodium hydroxide solution. Intense yellow coloration which washed-out after the addition of Sulphuric acid, indicates the existence of flavonoids.

Magnesium and Hydrochloric Acid Reduction

6 mL of alcohol along with magnesium were dispensed to plant extract. Then HCl was added in the extract. Pink-crimson color indicated the presence of flavonol glycosides.

Test for Tannins

Gelatin Test

Emergence of white precipitate revealed the presences of tannins after addition of 1% of

gelatin solution comprising sodium chloride to the plant extract.

Tests for Saponins

Froth Forming Test

Extract was taken in the cylinder, distilled water was poured to it and then shaken for 10-15 minutes. Formation of foam showed the occurrence of saponins.

Tests for Terpenes

Copper Acetate Test

1-2 drops of copper acetate solution were added into the extract. The bright green color forms confirmed the presence of diterpenoids in the extract.

Salkowski's Test

Chloroform was poured into the extract and filtered. About 3 drops of concentrated H_2SO_4 were added into filtrates and allowed to settle down after shaking. Arrival of yellow golden color showed the triterpenoids in the extract.

Quantitative Analysis of Total Phenols

The total phenolic content of the extract was monitored by the Folin–Ciocalteu method (Kaur and Kapoor, 2002). Briefly, crude extract (1 mg/mL) was mixed thoroughly with Folin–Ciocalteu reagent for 4 min, followed by the addition of 20% sodium carbonate. The mixture was allowed to stand for 1 hour in the absence of light, and absorbance was measured at 650 nm. The total phenolic content was calculated from the calibration curve, and the results were depicted as mg of gallic acid equivalent per g dry weight.

Cytotoxicity Assay

1. The cell line which was previously stored in RPMI medium was checked for contamination in inverted microscope and then the media was removed.
2. 0.25% trypsin was added to the culture flask and incubated for 2 minutes for the detachment of the cells.
3. The cells were taken in a centrifuge tube and FBS (twice times) was added to it. Then these cells were spun for 4 minutes at 2000 rpm.
4. After removing supernatant, the pellet was made to 1ml with the fresh complete RPMI medium and counted in Neubauer's chamber.
5. 10,000 cells were seeded to each well in 96 well culture plate dissolved in 100µl media and were allowed to adhere overnight at 37ºC and 5% CO_2.
6. Next day, non-adherent cells in the supernatant media were removed and 100µl complete RPMI media was added.
7. Cells were supplemented with various concentrations of plant extract (10-500 µg/ml) and then incubated for 72 hours.
8. The cytotoxicity was checked by using the colorimetric assay with 3-[4, 5-dimethylthiazol2-yl]-2, 5-diphenyltetrazolium bromide (MTT).
9. 100µL of MTT solution (5mg/mL in PBS) was added to each well and incubated for four hrs.
10. The formazan crystals were then dissolved by addition of 100µL of DMSO.
11. The absorbance was taken by using microplate reader at a wavelength 560nm.
12. CC_{50} (Cytotoxic concentration of compounds to cause death to 50% of viable cells) was calculated by SPSS software (Mehta *et al*., 2010).

RESULTS AND DISCUSSION

The phytochemical analysis revealed that the *Rheum emodi* extract consists of mixture of phytochemicals like Phenols, flavonoids,

tannins, terpenoids and alkaloids. However, saponins were found to be absent in the hydroethanolic extract of *Rheum emodi* as shown in table 1.

Malik *et al*., 2018 also reported the presence of terpenoids, glycosides, alkaloids, flavonoids, and phenols in *Rheum emodi* extracts. However, the present study is contradicting with Malik *et al*., 2018 in that they showed the presence of saponins in the *Rheum emodi* extract while in the present study no saponins were detected. Singh and Chaturvedi, 2018 also demonstrated the absence of saponins and presence of other phytochemicals such as terpenoids, glycosides, alkaloids, flavonoids, and phenols. In addition to it, Srinivasarao *et al*., 2015 also reported the presence of glycosides, flavonoids, terpenes, alkaloids, saponins, terpenoids, steroids, carbohydrates, and anthraquinones in *Rheum emodi* extracts.

Quantitative Estimation of Phenols

The total phenols were monitored by Folin Ciocalteu's assay using calibration curve of standard phenol, gallic acid. It was found that hydroethanolic extract of *Rheum emodi* has total phenols 248.22±2.3 mg gallic acid/g. The equation of calibration curve was y = 0.0034x+0.242 and the regression co-efficient (R2) was 0.983. It is in parallel with the Malik *et al*., 2018 which reported the 271 mg gallic acid/g phenolic content in methanolic extract of *Rheum emodi.*

Cytotoxicity Assay

To determine the cytotoxicity of the *Rheum emodi* against the *RAW* macrophage cell line, different concentrations of the plant extract were tested in the current study. It is known that higher the CC_{50} value, safer is the drug. It was observed that the cytotoxicity increases with increase in the concentration of the extract of *Rheum emodi* and CC_{50} of extract was found to be 525.73±3 µg/ml at 72 hrs. In contrast to it, the CC_{50} of AmB was observed to be 49.51±2.1 µg/ml.

Table 1. Phytochemical Analysis of *Rheum emodi* etract

Phytochemicals	*Rheum emodi*
Phenols	+++
Flavonoids	++
Diterpenoids	++
Triterpenoids	++
Alkaloids	+
Tannins	+
Saponins	-
Flavonol glycosides	+

+ = trace amount, ++ = moderately present, +++ = highly present, - = absent

Fig. 1. Calibration Curve of Gallic Acid

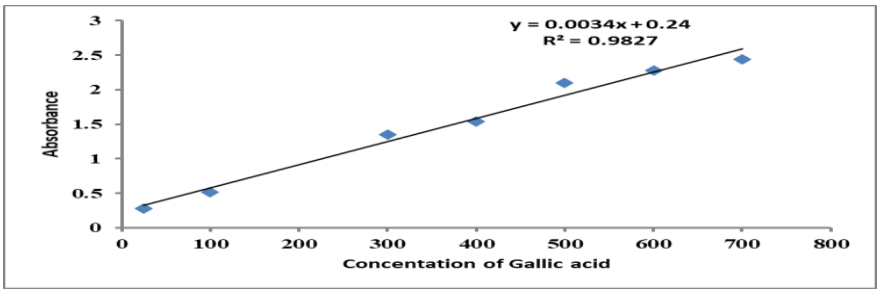


Fig. 2.Percentage cytotoxicity of the *Rheum emodi* at various concentrations.

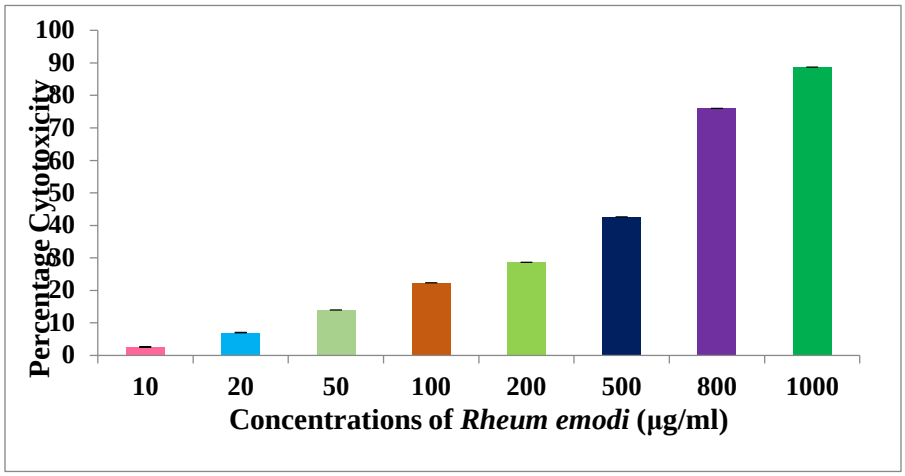
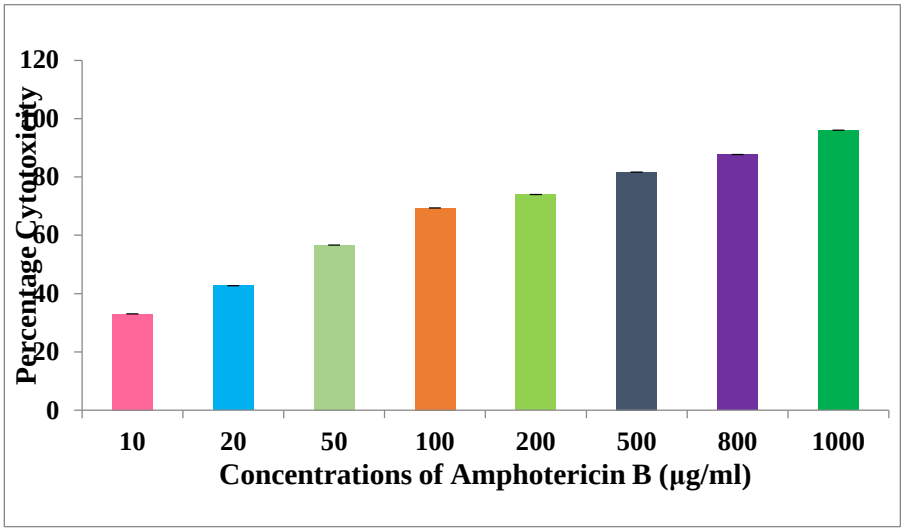


Fig.3 Percentage cytotoxicity of the Amphotericin B at various concentrations.



CONCLUSION

This research revealed that hydroethanolic extract of *Rheum emodi* contained major phytocompounds phenols, alkaloids, flavonoids, and terpenoids. It showed less cytotoxic activity towards the macrophage cells which depicts that this plant extract can be used as an immunomodulator for several immunosuppressive diseases. Further studies should be carried on its phytochemistry to find out the active compounds for immunosuppressive diseases.

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PRODUCTION AND EVALUATION OF STORAGE STABILITY OF NIGERIAN PUMPKIN (*Cucurbita pepo*) SEED OIL

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ABSTRACT

Nigeria now only produces vegetable oils like palm, peanut, soybean, and others; but, due to a lack of understanding of its potential, Nigerian pumpkin (*Cucurbita pepo*) seed oil has not been effectively utilized by the food sector. This study looks at how Nigerian pumpkin (*Cucurbita pepo*) seed oil is produced and evaluated as well as how storage affects the stability of the oil's physical and chemical qualities. Results from the extracted oil after 4 weeks of storage revealed that the refractive index value ranged from 1.47 to 1.48, specific gravity ranged from 0.90 units to 0.93 units, melting point ranged from 36.33 to 42.33oc, smoke point ranged from 136.33 to 134.81oc. Iodine values ranged from 99.80 to 100.40, peroxide values ranged from 9.10 to 10.12, free fatty acid values ranged from 9.70 to 10.85, and saponification values ranged from 193.28 to 193.87. The results obtained after a 4 week storage period revealed that there had been no significant change in the extracted oil's refractive index, specific gravity, smoke, flash, and fire points, iodine, peroxide, free fatty acid, and saponification values, but there had been a significant change in the oil's melting point with longer storage periods. With these results, the *Cucurbita pepo* seed oil demonstrated a high level of stability, which is an indication that it can serve as a substitute for the conventional vegetable oils being utilized.

Keywords: *Cucurbita pepo*, physical properties, chemical properties

INTRODUCTION

Nigerian pumpkin (*Cucurbita pepo*),known as " *Ugboguru*" in the Eastern part of Nigeria and "*Elegede*" in the South Western section of Nigeria, is mostly grown for its edible leaves, meat, and seed (FAO, 1993). The seeds are a crucial source of commercial vegetable oil that may be used for cooking since they have a ratio of 50% oil to 30% crude protein (Messiaen 1992). The pumpkin, scientifically known as *Cucurbita pepo*, is a member of the *Cucurbitaceae* family. It is frequently cultivated in tropical areas, and has a comparatively high economic significance globally. Pumpkin has been used by the food industry to make juices, purees, jams, and alcoholic beverages (Jiao *et al.*, 2014). The term "pumpkin seed" refers to the pumpkin's edible seed, which is rich in bioactive substances and typically utilized by many people as functional foods and herbal medications. Five species make up the

economically significant genus *Cucurbita: C. maxima, C. pepo, C. moschata, C. ficifolia, and C. turbaniformis, with C. pepo* showing the most variety, particularly in terms of fruit qualities (Gemrot *et al*., 2006).

Pumpkin is a widely consumed vegetable in Indonesia and is regarded as a functional food because of its extraordinarily high supplies of bioactive chemicals with favorable health effects (Montesano *et al*., 2018). Additionally, the fats and oils business has paid close attention to pumpkin seed oil as a possible nutraceutical as well as an edible oil (Rezig *et al*., 2012).The quality of the oil that is extracted is undoubtedly affected by the assertion that C. pepo is more resilient and less susceptible to deterioration (Markovic and Bastic, 1995). According to research by Cuco *et al*. (2019), pumpkin seed oil contains phytosterols, phenolic compounds, antioxidants, tocopherols, and small amounts of carotenoids that are linked to some biological activities that are good for human health. These include preventing gastric, breast, colorectal, lung, and other cancers (Elfiky *et al*., 2012); delaying the progression of hypertension; alleviating hypertension (Zuhair *et al.,* 2000a); and prostate cancer prevention, reducing high cholesterol and arthritic pain, reducing bladder and urethral pressure (Fruhwirth *et al*., 2003; Fu *et al.,* 2006), improving bladder compliance and treating human overactive bladder (Nishimura et al., 2014), and providing good antioxidant sources (Nawirska-Olszaska *et al*., 2013a; Naziri *et al*., 2016). Because of the beneficial impacts on health, researchers have thus far concentrated in particular on the composition and concentration of fatty acids, tocopherols, and sterols in pumpkin seed oil (Rabrenovic *et al*, 2014). Additionally, due to its health advantages such as antidiabetic (Boaduo *et al*, 2014), antibacterial (Hammar *et al*, 1999), antioxidant, and anti-inflammation (Nawirska-Olszaska *et al*., 2013b), pumpkin has attracted attention as an exceptional protective against many diseases, such as hypertension and carcinogenic diseases (Zuhair *et al*, 2000b). Due to a lack of understanding of its potential and qualities, Nigerian pumpkin (*Cucurbita pepo*) seed oil has not been utilized to its full potential by the food sector.

Nigeria can only currently produce vegetable oils like palm, groundnut, soybean, sesame, and others; however, studies on Nigerian pumpkin (*Cucurbita pepo*) seed oil can be investigated, and it is hoped that they will produce positive results that will make it suitable for use similarly to other vegetable oils. To the best of our knowledge, no studies have been conducted on pumpkin oil's durability despite all of its advantages. The current study aims to evaluate some physical and chemical aspects of pumpkin seed oil and to check its stability over a 4-week storage period in order to speed up its massive production and contribute to meeting the nutritional needs of the Nigerian oil and food industries as well as the entire world.

MATERIALS AND METHODS

Source of Raw Materials

The *Cucurbita pepo* seeds were purchased from Ahiaukwu local market, in Olokoro Umuahia, Abia State Nigeria while laboratory and other facilities were obtained from the Central Laboratory Services of National Root Crops Research Institute, Umudike Abia State Nigeria.

Sample Preparation

The fruits were broken, seeds collected, washed and sun dried (for one week). This process was to make the seed dehullable. The dried seeds were deshelled manually (by hand peeling) and later taken to the laboratory where it was dried in the oven at 50^{o}c. This was followed by grinding of the cotyledon with an electric grinder (Thomas Milling machine). Finally, the

ground seeds were collected and stored in a clean and well-dried sampling bottle.

Oil Extraction

The Franz Von Soxhlet extraction method described by A.O.A.C. (2000) was used for the extraction of the oil. 5.0g of the powdered seeds were wrapped in a weighed filter paper and placed in the thimble and about 200ml of normal hexane was poured into the weighed round-bottomed flask. The hexane was heated to boiling with an electro thermal heater for 4hrs continuous extraction. The defatted sample was removed and solvent recovered. The flask and its oil content were further dried in the oven at 60^{o}c for 30 mins and cooled in a desiccator.

Physical Analysis

Determination of Specific Gravity

This was carried out according to the method described by Onwuka (2010). A 50ml pycometer bottle was thoroughly washed with detergent, water and petroleum ether, dried and weighed, and the bottle was filled with water, weighed again, and dried. After drying the bottle, it was filled with the oil sample weighed and recorded. The specific gravity and density was calculated thus:

$$Specific\ gravity = \frac{weight\ of\ X\ ml\ of\ oil}{weight\ of\ X\ ml\ of\ water}$$

Determination of Melting Point

This refers to the upper limit of the temperature range through which the melting point of the fat takes place or, when determined according to empirical methods, a point very near this (Knut, 2008). The melting point was determined using the Fisher – john melting point apparatus as described by Kondyles (1990). A little smear of the oil was made on the heating plate of the Fisher–John melting apparatus and covered with the objective or observation lens. As the apparatus was switched on, the temperatures at which the oil began to melt were observed, and when the little smear completely melted through an inserted thermometer was observed and recorded too.

Determination of Smoke, Flash, and Fire Points

The smoke, flash, and fire points of fatty materials are measures of their thermal stability. The smoke point of an oil is the temperature at which oil or fat begins to break down to glycerol, free fatty acids, and produce bluish smoke. The glycerol is then further broken down to acrolein, which is a component of the smoke (Wolk, 2007). The smoke point of an oil does tend to increase as free fatty acids content decreases and the degree of refinement increases (Morgan, 1998).

Flashpoint refers to the point at which the vapors from the oil can first ignite when mixed with air or will flash but not support combustion (John, 1996). Fire point is the temperature at which the substance will continue to burn for at least 5 seconds after ignition by an open flame and support combustion (Eman *et al*, 2019). These tests were determined as described by Onwuka (2010). 10ml of the oil was poured into an evaporating dish; a thermometer was suspended at the center of the dish, which ensured that the bulb dipped inside the oil without touching the bottom of the dish. The temperature of the oil was raised and the 'smoke point' was recorded at the temperature where the oil sample gave out a thin bluish smoke continuously. Similarly, the temperature at which the oil started flashing without supporting combustion was equally recorded as the 'flash point', while the temperature at which the oil started supporting combustion was recorded as the 'fire point'.

Determination of Refractive Index

Refractive index of oil is the constant that is used as a ratio in the relationship between angle of incidence and the angle of refraction (Klofutar, 1999). This was determined according to AOCS (1993) as described by Onwuka (2010) using Abbe refract meter.

The refract meter with a light sensor was set at 20^{o}c while the oil sample was smeared on the lower prism of the instrument and closed. By a means of the angled mirror, a light was passed in which the reflected light appeared in a form of a dark background. Using the fire adjustment, the telescope tubes were moved until the black shadow appeared central in the cross wine indicator and the refractive index was read off. The refractive index was calculated as:

$$Refractive\ index = 1.4643 - 0.0000665 - \frac{0.0096\ A}{5 + 0.00011711}$$

Where: *S = saponification value*

A = acid value

I = Iodine value

Refractive index = R + 0.00380 θ

Where *R = refractive index*

*Θ = no of degrees in centigrade by which the measurement temperature is above the specified temperatur*e.

Chemical Analysis

Determination of Iodine Value

The iodine value of oil is the mass of iodine in grams that is consumed by 100grams of the sample. It is used to determine the amount of unsaturation in fatty acids (Alfred T. 2005). This analysis was carried out and the iodine value determined according to the AOAC (2005) methods by Wiji. About 250ml capacity10ml carbon tetrachloride was added in order to dissolve the fat, 20ml wiji's solution was added and allowed to stand in the dark for 30 minutes in a bottle with moistened potassium iodide solution stopper. After the 30 minutes, 15ml of potassium iodide solution (10%) and 100ml water was also added, mixed, and finally titrated with 0.1ml thiosulphate solution using starch as indicator before the end – point. A blank titre was also carried out at the same time with 10ml carbon tetrachloride. The iodine value was calculated using the expression:

$$Iodine\ value = \frac{(b - a)\ x\ 0.01269 \text{ x } 100}{weight\ (g) of\ sample}$$

Determination of Peroxide Value

Peroxide value is the amount of peroxide oxygen per 1 kilogram of fat or oil. It gives a measure of the extent to which an oil sample has undergone primary oxidation. It is determined by measuring the amount of iodine, which is formed by the reaction of peroxides (formed in fat or oil), with iodide ion, which causes the oils' rancidity (Chakrabarty, 2013) .This, was determined by the titrimetric method as described by AOCS (1993). 1g of the oil sample was added of 1g powdered potassium iodide and 20ml of solvent mixture in a clean dry b oiling tube. It was placed in a boiling water so that the liquid boiled within 30nseconds and was allowed to boil vigorously for not more than 30 seconds. The contents was transferred into a flask containing 20ml potassium iodide solution (55) and titrated with 0002m sodium thiosulphate solution using starch. A blank titration was carried out at the same time. The peroxide value was reported as the number of milligram of 0.002N (m) sodium thiosulphate per gram of sample.

Determination of Saponification Value

This is the number of milligrams of potassium hydroxide required to saponify 1g of fat under specified conditions. It is a measure of the average molecular weight (or chain length) of all the fatty acids present (Chakrabarty, 2013).This was determined using the AOAC (2000) method. 2g of the sample oil was weighed into a

conical flask and added with 25ml of alcohol potassium hydroxide solution. It was boiled in boiling water for 1 hour and shake frequently. 1ml of phenolphthalein (1%) solution was added also and titrated with excess alkali with 0.5m hydrochloric acid (titration =9ml) while blank titration was carried out the same time (titration = 6ml). Saponification was calculated thus:

$$Saponification\ value = \frac{(b-a)x\ 28.05}{weight\ (g) of\ sample}$$

Where *b = blank titre*

a = test sample titre

28.05 = constant

Determination of Free Fatty Acids (FFA)

This is the number of milligram of potassium hydroxide required to neutralize the free acid in 1 gram of the sample. It measures the extent to which the glycerides in the oil have been decomposed by lipase action. The decomposition is accelerated by heat and light. As rancidity is usually accompanied by free fatty acid formation, the determination is often used as a general indication of the condition and edibility of oils (Cocks et al, 1996). This was determined according to AOAC (2005) methods. 25ml diethyl ether, 25ml alcohol and 1ml phenolphthalein solution (1%) were mixed and carefully neutralized with 0.1m sodium hydroxide solution. 1 – 10g of the oil sample was dissolved in the mixed neutral solvent and titrated with aqueous 0.1m sodium hydroxide solution while it was shake constantly until a pink colour appeared which stayed for about 15 sec. It was calculated as follows:

$$Free\ fatty\ acid\ value = \frac{\text{Titre (ml)}\ x\ 5}{weight\ of\ sample\ used}$$

Statistical Analysis of Data

The data generated was analyzed using a one-way Analysis of variance (ANOVA) method while significance of treatment was tested at 95% probability level using the Least Significance Difference (LSD) method.

RESULTS AND DISCUSSION

Physical Properties of Nigerian Pumpkin (*Curcubita pepo*) Seed Oil From 0-4weeks Storage Period.

The physical properties of the oil after 4 weeks storage are presented in table 1.1 The refractive index of an oil is the degree of deflection of a beam of light that occurs when it passes from one transparent medium to another. There was no significant difference ($p>0.05$) in the values of the oil sample which ranged from 1.47 – 1.48. Unlike the present study, Murthy *et al* (1996) analyzed the refractive index only at the initial stage of storage, whereas Agarwal *et al* (2000), Semwal and Arya (2001) and Padmarathy *et al* (2001) reported changes in refractive index on storage at lower temperature, but increase in the refractive index was higher at high temperature. The result of the refractive index from this study showed consistency without any change, which reflected the stability of the oil. The specific gravity of the oil sample ranged from 0.90 units to 0.93 units and is closely related to the standard range of 0.898 – 0.901 units approved by SON (2000). There was no significant difference (*$p>0.05$*) observed during the storage of the oil sample. The observed little rise in the values may be attributed to the formation of polymetric fractions of high molecular weight due to hydrolytic and oxidative changes (Markovic and Bastic, 1996). There was significant differences (*$p<0.05$*) in the melting points of the oil sample during storage. The values ranged from $36.33^{O}C$ – $42.33^{O}C$ and can be seen to have increased in little over the 4-week storage. However, the melting point values of the oil sample falls within the range of $27^{O}c$ – $50^{O}C$ for edible oils as specified by SON (2000). Thus, the oil sample will remain liquid at room

temperature. The smoke point, which is the temperature at which fats or oils begins to break down to glycerol and free fatty acids and produce smoke was observed to have values that ranged from 136.33^{o}C – 134.81^{o}C from week 0 to week 4. There was no significant difference (*p>0.05*) in the smoke points obtained. The low values obtained can be attributed to exposure to oxygen, light or temperature, which lowers some points of vegetable oils during storage (Gocks and Rede, 2006). This goes a long way to show the shelf stability of the oil sample. The fire point values ranged from 187.33^{o}C – 184.91^{o}C as seen in week 0 and week 4. There was no significant difference (*p>0.05*) in the fire point values obtained during the 4 weeks storage. This also indicates the shelf stability of the oil sample. The flash point values were observed to range from 142.67 – 140.84 in week 0 and week 4 during storage. There was no significant difference (*p>0.05*) in the flash points of the oil sample. The low value obtained in this indicates the shelf stability of the oil sample.

Chemical Properties of Nigerian Pumpkin (*Curcubita pepo*) Seed Oil From 0-4weeks Storage Period.

The chemical properties of the oil after 4 weeks storage are presented in table 2.1 The iodine value, which is the measure of the level of unsaturation in oil (AOCS, 1993) ranges from 99.80 – 100.40 wijis with no significant difference (*p>0.05*), and this indicates the high level of unsaturation. The high composition of unsaturated fatty acids is an asset in nutrition as high content of saturated fatty acids are implicated in cardiovascular diseases (Russell *et al*, 2009). However, the values obtained indicate that the oil sample is susceptible to oxidation. The peroxide value ranged from 9.1meq/kg – 10.02meq/kg. There was no significant difference (p>0.05) in the peroxide value of the oil sample. Peroxide value determines the extent to which the oil has undergone rancidity, thus it could be used as an indication of the quality and stability of fats and oil (Ekwu *et al*, 2004). The peroxide values obtained are within the range of standard value of 10meq/kg by SON (2000) for edible oils. The values obtained at week 3 and week 4 could indicate the onset of primary oxidation due to lipid degradation by enzymes like peroxidase and lipoxygenase (Onyeka *et al*, 2005). The free fatty acid (FFA) values ranged from 9.70mgKoH/g – 10.85mgKoH/g, and were not significantly different (p>0.05). Free fatty acids show the level of rancidity taken place in the oil. The values obtained at week 3 and week 4 indicates the level of rancidity that has taken place in the oil sample. The saponification values ranged from 193.66mg/KoH down to 192.65mg/KoH. There was no significant difference (p>0.05) in the values obtained. These values are within the range of 189 – 198mgKoH for edible oils as specified by SON (2000). This shows that the fatty acids present in the oil sample have high number of carbon atoms.

Table 1.1 Physical properties of Nigerian pumpkin (*Cucurbita pepo)* seed oil from 0-4 week's storage period.

Period	RI	SG	MP	SP	Fire P.	Flash P.
0wk	1.47^{a}±0.00	0.90^{a}±0.00	36.33^{a}±0.58	136.33^{a}±1.53	188.33^{a}±1.15	142.67^{a}±1.53
1wk	1.47^{a}±0.00	0.91^{a}±0.00	36.33^{ab}±1.00	136.35^{a}±1.51	187.01^{a}±1.15	142.21^{a}±1.53
2wk	1.47^{a}±0.00	0.91^{a}±0.00	39.67^{b}±0.58	135.36^{b}±0.71	186.72^{b}±0.72	141.82^{b}±1.52
3wk	1.47^{a}±0.00	0.92^{a}±0.00	40.33^{c}±1.15	135.67^{b}±0.52	186.20^{b}±0.21	141.21^{c}±1.53
4wk	1.48^{a}±0.00	0.93^{a}±0.00	42.33^{a}±1.15	134.81^{c}±0.58	184.91^{c}±0.01	140.82^{c}±1.53
LSD	0.05	0.18	0.53	0.13	0.15	0.15

Note: values are means of duplicate determinations. Means with different superscripts are significantly different at (*p > 0.05).*
Key: RI = Refractive Index, SG = Specific gravity, MP = Melting point, SP = Smoke point, Fire. P = Fire point, Flash. P = Flash point

Table 2.1 Chemical properties of *Cucurbita pep*o seed oil after 4 weeks storage

Period	IV	PV	FFA	SV
0wk	99.80^{a}±0.37	9.10^{a}±0.12	9.70^{a}±0.45	193.66^{a}±0.81
1wk	99.92^{a}±0.37	9.12^{a}±0.12	9.91^{a}±0.16	193.62^{a}±0.81
2wk	100.00^{a}±0.64	9.17^{a}±0.12	10.07^{a}±0.16	193.28^{a}±0.81
3wk	100.00^{a}±0.47	10.01^{b}±0.12	10.57^{b}±0.16	192.87^{b}±1.29
4wk	100.04^{b}±0.73	10.12^{b}±0.31	10.85^{b}±0.16	192.65^{b}±0.99
LSD	0.26	1.00	0.29	0.13

Note: values are means of duplicate determinations. Means with different superscripts are significantly different at (*p > 0.05).*
Key: IV = Iodine value, PV = Peroxide value, FFA = Free fatty Acid, SV = Saponification value

CONCLUSION AND RECOMMENDATION

This study examined the impact of four weeks of storage on the physical-chemical characteristics of Nigerian pumpkin (Cucurbita pepo) seed oil. According to the findings from the storage period, the physical and chemical properties of the oil sample did not significantly alter. Although some of the metrics, including the melting point, slightly changed with time, the Cucurbita pepo seed oil demonstrated a high level of stability. To prevent the easy component deterioration that is typical of fats and oils from influencing the quality of the oil, adequate storage conditions must be offered throughout the storage period.

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May almighty God reward you all bountifully wherever you may be. Amen!!

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A REVIEW OF RAINFALL TREND STUDIES CONDUCTED IN TROPICAL SAVANNAH CLIMATE REGION OF NIGERIA

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ABSTRACT

Changing patterns of rainfall are among the many consequences, which are attributed to climate change. Regional variations can be much wider, and considerable spatial and temporal variations may exist between climatically different regions. The tropical region is characterized with high inter-annual and intra-seasonal rainfall variability. It is projected that this will increase rainfall extremes, such as intense rain as well as severe dry and wet phases with impact in many economic sectors.This study reviews rainfall trend studies that were carried out in tropical savanna climate of Nigeria. The result of the review showed that most of the authors adopted the non-parametric Mann– Kendall test in determining the statistical significance of trends, while the magnitude of trends was derived from the Sen's slope estimator. Most results of the trend analysis revealed decline in annual rainfall in the Sudano-Sahelian part of the country, while a significant positive increase in north central and northern part was then observed in the country as a whole. Increase in rainfall trends can result in increasing floods, thereby affecting water quality, while a decrease in precipitation trends could imply an increase in the occurrences of drought. Therefore, trend analysis of precipitation, temperature as well as other climatic variables on different spatial scales will to a large extent assist in the construction of future climatic scenarios.

Keywords: *Review, rainfall trends, Mann-Kendal test, climate change and tropical savanna., Nigeria*

INTRODUCTION

Rainfall amount and its distribution greatly influence environmental conditions and a wide range of socio-economic activities. Rainfall amount during the growing season is critical to development and yield of crops (Umar, 2010; Akpodiogaga and Odjugo, 2010; Mawunya *et al*., 2011; Sobowale *et al*., 2016). The prevalence of rain-fed agriculture, especially in sub-Saharan Africa makes the region to be fraught with food insecurity amid rising population.

Rainfall variability is an inevitable phenomenon, and can therefore, be defined as the amount by which the actual rainfall in station differs in average from its mean value either above or below (Akpodiogaga and Odjugo, 2010). It affects water resources sustainability, which includes the availability, management, and utilization of water resources (Umar, 2010). This in turn may affect ecosystems, land productivity, agriculture, food security, water quantity and

quality, and human health (USEPA, 2014). Rainfall variability represents a substantial risk for famers, since water supply and rainfall-induced events of agricultural importance such as on-set start (planting) and length of growing season, frequency of high intensity (erosive) rainfall events, cessation and frequency of dry spells are difficult to predict (Adejuwon *et al*., 2004).

Rainfall variability has historically been found as a major cause of food insecurity and famine in Nigeria country (Adejokun, 2009). This is clearly, because the agricultural sector is facing increased and continued risks of climate change. It is apparent that crop yield primarily depends on weather conditions, diseases and pests, planning of harvest operation etc. of the region (Adejokun, 2009). Due to this fact, effective management of these factors are necessary and used to estimate the probability of such unfavourable situation in order to minimize the consequences (Adejokun, 2009).

Trend detection in long time series of rainfall data is an important and difficult issue, of increasing interest for both hydrology and climatology over the last three decades. It is paramount in order to examine climate changes scenarios and enhance climate impact research (Mustapha, 2013; Abdulkareem and Sulaiman, 2016). The majority of water resources projects are planned, designed and operated based on the historical prototype of water availability, quality and demand; assuming constant climatic behaviour. It is therefore essential to investigate present and probable future climatic change patterns and their impacts on water resources so that appropriate adaptation strategies may be implemented (Abdulaziz and Burn, 2006; Abdulkareem and Sulaiman, 2016). This makes trend detection in long time rainfall data vital for better planning and designing regional water resources management. Trend analysis is widely implemented to examine hydrological variables such as rainfall, stream flow and river discharge. For example, several researchers found that trends in observed daily rainfall are generally a complex function of the climatic environment, rainfall intensity and season (Ventura, 2002; Abdulkareem and Sulaiman, 2016). Fluctuations and overall trends in annual and seasonal rainfall as well as the length of the rainy season/growing season are of paramount importance in rainfall climatological studies especially in the tropics, where rainfall largely determines the crop calendar of any given area. Fluctuation in rainfall trend has been a major factor responsible for crop failure (Bimbol and Zemba, 2007).

Analyses of rainfall trends in Nigeria has been carried out largely on annual basis (Odekunle, 2010; Umar, 2010; Atedhor, 2014; Atedhor and Enaruvbe, 2016). Agriculturally however, it is the specific pattern of rainfall at the different stages of the cropping calendar that is more important (Atedhor, 2019). In view of this, this review on rainfall trend analyses in tropical savanna climate attempts to evaluate statistical tools used in analysing rainfall data in Nigeria.

Rainfall Trend Analyses in Tropical Savannah Climate

A total number of 20 research articles on rainfall trends that were carried out in a tropical savanna were reviewed for this study. Relevant information from the authors' findings were collected across the study locations, from which a summary table (Table 1) was then deduced. Several methods were adopted for the studies, of which are; the non-parametric Mann-Kendall trend tests, Simple linear regression, Cramer's test, Time series analysis, descriptive statistical approach as well as the Standardized coefficients of skewness and kurtosis among others.

The results showed that 49% of the studies conducted, adopted the non-parametric Mann-Kendall trend tests method, 30% used simple

linear regression and Cramer's test, only 20% adopted the descriptive statistical approach, and 1% used Standardized coefficients of skewness and kurtosis and time series analyses. However, the non-parametric Mann-Kendall trend tests method can be said to be the most widely and commonly used method among all.

Mann-Kendall Trend Test

This test has been widely used in hydrological studies to test for trend in the time series data. It is a rank-based procedure, robust to the influence of extremes and suitable for application with skewed variables widely used to test the normality of hydrologic variables (Hamed, 2008; Abdulkareem and Sulaiman, 2016). More particularly, this technique can be adopted in cases with distribution-free data containing outliers and non-linear trends (Birsan, 2005; Abdulkareem and Sulaiman, 2016; Abdulkareem *et al*., 2021). According to this test the null hypothesis (H_0) indicates that the annual distribution of the data (x_1....x_n) is a sample of *n* independent and identically distributed random variables (Abdulkareem and Sulaiman, 2016; Abdulkareem *et al*., 2021). The alternative hypothesis H_1 of a two sided test is that the distribution of x_k and x_j are not identical for all $k,j \leq n$ with $k \neq j$. The test statistic is given below (Kahya and Kalayci, 2004; Abdulkareem and Sulaiman, 2016; Abdulkareem *et al*., 2021).

The null and the alternative hypothesis of the Mann-Kendall test for trend in the random variable *x* are:

$$H_0: \Pr(x_j > x_i = 0.5, j > i, \quad (1)$$

H_A $\Pr(x_j > x_i \neq 0.5$, (two-sided test)

The Mann-kendall statistic *S* was calculated as;

$$S = \sum_{k=1}^{n=1} \sum_{j=k+1}^{n} sgn(x_j - x_k) \quad (2)$$

Where x_j and x_k are the data values in years *j* and *k* respectively, with *j*>*k*, and sgn () is the signum function:

$$\text{sgn}\,(x_j - x_k = \begin{cases} 1 \;\; If\; x_j - x_k > 0 \\ 0 \;\; If\; x_j - x_k = 0 \\ -1\; If\; x_j - x_k < 0 \end{cases} \quad (3)$$

Under the null hypothesis the distribution of *S* can be approximated well by a normal distribution (for large sample sizes *n*), with mean μ_S and variance $\delta^2{}_S$ given by:

$$\mu_S = 0,$$
$$\delta^2{}_S = [n(n-1)(2n+5) - \sum_{i=I}^{m} t(i)(i-1)(2i+5)]/18 \quad (4)$$

Eq. (5) gives the variance of *S* with a correction for ties in data with t_i denoting the number of ties of extent *i*. The standard normal variate is then used for hypothesis testing, and is called here the trend test statistic *Z*.

$$Z = \begin{cases} \frac{S-1}{\sigma_S} \; If\; S > 0 \\ 0 \; If\; S = 0 \\ \frac{S+1}{\sigma_S} \; If\; S < 0 \end{cases} \quad (5)$$

For a two-tailed test, the null hypothesis is rejected at significance level 'α' (Type I error). If $|Z| > Z_{\propto/2}$, where $Z_{\propto/2}$ is the value of the standard normal distribution with an exceedance probability $a/2$. If the null hypothesis is rejected, the Man-Kendall test revealed that there is upward trend then the true slope may be estimated by computing the least square estimate of the slope. Sen Slope estimator is used to quantify the slope of the trend, if the null hypothesis is rejected. Abdulkareem and Sulaiman (2016) and Abdulkareem *et al*. (2021) reported that the estimator could be used to depict the quantification of change per unit time. The slope estimates Q_i of *N* pairs of data are calculated using equation 6:

$$Q_i = (x_j - x_k)/(j-k) \quad (6)$$

Where *N* is the values of slopes ranked from the smallest to the largest. If *N* is odd, Sen's slope is calculated as using equation 7:

$$Q_{median} = Q(N+1)/2 \quad (7)$$

If *N* is even, the estimator arises from equation 8:

$$Q_{medium} = Q = [Q_{\frac{N}{2}} + Q_N + \frac{2}{2}]$$

(8)

Obot *et al.* (2010) used Mann-Kendall test to test for significant trend in rainfall in Maiduguri, Kaduna, Lokoja, Ibadan, Enugu and Calabar, Nigeria within a 30 years period (1978-2007). From their results, (Table 1) Maiduguri showed an increasing trend at a rate of 9.88 mm/year. While a no significant trend was found in the rest of the locations. Abubakar and Isaiah (2014) utilized man-Kendall and Sen's slope estimator in another study with the aim of testing trends and frequency of rainfall in the North-west, Nigeria using rainfall data from 1905-2008 (Table 1). Results of Sen's test showed that trends are significant at 99% confidence level. Sen's slope revealed that there were downward trends in the rainfall for the last 30 years in all the five locations.

The non-parametric Mann– Kendall test was used by Bose *et al*. (2015) to determine the statistical significance of trends in Northern Nigeria from 1970 to 2012. While the magnitude of trends was derived from the Sen Slope estimator of the linear trends using Kendall robust line fitting. The findings revealed that a significant positive increase of 2.16 mm in rainfall was recorded in the entire northern Nigeria within the period of 1970 to 2012. It was concluded that, there was a high variability in rainfall in the northern Nigeria, which signified a clear evidence of climate change in the region. In another related research, Adedeji *et al*. (2018) adopted simple linear regression analysis and modified non-parametric Mann-Kendall test to analyze for trends in Sokoto and Maiduguri (Sahel savanna), Kaduna and Bauchi (Sudan savanna), Ilorin, Enugu and Makurdi (Guinea savanna), Ikeja, Port-Harcourt and Benin (Rainforest). Their results showed increasing rainfall trends in all the studied location except for Port-Harcourt that showed a decreasing trend. However, rainfall was only statistically significant in Benin, Ilorin, Bauchi and Maiduguri at 95% confidence level. The study further revealed that Nigeria is experiencing a rise in rainfall

Adamu (2013) conducted trend analysis using t-test, Sen's slope estimator and Mann-Kendall tests (Table 1). The research was conducted with the aim of studying climate change on agriculture using annual rainfall and temperature data from 1971-2010 in Zaria, Kaduna State. The results showed that Sen's slope estimator revealed that rainfall recorded downward trend of 94 mm/year in 1971-1980 decade. While it recorded upward trends of 90 mm/year, 30 mm/year and 119 mm/year respectively during 1981-1990, 1991-2000 and 2001-2010 decades, but none is statistically significant at 95% confidence level. Mann-Kendall and Sen's slope estimator tests were utilized by Ismail and Oke (2012) in Sokoto, Kano, Kebbi, Katsina and Kaduna with the aim of analysing trend in these locations. The researchers affirmed the presence of downward trends in the last 30 years in all locations and significant at 99% confidence level.

Rainfall and temperature data from northeastern states of Borno, Yobe, Gombe, Bauchi, Adamawa and Taraba were used to evaluate trends using Mann Kendal test by Hassan et al. (2017). Their results showed a decreasing trend in annual total rainfall over both a long-term period (1982-2014) and a first short-term period 1949-1981). While a positive trend for the second short-term period, (1982-2014) was observed. They concluded that rainfall has increased only in the most recent years period (1982- 2014). The work of Yunusa *et al*. (2017) in Birnin Gwari, Kaduna North, Kauru Saminaka, Kangimi, Zaria, Kaduna South, Kafanchan, Kagrko, Zonkwa, Nigeria was carried out to assess the characteristics of rainfall variations from 1966-2015 using Mann-Kendall trend. Results of the study showed that

Kaduna north witnessed an increase of 58.889mm per year.

Table 1 Summary of some previous Rainfall Trend studies in Tropical Savanna Climate, Nigeria

No	AUTHORS	LOCATION	OBJECTIVES	METHODOLOGY	FINDINGS
1.	Ati *el al*. (2007)	Samaru, Potiskum, Sokoto and Katsina.	To investigate the current trend in weather condition in the Sudano-Sahelian zone in Nigeria using a rainfall data of 1953-2002.	The series of data were tested for normality using the standardized coefficients of skewness and kurtosis.	Results indicated a decrease in annual rainfall in the zone, from the mid-1960s up to the mid-1990s. Recent trends showed increase in annual rainfall from the mid-1990s.
2.	Abaje *et al.* (2010)	Kafanchan, Kaduna.	To detect the recent trends in rainfall regime of the area using rainfall data of 35 years (1974-2008).	Rainfall series was divided into 10-year overlapping sub-periods, and the Cramer's test was used to compare the means of the sub-periods with the mean of the record period.	The results of the linear trend lines further revealed that the decline in the annual rainfall yield is predominantly because of the substantial decline in July, September and October rainfall. The results of the test revealed that the sub-periods for the months of June and October were significantly drier.
3.	Obot *et al.* (2010)	Maiduguri, Kaduna, Lokoja, Ibadan, Enugu and Calabar, Nigeria.	To find out the characterized trend of total amount of rainfall through randomly selected locations in the six geopolitical zones within a 30 years period (1978-2007).	The non-parametric Mann-Kendall test was used to test for significant trend in rainfall.	While the rest of the locations had no significant trend, Maiduguri showed an increasing trend at a rate of 9.88mm/year, where formally the trend there from the period 1961-1990 was decreasing.
4.	Abubakar and Isaiah (2014)	Sokoto, Kano, Kebbi, Kaduna and Katsina.	To test for trends and frequency of rainfall in the North-west geo political zone of Nigeria using rainfall data from 1905-2008.	Mann-Kendall, Sen's slope technique as well as Pearson log type III were adopted for the study.	Results of Sen's test showed that trends are significant at 99% confidence level. Sen's slope revealed that there were downward trends in the rainfall for the last 30 years in all the five locations.
5.	Adamu (2014)	Zaria, Kaduna State.	To study climate change on agriculture using annual rainfall and temperature data from 1971-2010.	Trend analysis was carried out using t-test, Sen's slope estimator and Mann-Kendall tests.	The Sen's slope estimator revealed that the rainfall recorded downward trend of 94 mm/year in 1971-1980 decade; while it recorded upward trends of 90 mm/year, 30 mm/year and 119 mm/year respectively during 1981-

					1990, 1991-2000 and 2001-2010 decades, but none is statistically significant at 95% confidence level.
6.	Ismail and Oke (2012)	Sokoto, Kano, Kebbi, Katsina and Kaduna.	To analyze the existence of rainfall trends in the study regions.	Mann-Kendall and Sen's slope estimator tests were used.	Findings showed the presence of rainfall trends in these regions. The trends were downward in the last 30 years in all locations, and significant at 99% confidence level.
7.	Bose *et al*. (2015)	Adamawa, Bauchi, Borno, Kaduna, Katsina, Kebbi, Sokoto, Zamfara, Kwara, Nassarawa and Niger.	To contribute in understanding the pattern of rainfall trend (significance and magnitude) in Northern Nigeria from 1970 to 2012.	The non-parametric Mann–Kendall test was used to determine the statistical significance of trends while the magnitude of trends was derived from the Sen slope estimator of the linear trends using Kendall robust line fitting.	The findings revealed that a significant positive increase of 2.16 mm in rainfall was recorded in the entire northern Nigeria within the period of 1970 to 2012. It was concluded that, there was a high variability in rainfall in the northern Nigeria which signified a clear evidence of climate change in the region.
8.	Olarenwaju and Fayemi (2015)	Kogi, Kwara, Kaduna, Plateau and Abuja.	To assess climate change scenario in the North central part of Nigeria using rainfall data of 51 years (1962-2012).	Time series analysis was used to model the trends in the rainfall data for the selected stations.	Results showed increasing trends of 0.22 mm and 3.38 mm in Lokoja and Abuja per annum, while Ilorin, Jos and Kaduna each exhibited a decline of 0.18 mm, 0.23 mm and 0.44 mm per annum respectively. However, for the entire North central region, a positively significant increase of 0.58 mm of rainfall per annum was observed. Based on the prediction, rainfall increase of 14.49% from what was observed in 2013 (the base year) is expected by 2042.
9.	Atedhor and Enaruvbe (2016)	Enugu, Ilorin, Lokoja, Makurdi, Minna, Bida, Kaduna, and Jos, Nigeria.	To examine growing season rainfall trends, alterations and drought intensities using monthly rainfall data.	Simple linear regression and second order polynomial were used to investigate the rainfall trend. Simple percentage and t-test statistics were used to examine the monthly and growing season changes in rainfall.	The results revealed upward trends in Bida, Lokoja and Enugu during the 1941-2010 period with that of Lokoja being sharpest while Ilorin, Minna, Makurdi, Jos and Kaduna experienced downward trend with that

					of Jos being the sharpest. Rainfall in Minna, Lokoja, Enugu, Makurdi and Kaduna exhibited curvilinear attribute while Ilorin, Bida and Jos exhibited a linear pattern. Only Makurdi and Jos revealed significant difference between the 1941-1975 and 1976-2010 periods.
10.	Hassan *et al*. (2017)	Borno, Yobe, Gombe, Bauchi, Adamawa and Taraba.	To evaluate rainfall trends and temperature patterns in north-eastern Nigeria.	Mann– Kendall test was employed for the study.	Results showed a decreasing trend in annual total rainfall over both a long-term period (1982-2014) and a first short-term period 1949-1981), while a positive trend for the second short-term period (1982-2014) has been observed. They concluded that rainfall has increased only in the most recent years period (1982- 2014).
11.	Yunusa *et al*. (2017)	Birnin Gwari, Kaduna north, Kauru Saminaka, Kangimi, Zaria, Kaduna south, Kafanchan, Kagrko, Zonkwa, Nigeria.	To assess the characteristics of rainfall variations in Kaduna state from 1966-2015.	Mann-Kendall trend test was used to detect for trends	Results showed that Kaduna north is witnessing an increase of 58.889mm per year. The increasing trend comes in the fourth decade (1996-2015). While results of the Sen's slope estimator showed that Kaduna north is witnessing significant negative trends a rising insignificant decreasing trend magnitude. Decadal periods revealed a decreasing trend in Zaria.
12.	Abaje *et al*. (2018)	Zaria, Kafanchan and Kaduna.	To examine the spatio-temporal distribution of rainfall in Kaduna state from southern to northern part of the state for a period of 56 years (1961-2015).	10-year running mean, Linear trend line equation, Cramer's test and Student's t-test were used.	Findings from the Cramer's test for both the monthly and annual rainfall revealed an upward trend in the last three decades (1991-2000, 2001-2010 and 2011-2016) for Kafanchan and Zaria stations, and the present decade 2011-2016 for Kaduna.

13.	Adedeji *et al*. (2018)	Sokoto and Maiduguri (Sahel savanna), Kaduna and Bauchi (Sudan savanna), Ilorin, Enugu and Makurdi (Guinea savanna), Ikeja, Port-Harcourt and Benin (Rainforest)	To investigate rainfall variability and trends using rainfall data of 31 years (1985-2015) across major climatic zones in Nigeria	Simple Linear Regression analysis and modified non-parametric Mann-Kendall test were used to analyze for trends exhibited by the variable.	Results showed increasing rainfall trends in all the studied location except for Port-Harcourt that showed a decreasing trend. However, rainfall was only statistically significant in Benin, Ilorin, Bauchi and Maiduguri at 95% confidence level. This study revealed that Nigeria is experiencing a rise in rainfall.
14.	Yahaya *et al*. (2018)	Bida, Yola, Minna, Jos, Katsina, Yelwa, Bauchi, Kaduna, Maiduguri, Kano, Gusau, Sokoto and Nguru.	The study analyzed rainfall concentration, temporal trends, and rates of change in savanna zones of Nigeria.	Mann-Kendall analysis was adopted for the study.	The Mann-Kendall analysis of the PCI values revealed that 8 of the 13 stations (62%) experienced downward trends. This implies that rainfall is sliding towards a moderate to uniform distribution. The trends, and consequently the variability in the annual and seasonal rainfall, revealed that with the exception of Yola and Jos stations, where trends were downward, the overall rainfall was increasing significantly in some areas and insignificantly in others.
15.	Abaje and Oladipo (2019)	Zaria, Kafanchan and Kaduna.	To examine the evidence of climate change in Kaduna state, from the analysis of temperature and rainfall data (1971-2016).	Linear regression, second order polynomial, standard deviation and Cramer's test were used to determine the changes in the climatic parameters.	The linear trend line of the annual rainfall revealed a mean increase of 303.32 mm for the state. Findings further showed a decreasing trend from 1971 to the late 1990s and an increasing trend afterwards up to 2016. Decadal analysis of rainfall in all the stations generally showed an increasing trend in the last two decades.
16.	Itiowe *et al*. (2019)	Abuja, Nigeria.	To analyze rainfall trends and patterns between 1986 and 2016 in the region.	Standardized precipitation index and coefficient of variability statistical tools were employed.	Result obtained indicated that there was a downward trend in the rainfall amount received in Abuja over the last 31 years. Also, a gradual decline in rainfall was observed using the SPI

					to compare the three decades under review.
17.	Ibrahim *et al*. (2020)	Bida, Yola, Minna, Jos, Katsina, Yelwa, Bauchi, Kaduna, Maiduguri, Kano, Gusau, Sokoto, Nguru and Abuja	To analyze the trends in extreme rainfall for some stations in savanna zones of Nigeria for a period of 35 years (1981-2015).	Mann-Kendall test was used to evaluate for possible trends.	The results showed an increase in the occurrence of extreme rainfall events in the selected variables. The increase trends are possible pointer to climate change and a possible influencing factor to the frequent occurrence of flooding across the study areas.
18.	Lawal and Yamusa (2020)	Zaria, Nigeria	To examine the changing pattern of rainfall amount and rain days	Monthly rainfall was obtained by summing over the individual daily rainfalls.	Findings showed that August had the highest number of rainy days across all the periods, however a decrease from 19.0 days in the 1960s to 1960s in the 2010s was observed. This may be due to the current challenges with global warming which increases the intensity of annual rainfall but shortens the duration of the rainy days.
19.	Mande (2020)	Kaduna, Nigeria	To assess the impact of climate change on the environment.	Descriptive statistical approach was adopted.	Decade's rainfall revealed an upward trend of 408mm. The rainfall regime in the metropolis is highly variable and its seasonality change is another good indicator of climate change.
20.	Atedhor (2019)	Sokoto, Katsina, Gusau, Kano, Mguru, Potiskum, Maiduguri and Yola, Nigeria	To examine trends of rainfall amount during the onset and cessation over the Sudano-Sahelian region of Nigeria using 64 years (1951-2014) rainfall data for the 8 synoptic weather stations	Simple regression was used to analyze the trends of rainfall during the onset and cessation.	Results showed that rainfall declined in Katsina, Nguru and Yola at annual rates of -0.036 mm, -0.197 mm and -0.143 mm respectively during the onset while Sokoto, Kano, Potiskum and Maiduguri witnessed increase at annual rates of 0.040 mm, 0.188 mm, 0.269 mm, o.026 mm and 0.025 mm respectively. Sokoto, Katsina, Potiskum, Nguru and Yola experienced decreasing rainfall trend at

					annual rates of -0.232 mm, -0.112 mm, -0.082 mm, -0.153 mm and -0.360 mm respectively during cessation while Kano and Maiduguri recorded increase at annual rates of 0.180 mm, 0.246 mm and 0.037 mm respectively. Rainfall trends were significant in Kano and Yola during onset and cessation respectively.

The increasing trend comes in the fourth decade (1996-2015). While results of the Sen's slope estimator showed that Kaduna north witnessed significant negative trend with a rising insignificant decreasing trend. While decadal periods revealed a decreasing trend in Zaria. The Mann Kendal test was further utilized to analyze the trends in extreme rainfall for some stations (Bida, Yola, Minna, Jos, Katsina, Yelwa, Bauchi, Kaduna, Maiduguri, Kano, Gusau, Sokoto, Nguru and Abuja) in savanna zones of Nigeria for a period of 35 years (1981-2015). The study, which was carried out by Ibrahim et al. (2020) found out an increase in the occurrence of extreme rainfall events in the selected variables. The increased trends are possible pointer to climate change and a possible influencing factor to the frequent occurrence of flooding across the study areas.

CONCLUSIONS

A review of rainfall trend studies was carried out in the tropical savanna climate in Nigeria. Various authors adopted several methods during the course of their research works. It can be deduced from their findings that; all the methods adopted for the trend analysis are efficient and can be adopted for further researches, but it is obvious that the nonparametric Mann-Kendall trend test is the most commonly and efficiently used. However, trend analysis of precipitation, temperature as well as other climatic variables on different spatial scales will largely assist in the construction of future climatic scenarios.

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ASSESSING THE CONDITION OF KASHIN-DILA RANGELAND OF MALLAM-MADORI LOCAL GOVERNMENT AREA, JIGAWA STATE, NIGERIA

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ABSTRACTS

This research was conducted to evaluate the range condition of Kashin-dila rangeland of Mallam-Madori Local Government Area, Jigawa State, Nigeria. The rangeland was stratified into two areas (grassland and shrubland), where vegetation cover and forage distribution were measured fortnightly, using the line intercept method and tree density was estimated once, at the beginning of the study period, using the Point-Centred Quarter (PCQ) method. Average tree density and canopy cover of the rangeland were 10 trees ha-1 and 2% respectively in the grassland area of the rangeland, and 2300 plants ha-1 and 74% for shrubland area. The vegetation cover of the rangeland was excellent during the wet season (June to October, 2023) as 80.3% of the rangeland area was covered with different forages, with only 19.7% as area without vegetation or bare ground, Poaceae covered 6.967% of the rangeland, Cyperaceae covered 0.003%, Fabaceae covered 33.286% and 40.044% was covered with other forage species. According to the mean values, 65.25% of the total area was covered with plants. The general condition of the Kashin-dila rangeland (65.25%) was determined as "Good" and it can be recommended for grazing ruminant livestock more especially during rainy seasons.

Keywords; Assessment, Kashin-dila rangeland, Range condition, Vegetation cover.

INTRODUCTION

Rangelands constitute the main sources of nutrition for domestic and wild herbivores, which are characterized as lands dominated by grasses, legumes, shrubs or trees (Mosisa et al., 2021). It is reported that rangelands cover about 40% of all land surfaces worldwide and 69% of all agricultural land. (Ruvuga et al., 2021; Niamir-Fuller et al., 2012; Desalew, 2008).

Rangeland condition can be defined as the state of rangeland health expressed in terms of its ecological status, resistance to soil erosion and potentials for producing forage for sustained optimum livestock production (Hassen, 2022; Zerga and Teketay, 2018; Trollope et al., 1990). Sustainable rangeland condition is described as the state at which soil integrity and rangeland ecological processes are sustained (Ruvuga et al., 2021; Whitford et al., 1998). It reflects landscape capacity to perform ecosystem functions, ability to support biodiversity conservation and potential for livestock production (Van Der Westhuizen et al., 2005;

Whitford et al., 1998). There is a direct relationship between rangeland condition and productivity. Good rangeland condition can support and improve livestock performance, while livestock grazed on degraded rangeland perform poorly (Odadi et al., 2017; Fynn and O'Connor, 2000). Reducing tree cover may increase livestock production without having negative effects on herbaceous forage distribution, though it is not suitable for some rangelands sustainability (Chinder et al., 2020; Chidumayo and Kwibisa, 2003). Overall, dry rangeland condition varies due to abiotic and biotic factors such as annual rainfall, fire occurrence and grazing livestock distribution (Ondier et al., 2019; Pfeiffer et al., 2019; Lohmann et al., 2012; Tessema et al., 2011).

The physical characteristics of rangeland are soil, climate and topography that determine the type of vegetation and its productivity in the rangeland. Climate is critical component to rangeland management. Precipitation is one of the important elements among the climate factors vital for determining the type and productivity of vegetation in area. On the bases of climatic variable and magnitude of the animal use (Hassen, 2022; Niguse and Gizachew, 2014).

Coefficient of variation (CV) of annual precipitation can be used to categorized dry rangelands into equilibrium or non-equilibrium systems (Engler and Von Wehrden, 2018). The threshold CV value is 33%, with systems below that value being in equilibrium and systems above in non-equilibrium. Systems in equilibrium show lower variations in inter-annual precipitation and can be improved with controlled stocking rate (Ferrer et al., 2019; Vetter, 2005). In addition to grazing, high inter-annual rainfall variation influences plant species composition and aboveground biomass in the non-equilibrium system (Engler and Von Wehrden, 2018). The systems have different management implications for dry rangeland. In equilibrium systems, local management and control of stocking rates may maintain rangeland condition, while in non-equilibrium systems livestock mobility and adaptive grazing are more important (Vetter, 2005).

Therefore, assessing the condition of vegetation utilized by grazing and browsing herbivores are essential for sustainable utilization of rangeland ecosystem. The concept of rangeland condition is encompassing to indicate the state of health of the rangeland in terms of its ecological status, resistance to soil erosion and potential for producing forage for sustained optimum livestock production (Hassen 2022; Dalle et al., 2014).

The condition of dry rangeland can be categorised as very poor (0%), poor (1-25%), fair (26-50%), good (51-75%) or excellent (76-100%), based on available vegetation cover (Ruvuga et al., 2021; Sangeda and Maleko, 2018).

MATERIALS AND METHODS

This research was carried out at Kashin-dila rangeland of Mallam-Madori Local Government Area of Jigawa State, Nigeria. The area is located close to Kashin-dila village, along Hadejia-Mallam-Madori road (9km and 12km away from Mallam-Madori and Hadejia towns respectively). The average altitude of the rangeland is 356m above sea level and the total area covers 564.2 hectares on latitude 12030'22"N and longitude 9056'53"E (Figure 1). The annual rainfall ranges between 200 - 600mm with relative humidity of 75 % during the rainy season and a mean annual temperature of 28 0C. Cattle, sheep and goat are usually the most important animals grazing in the area by Fulani pastoralists (Field Survey, 2023;

Muhammad et al., 2023; Bird Life International, 2021).

Soil Properties

Soil samples were taken at random from the respective sample plots in the rangeland using a soil auger at 0-30 cm depths and pooled to form a composite sample for physical and chemical composition analysis. The collected soil samples were air-dried, sieved, and analyzed for texture class, bulk density, organic matter amounts, salinity, lime and pH values to determine the general properties of the soil of study area as in the study of Babalik and Kilic (2015).

Vegetation Cover

The rangeland (564.2 hectares) comprised of two distinctive vegetation areas; an area predominantly covered with grasses (grassland) and an area predominantly covered with shrubs (shrub land). The rangeland was stratified into these two areas, where vegetation cover and forage distribution were measured fortnightly, using the line intercept method (Godínez-Alvarez et al., 2009). A 50 m tape measure was used as the sampling unit. The measuring tape was laid starting from the sampling point on the transect line and the linear distance of tape measure that intercepted grasses, sedges, legumes, forbs, shrubs, tree canopy and bare ground were recorded. Tree density was estimated once, at the beginning of the study period, using the point-centred quarter (PCQ) using Bryant et al. (2004) method. In this method, a steel cross was thrown randomly from the individual sampling point, the nearest tree was identified and distance from centre of the cross to the identified tree was measured using 50 m tape measures in all four directions of the cross (Ruvuga et al., 2021; Babalik and Kilic, 2015).

Range Condition Assessment

A simple range condition assessment was done considering the climax of vegetation cover of the rangeland. Range condition was measured by the extent to which it departs from climax. The approach assumes that climax can be determined for each range sites. Excellent class would represent climax, i.e., Excellent (76-100), Good (50-75), Fair (26-50), and Poor (0-25) respectively (Ruvuga et al., 2021; Desalew, 2008).

RESULTS AND DISCUSSIONS

Response of Forage Production to Rainfall Distribution

Moisture can be considered as the primary controlling factor of forage production in rangeland systems (Li et al., 2019; Larsen et al., 2014). A high precipitation of 287 mm and above will result in higher peak biomass of rangelands and with sufficient precipitation to maintain soil moisture content, plants experienced little water deficit (Li et al., 2019). In contrast, the 2023 growing season received only 118.5 mm of precipitation with large gaps between rainfall events (Table 1 and figure 2). This precipitation distribution hindered the growth of most annual forages on the rangeland by intensifying the soil moisture deficit. Germination and growth can be very different inter-annually in annual range systems. Peak growth is highly dependent on the amount and timing of precipitation. Agro-ecological conditions (e.g. soil and climate) can vary widely between regions which makes direct comparisons between this result and those from other regions a challenging prospect (Mosisa et al., 2021; Li et al., 2019; Babalik and Kilic, 2015).

Soil Properties of the Rangeland

The chemical and physical properties of the soil have a great impact on plant biology, evolution, and biota (Rajakaruna and Boyd, 2008). The mean values obtained from the rangeland soil analysis are given in Table 2. Soil structures of both rangeland areas were sandy loam texture. Bulk density as an indicator of soil compaction was calculated as the dry weight of soil divided by its volume and it reflects the soil's ability to function for structural support, water and solute movement and soil aeration. The average bulk density (1.413 g/cm3) of the soil is within the range of 1.33 – 1.60 g/cm3 recommended by Arshad et al. (1996). On average, it can be seen that the soil pH of the rangeland was slightly acidic which is in accordance with low amounts of lime. The average soil pH (6.88) is similar to 6.89 reported by Cacan and Basbag (2019) with slightly higher lime value of 5.98 – 8.55%. The average organic matter (4.55%) is within the range of 4.20 – 5.80% reported by Babalik and Kilic (2015). The soils were generally salt-free. Zhang et al. (2018) stated that the nutritional quality of fodder is influenced by the physical characteristics of the soil, such as texture and porosity. For instance, poorly aerated soils significantly restrict or decrease the absorption of vital nutrients, particularly phosphorus. According to a study, trees grown on light-textured soil often yield higher levels of cellulose, crude ash, crude protein, and dry matter than trees planted in heavy-textured soil (Geren et. al., 2009).

Vegetation Cover of the Rangeland

The rangeland was distinctively made up of two areas with different vegetation covers. These areas were categorized based on the predominant vegetation covers as grassland; where the predominant vegetation in the area was grasses and the area predominantly covered with shrubs as shrub land (Figure 3a & b). The vegetation cover of the rangeland was excellent during the wet season (June to October, 2023) as 80.3% of the rangeland area was covered with different forages, with only 19.7 as area without vegetation or bare ground, poaceae covered 6.967% of the rangeland, cyperaceae covered 0.003%, fabaceae covered 33.286% and 40.044% was covered with other forage species (table 3). According to the mean values, 65.25% of the total area was covered with plants. This is very good percentage close to the climax of the range condition that highly exceeded the mean values of 26.65% plant-covered area reported by Babalik and Kilic (2015).

Average tree density and canopy cover of the rangeland were 10 trees ha-1 and 2% respectively in the grassland area of the rangeland, 450 trees ha-1 and 78% respectively for shelterbelt area and 2300 plants ha-1 and 74% respectively for shrub land area. This can be compared with Ruvuga et al. (2021) who reported tree density of 934 trees ha-1 and 1147 trees ha-1 and canopy cover of 36.5% and 41.6% respectively, when they considered two distances from settlement area.

Range Condition According to Vegetation Cover of the Rangeland

A simple range condition assessment was done and the condition was established considering the climax of vegetation cover of the study area as shown in table 4. Range condition was measured by the extent to which it departs from the climax. The approach assumes that climax can be determined for each range sites. Excellent class represents climax, i.e., Excellent (76-100), Good (50-75), Fair (26-50), and Poor (0-25) (Ruvuga et al., 2021; Desalew, 2008). The general condition of the Kashin-dila rangeland (65.25%) was determined as "Good".

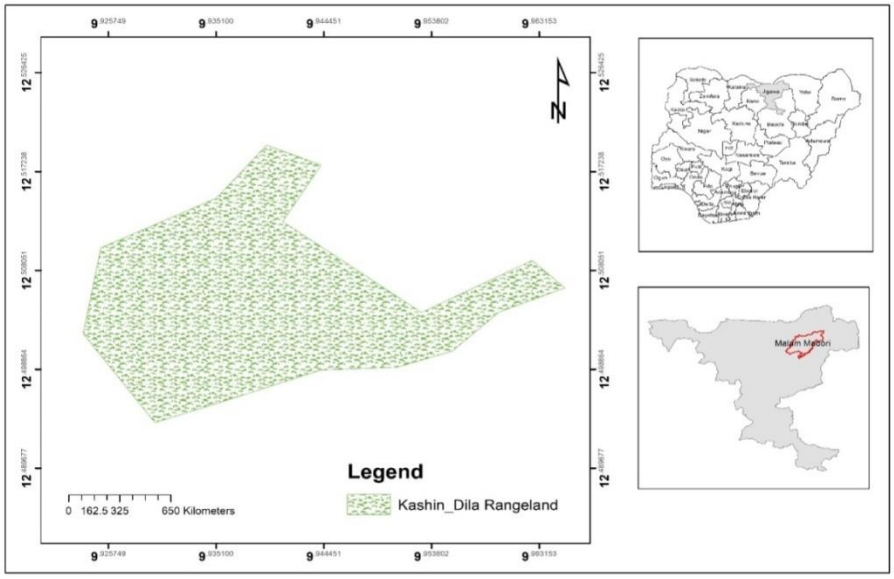

Figure 1. Kashin-dila rangeland

Table 1. Climate distribution during 2023 growing season

2023	Rainfall (mm)	Temperature (^{0})	Relative humidity (%)
January	-	21.0	66.9
February	-	23.2	48.1
March	-	22.6	42.0
April	-	21.0	31.0
May	-	29.8	44.8
June	62.5	22.1	38.7
July	153	22.2	54.2
August	198	29.5	41.7
September	60.5	27.6	54.4
October	30	24.5	37.4
November	-	24.5	69.5
December	-	24.0	62.7
Average	118.5	24.3	49.3

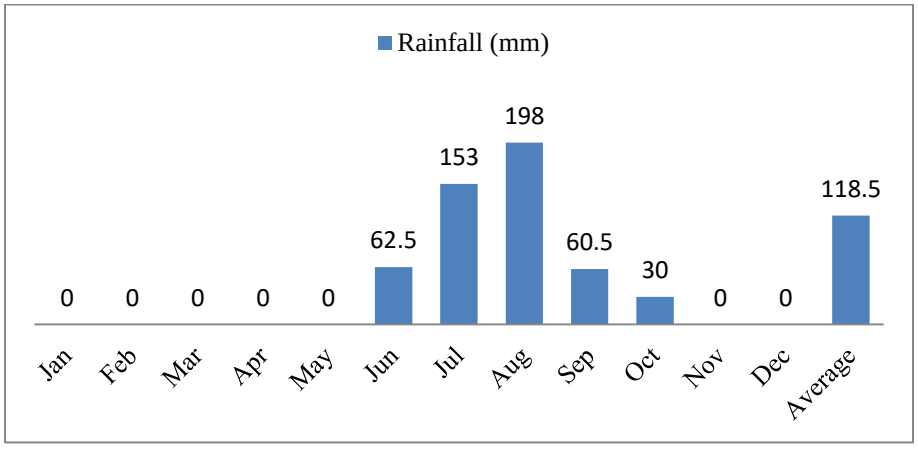

Figure 2. Annual rainfall distribution (2023)

Table 2. Soil properties of the rangeland

Rangeland areas	Soil type	Bulk density (g/cm^3)	Lime value(%)	Organic matter (%)	pH	Salinity
Grassland	Sandy loam	1.434	5.04	4.10	6.64	Salt-free
Shrub land	Sandy loam	1.392	5.22	5.00	7.12	Salt-free
Average	Sandy loam	1.413	5.13	4.55	6.88	Salt-free

Figure 3a. Vegetation structure of the grassland area in the rangeland

Figure 3b. Vegetation structure of the shrub land area in the rangeland

Table 3. Vegetation cover of the rangeland

Rangeland Area	Category	Vegetation cover (%)	Total (%)
Grassland	*Poaceae*	3.350	
	Cyperaceae	0.002	
	Fabaceae	21.517	
	Others	5.231	30.1
Shrub land	*Poaceae*	3.617	
	Cyperaceae	0.001	
	Fabaceae	11.769	
	Others	34.813	50.2
Total	*Poaceae*	6.967	
	Cyperaceae	0.003	
	Fabaceae	33.286	
	Others	40.044	80.3

Table 4. Range condition according to vegetation cover of the rangeland

Rangeland Area	Vegetation cover (%)	Range condition
Grassland	21.23	Poor
Shrub land	44.02	Fair
Total	65.25	Good

CONCLUSION AND RECOMMENDATIONS

This research was conducted to assess the range condition of Kashin-dila rangeland. The rangeland was stratified into two areas (grassland and shrubland), where vegetation cover and forage distribution were measured fortnightly, using the line intercept method and tree density was estimated once, at the beginning of the study period, using the point-centered quarter (PCQ) method. Average tree density and canopy cover of the rangeland were 10 trees ha-1 and 2% respectively in the grassland area of the rangeland, 450 trees ha-1 and 78% respectively for shelterbelt area, and 2300 plants ha-1 and 74% respectively for shrub land area.

The vegetation cover of the rangeland was excellent during the wet season (June to October 2023) as 80.3% of the rangeland area was covered with different forages, with only 19.7 as area without vegetation or bare ground, poaceae covered 6.967% of the rangeland, cyperaceae covered 0.003%, fabaceae covered 33.286% and 40.044% was covered with other forage species. According to the mean values, 65.25% of the total area was covered with plants. This is a very good percentage close to the climax of the range condition. The general condition of the Kashin-dila rangeland (65.25%) was determined as "Good". Further research is recommended to have substantive conclusions on the rangeland condition as not all vegetation in the rangeland is nutritionally important to the grazing animals. It also recommended that research be conducted at different seasons, to determine the effect of the seasons on range condition.

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SMALLHOLDER FARMERS SET TO BENEFIT FROM CLIMATE RESILIENT RICE PRODUCTION PRACTICES FROM RICOWAS PROJECT

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ABSTRACT

Smallholder farmers rice production practices in West Africa are largely traditional, marked by low yields and dependent on agrochemical inputs that are often neither affordable to them nor environmentally sustainable. This couple with the negative impact of climate change threatens rice production, food security and livelihood of smallholder farmers in the region. Developing effective adaptation strategies is critical to minimizing the harmful effects of climate change and sustain productivity of rice crop across the region. RICOWAS project was developed to improve the climate change resilience and increase rice systems productivity of smallholder farmers across West Africa using Climate Resilient Rice Production approach (CRRP). The project intents to achieve its objectives through the three components which include strengthening human and institutional capacity in CRRP, assist farmers to scale-up CRRP and create communication, advocacy and partnerships for the CRRP scaling up. RICOWAS will collaborate with national and regional stakeholders to ensure successful implementation of the project activities in various West African countries. The project targets to reach 151,131 direct beneficiaries who are smallholder rice farmers across the 13 ECOWAS countries to increase productivity and boost their income and livelihood. In Nigeria, the project targets to reach 30,000 smallholder rice farmers among which 10,000 women. A total of 71,240 Hectares across the 13 ECOWAS region and 15,000 Hectares in Nigeria are expected to be covered with CRRP in the next four years.

Key words: RICOWAS, Smallholder, farmer, climate, resilient

INTRODUCTION

Existing evidence shows that climate patterns are getting more unpredictable, with the associated floods and droughts variabilities, its effect on crop production and food security would be detrimental (Lesk et al 2016). The dominant rain-fed agriculture characterizes small-scale farming, and farmers in developing regions in Asia, Africa, Latin America, and the Caribbeans are often susceptible to the effects of climate change variability (Frank and Buckley 2012). West Africa has been identified to be particularly vulnerable to climate change due to the combination of a highly variable climate. It is among the most variable in the world on intra-seasonal to inter-decadal timescales mainly due to high reliance on rainfed agriculture and limited economic and institutional capacity to cope with climate change (Riede *et. al.,* 2016). Developing effective adaptation strategies is critical to minimizing the harmful effects of climate change (Tesfaye, Seifu 2016). It is argued that without adaptation, the vulnerability

of smallholder farming households will worsen, especially if climate change becomes unpredictable (Smit and Pilifosova 2001).

Smallholder common rice production practices in West Africa are largely traditional, marked by low yields and dependent on agrochemical inputs that are often neither affordable to them nor environmentally sustainable. Both systems are highly susceptible to climate change. With farmers trying to cope, it can be expected that pressure on natural resources will increase, be it on vegetation, soils or water, leading to overuse, degradation, potential conflicts, rural exodus and international emigration. To mitigate these effects, introducing adaptation measures and strengthening resilience is a necessity.

RICOWAS PROJECT

Using a Climate Resilient Rice Production approach (CRRP), RICOWAS project was developed to improve the climate change resilience and increase rice systems productivity of smallholder farmers across West Africa. The project aims at improving and scaling up the System of Rice Intensification (SRI) and Sustainable Land and Water Management (SLWM)in West Africa building on the SRI-WAAPP regional project results. The project is implemented at regional level by the Sahara and Sahel Observatory (OSS), financed by the Adaptation Fund (AF) and implemented in 13 ECOWAS countries. Agricultural Research Council of Nigeria is implementing the project activities in Nigeria.

The overall objective of the project is to improve resilience to climate change and increase the productivity of smallholder rice systems in West Africa using a climate-resilient rice production approach, benefiting the 13 ECOWAS countries. The specific objectives are as follows:

- To strengthen the resilience and capacity of smallholder rice farmers and other rice sector actors to use sustainable agro-ecological land and water management strategies that address climate change threats in their respective localities;
- Helping farmers to implement and improve CRRP, using the Intensive Rice Cultivation System method and locally adapted soil and water conservation management approaches;
- Support a communication platform and engage in advocacy to promote effective exchange of knowledge and expertise among various stakeholders in West Africa and elsewhere;
- Facilitate the creation of a coalition of partners at national and regional levels for the improvement of the CRRP.

The project intents to achieve its objectives through the three components which include strengthening human and institutional capacity in CRRP assist farmers to scale-up CRRP and create communication, advocacy and partnerships for the CRRP scaling up in the region. The project aims to strengthen capacities of national and regional research centres, national and regional executing entities and extension institutions involved in dissemination of SRI and CRRP. The project will also assist smallholder rice farmers in the project zones to successfully adopt SRI and CRRP practices, achieving higher rice productivity, and improved their incomes and livelihoods as well as strengthening rice value chain through Public Private Partnerships (PPP) and agricultural associations and cooperatives, and thus improved the resilience of smallholder rice farmers to the harmful effects of climate change. The component three of the project is to create awareness and knowledge of CRRP in West Africa as well as strengthening Partnerships and

coordination to enable the mainstreaming of CRRP in West Africa, thereby synergies among partners established in CRRP in West Africa.

The project intends to collaborate with researchers, ministries and departments of agriculture, socio political groups, rice farmers, extension institutions, universities and NGOs to deliver climate resilient rice production practices to smallholder farmers across the 13 west African countries.

SYSTEM OF RICE INTENSIFICATION

SRI is a knowledge-based methodology that allows farmers to improve rice production and the fertility of the soils with the resources available on their farms. As an agronomic approach, any variety improves its productivity when planted with SRI, be it a high-yielding or a local variety. Once farmers have learned the technique, they can improve their farming outputs within one cropping season. This makes SRI a very effective method, especially for the more vulnerable groups of the population. The System of Rice Intensification is an agro-ecological and low-input methodology to increase rice productivity. It allows yields to increase by 20-50% and more while using 90% less seed, 30-50% less water and 30-100% fewer agro-chemicals. Based on the principles of early plant establishment, reduced competition among plants, enriching soils with organic matter, and reduced water use, rice plants grow more vigorously and can better express their genetic potential than under conventional approaches. Healthier and stronger plants with deeper roots can better withstand weather calamities such as drought, floods, and strong winds, and assure (some) production, while conventionally planted crops succumb more easily to these forces, often leaving farmers without harvests (Styger and Uphoff, 2016).

RICOWAS PROJECT IN NIGERIA

Rice is grown in all the thirty-six (36) states plus Federal Capital Territory (FCT) and in all the agro-ecological zones of Nigeria. The dominant rice system is rainfed which comes along with risks from the increasing variability of climate that resulted in the disruption of the growing seasons, shortening of the cropping season, exacerbated dry spells, droughts, and heatwaves. This scenario creates greater likelihoods of floods, shortage of irrigation water, strong winds and storms, and changes in incidences and geographic range of pests and diseases, all of which can lead to substantial rice yield reductions or crop failure.

RICOWAS Project activities in Nigeria is going to be implemented in five states namely Gombe, Jigawa, Niger, Nasarawa and Ebonyi. Fifteen local Governments namely Auyo, Miga and Jahun in Jigawa state, Lavun, Wushishi and Katcha in Niger state, Doma, Obi and Awe in Nasarawa state, Yamaltu-Deba, Balanga and Kaltungo in Gombe state and Ikwo, Afikpo-North and Ohaukwu in Ebonyi state are to benefit from the project intervention.

CRRP PROMOTED BY RICOWAS PROJECT

The CRRP best practices promoted by RICOWAS project include seed management involving seed selection, harvest, cleaning, storage, best practices for quality seed production with SRI, seed preparation before planting involving seed soaking, discarding unviable seeds and seed drying before planting. Other CRRP practices promoted by RICOWAS project include transplanting of single seedling at 8-12 days, alternate wetting and drying, SMART-Valley approach, contour plowing, mulching of soil surface, organic matter application to improve soil water storage and

short-season rice varieties. Furthermore, chemical fertilizer uses to complement organic fertilizer including urea deep placement, weed management and pest and diseases management were also promoted by the project.

TARGET BENEFICIARIES

The project targets to reach 151,131 direct beneficiaries who are smallholder rice farmers across the 13 ECOWAS countries to increase productivity and boost their income and livelihood. In Nigeria, the project target 30,000 smallholder rice farmers among which 10,000 are women. The expected area to be covered by CRRP during the project period are 71,240 Hectares across the 13 ECOWAS region and 15,000 Hectares to be achieved in Nigeria.

CONCLUSION

The growing demand for rice in West Africa and the production constraints faces by smallholder rice farmers related to climate change and its negative impact to its productivity, the coming of RICOWAS project into the ECOWAS region is a welcome development. Smallholder rice farmers across the region are now set to benefit from CRRP to boost their rice productivity, improve food security and increase their livelihood.

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ANIMAL PRODUCTION

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EFFECTS OF CALVING INTERVAL, ARTIFICIAL INSEMINATION ON FRESIAN×BUNAJI CATTLE AND THEIR CALVES' WEIGHT VARIATION UNDER SEMI-INTENSIVE SYSTEM OF MANAGEMENT

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ABSTRACT

Artificial insemination is the process of introducing male semen to female animal counterpart. The study was conducted to determine the effects of calving interval(days), number of artificial inseminations of Friesian x Bunaji cows and their calves weight(kg) at different season. The breeding records consisted 37 records on calving interval (CI), 72 records on artificial insemination (AI), 30 records on calves weight (CW) of Friesian x Bunaji cows generated from Dairy research program of National Animal Production Research Institute Shika - Zaria. The variation in mean calves weight presented in this study for1st parity wet season, 2nd parity wet season and 1st parity dry season, 27.9±1.71kg, 26.24±1.7kg and 17.6±8.87kg respectively was due differences in season, health of the dam, management activities, genetics factors etc. During the wet season where there was abundant pasture pregnant cow tend to have large birth weight than during the dry season where there was scarce of forage materials. The CI 464±14days for wet season 2 was greater than 439±31days for dry season 1. The number of AI for wet season 1,1.7±0.1 was closer to 1.8±0.2 for wet season 2. AI affect the calving interval, the less the number of AI per cow the less the CI. Early conception result in less CI. Tendency of conception is rare in AI than natural mating. The maximum number of AI obtained from this study was 6 times while the minimum was 1. Number of AI affect the CI. They should be an arrangement for pregnant cows to calves during the wet season in order to have large birth weight as from these findings 27.9±1.7, 26.24±1 for first and second parity wet season respectively. The number of AI per cow should be minimum in order to lower CI. CI of 365 and 377days, one number of AI per cow per conception from these findings were recommended.

Keywords**:** Friesian × Bunaji, Calving interval, Artificial insemination, Calf weight, Shika

INTRODUCTION

The feature of any successful livestock production system is that animals reproduce regularly; and the reproductive process is influenced mainly by the way in which animals are managed. The process which starts with conception and ends with the birth of offspring is one of great significance. After puberty, when animals become capable of reproduction, a host of hormones interplay to result in female animals showing symptoms of heat, or estrus, on a regular basis (Masama *et al.,* 2003).Cattle producers practicing artificial insemination in

the absence of Bulls rely on the homosexual behavior of cows, which mount each other during estrus, to identify animals on heat. Estrus lasts longer in mature cows than in young heifers, and longer in European cattle breeds than in indigenous breeds (Partners in Reproduction, 2012). Milk production depends on the reproductive efficiency of the cows, with the best cows being those that calf at early age with little number of services per conception and with minimum calving interval thereafter (Ngodigha *et al.,* 2009).

An artificial insemination (AI) center using imported frozen semen was started by the National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Shika, Zaria, in 1976. Reproduction efficiency is a major factor affecting the production and economic efficiency of dairy cows (Roth *et al.,* 2000 and Rensis and Scaramuzzi, 2003). Artificial insemination reduces many risks involved with breeding. Natural mating is stressful with tendency of injuries of both the animal and producers animalsmart.org (2024).

Adequate feeding is a measure growth factor influencing the calf growth rate in Nigeria. Environmental factor which affect the nutritional status of calves would influence calf growth performance. Thus calves born during the wet season have been found to have higher preweaning growth rate (Alaku 1982; Oni *et al.,* 1988). Therefore, the aim of the study was to determine the reproductive performance and calves' weight of Friesian x Bunaji cows in wet and dry season.

MATERIALS AND MEHOD

Location

The study was carried out in the Dairy Research Programme Farm of the National Animal Production Research Institute, Ahmadu Bello University, Shika-Zaria. Shika is located in the Northern Guinea Savannah on latitude 11^{o}N, longitude 12^{o}E, altitude 610m. Mean annual rainfall is 1100mm lasting from May to October with peak rainfall between July and September with relative average humidity of about 72% at the period of research. The mean temperature was about 24.4^{o}C (14.5-39.3^{o}C) with the lowest temperature occurring during early dry season (November to January). Higher temperatures are experienced during the research period of late dry season (February-April) with mean relative humidity between 20-37% (Google map, 2013).

EXPERIMENTAL ANIMALS AND THEIR MANAGEMENT

The animals were raised during the rainy season on paddock-sown pastures, while hay or silage supplemented with concentrate mixture of cottonseed cake, maize or guinea corn were offered during the dry season at 3.5kg/day when animals were housed in open sheds. They had access to water and salt-lick at all times. Regular spraying against ticks was observed, while vaccination was carried out against contagious diseases, namely Anthrax and Contagious bovine pleuropneumonia (CBPP). The pregnant cows were separated in maternity pens at third trimester of pregnancy, immediately after birth, new born calves were weigh and recorded using hanging scale. Calves were separated from their dams three days after birth and bucket-fed until three months of age when they were weaned. The cows were machine-milked in the morning and evening daily.

DATA ANALYSIS

The data were analyzed using descriptive statistics which consisted 37 records on calving interval (CI), 72 records on artificial insemination (AI), 30 records on calves weight (CW) of Friesian x Bunaji (75% crossed).

RESULTS AND DISCUSSION

Calving interval (CI): Is the time length between two successive calving. The suitable CI is 365 days while in some cases it ranges between 365-450 days. CI depends on physiological activities in cow related to early return to estrus, number of insemination before conception and the length of lactation. The mean calving interval (MCI) 464 days obtained from this study for Friesian× Bunaji cows in 2nd parity is the same reported by Pritchard *et al*.,(2013). Also in the 3rd parity 439 days is slightly higher than 436 days for other group of cattle. CI influences the regularity of birth, the number of calves produced by a cow, milk production per lactation or per year and for the entire production life.464 days and 439days obtained from this research were higher than 383-393days reported by Buvanendran *et al.*,(1981) for Friesian × Bunaji cows. However, fertility in dairy cattle has an important effect on herd economics. Therefore, short calving interval gives more offspring and a higher milk yield per day from cows in milk, but also a higher risk of periparturient diseases occurrence per cow-year, so it has been questioned whether short calving interval is still economically optimal Jan Tind Sorensen and Soren Ostergaard (2003).

Calve weight (CW): The variation in mean calves weight(MCW**)** presented in (Table 1) in this study from the 1st, 2nd and 3rd parity 27.9±1.71, 26.24±1.7kg and 17.6±8.87 respectively was due differences in season, health of the dam, management activities, genetics factors etc. During the wet season where there was abundant pasture, pregnant cow tend to have large birth weight than during the dry season where there is scarce of forage materials. Late rainy season birth weights 18kg reported by Yashim *et.al.,* (2011) was lessthan 27.9±1.71 and 26.24±1.7kg for wet season from this findings. Late dry season 13.67kg was lessthan17.6±8.87kg and closer to early dry season 16.71kg as reported byYashim *et.al.,*(2011).

Number of artificial insemination (AI): It affect the calving interval, the less the number of AI per cow the less the CI. When the cow conceived earlier the days for CI will be less. Conception tendency is less in AI than natural mating. The maximum number of AI obtained from this study was 6 times closer to 5 times reported by Alphonsus *et al.,* (2014). While the minimum was 1times similar to what was reported by Alphonsus *et al.,* (2014). Number of inseminations per conception (NIC) is widely used as index of fertility.

The average number of insemination per conception (NIC) reported in this study 1.7±0.1 for wet season 1 was closer to 1.64 ± 0.17 and 1.62 reported by Lobago, (2007) in small holder dairy farms but higher than the range of 1.30-1.50 given by Radostits, (2001) and Goshu *et al.,* (2007), and the 1.30 reported by Akpa *et al.,* (2011). However, the values obtained in this study were lower than the estimates of 2.15 reported by Yohannes and Hoddinott (2001) in Asela dairy farm, 2.00 obtained by Ngodigha *et al.,* (2009) in commercial dairy farms and lower than the 2.3 reported by Eid *et al.,* (2012) for imported cows and and 2.11 for Fresian cows in Pakistan (Niazi and Aleem, 2003).

The disparity in the number of insemination required per conception is probably due to one or more of the following reasons; viability of the semen and skill of the inseminator (Buckley *et al.,* 2000), reproductive health of the cows and variation in environment and herd management (Niazi and Aleem 2003; Ngodigha*et al.,* 2009).

Table (1): Breeding records on Friesian×Bunaji cows for 1st parity wet season, 2nd parity wet season and 3rd parity dry season parity.

P.	NO. of AI	CI (days)	CW (Kg)	NO. of AI	CI (days)	CW (Kg)	NO. of AI	CI (days)	CW (Kg)
M.	1.7±0.1	NIL	27.9±1.7	1.8±0.2	464±14	26.24±1.	NIL	439±31	17.6±8.8
Min.	1		20	1	365	10		377	25
Max	6		39	6	630	32		519	28

P= parameters, M. = means, CW = calves weight, CI = calving interval, AI =Artificial insemination, Min. = minimum record, Max. = maximum record.

CONCLUSION AND RECOMMENDATIONS

Dry and wet seasons influence the calves birth weight, during wet season, birth weight was large than during the dry season as from these findings 27.9±1.7, 26.24±1 for first and second parity wet season respectively. Numbers of AI affect the CI. They should be an arrangement for pregnant cows to calves during the wet season in order to have large birth weight.The number of AI per cow should be minimum in order to lower CI. CI of 365 and 377days, one number of AI per cow per conception from these findings were recommended.

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PREVALENCE OF INDIGESTIBLE FOREIGN BODIES IN SLAUGHTERED RUMINANTS AT BAUCHI CENTRAL ABATTOIR, BAUCHI STATE

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ABSTRACT

This study was aimed to determine the prevalence of indigestible foreign bodies (IFB) in slaughtered ruminants and its associated risk factors. Five hundred and eleven (511) stomach compartments of slaughtered ruminants were examined ante and post mortem from August to November, 2023 at Bauchi Central Abattoir, Bauchi state. The data was analyzed using Statistical Package for Social Sciences (SPSS) version 23.0. An association between age, sex, species, body condition score and presence of IFB were determined using Chi-square (χ^2). P-value ≤ 0.05 was considered significant in the study. The overall prevalence of IFB was 30.7%, with goats recorded the highest prevalence (32.8%), followed by cattle (30.7%) and sheep (28.0%). Older animals showed a highest average prevalence (44.1%) of IFB. The study also revealed highest average prevalence of (48.6%) IFB in slaughtered ruminant with poor Body condition Score (BCS). Various types of IFB were identified, with plastics being the most common (15.1%), followed by cloth (6.8%) and metal (2.3%). The findings indicate the implication of improper waste disposal practices, particularly non-biodegradable materials, contributing to prevalence of IFB which underscores the economic and health implications of IFB ingestion in slaughtered ruminants. This study recommends for community awareness programs on proper waste management, promoting bio-degradable materials and government interventions to regulate waste disposal practices and mitigate environmental pollution.

Keywords: Bauchi Central Abattoir, Indigestible Foreign Bodies, Prevalence, Slaughtered Ruminants

INTRODUCTION

Nigerian livestock population is estimated to be about 13.9 million cattle, 22.1 million sheep and 34.5 million goats. Nigeria has great potential for increased livestock production, both for local use and for export. However, expansion was constrained by inadequate nutrition, disease, lack of support services and inadequate information on how to improve animal breeding, marketing and processing. Thus, the country is not utilizing this huge potential livestock resource and an improvement in this sector. Therefore, has the potential to contribute significantly to national income and to the welfare of the majority of rural families. The high concentration of animals in the hands of nomadic herders, together with the fact that some herders often keep their animals for status and pride, thereby reducing the economic potential of Nigeria livestock industry

(CSA, 2009). Ruminants play significant contribution in Nigerian economy as source of meat, milk, drought power, income and foreign exchange. However, as other livestock in the country their contribution is below their expected potential due to diseases risk, unsuitable breeding strategies, insufficient management systems, weak husbandry systems and poor feeding (Lawal-Adebowale, 2012). Foreign bodies are among the most common surgical emergency in veterinary medicine. Ruminant animals are more susceptible to foreign body syndrome than other animals because they do not use their lips for prehension and are more likely to eat chopped feed; lack of oral discrimination in ruminants may lead to ingestion of foreign bodies, which would be less likely to occur in other species (Desiye and Mersha, 2012; Ali and Awoke, 2019).

Traumatic reticulo-peritonitis (TRP) is a relatively common disease in adult cattle caused by the ingestion and migration of a foreign body in the reticulum. The typical foreign body is a metallic object, such as a piece of wire or a nail, often greater than 2.5 cm in length. The majority of affected cattle (87%) are dairy cattle and 93% are older than 2 years of age. Hailat et al., (1996) reported that older dairy cattle are more likely to have the IFB than beef and young ones. This is because of their likelihood to feed on chopped feed, such as silage or hay especially during pregnancy due to hormonal changes and duration in their respective herds. A large number of adult dairy cattle and other ruminants have metallic foreign bodies in their reticulum without signs of clinical disease. It is likely that a predisposing factor in otherwise normal cows, such as tenesmus or a gravid uterus, causes migration of the foreign body into the reticular wall (Rebhun et al., 1995). Ingestion of foreign body in ruminant animals result in a condition of great economic importance and causes severe loss of production and high mortality rate. The ingestion of foreign body is mainly related with nutritional deficiencies and feeding management and cause various problem in different organ of the animal, mainly in rumen and reticulum. The problem that are caused vary with the duration of the foreign body present, the location of the foreign body, the degree of obstruction that is caused as well as problems associated with the material of the foreign body. Ruminants are notorious for ingesting non-dietary foreign bodies (Asrat et al., 2015; Ali and Awoke, 2019).

The disease of rumen and reticulum are great economic importance because of severe losses on productivity of the animals sometimes leading to the death of the animals (Radostits et al., 2007). Entrance and migration of foreign bodies through the body tissues lead to many complications that differ according to the nature of the foreign body and the way of its entrance in to the tissues. Traumatic reticulo-peritonitis (TRP) relatively common disease in cattle caused by the ingestion of foreign bodies in the reticulum swallowed metallic objects such as nail or pieces of wire fall directly on the reticulum or pass into the rumen and subsequently carried over the rumeno-reticular folds in to the cranioventral part of the reticulum (Jones et al., 1997). Non-metallic foreign bodies in the reticulorumen cause recurrent rumen tympani in animals, over a period of time, these materials, form large tight balls inside the rumen leading to anorexia decreased production and progressive loss of body condition (Jafarazadeh et al., 2004). The presences of foreign bodies in the rumen and reticulum also hamper the absorption of volatile fatty acids (VFA) and consequently reduction in the rate of animal fattening. The perforation of the wall of the reticulum allows leakage of ingesta and bacteria which contaminates the peritoneal cavity, resulting in local or diffuse peritonitis is the swallowed objects can also penetrate pleural cavity causing pleuritis and

pneumonitis and into the pericardial sac causing pericarditis (Cavedo et al., 2004).

The condition is serious in our country usually in urban and peri-urban areas where extensive building is carried out and proper plastic material disposal is no conditioned and so thrown on roads and near the fence or anywhere and that is way our dairy cattle are dying mainly associated with foreign bodies (Ramaswamy and Sharama, 2011). In Nigerian, information regarding the magnitude and occurrence of fore stomach foreign bodies is very limited. The fact that rumen impaction by these foreign bodies is mainly a symptomatic in nature and only diagnosed in live animals if the material is accumulated in large amount and thus, it can be adequately studied in abattoirs (Desiye and Mersha, 2012).

Therefore, the objectives of this study are to determine the prevalence of rumen and reticulum indigestible foreign bodies among ruminants slaughtered at Bauchi Central Abattoir and type of rumen and reticulum foreign bodies.

MATERIALS AND METHODS

Study Area

The study was conducted at Bauchi central abattoir, Bauchi State. Bauchi State occupies a total land area of 49,119 km² representing about 5.3% of Nigeria's total land mass and at an elevation of 616 m. The coordinate of the abattoir is latitudes 10° 3' and 13° 3' North and longitudes 10° 50' and 12° 50' East. The state is bordered by seven states, Kano and Jigawa to the North, Taraba and Plateau to the South, Gombe and Yobe to the East and Kaduna to the West. Bauchi state is one of the states in the Northern part of Nigeria that span two distinctive vegetation zones, namely, the Sudan savannah and the Sahel savannah. The rainfall in Bauchi state ranges between 1300 mm per annum in the south and only 700 mm per annum in the extreme north (BSADP. 2022).

Study Animals

The study was conducted on both male and female animals apparently healthy slaughtered ruminants at Bauchi Central Abattoir, Bauch State. The cattle were local breed, which originated from various localities. The geographical origin of all ruminants slaughtered at Bauchi central abattoir brought from different locations. Age, body condition and breed were considered as risk factors for occurrence of foreign bodies.

Study Design, Sample Size Determination and Sampling Technique

A cross sectional study was conducted to determine the prevalence of Indigestible Foreign Bodies (IFB) in slaughtered ruminant. The sample size was determined, using the expected prevalence in the study area which was assumed to be 50% at 95% confidence interval. Hence, three hundred and eighty-four (384) sample size were determined using 50% based line prevalence at 95% confidence interval but was increased to five hundred and eleven (511) sample size for accuracy. Out of the total ruminant animals slaughtered at Bauchi central abattoir during the study period, male and female animals were selected and examined by using simple random sampling method.

The sampling was done from August to November, 2023 using simple random sampling technique method to select the study animals and the fore stomach of individual animals was examined thereafter. Significance was determined at $P<0.05$ and the prevalence of different indigestible foreign bodies and types was presented as percentage (Rabana et al., 2022).

Ante-mortem and Post-mortem Examination

Ante-mortem examination on individual animals was done for assessment of age, and body condition. Age was categorized into young, adult and old based on dentition pattern and body condition of the animal. Based on dentition pattern, the age of each selected animal was determined according to the animal's teeth based on dental eruption and wear of the incisor teeth as previously described by Pace and Wakeman (2003). Body condition score for each selected animal was recorded as poor, medium and good based on the appearance of the animal, as well as the manual palpation of muscles and fat deposition levels over and around the vertebrae of the lumbar vertebrae and traverse processes as previously described by Thompson and Meyer (1994).

Each animal selected for the study was further identified by providing a unique identification number that could be used for both ante- mortem and post-mortem examinations of the animal and each animal was marked for the identification by writing a code on its gluteal muscle using ink.

In the postmortem examination fore stomach was examined immediately after slaughter in the evisceration stage, the stomach was carefully removed from the abdominal cavity and was thoroughly examined by visual inspection and palpation with open and explore for the prevalence of any foreign non dietary material by visualization and palpation. All the contents were examined thoroughly for the presence of foreign bodies. Any foreign bodies were obtained during inspection washed with water to remove adhering feed material and identify type of foreign bodies. When the finding was positive, the location and type of the foreign bodies was recorded otherwise recorded as negative in postmortem record sheet.

Statistical and Data Analysis

The data obtained was coded in Microsoft excel and subjected to descriptive statistics and chi square (χ^2) in order to assess the magnitude of the difference of comparable variables using SPSS version 20.0 software. Pearson chi square (χ^2) test was employed to assess the existence of association between prevalence of the foreign bodies and different potential risk factors considered. For chi-square (χ^2) test, P-value ($P<0.05$) was considered significant. The total prevalence of fore stomach foreign bodies was calculated as percentage by dividing total number of positive cattle for foreign bodies to the total number of animals examined.

RESULTS AND DISCUSSION

Prevalence of Indigestible Foreign Bodies in Slaughtered ruminants

During the study, different foreign bodies were identified and recorded, and the overall prevalence of indigestible foreign bodies in domestic ruminants was 30.9% (158/511). During the study, the prevalence of indigestible foreign bodies concerning the potential risk factors was also further assessed and recorded. Of the total of five hundred and eleven (511) different ruminant animal species (70 goats, 57 sheep and 384 cattle) examined for the presence of indigestible foreign bodies, 158 (30.9%) were found positive for various forms of indigestible foreign bodies in their stomach compartments, mainly rumen and reticulum. Among the positives, relatively the highest was recorded in goats 32.9% (23/70), while the least was recorded in sheep with 28.1% (16/57).

The findings in this study were higher than the findings studies reported by Tesfaye et al. (2012) and Tesfaye and Demissie (2012), 23.9%; Desiye and Mersha (2012), 13.2% and Roman and Hiwot (2010), 9.2%, in different parts of

Ethiopia but lower than reports by Negash et al. (2015). The reason for the disparity may be due to regional, environmental, indiscipline and management system differences at the study areas. This may also be linked to disposal of less biodegradable wastes like plastics, as well as lack of mineral and vitamin supplementation, especially during feed scarcity or draught, or during pregnancy. Similarly, in Nigeria, there is a feed scarcity, particularly during the prolonged dry season, and most small ruminant owners do not provide extra feed to their animals. Ingestion of indigestible foreign materials by ruminants is a common worldwide problem especially among extensively managed ruminants previously reported from Nigeria (Remi Adewumi et al., 2004; Bwala et al., 2016), Jordan (Hailat et al., 1998) and Sudan (Ghurashi et al., 2009). The present prevalence rate of foreign bodies was higher than findings of Desiye and Mersha (2012), who reported 13.22 % of rumen and reticulum foreign body in cattle slaughtered at Jimma Municipal Abattoir and slightly lower than the report of Rahel (2011) who reported 17.1% of prevalence of forestomach foreign bodies in Hawasa Municipal Abattoir, Ethiopia and Dawit et al (2012), who reported 23.9% different types of foreign bodies in their rumen and/or reticulum of cattle at Hirna municipal abattoir. The variation in the prevalence of foreign bodies in the studies areas could be due to differences in the waste management systems, sample sizes and period of sampling between the study areas.

Prevalence of Indigestible Foreign Bodies in Different Age Groups Of Domestic Ruminants

During the study, the prevalence of the indigestible foreign bodies in the different age groups of every ruminant was assessed. Accordingly, the higher number of positives were recorded in older animals.

In this study, the highest prevalence of various indigestible foreign bodies was detected in aged animals' rumen and reticulum. This finding agrees with the reports of (Abebe and Nuru, 2011) on sheep and goats, which may be due to the progressive accumulation of indigestible, consumed items over a long period. Moreover, the time of the study also could play a role for the differences where in recent times the rate of intensification of animal management is increasing and as a result the probability of animals to be exposed to foreign materials might be declined as the animals are staying in a limited confinement for longer time. The highest frequency occurrence of fore stomach and reticulum foreign bodies by ruminant animals according to Desiye and Mersha (2012), is 81.3% of foreign bodies in cattle greater than 10 years age.

Rahel (2011) also reported 17.9% of the animals had higher frequency of foreign bodies in fore stomach and reticulum in the old age. Radostitis et al. (2007) reported old dairy cattle are the most commonly affected group. Ismael et al. (2007) from Jordan also reported the metallic foreign bodies were found in 10 (32.3%) of the cows from medical records of 31 old dairy cows suffering from the recurrent rumen tympany. This might be associated with increase of exposure through life and many were found accumulate and lead the undead animals to be positive.

Prevalence of Foreign Bodies Concerning Animal Body Condition Score in Different Domestic Ruminants

The prevalence of different indigestible foreign bodies in different body condition scores of domestic ruminants was assessed. Accordingly, about 50.8% (30/59), 34.2% (40/117) and 27.4% (57/208) of the poor, medium and good body conditioned ruminants were found positive

respectively without a statistically significant difference (Table 3).

The results of this finding also agree with Rahel (2011), who reported that animals in poor body condition had a greater rate of incidence. The poor bodily condition might be attributed to the presence of a foreign body that interferes with the absorption of volatile fatty acids and effective feed conversion. The highest frequency of occurrence of foreign bodies was detected in poor body condition animals, and this finding is in agreement with Desiye and Mersha (2012), who found 72.7 % in poor body condition score animals followed by medium (36.0%) and good body condition score animals (7.3%) is the least. Rahel (2011) and Tesfaye et al (2012) also reported higher frequency of foreign body occurrence in animals having poor body condition than in good body conditioned animals. Poor body condition by itself might be due to the contribution of the foreign body that is the animal loss weight after it has been exposed or it might be due to the interference of foreign body with the absorption of volatile fatty acid (VFA) and thus causes reduced weight gain reported by (Remi-Adewunmi et al., 2004; Ismael et al., 2007; Rahel, 2011). Hairball sometimes occur in ruminant in fore stomachs and abomasum (Maxie, 2007) and overtime time, these materials form large tight balls inside the rumen leading to anorexia, decreased production and loss of body condition (Tyagi and Singh, 1993) as such foreign bodies hinders the process of fermentation and mixing of contents leadings to poor body condition.

Types of Indigestible Foreign Bodies Recorded among Domestic Ruminant Species

The study revealed various types of indigestible foreign bodies like plastic, cloth, leather, sack and metals were identified from parts of the stomach of domestic ruminants. Of the foreign bodies, about 17.5% (30/171) and 12.8% (17/125) were found to be plastic materials in goats and sheep, respectively. On the other hand, many types of indigestible foreign bodies were identified in the stomach compartments of cattle. Among these were plastic 13.6% (12/88), cloth 12.5% (11/88), leather 1.0% (4/88), sack 5.7% (5/88) and metal 10.2% (9/88; Table 4). The highest record of indigestible foreign bodies was plastics (44.0%) in different stomach compartments of animals.

This finding was in line with several findings from another nearby region of Ethiopia (Abebe and Nuru, 2011; Tesfaye et al., 2012), and Nigeria (Nongcula et al., 2017). This may be due to less biodegradability of the synthetic plastic materials, negligent disposal and less availability of industry for recycling in the study area. Abebe and Nuru (2011) had stated that urban and semi-urban areas are polluted with plastics, ropes, hairs, wool and are growing problem for grazing animals because of the poor management system and inadequate availability of feed especially during long dry seasons. Metallic foreign bodies were most frequently recovered from reticulum. Radostits et al. (2007) reported that in industrialized countries, metallic foreign bodies present in the reticulum up to 90% of normal animals. The reason might be due to retention of these foreign bodies by honey comb structure of the reticular mucosa and their heavy weight give chance to be attracted to the lumen of the reticulum due to gravitational attraction force of heavy foreign bodies to the ventral part of fore stomach. The current results also agree with Remi-Adewunmi et al. (2004), who found 58.5% in rumen and 19.3 % in reticulum of Achai Cattle.

Table 1: Prevalence of Indigestible Foreign Bodies in Slaughtered Animals

Species	No. examined	No. of Positive Animals	Prevalence (%)	Chi-square (χ^2)	*P-Value*
Goat	70	23	32.9	0.765	> 0.05
Sheep	57	16	28.1	–	–
Cattle	384	119	31.0	–	–
Total	511	158	30.9		

Table 2: Prevalence of indigestible foreign bodies in different age groups of domestic ruminants

Species	Age group	Animals examined	Positive for foreign bodies	Prevalence (%)	Chi square (χ^2)	P-value
Goat	Old	20	09	45.0	2.170	> 0.05
	Young	15	03	20.0	–	–
	Adult	35	12	34.3	–	–
	Total	70	24	34.3		
Sheep	Old	22	10	45.5	1.976	> 0.05
	Young	10	01	10.0	–	–
	Adult	25	12	48.0	–	–
	Total	57	23	40.4		
Cattle	Old	84	35	41.7	4.282	> 0.05
	Young	127	38	29.9	–	–
	Adult	173	50	28.9	–	–
	Total	384	123	32.0		

Table 3: Prevalence of Foreign Bodies Concerning Animal Body Condition Score in Different Domestic Ruminant

Species	Body condition score	Number of animals	Animals foreign bodies	Prevalence (%)	*Chi square* (χ^2)	P-value
Goat	Poor	25	10	40.0	1.451	> 0.05
	Medium	20	08	40.0	-	–
	Good	25	02	8.0	-	–
	Total	70	20	28.6		
Sheep	Poor	20	11	55.0	2.018	> 0.05
	Medium	22	07	31.8	-	–
	Good	15	01	6.7	-	–
	Total	57	19	33.3		
Cattle	Poor	59	30	50.8	2.723	> 0.05
	Medium	117	40	34.2	-	–
	Good	208	57	27.4	-	–
	Total	384	127	33.1		

Table 4: Types of indigestible foreign bodies recorded among domestic ruminant species

Species	No. examined	Plastic (%)	Cloth (%)	Leather (%)	Sack (%)	Metallic
Goat	171	30 (17.5)	9 (5.3)	5 (2.9)	6 (3.5)	–
Sheep	125	16 (12.8)	6 (4.8)	2 (1.6)	3 (2.4)	–
Cattle	88	12 (13.6)	11 (12.5)	4 (1.04)	5 (5.7)	9 (10.2)
Total	384	58 (15.1)	26 (6.8)	11 (2.9)	14 (3.7)	9 (2.3)

CONCLUSION AND RECOMMENDATIONS

The current study revealed the prevalence rate of various forms of indigestible foreign bodies in the rumen and reticulum of cattle, sheep and goats slaughtered at Bauchi Abattoir. From the identified foreign bodies, the majorities were plastics and from animals with poor body conditions. This finding reveals that the ingestion of indigestible foreign bodies is common and mainly associated with decreasing body conditions. In addition, the problem is also associated with limited feed availability, especially during the dry season and poor management system, less biodegradability, negligent disposal of wastes like plastic bags to the environment and less expansion of industry for the recycle. Consequently, this problem is posing great economic loss to the nation through its effect on animal and environmental health.

It is therefore recommended that there should be the creation of community awareness through training on the proper waste management and recycling to minimize the effect on animal and environmental health. In addition. There should be an improvement in the management system of animals and the use of biodegradable paper and government should encourage the policymakers to devise and adopt strategies for the regulation of waste management and mitigation of environmental pollution.

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PROFILING THE EXPRESSION OF HEAT SHOCK PROTEIN GENES IN SERUM OF NOILER BIRDS RAISED UNDER TROPICAL WEATHER.

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ABSTRACT

Heat shock proteins are highly protected proteins that act as molecular chaperones and are expressed in response to changes in heat stress condition. This study is designed to determine the expression profile of genes that are related to heat stress response in blood samples obtained from noiler strain of birds. Real-time polymerase chain reaction was performed to analyze the transcript of *Hsp90, Hsp70, Hsp60 and Hsf1* serum of noilers under varying temperature-humidity indices (THIs). Results show high expression levels of H*sp*70 and H*sp*90 and hsf1 genes at increased THI level ($P<0.05$) than those at low THI level. No differences in the expression pattern of the H*sp*60 gene between the two This. Conclusively, the over expression of H*sp*70, Hsp90 and hsf1 genes in noiler strain of birds suggest better heat tolerance and adaptability to tropical climate. It also inferred high protective cellular mechanism from damage induced heat stress. Thus, noiler birds can be suggested for poultry farmers as commercial meat, egg and breeding stock.

Keyword: Protein, Genes, Heat, Serum, Weather, Noiler Bird

INTRODUCTION

Changes in climatic indices greatly limit the production of food and livestock products (milk, eggs, hides, skins) majorly in tropical regions. Unfavorable weather conditions predisposes livestock to heat stress which affect animals that are domesticated (Agbana *et al*, 2024). Heat stress in livestock occurs when there is an increase in body temperature of farm animals which stimulate cellular response to compensate for the heat gain (Thornton *et al*, 2021). It is a condition that results when fluctuations in environmental conditions challenge livestock thermoregulatory mechanisms.

Literatures have reports on the effects of heat stress on farm animals which include decreased milk and meat production (Summer *et al*, 2019), reduction in fertility rate (Paula-Lopez *et al*, 2013), poor immunity status due to changes in animal physiology and lower quality of dairy and meat products (Ouellet *et al*, 2021).

Heat stress is determined partly in animal husbandry by a temperature-humidity index (THI) parameter that consider relative humidity and environmental temperature as stressor (Ouellet *et al*, 2021). THI enables researchers to classify stressed animals into mild, moderate and severe heat stressed condition. Omics technology as however been used recently to

effectively classify and study the molecules chaperones, biological processes and mechanism of heat stress conditions (Ribeiro *et al*, 2020). Transcriptomics has been employed in determining responses of animals to heat stress at molecular level combining environmental parameters, diets and genotypes (Liu *et al*, 2020, Ribeiro *et al*, 2020). Proteomics allows for identifying and classifying proteins and genes responsible for heat stress as they are expressed. Body temperature above certain threshold induces gene expression in the biosynthesis of these heat shock proteins and their expression levels in various farm animals (Deb *et al*, 2014). Over expression of heat shock proteins activates cellular protective mechanism against hyperthermia.

It is worthy of note that naturally, the survivability of farm animals under tropical conditions depends on the adaptations developed overtime by animals through successive exposure to continuous stressor (Agbana *et al*, 2024, Lees, *et al*, 2019).

The noiler, a breed of birds developed from selective cross program between Nigerian indigenous chicken and the White Plymouth rock chicken has exceptional qualities of resilience and ability to survive in various challenging environments while exhibiting rapid growth rate, weight gain and high meat yield traits which is an advantage over other breeds. It has been reported that noiler embryos showed better response to heat stress than other breeds of poultry (Agbana *et al*, 2024).

Dogara *et al*. (2021) observed that noilers are excellent producers of quality eggs. At present, studies of gene expression profiles of genes related to heat stress in Noiler birds under tropical climate are scarce. Thus, it is expedient to establish gene transcripts of heat shock proteins as molecular chaperone and tools for identifying better adapted livestock under tropical conditions. This study therefore, aimed at examining the expression pattern of heat related genes to severe heat stress condition in blood samples from noiler breed of birds.

MATERIALS AND METHODS

Study Location

The experiment was carried out at the Teaching and Research farm, Department of Animal Health and Production Technology, Kogi State Polytechnic, Itakpe campus which lies on latitude 7.63 ^{o} North and longitude 6.35 ^{o}East with an annual rainfall of 1280 mm, 76% relative humidity and average annual temperature of 28.64 ^{0}C (Google earth, 2022).'

Study Period

The study was conducted during the dry and hot season of the Guinea savanna from February to April, 2023.

Experimental Animals and Management

One hundred (100) day old noiler birds were purchased from a certified poultry dealer, reared in on deep litter system for eight weeks under strict sanitary conditions and nutritional managed on commercial starter feed of CP = 20.0 %, Fat = 5.0 %, Crude fibre = 6.0 %, calcium = 0.90 %, phosphorus = 0.38 %, lysine = 0.05 %, methionine = 0.50 % and metabolizable energy = 3000 kcal/kg. At 5 weeks, the feed was replaced by a commercial grower feed of CP =14.0 %, Fat = 7.0 %, Crude fibre = 10.0 %, calcium = 1.00 %, available phosphorus = 0.34 %, lysine = 0.03 %, lysine = 0.05 % and metabolizable energy = 2,800 kcal/kg. Feed and water was given to bird *ad-libutum*. The birds comprises of 37 black, 33 brown and 30 spotted.

Sample Collection

At 8 week, 5 ml blood samples each were collected randomly from 70 birds by venipuncture of the wings twice daily between 6:00 am and 8:30 am (morning) and then from 12:00 pm to 2:30 pm (afternoon) into labelled tubes. Blood samples were divided into aliquots of 2 mL in vial tubes and frozen in Nitrogen at -20^{o}C until analysis.

Meteorological Data

The air temperature and relative humidity data were obtained over the experimental periods from the Geological station equipment's. Temperature monitoring was done 25 days before taking the blood samples with the aid of a digital thermometer in the morning and evening. This is to determine the coolest and hottest hours of the day in the dry season. The temperature-humidity index for birds was calculated from the formula of Fonseca *et al*. (2018).

THI = 0.8 x AT + (RH /100) x (AT-14.4) + (46.4)

Where,

THI = Temperature-Humidity Index

AT = Air temperature (^{o}C)

RH = Relative humidity (%)

THI data were used to categorized animal safety index into –

<82 = absence of heat stress, 82 - <84 = moderate heat stress, 84 - <86 = severe heat stress, over 86 = extreme severe heat stress.

RNA Extraction and cDNA Synthesis

Total RNA was extracted from serum samples of birds adopting the procedure of Taborda - Charris *et al.*(2023) using the RNA-solv reagent kit according to the manufacturer's protocol. All RNA samples were diluted to 200 ng/µL and cDNA was synthesized prior reverse transcription by GoScript TM reversal transcription system kit following manufacturer's instructions. Aga - rose gel electrophoresis was performed to test cDNA quality.

Real-time PCR Analysis

The relative expression of H*sp*60, H*sp* 70, Hsp 90 and H*sf 1* genes was measured in duplicate by quantitative real-time PCR (qPCR) in a Thermo fisher Scientific Real-Tme PCR system by fast ramp program of GoTaq qPCR Master Mix (Promaxx). The relative gene expression was normalized using *actinβ* as a reference gene. Primer sequences for h*sps* by qPCR assay are presented in Table 1. Thermal cycling conditions were initial denaturation for 3 min at 95^{o}C then, 35 cycles of denaturation for 5 s at 95^{o}C, and annealing for 30 s at 65^{o}C. A melting step was performed at 95^{o}C for 2 s, and 20 s. Data gotten were analyzed by 2 -ΔΔCT method.

Statistical Analysis

Data obtained from cycle threshold and differences in relative gene expression between month groups were analyzed by ANOVA on SAS package. Significant differences in mean values were separated at P<0.05.

RESULTS AND DISCUSSION

Table 2 shows the meteorological data of the experimental site from the month of February to April, 2023. The air temperature (34.8), relative humidity (46.63%) and THI (84.74) values are statistically (P<0.05) higher in the month of April than February (29.5, 34.51%, 75.24) and March (32.00, 38.74%, 83.53), respectively. The observed values of THI assessed heat stress severity of birds as ranging from moderately heat stress in the month of March to severe heat stress in April This indicate that birds were raised within the period of heat

stress. Hence, physiologically, experimental birds are in their thermal discomfort zones. This support the features and nature of Guinea savanna ecological zone of Nigeria where severe heat conditions were recorded during the days in months of April, May and June of the year. The observation support the findings of Garba *et al*.(2022) who reported similar trends for cattle raised under Guinea savanna at the same months of the year. In this study however, higher values was recorded for relative humidity. The difference in values may be due to variations in studied ecological zones.

The temperature-humidity index (THI) of the birds though higher in month of April, recorded lowest value in early hours of the day between 5.00 am and 7.00 am and were at calculated value of 65% while, the hottest and high humidity hours were between 12.00 pm and 4.00 pm at THI value of 83. Thus, by implication, blood samples were collected at one hour after coolest time of the day and within the highest THI values.

Differential Gene Expression Profile of Hsp60, Hsp70, Hsp90 and Hsf1 in Noiler Birds.

The results for changes in the expression of hsp genes in serum samples of noiler subjected to heat stress condition is presented in Table 3. Our results showed a significantly ($P<0.05$) higher mRNA expression of hsp70, hsp90 and hsf1 in serum samples taken from birds that by THI assessment correspond to being under severe heat stress condition compared to absence of heat stress. Hsp70, Hsp90 and hsf1 have been implicated in cells protection, proteotoxic conditions and regulators of stressors. Over expression of these genes therefore suggest cellular thermo-tolerance of noiler birds. The mRNA overexpression profile of H*sp*70 in this study, agrees with previous findings of Bharati *et al* (2017) where the overexpression of hsp70 gene was reported in cattle after their exposure to heat at higher temperatures. The initiation of H*sp*90 has been reported to prevent apoptotic cell death by rapidly activating pro-caspase-3 during apoptosis (Khan et al, 2020).

Thus, noiler is a strain of birds that has physiological and genotypical adaptations to reduced heat load and heat losses capable of being use for both meat and egg production under tropical climate.

Table 1: Primer sequences for hsp60, hsp70, hsp90 and hsf1

Gene		Primer sequence (5'-3')	Primer length (NT)	Amplicon size (bp)
Hsp60	F	GGAAAGGTGAAC	20	214
	R	CAGGCAATGCAA	20	
Hsp70	F	AGGACTTCGACA	22	141
	R	TGCTGGACGACA	20	
Hsp90	F	GGAGGATCACTGA	20	175
	R	GATTAGCTCCCAT	20	
Hsf 1	F	CCCCGACCACCTA	18	138
	R	GCGACGCTGAGGC	17	
Actinβ	F	GGGATGAGGCTCC	23	112
	R	AGCTCGTTGAAGT	20	

Table 2: Meteorological data of experimental site

Parameters	February	March	April	SEM
Air temperature (^{o}C)	29.50 [c]	32.00 [b]	34.80[a]	0.65*
Relative humidity (%)	34.51[c]	38.74[b]	46.63[a]	1.31*
THI	75.24	83.53	84.74	2.02*

[a,b,c] means with different superscripts differ significantly P<0.05

Table 3: Differential Heat shock protein gene expression in serum of heat stressed noiler.

	mRNA expression (fold change)			
Time	Hsp 60	Hsp 70	Hsp 90	Hsf1
AM (Morning)	3.30	5.0 [b]	3.80[b]	05.65[b]
PM (Afternoon)	4.50	30.8[a]	30.63[a]	30.31[a]

[a,b,c] means with different superscripts differ significantly P<0.05

CONCLUSION

The results of this study established that THI threshold influences changes in gene expression of some genes related to heat stress in noiler birds raised under tropical conditions especially, under severe heat stressed condition (afternoon). Heat stress conditions stimulated the expression of hsp70, hsp90 and hsf1 genes compared the THI range for not stressed (morning) birds, providing cell protection and cellular adaptability in noiler birds. This information may be helpful for poultry farmers in selecting breeding stocks.

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MELATONIN AND *Allium sativum* (GARLIC) PROTECT DIBUTYL PHTHALATE (DBP) INDUCED DAMAGE IN TESTICULAR AND EPIDIDYMAL SPERMATOZOA OF RABBIT BUCKS

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ABSTRACT

This study was designed to evaluate the effects of Melatonin and *Allium sativum* (garlic) on dibutyl phthalate (DBP) induced toxicity on histopathology of testes and epididymides of rabbit bucks. This study aimed to investigate the ameliorative and protective effects of melatonin and garlic on DBP induced toxicity in the testes and epididymides of rabbit bucks. Forty two (42) rabbit bucks were used for this study, bucks were randomly divided into 7 groups of 6 bucks each. Group A was administered olive oil for 16 weeks, group B (olive oil + DBP for 16 weeks), group C (melatonin for 8 weeks, then olive oil + DBP for another 8 weeks), group D (garlic for 8 weeks, then olive oil + DBP for another 8 weeks), group E (olive oil + DBP for 8 weeks, then melatonin for another 8 week), group F (olive oil + DBP for 8 weeks, then garlic for another 8 weeks) and group G (olive oil + DBP for 8 weeks, then melatonin and garlic for another 8 weeks). The observation period lasted for 112 days, the bucks were sacrificed and the testes and epididymides were harvested for histopathology examination. DBP exposed group B, without treatment showed degenerative changes with apparent absence of sperm cell in the testes, while epididymis of group B also showed fewer sperm cells compared to other treatment groups. In conclusion, the study discovered that DBP has deleterious effects on spermatozoa in the testes and epididymides, also the administration of melatonin and garlic has both protective and ameliorative effects.

Keywords: *Allium sativum*; Dibutyl phthalate; Epididymal spermatozoa; Melatonin; Testicular spermatozoa.

INTRODUCTION

Reactive oxygen species (ROS) and antioxidants concentration/activities remain in a balanced state, but when the balance is disrupted towards an overabundance of ROS, oxidative stress (OS) occurs (Agarwal and Gupta, 2006). Oxidative stress (OS) affects many physiological processes in the male such as sperm motility, fertilizing ability and deoxyribonucleic acid (DNA) integrity and female (from oocyte maturation to fertilization, embryo development and pregnancy). It has been reported that age-related

decline in fertility is modulated by OS (Agarwal and Gupta, 2006).

Dialkyl or alkyl aryl esters of 1, 2-benzene dicarboxylic acid (phthalic acid) mainly referred to as phthalate esters (PEs) are synthetic chemicals that are ubiquitous in the environment. The PEs are used extensively as plasticizers in many consumer plastic products, including: Children toys, food wrapping materials, cosmetics, even some biomedical devices like dialysis tubing and intravenous bags. They are also used in enteric coating of some pharmaceutical preparations (Oehlmann *et al.,* 2009; Umar *et al.*, 2014). They are not covalently bound to polyvinyl chloride (PVC) compounds, so they easily leach out overtime into the biosphere, becoming available for biological exposure through ingestion, inhalation and dermal exposure (Heudorf *et al.,* 2007; Swan, 2008). Di (n-butyl) phthalate (DBP), is metabolised into monoester, mono-butyl phthalate (MBP) which is a potent testicular toxicant (Oishi and Hiraga, 1980), and this is considered to be the active agent in testicular toxicity rather than the parent compound (Sjoberg *et al.*, 1986; Mylcreest *et al.*, 2000).

Allium sativum (garlic) is rich in antioxidants, which help scavenge free radical particles that damage cell membranes and DNA which may be beneficial to the ageing process (Leelarungrayub *et al.*, 2006; Capasso, 2013; Shinkut *et al.*, 2016a). The beneficial effect of garlic supplementation in reducing blood pressure and offering cardioprotection seems to be due to its ability to counteract oxidative stress (Dhawan and Jain, 2005). The antioxidant activity of garlic has been attributed to a variety of sulphur-containing compounds and their precursors (Nishimura *et al.,* 2004; Singh *et al*., 2004). Flavonoid; one of the active constituents of garlic confers protection against the harmful effects of ROS (Shinkut, 2015). *In vitro* studies show that flavonoids have potent antioxidant activities (Prochazkova *et al.,* 2011; Attia *et al.,* 2016; 2017).

Melatonin, a tryptophan derived molecule with pleiotropic activities, is also a potent endogenously produced substance with free radical scavenging and broad spectrum antioxidant activity (Tan *et al.,* 1993; Tan *et al.,* 2002). One of the most effective antioxidants for the protection of testicular function is melatonin (Aitken and Romans, 2008). Melatonin has been reported to reduce oxidative stress in the testes induced by ethanol (Oner-Iyidogan *et al*., 2001), indomethacin (Othman *et al.,* 2001), X-irradiation (Hussein *et al.,* 2006), and streptozotocin induced diabetes (Armagan *et al*., 2006).

Studies have associated declining reproduction, especially male fertility to toxicants found in the environment, particularly endocrine-disrupting chemicals (EDCs), such as phthalates (Wong and Cheng, 2011; Nordkap *et al*., 2012). Di-n-butyl phthalate (DBP) is one of such that has attracted special attention due to its high production volume in millions of tons annually (Swan and Elkin, 1999; Guerra *et al.,* 2010). As a result, human and animal exposure becomes inevitable with devastating negative consequences on reproduction (Asghari *et al.,* 2015; Hamdy *et al*., 2015; Rehani *et al.,* 2015). In addition, DBP was reported to increase generation of ROS within the testes, simultaneously decreasing antioxidant concentration, resulting in impaired spermatogenesis (Lee *et al.,* 2007; Zhou *et al.,* 2011).

The objective of the study was to determine the protective and ameliorative effects of melatonin and *A. sativum* on dibutyl phthalate-induced damage on testicular and epididymal histopathology of rabbit bucks.

MATERIALS AND METHODS

Study Area

The study was carried out at the Department of Theriogenology and Production, Faculty of Veterinary Medicine, ABU Zaria. It is situated in the Northern Guinea Savannah Zone of Nigeria and lying between latitudes 11˚3 N and 12˚N and between longitudes 7˚42 E and 8˚E at an elevation of 646 m above sea level. The mean annual rainfall in the area is 1100 mm lasting from April/May to September/October (816 mm/month). Mean daily temperature during the wet season is 25˚C and mean relative humidity of 72%. The dry season lasts from November to April, with the daily temperature ranging from 14 to 36˚C and relative humidity of 20-30% (www.world66.com).

Experimental Animals

Forty two (42) apparently healthy, New Zealand white rabbit bucks (*Oryctolagus cuniculus*), with mean age of 10.0 ± 2.0 month old and mean body weight of 1.80 ± 0.1kg were used for the study. The New Zealand white bucks were sourced from rabbit farms within Zaria and environs then screened and treated with Ivermectin (Kepromec® Holland, dosage 0.1mg/kg) against endoparasites and helminthes infestation. Also, penicillin-streptomycin (Penstrep, dosage of 20,000 IU and 20mg/kg) was used to prophylactic treat against possible bacterial infection, before the commencement of the experiment. Water and feed were provided *ad libitum.* The bucks were housed in standard rabbit cages with dimension of 1.8×0.6m, one buck per cage at the animal house.

Allium sativum

Allium sativum (garlic) bulbs were sourced from Sabon Gari market, Zaria, Kaduna State, and sent to the Herbarium, Department of Biological Sciences, Ahmadu Bello University, Zaria for confirmation. The fresh bulbs were peeled and dried under shade, the dried bulbs were then weighed and added to the feed raw materials and ground together to form the experimental diets (5% or 5 kg of garlic was weighed and added to 95% or 95 kg of other feed ingredients to make up 100 kg of the experiment diet for garlic treatment groups).

Chemical Acquisition and Preparation

Di(n-butyl) phthalate DBP (CAS Number 84-74-2-technical grade-99% purity) was purchased from Sigma Aldrich USA. Dosage of 750 mg/kg to be given to the experimental bucks was calculated and reconstituted in olive oil (Goya Extra Virgin Olive Oil, Sevilla, Spain) to form a solution of 50 % DBP as described by Nair (2015). Melatonin (MEL, 5 mg/Tablet, Nature made, USA) was dissolved in 10 ml of distilled water to make 0.5 mg/ml suspension daily before administration to the experimental bucks (Umosen *et al.,* 2012). All preparations were administered to the animals orally using a gastric tube.

Ethical Permit

Approval for this study was sought and obtained from the Ahmadu Bello University Committee for Animal Use and Care with the approval number: ABUCAUC/2018/059.

Experimental Design

Groupings

The Forty two (42) rabbit bucks were randomly divided into seven (7) groups of six (6) bucks each, designated as groups A, B, C, D, E, F and G. All group received treatment as described by Shinkut *et al*. (2020a, b, c) as shown below:

Group A: Administered Olive oil alone at 1.5 ml/buck ×5/7 (working days of the week) for 16 weeks

Group B: Administered Olive oil at 1.5 ml + DBP (750 mg/kg) ×5/7 for 16 weeks

Group C**:** Pretreated with melatonin @ 0.5 mg/ml ×7/7 for 8 weeks, then Olive oil 1.5 ml + DBP (750 mg/kg) ×5/7 administered for another 8 weeks.

Group D: Pretreated with *A. sativum* 5.0% ×7/7 for 8 weeks, then Olive oil 1.5 ml + DBP (750 mg/kg) ×5/7 administered for another 8 weeks.

Group E: Administered Olive oil 1.5 ml + DBP 750 mg/kg ×5/7) for 8 weeks, then treated with Melatonin @ 0.5 mg/ml ×7/7 for another 8 weeks.

Group F: Administered Olive oil 1.5 ml + DBP 750 mg/kg ×5/7) for 8 weeks, then treated with *A. sativum* 5.0% ×7/7 for another 8 weeks.

Group G: Administered with Olive oil 1.5 ml + DBP 750 mg/kg ×5/7) for 8 weeks, then treated with Melatonin @ 0.5 mg/ml + *A. sativum* 5.0% ×7/7 for another 8 weeks.

The rabbit bucks were allowed to acclimatised for 30 days before the commencement of the study. All rabbits were fed diets corresponding to their groups as shown in Table 1, as described by Shinkut *et al*. (2020a,b,c). The diets were of isonitrogenous and isocaloric values and the study was an experimental laboratory design.
After 120 days treatment and observation, five bucks were sacrificed from each group and the right testicles, and epididymides were harvested for histopathology examination (Shinkut *et al*., 2016b).

Histological Examination of Testes and Epididymides

The five bucks sacrificed from each group, the right testes were carefully separated from the right epididymides and harvested. After fixation in Bouin's solution, the tissues were dehydrated, infiltrated with liquid paraffin and embedded in paraffin blocks sectioned at 5 microns thickness using a rotatory microtome, then each section was stained with Haematoxylin and Eosin (H & E) using standard staining procedures according to Luna (1968) and examined under the light microscope at ×400.

RESULTS

Presented here are Photomicrograph of testes and epididymides of rabbit bucks of the treatment groups A, B, C, D, E, F and G at week 16 of the study.

Testicular Histology

The lumen of the seminiferous tubules of group B shows the absence of spermatozoa, while those of other groups contained spermatozoa as shown in Fig 1-3

Epididymides Histology

There was sparse distribution of spermatozoa within the lumen of the cauda epididymides of group B, compared to other groups (A, C, D, E, F and G). There was no obvious pathological lesion observed on the epididymides of the control groups (A and B) and the treatment groups (C, D, E, F and G) as shown in Fig 4-6.

Table 1: Composition of Experimental Diets for the individual groups

Treatment groups Composition (%)	A	B	C	D	E	F	G
Maize	30.16	30.16	30.16	28.57	30.16	28.57	28.57
Groundnut cake	28.12	28.12	28.12	26.64	28.12	26.64	26.64
Rice offals	35.32	35.32	35.32	33.46	35.32	33.46	33.46
Crude *Allium sativum*	0.0	0.0	0.0	5.0/0	0.0	0/5.0	0/5.0
Vitamin premix	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Palm oil	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Bone meal	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Methionine	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100	100	100
Dry matter	89.50	89.50	89.50	87.89	89.50	87.89	87.89
Crude protein	16.81	16.81	16.81	18.75	16.81	18.75	18.75
Ether extract	1.27	1.27	1.27	1.10	1.27	1.10	1.10
Crude fibre	8.65	8.65	8.65	8.54	8.65	8.54	8.54
Nitrogen free extract	53.96	53.96	53.96	52.46	53.96	52.46	52.46
Ash	7.20	7.20	7.20	8.65	7.20	8.65	8.65
ME(kcal/kg)	2,640.42	2,640.42	2,640.42	2,645.18	2,640.42	2,645.18	2,645.18

Metabolisable energy calculated according to formula of Pauzenga (1985): ME = 37 × %CP + 81 × %EE + 35.5 × %NFE. ME = Metabolizable energy; CP = Crude protein; EE = Ether extract; NFE = Nitrogen free extract; Crude *A. sativum* 5.0/0 = 5% *A. sativum* in diet for 8 weeks followed by 0% *A. sativum* in diet from 9-16 weeks. Crude *A. sativum* 0/5.0% = 0 % *A. sativum* in diet for 8 weeks followed by 5.0 % *A. sativum* in diet from 9-16 weeks

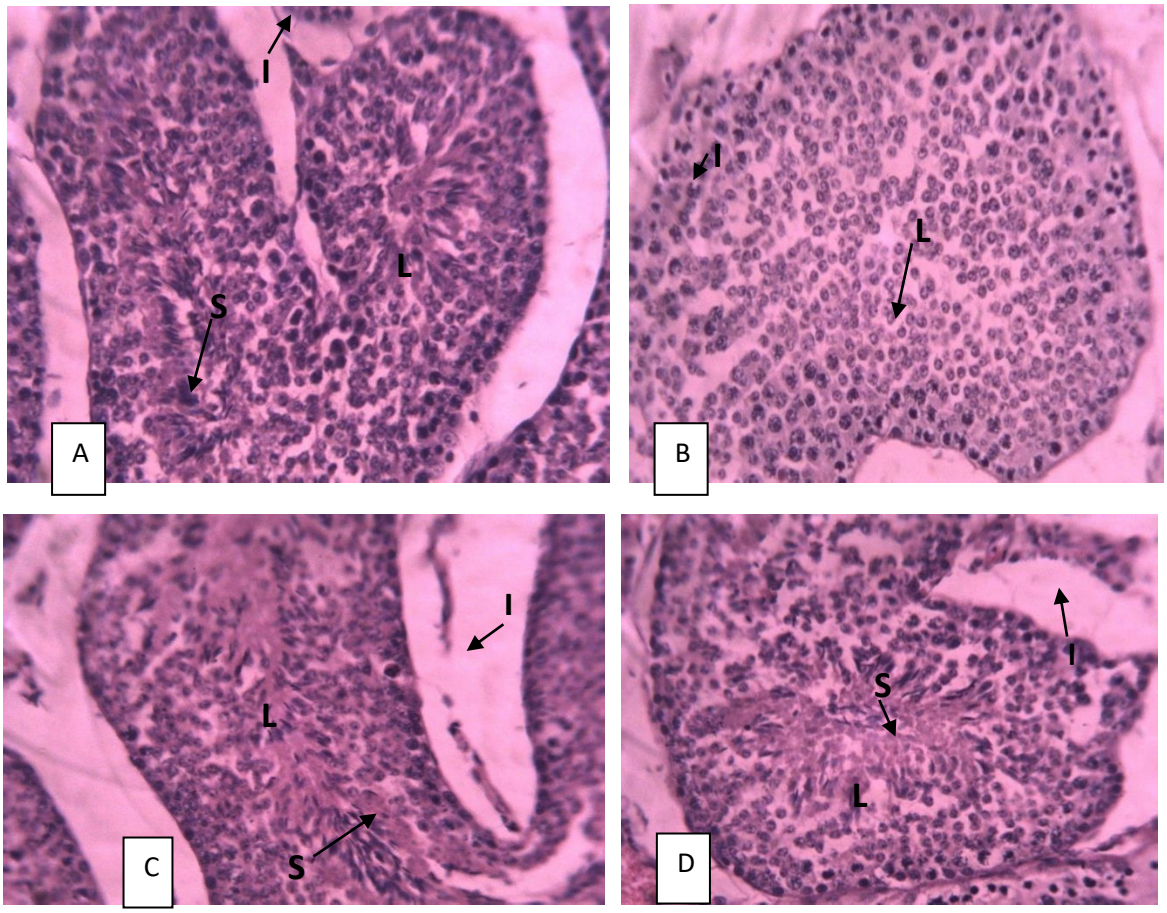
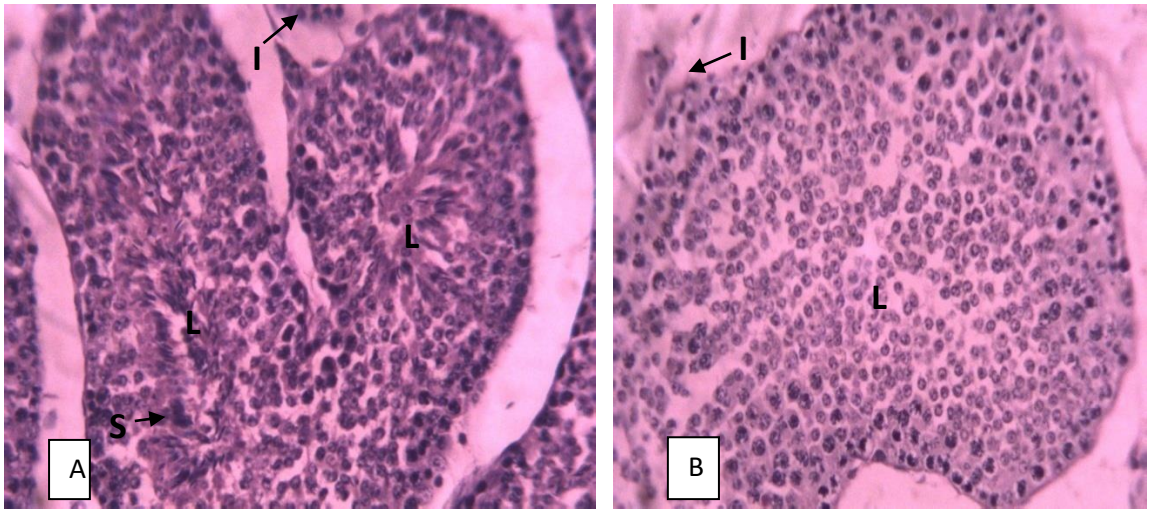


Fig 1: Photomicrograph of the testes of rabbit bucks. **A**: (administered olive oil for 16 weeks). Note the interstitial cell (I) and the presents of spermatozoa (S) in the lumen (L) of the tubules. **B**: (administered olive oil and DBP for 16 weeks). Note the interstitial cell (I) and the apparent absent of spermatozoa in the lumen (L) of the tubules, **C**: (administered melatonin for 8 weeks, then olive oil and DBP for 8 weeks). Note the interstitial cell (I) and the presents of spermatozoa (S) in the lumen (L) of the tubules. **D**: (administered garlic for 8 weeks, then olive oil and DBP for 8 weeks). Note the interstitial cell (I) and the presents of spermatozoa (S) in the lumen (L) of the tubules. (H & E × 250).



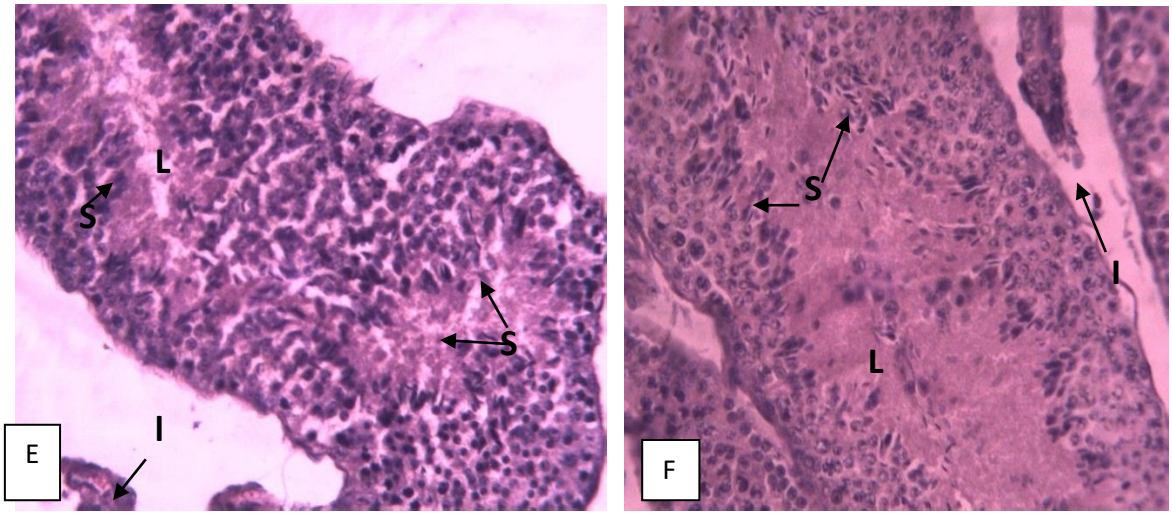


Fig 2: Photomicrograph of the testes of rabbit bucks. **A:** (administered olive oil for 16 weeks). Note the interstitial cell (I) and the presents of spermatozoa (S) in the lumen (L) of the tubules. **B**: (administered olive oil and DBP for 16 weeks). Note the interstitial cell (I) and the apparent absents of spermatozoa in the lumen (L) of the tubules. **E** (administered olive oil and DBP for 8 weeks, then melatonin for 8 weeks). Note the interstitial cell (I) and the presents of spermatozoa (S) in the lumen (L) of the tubules. **F** (administered olive oil and DBP for 8 weeks, then garlic for 8 weeks). Note, the interstitial cell (I) and the presents of spermatozoa (S) in the lumen (L) of the tubules. (H & E × 250).

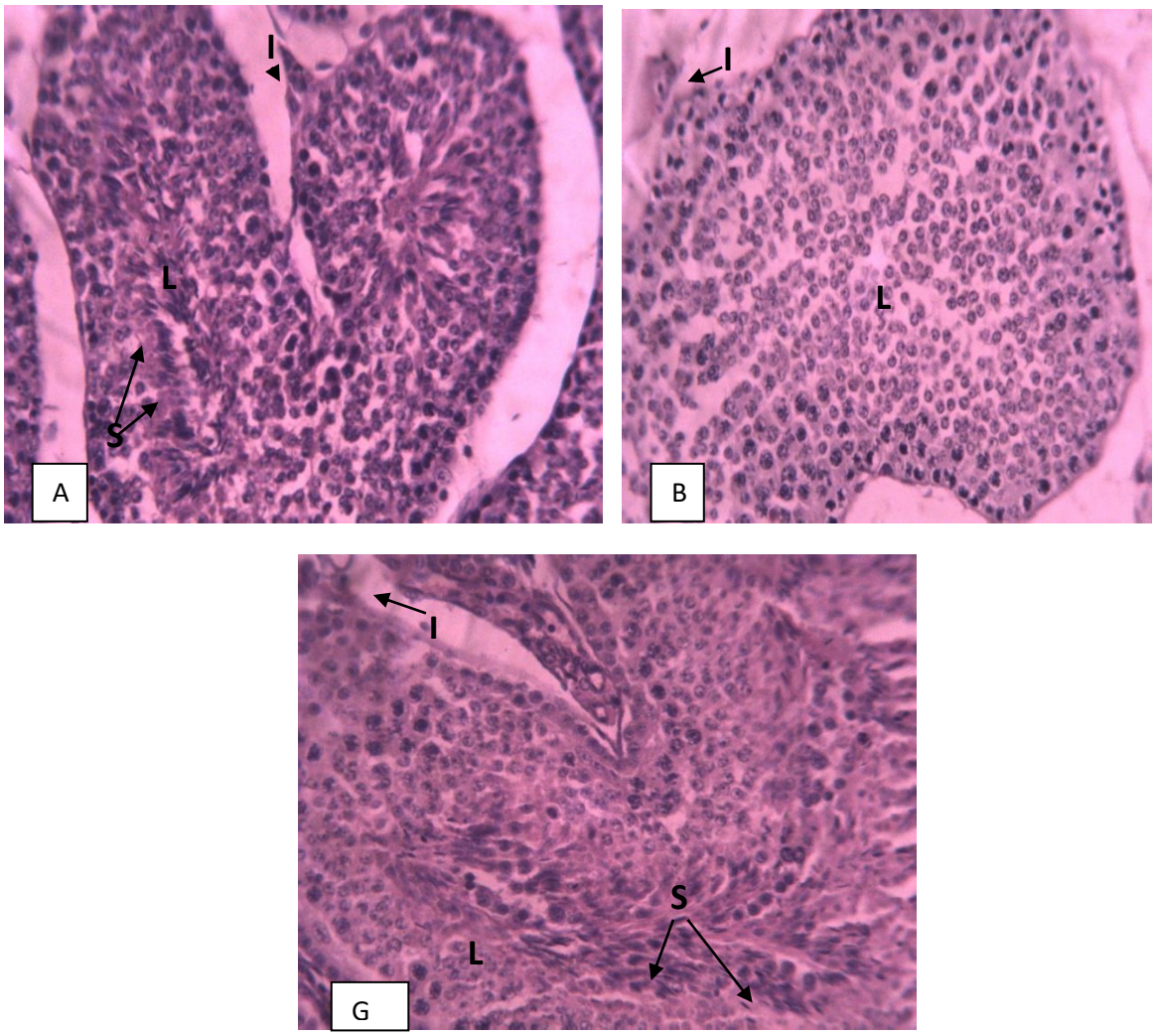
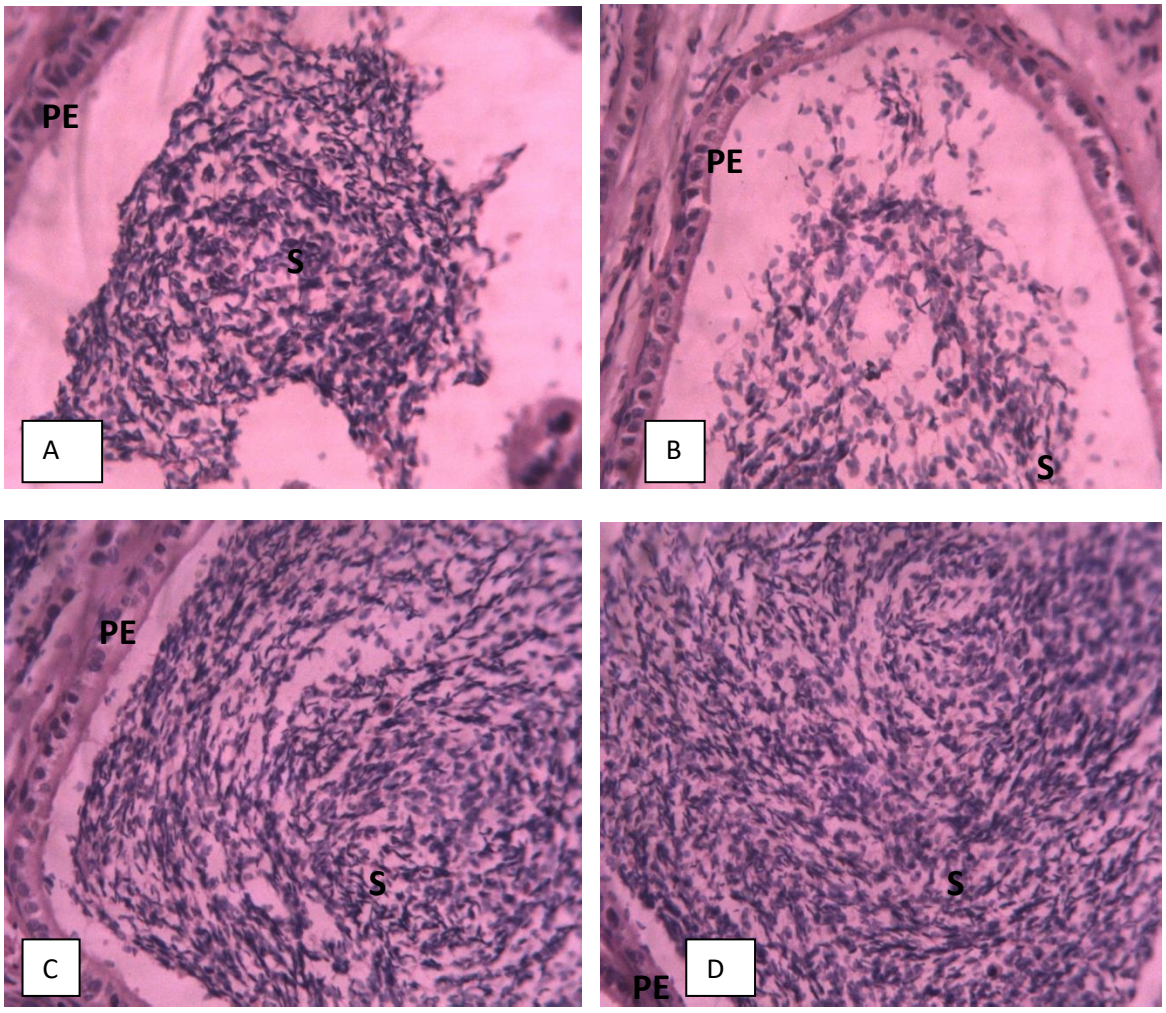


Fig 3: Photomicrograph of the testes of rabbit bucks. **A:** (administered olive oil for 16 weeks). Note the interstitial cell (I) and the presents of spermatozoa (S) in the lumen (L) of the tubules. **B**: (administered olive oil and DBP for 16 weeks). Note the interstitial cell (I) and the apparent absent of spermatozoa in the lumen (L) of the tubules. **G**: (administered olive oil and DBP for 8 weeks, then melatonin and garlic for 8 weeks). Note the interstitial cell (I) and the presents of spermatozoa (S) in the lumen (L) of the tubules. (H & E × 250).

Fig 4: Photomicrograph of the epididymides of rabbit bucks. **A**: (administered olive oil for 16 weeks). Note the spermatozoa (S) within the lumen, lined by pseudostratified epithelium (PE). **B**: (administered olive oil and DBP for 16 weeks). Note the sparsely distributed spermatozoa (S) within the lumen, lined by pseudostratified epithelium (PE). **C**: (administered melatonin for 8 weeks, then olive oil and DBP for 8 weeks). Note the spermatozoa (S) within the lumen, lined by pseudostratified epithelium (PE). **D**: (administered garlic for 8 weeks, then olive oil and DBP for 8 weeks). Note the spermatozoa (S) within the lumen, lined by pseudostratified epithelium (PE). (H & E × 250).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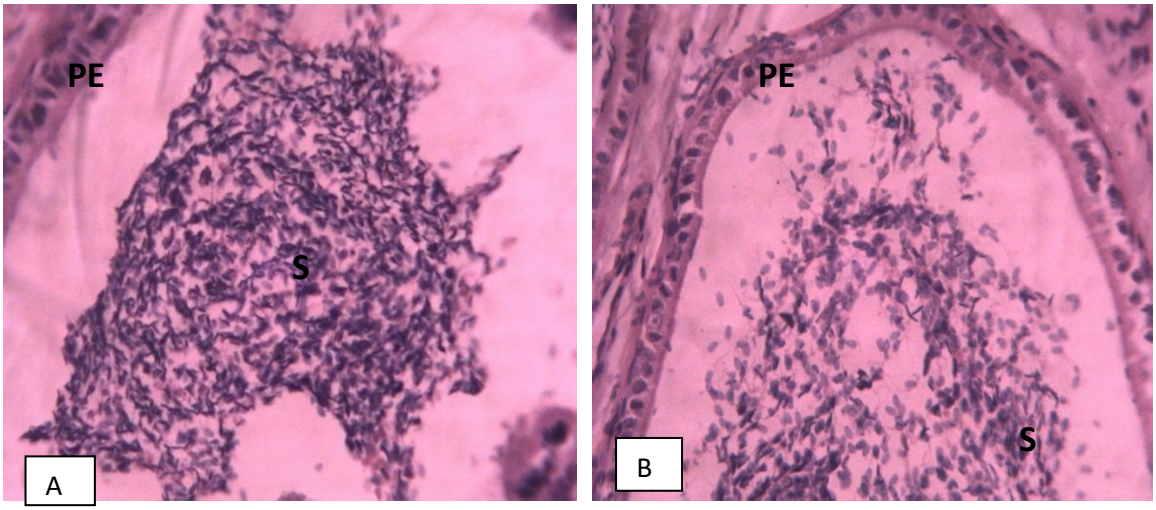
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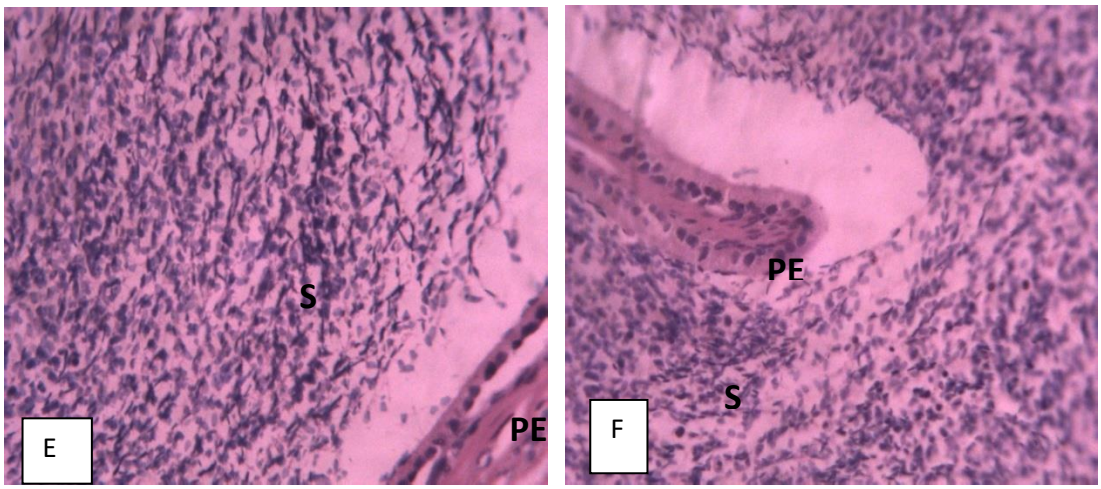
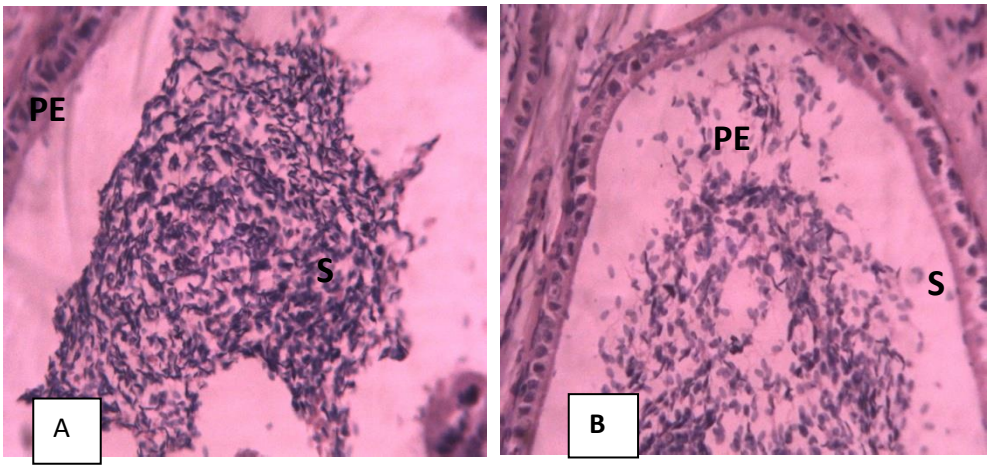


Fig 5: Photomicrograph of the epididymides of rabbit bucks. **A**: (administered olive oil for 16 weeks). Note the spermatozoa (S) within the lumen, lined by pseudostratified epithelium (PE). **B**: (administered olive oil and DBP for 16 weeks). Note the sparsely distributed spermatozoa (S) within the lumen, lined by pseudostratified epithelium (PE). **E**: (administered olive oil and DBP for 8 weeks, then melatonin for 8 weeks). Note the spermatozoa (S) within the lumen, lined by pseudostratified epithelium (PE). **F**: (administered olive oil and DBP for 8 weeks, then garlic for 8 weeks). Note the spermatozoa (S) within the lumen, with villus-like projection lined by pseudostratified epithelium (PE). (H & E × 250).



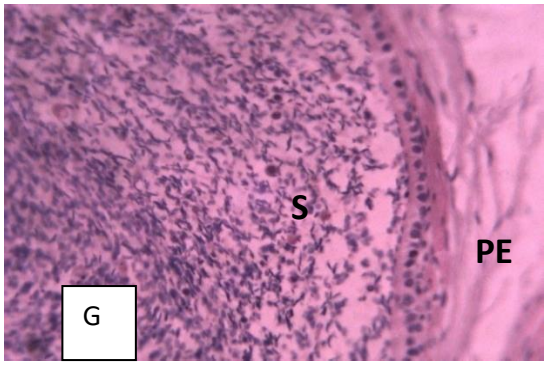


Fig 6: Photomicrograph of the epididymides of rabbit bucks. **A**: (administered olive oil for 16 weeks). Note the spermatozoa (S) within the lumen, lined by pseudostratified epithelium (PE). **B**: (administered olive oil and DBP for 16 weeks). Note the sparsely distributed spermatozoa (S) within the lumen, lined by pseudostratified epithelium (PE). **G**: (administered olive oil and DBP for 8 weeks, then melatonin and garlic for 8 weeks). Note the spermatozoa (S) within the lumen, lined by pseudostratified epithelium (PE). (H & E × 250).

DISCUSSION

Histological features of the testes showed the administration of DBP to rabbit bucks resulted in depletion of sperm cells in the seminiferous tubule of group B, compared to other groups (Fig 1-3), this we attributed to the following reasons: (i) That the impact of DBP on testicular spermatogenic function may have been earlier than that on testicular histological structure, meaning the effect was on the spermatogenic cycle (ii). Spermatozoa may be at great risk during DBP exposure (Zhou *et al*., 2010), than the other parts of the testis (iii) DBP administration probably provoked degeneration with absence of spermatogenic series and spermatogenesis from most of the seminiferous tubules (Hamdy *et al.,* 2015). Our observation in this study is in agreement with the findings of many researchers that the main target of phthalate esters is the seminiferous tubule of the testis (National Toxicology Programme, 2003). In addition, DBP may also target the Leydig's and Sertoli cells functions, which could affect testosterone (Mylchreest *et al.,* 2002; Shirota *et al*., 2005). The histopathology changes in the testis may be due to the ROS generated in the testis which affected gonadal function. This is in agreement with earlier findings by Zhou *et al*. (2010), Nair, (2015), Hamdy *et al*. (2015), Shinkut *et al.* (2016b). The observed normal cytoarchitecture of the seminiferous tubules of melatonin treated groups which also had spermatozoa within the lumen may be an indication of the antioxidant properties of melatonin and its potential to trap free radicals that cause oxidative damage within the testes (Malm *et al*., 2017). Flavonoids contained in garlic have also been reported to confer protection against harmful effects of ROS (Shinkut 2015). *In vitro* studies have also showed that flavonoids have potent antioxidant and free radical scavenging activity (Prochazkova *et al.,* 2011).

Furthermore, DBP exposure induced oxidative stress in the epididymides, it is known that spermatozoa are highly susceptible to the damage induced by ROS because of their high content of polyunsaturated fatty acids (Marchlewicz *et al*., 2004; Vernet *et al.,* 2004; Shinkut, 2015). Normal epididymis being enriched with antioxidant defense system protects the sperm during its transit through the caput to cauda region of epididymis and facilitates their maturation process (Vernet *et al*., 2004). Oxidative stress in the epididymis leads to insufficient amount of antioxidant defense system to protect spermatozoa with the epididymal epithelial cells themselves compromised (Marchlewicz *et al.,* 2004). This perhaps explains the decreased spermatozoa observed in the cauda epididymis of bucks exposed to DBP in this study (Fig 4-6). However, for the treatment groups we believe melatonin and garlic ensured oxidative homeostasis is maintained by protecting the sperm cells and preserving the structural integrity of the epididymis.

CONCLUSION AND RECOMMENDATIONS

i. Exposure to DBP on the testes and epididymis caused depletion of

spermatozoa in lumen of seminiferous tubules and cauda epididymides.

ii. This study has clearly demonstrated the potential for the use of melatonin and garlic both for protective and ameliorative actions against oxidative stress induced pathologies in the gonads of rabbit bucks.

iii. This study further affirmed DBP as a potent environmental health hazard with devastating consequence on reproduction.

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FISHERIES AND AQUACULTURE PRODUCTION

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EVALUATION OF SICKLE POD (*Cassia tora*) LEAF MEAL IN THE DIET OF AFRICAN CATFISH (*Clarias gariepinus* Burchell, 1822) FINGERLINGS

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ABSTRACT

The efficacy of *Cassia tora* leaf meal as an ingredient in the diet of the African catfish (*Clarias gariepinus*) fingerlings of mean weight 2.17±0.01g was evaluated over 63-days growth period. Five experimental diets were formulated at 0%, 3%, 6%, 9%, and 12% inclusion level of the leaf meal and serves as the dietary treatments. All the diets were iso-nitrogenous (45% crude protein level) and isocaloric (3,478.60kcal/kg metabolizable energy). A total of three hundred (300) fingerlings were allotted to the fifteen concrete tanks with three replicates. The proximate composition of *C. tora* leaf meal revealed a crude protein content of 28.52% while values for nitrogen free extract, lipid, crude fiber, and ash and moisture contents were 39.69%, 8.15%, 9.14%, 11.04% and 3.45% respectively. The growth indices for diet I (control) revealed highest mean weight gain (13.09g), weekly weight gain (1.46g), specific growth rate (4.05%/day) and percentage weight gain (604.42g). These were significantly higher than the values for other dietary treatments. Also, the feed conversion ratio (2.48), feed efficiency (0.43), protein efficiency ratio (0.29), and gross feed conversion efficiency (40.42) of fingerlings fed control diet were significantly ($P<0.05$) differed from other dietary treatments. Further investigation on the utilization and the anti-nutrient composition of *Casia tora* leaf meal in fish feeding and adopting appropriate processing methods for the removal of anti-nutritional factors is recommended.

Key words: *Cassia tora* leaf meal, *Clarias gariepinus*, growth performance, Nutrient utilization, Anti-nutrients.

INTRODUCTION

Clarias gariepinus (Burchell, 1822) is one of the most cultured fish species in Nigeria because of the good adaptability to captivity condition, rapid growth rate, taste, hardiness and disease resistance ability (Skelton, 1993; Olagunju *et al.*, 2007; Anoop *et al.*, 2009 and Vanguard, 2009). The plasticity of the catfish diet (Anoop *et al.*, 2009) and its ability to convert waste feedstuffs into useful fish flesh make the speciesthe choice fish of culture in Nigerian aquaculture (Anoop *et al.*, 2009 and Emokaro, 2010).

One of the most important components of aquaculture is fish feeding (Aydin *et al*., 2011). Fish feeds account for about 70% of aquaculture operations, and most fish farmers in Nigeria do not make use of standard fish feed due to high cost of feed ingredients (Anderson *et al*., 1997; Eyo *et al*., 2004; Adekunle *et al*., 2012; Orire and Sadiku, 2014). Thus, the importance of

efficiency of utilization of the fish feed cannot be over emphasized. Non-Conventional Feed Resources (NCFRs) are those that are not usually common in the market and are not the traditional ingredients for commercial fish feed production (Devendra, 1988; Madu *et al*., 2003). NCFRs are credited for being non-competitive in terms of human consumption and cheaper to purchase (Devendra, 1988). They are mostly by-products or waste products from agriculture, farm made feeds and processing industries. They may include all types of feed stuffs from animal (silk worm, maggot, termites, earth worm, snails, tadpoles etc.), plant waste (cotton seed meal, soy bean meal, maize bran, rice bran, palm kernel cake, groundnut cake and brewers waste) from plants (duckweed, cajanus and Chaya) waste from animals such as animal dung, offal, visceral, feather, fish silage, bone and blood (Devendra, 1988; Omitoyin and Faturoti, 2000). All these can be recycled to improve on fish feed production if economically justified and technologically possible (Devendra, 1988; Omitoyin and Faturoti, 2000). The present study aimed at investigating the potentials of using *Cassia tora* leaf meal as a plant protein feed ingredient in the diet of *Clarias gariepinus.*

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Teaching and Research Fish Farm of the Department of Fisheries and Aquaculture at the main campus of Usmanu Danfodiyo University, Sokoto. The site is located in Sudan Savanna vegetation zone of Nigeria on latitude 13^0 07' 78'' N and longitude of 5^0 12' 25'' E and on 275m above sea level (Google, 2011). The area is characterized by a long dry season which start from October to May, with cool dry air during the harmattan (November- February), and hot dry air during March – May. Raining season start in June and ends in September. Annual rainfall in the area ranged from 500 to 724 mm (Mamman, 2000). The mean relative humidity ranged between 14.9% and 40% in March and June, respectively. Ambient temperature can reach up to 41^0C during April and May and may fall below 20^0C during December and January.

Processing of *Cassia tora* Leaf

Cassia tora leaf was obtained from Rofia town in Niger State. The leaf was plucked from the stem, sun dried for 3 days, ground using pestle and mortar, and sieved using 1.18mm laboratory sieve to remove the residues. The fine particles were used in combination with other ingredients to produce pelleted feed.

Procuring and Processing of other Feed Ingredients

The feed ingredients used in the diet were fishmeal (Danish), lysine, methionine, and vitamin premix were purchased from Agro-tech., Minna, Niger State. The other feed ingredients that formed the ration included Groundnut Cake, fishmeal, Maize, Blood meal, Bone meal, Methionine, Lysine, Vitamin Premix, Palm Oil and table Salt and were sourced within Sokoto metropolis.

Proximate Analysis

The proximate analysis of the feed ingredients, experimental diets, and the experimental fish before and after the experiment were carried out in the Central Laboratory of the National Institute for Fresh Water Fisheries Research, New-Bussa, Niger State. The analysis included moisture content, ash content, crude fiber, crude lipid, crude protein and nitrogen free extract determination, using standard methods (AOAC, 2000).

Experimental Diets

Five diets containing varying levels of *C. tora* leaf meal at 0 % (Diet 1), 3% (Diet 2), 6% (Diet 3), 9 % (Diet 4) and 12% (Diets 5) were formulated following Pearson Square Method. The diets were isonitrogenous (each containing 45% crude protein) and isocaloric (3,478.60kcal/kg metabolizable energy). The appropriate quantities of ingredients in each diet were weighed and mixed thoroughly using electric feed mixer (Kenwood). Each diet was thereafter mixed with warm water to make dough. The mixed dough was subjected to pelleting using an Electric Feed Pelletizer (50kg/hour capacity) and 2mm disk diameter. The pelleted feeds were sundried and broken into smaller sizes appropriate to the fish size and stored until the commencement of the feeding trial. Table 1 shows the gross compositions of experimental diets.

Experimental Fish

A total of 300 *C. gariepinus* fingerlings of 2.17±0.02g mean body weight were purchased from National Institute for Freshwater Fisheries Research, New-Bussa, Niger State. The fingerlings were transported to the Fish Hatchery of the Usmanu Danfodiyo University, Sokoto. The fish were acclimatized for two weeks, during which they were fed with the control diet (45% crude protein and 3,480.06ME).

Experimental setup

The fingerlings were randomly distributed into fifteen circular concrete tanks (1x1m) of $0.79m^3$ volume with 20 fingerlings in each tank. The five experimental diets were randomly allocated to the experimental tanks, in a completely randomized block design (CRBD) with three replicates per treatment. The water for the experiment was sourced from the borehole in the farm

Experimental Fish Management

Experimental fish in each concrete tank were fed at 5% body weight for 9 weeks. The fish were fed two times daily. The tanks were cleaned, and uneaten feeds together with faecal residues were siphoned out before feeding. Water levels were maintained in the tanks. The tanks were washed completely every week and water completely replaced.

Water Quality Analysis

Temperature and pH were monitored throughout the course of the experiment. Temperature was measured with simple mercury thermometer graduated in 0.01^0C. The temperature readings were taken at every feeding time. Hydrogen ion concentration was monitored with pH meter at every feeding period.

Measurement of Weight Increment

The body weight was recorded on weekly basis by weighing all the fingerlings in each experimental unit on an electric top loading weighing balance. The average weekly weight gain in each tank was obtained by subtracting the average weight of fingerlings during the previous week from the average weight during the current week, until end of the experiment (9 weeks).

Data Collection

During the experiment the following data were collected;

Survival rate (SR)

$$SR = \frac{\text{Initial number of fish stocked} - \text{mortality}}{\text{Initial number of fish}} \times 100$$ Bagenal (1978)

Mean weight gain (g) = Final mean weight (g) - Initial mean weight (g)

Percentage Weight Gain

$$PWG = \frac{\text{Final mean weight} - \text{initial mean weight}}{\text{Initial body weight}} \times 100$$ Webster and Chhorn (2001)

Specific Growth Rate (SGR)

$$SGR = \frac{In_{W2} - In_{W1}}{T_1 - T_2} \times 100$$ Stickney (1979)

Where In = Natural logarithm

$W_2 - W_1$ = final and initial weight of fish (g) and

$T_2 - T_1$ = period in days

Condition factor (K)

$$K = \frac{100W}{L^3}$$ Bagenal (1978)

W = final mean body weight (g)

L^3 = mean standard length (cm)

Feed Conversion Ratio (FCR)

$$FCR = \frac{\text{Feed fed (g)}}{\text{Weight gain (g)}}$$ Hepher (1988)

Feed Efficiency Ratio

$$FER = \frac{\text{Weight gain (g)}}{\text{Feed fed (g)}}$$ Hepher (1988)

Gross Feed Conversion Efficiency (GFCE)

$$GFCE = \frac{1}{FCR} \times 100$$ Chow *et al*. (1985)

Protein Efficiency Ratio (PER)

$$PER = \frac{\text{Weight Gain (g)}}{\text{Crude Protein Consumed}}$$ Hepher (1988)

Apparent Net Protein Utilization (AppNPU)

$$APPNPU = \frac{N_b - N_a}{N_i} \times 100$$ Chow *et al*. (1985)

Where N_b = Body protein at end of the experiment

N_a = Body protein at the beginning

N_i = Amount of Nitrogen (protein ingested)

Statistical Analysis

The data on nutrient composition of *C. tora* leaf meal, phytochemical test, growth performance, nutrient utilization, hematological parameters, water parameters and economic indices obtained were subjected to analysis of variance (ANOVA) and the treatment means were separated using Duncan Multiple Range Test (Steel and Torrie, 1980). The analysis was carried out using SPSS version 20.0.

RESULTS AND DISCUSSION

CHEMICAL COMPOSITION OF *Cassia tora* LEAF MEAL

Table2 shows the proximate composition of *C. tora* leaf meal obtained in this study. The values obtained for crude protein (28.52±0.52%), lipid (8.15±0.02%) and nitrogen free extract (39.69±1.09%) revealed that the leaf contained appreciable amount of the nutrients which can be used as fish feed. The protein level of 28.5% obtained in this study indicates its potential as a protein supplement in feeds. Robinson *et al*. (2001) reported that feed ingredients with crude protein greater than 20% are considered as protein source which qualifies *Cassia tora* leaf meal as alternative protein source.

The result obtained for crude protein, lipid and nitrogen free extract contents were relatively higher than that obtained from the findings of Kubmarawa *et al.* (2011) who analyzed *Cassia tora* leaf meal. The variations in proximate compositions with the other study may be due to environmental factors such as soil types, season, geographical location, provenances, harvesting time and stage of maturity (Kubmarawa *et al.,* 2011). The ash content represents the index of mineral elements present in the leaf. The ash level (11.04%) also compared well with some non-conventional feedstuffs such as *Celtis integrifolia* leaf meal with ash level of 13.53% (Kubmarawa *et al.,* 2011).

Fish Body Composition

The carcass proteins of the experimental fish for all dietary treatments were higher than the initial carcass protein as shown in Table 3. This indicated that fish growth was not only due to weight gain, but also associated with synthesis and increased tissue protein production as reported by (Fuller, 1969). This could also be the attributed to the crude protein content of the

experimental diets. Protein is essential in the diets of fishes as sources of amino acids which are building blocks of flesh, enzymes eggs, milt, antibiotics and some hormones (Dupree and Huner, 1984).

Fish Growth Performance

Table 4 shows the result of growth performance of *C. gariepinus* fed *C. tora* leaf meal. The highest mean final body weight (15.26±3.04g), mean weight gain of 13.09±3.04g, weekly weight gain (1.46±0.34g), specific growth rate (4.05±0.39%/day) and percentage weight gain **(**604.42±140.40%**)** were recorded in fish fed diet I (0% control) and this was significantly ($P<0.05$) higher when compared with those obtained in II, III, IV and V diets. it was also observed that fish growth parameters decreased with increase in *C. tora* leaf meal in the diets. The differences in the growth performance may be link to protein quality of the diets. Fish meal protein is known to be of superior quality than vegetable protein and therefore the decreased level of the fish meal with increased level of the *Cassia tora* leaf meal could have accounted for decreased fish growth recorded. Similar findings were reported by Aderolu and Sogbesan (2010) and Tiamiyu *et al*. (2015) using coca yam peels and melon, respectively.

Ramachandran and Ray (2007) reported a decreased trend in growth parameters of *Labeo rohita* fed black grass seed meal. The growth and nutrient utilization decreased as *C. tora* leaf meal increased in the diets. Amisah *et al.* (2009) reported similar findings after feeding *C. gariepinus* with *Leucaena lecocephala* leaf meal. Hanan *et al.* (2014) also recorded similar trend of decrease in weight gain when *O. niloticus* was fed with raw *M. oleifera* leaf meal as plant protein supplement.

This observation supports the findings from previous studies of Richter *et al.* (2003), who found that higher inclusion level of *M. oleifera* leaf meal in fish lowered the growth performance because of the presence of anti-nutrients such as phenol, tannins phytates and saponins. The reduced growth performance in fish fed the *C. tora* leaf meal in this study might be due to low feed intake probably resulting from reduced palatability and diet acceptability caused by anti-nutrients (Price *et al.,* 1987; Amadi *et al.,* 2006). Tannins are capable of lowering available protein by antagonistic competition and can therefore, elicit protein deficiency syndrome called 'Kwashiorkor' in humans (Maynard, 1997). Olsvik *et al*. (2011) stated that plant based feed may reduce the fish growth due to reduction in feed intake. The trends in the fish mean weekly weight (growth) on the dietary treatments and the duration of feeding are shown in Figure 1.

Feed Conversion and Nutrient Utilization

The FCR of the fish in this study was poor at higher inclusion level of *Cassia tora* leaf meal (Table 5). The fact that weight gain was recorded in all experimental diets was an indication that the fish was able to convert the protein fed to muscles. Ability of an organism to convert nutrient especially protein will positively influence its growth performance. These results obtained seem to have direct relationship with the fish feed intake which reduced with increased level of the leaf meal in the diet.

Feed efficiency and protein efficiency Ratio were highest in fish fed the control diet and were significantly ($P<0.05$) higher than all the other dietary treatments, the values decreased as the leaf meal increased in the diets. Dienye and Olumuji (2014) reported similar results with *C. gariepinus* fed *M. Oleifera* leaf meal. The importance of feed efficiency by fish as a determinant of fish growth performance has

been strongly emphasized (Preston *et al.*, 1987; Faturoti, 1989; Pillay, 1990). Fish fed diet I control recorded the best-feed conversion ratio of 2.48±0.14, while the poorest (4.42±0.80) feed conversion ratio was obtained in fish fed diet V (12% CLM).

The AppNPU of the dietary treatment ranged from 15.38±2.16 in fish fed diet I (control) to 5.64±4.22 in those fed diet (V) containing 12% CLM (Table 5). However, there was significant ($P<0.05$) difference between the AppNPU of the dietary treatments. Lower values of AppNPU were obtained in this present study than those reported in Bekibele (2005) this suggested that the fish in-efficiently utilized the feed fed in body tissue synthesis.

Table 1 Gross composition of experimental diets

	Experimental Diets				
Ingredients	I (0%CLM)	II (3% CLM)	III (6% CLM)	IV (9%CLM)	V (12% CLM)
Maize	14.11	12.39	10.66	8.95	7.20
GNC	39.69	39.06	38.42	37.78	37.15
Fish meal	29.77	29.29	28.82	28.33	27.86
CLM	0.00	3.00	6.00	9.00	12.00
Blood meal	9.92	9.76	9.61	9.44	9.29
Bone meal	2.25	2.25	2.25	2.25	2.25
Vitamin premix	1.00	1.00	1.00	1.00	1.00
Palm oil	2.00	2.00	2.00	2.00	2.00
Salt	0.25	0.25	0.25	0.25	0.25
Methionine	0.50	0.50	0.50	0.50	0.50
Lysine	0.50	0.50	0.50	0.50	0.50
TOTAL	100.00	100.00	100.00	100.00	100.00
Calc. ME (Kcal/kg)	3,480.06	3,479.47	3,478.99	3,477.61	3,476.89

"GNC" Groundnut Cake, "ME" Metabolizable energy, "CLM" *Cassia tora* leaf meal

Table 2: Proximate Composition of experimental ingredients

	Nutritional values					
Ingredients	Moisture %	Ash%	Crude protein%	Lipid %	Crude fiber %	Nitrogen free extra %
Cassia tora leaf	3.45±0.05	11.04±0.04	28.52±0.52	8.15±0.02	9.14±0.03	39.69±1.09
Blood meal	3.09±0.09	3.96±0.06	63.80±0.70	2.13±0.03	0.99±0.04	26.02±0.02
Groundnut cake	2.89±0.33	5.53±0.03	38.04±0.04	8.50±0.04	5.03±0.03	36.67±0.10
Maize (white)	2.00±0.10	1.00±0.20	8.75±0.05	1.50±0.05	1.00±0.10	85.75±0.63
Fish meal	6.40±0.10	10.90±0.31	75.00±2.00	11.50±0.5	0.50±0.10	4.30±0.20

Table 3: Proximate composition of experimental fish fed experimental diets

	Treatments					
Parameters	Initial fish	I (0%)	II (3%)	III (6%)	IV (9%)	V (12%)
Moisture	75.87±0.27^{a}	68.09±0.94^{d}	69.72±0.89^{c}	72.32±0.47^{b}	72.41±0.66^{b}	71.03±1.44^{bc}
Ash	2.31±1.12	2.99±0.28	3.05±0.40	2.15±0.34	3.02±0.59	1.97±0.03
Crude fiber	0.69±0.16^{bc}	0.88±0.02^{a}	0.79±0.03^{abc}	0.68±0.02^{c}	0.82±0.02^{ab}	0.75±0.05^{bc}
Crude protein	17.91±0.50^{d}	24.83±0.47^{a}	23.84±1.95^{a}	22.98±0.57^{ab}	21.38±0.75^{bc}	20.45±1.40^{c}
Lipid	2.17±0.28^{b}	3.03±0.33^{a}	2.85±0.15^{a}	2.74±0.11^{a}	2.74±0.37^{a}	1.83±0.17^{b}
Nitrogen free ext.	1.23±0.53^{a}	0.17±0.04^{b}	0.49±0.34^{b}	0.56±0.43^{b}	0.60±0.09^{b}	0.73±0.19^{ab}

Means in rows having same letters are not significantly different ($P>0.05$)

Table 4: Growth performance of *C. gariepinus* fed the experimental diets

	Diets				
Parameters	I (0%)	II (3%)	III (6%)	IV (9%)	V (12%)
No. of fish	60	60	60	60	60
Mean survival rate (%)	68.33±7.63^{ab}	75.00±10.00^{a}	48.33±2.88^{c}	58.33±7.63^{bc}	58.33±7.63^{bc}
Mean Initial Body Weight (g)	2.17±0.02	2.15±0.02	2.17±0.01	2.16±0.02	2.18±0.00
Mean Final Body Weight (g)	15.26±3.04^{a}	10.38±1.11^{b}	10.14±0.76^{b}	9.19±1.66^{b}	7.35±0.82^{b}
Mean Weight Gain (g)	13.09±3.04^{a}	8.21±1.10^{b}	7.96±0.76^{b}	7.04±0.81^{b}	5.21±0.80^{b}
Weekly Weight Gain (g)	1.46±0.34^{a}	0.91±0.12^{b}	0.88±0.08^{b}	0.78±0.09^{b}	0.58±0.08^{b}
Specific Growth Rate (%/day)	4.05±0.39^{a}	3.3±0.22^{b}	3.29±0.15^{b}	3.09±0.19^{b}	2.61±0.25^{c}
Percentage Weight Gain (%)	604.42±140.40^{a}	378.29±49.09^{b}	366.11±34.92^{b}	326.81±36.78^{b}	242.40±35.91^{b}
condition factor	0.74±0.09	0.57±0.13	0.65±0.14	0.72±0.08	0.79±19

Means in rows having same letters are not significantly different (P >0.05)

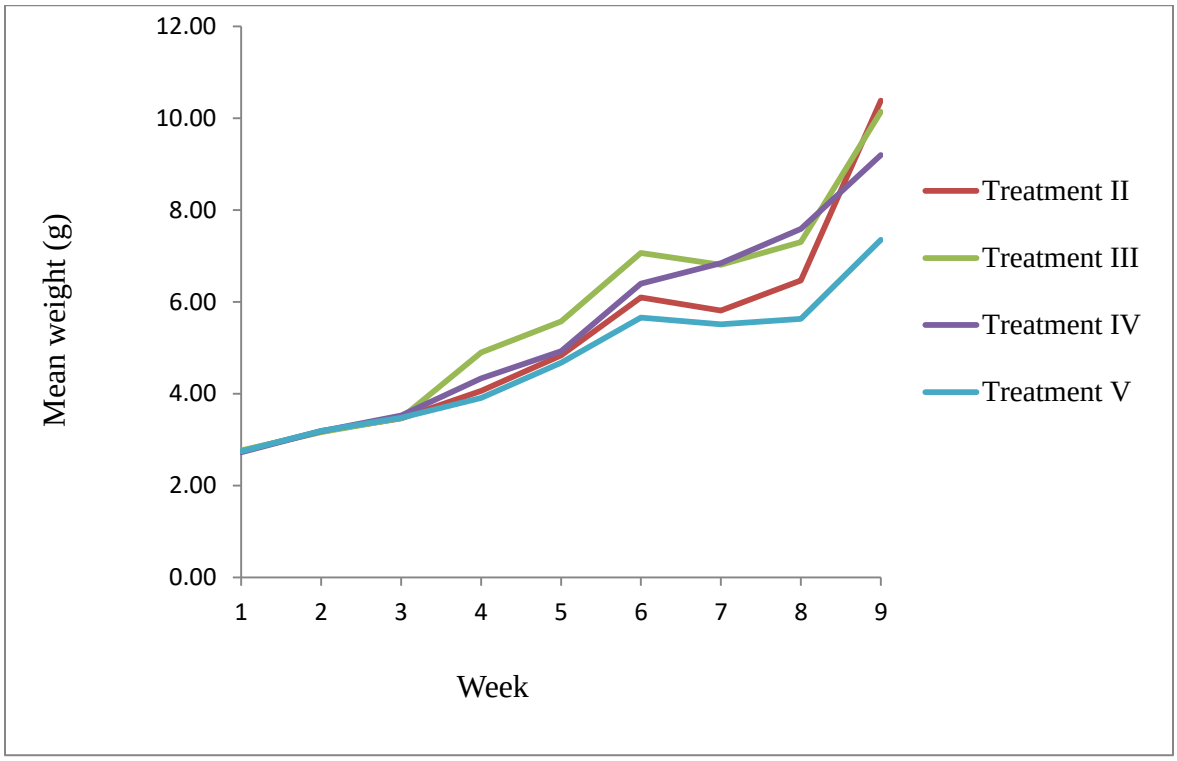

Figure 1: Mean Weekly Weight

Table 5: Nutrient utilization indices of *C. gariepinus* fed *C. tora* leaf meal

	Diets				
Parameters	I (0%)	II (3%)	III (6%)	IV (9%)	V (12%)
Feed conversion Ratio	2.48±0.14^{b}	3.58±0.42^{a}	3.80±038^{a}	3.98±0.20^{a}	4.42±0.08^{a}
Gross feed conversion efficiency	40.42±2.29^{a}	28.15±3.14^{b}	26.49±2.75^{b}	25.18±1.31^{b}	23.18±4.69^{b}
Protein Efficiency Ratio	0.29±0.06^{a}	0.18±0.02^{b}	0.17±0.17^{b}	0.15±0.02^{b}	0.11±0.01^{b}
Feed Efficiency	0.43±0.02^{a}	0.35±0.01^{b}	0.32±0.14^{b}	0.32±0.04^{b}	0.30±0.02^{b}
Apparent Net Protein utilization	15.38±2.16^{a}	13.37±3.22^{a}	11.53±0.16^{ab}	7.75±0.56^{bc}	5.64±4.22^{c}

Means in rows having same letter are not significantly different (P >0.05)

CONCLUSION AND RECOMMENDATION

The nutrient composition of the *Cassia tora* leaf meal indicated its potential for use as a dietary ingredient for fish feed. However, the result concluded that increase in *Cassia tora* leaf meal in the diet led to a decrease in fish growth response (mean weight gain, weekly weigh gain, specific growth rate and percentage weight gain). The control diet (that contained 0% leaf meal) gave the best fish growth performance. The findings on the nutrient utilization indices indicate lowest feed conversion ratio, protein efficiency ratio, feed efficiency ratio and apparent net protein utilization in all the experimental diets containing *Cassia tora* leaf meal.

The finding recommended that the ant-nutritional factors in the leaf meal must be analyzed and effectively reduced before incorporation into fish feed. Crude protein content of *Cassia tora* leaf meal can be enhanced through processing techniques.

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LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF AFRICAN CATFISH (Clarias gariepinus) AND BIGHEAD CATFISH (Heterobranchus longifilis) JUVENILES REARED UNDER LABORATORY CONDITION IN JOS, PLATEAU STATE. NIGERIA

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ABSTRACT

Length-weight relationships are essential for environmental monitoring programs and to assess fish/fisheries stocks. This study evaluated the length-weight relationships and condition factor of the African Catfish (*Clarias gariepinus*) and Bighead catfish (*Heterobranchus longifilis*) juveniles for 24 weeks. The experiment was divided into two phases; first is the artificial induced breeding of the fish species using synthetic hormone and rearing of the hatchlings for 9 weeks. The second phase is the rearing of the 9 weeks old juveniles for 24 weeks to evaluate the length-weight relationships of the juveniles. An experimental design of 2x3 (2 treatments and 3 replicates) was used, parental crossing of *Clarias gariepinus* and *Heterobranchus longifilis* were carriedout, each of the treatment was replicated. Data collected on the body weight (g) and total length (cm) were evaluated for length-weight relationships. Correlation and regression were estimated by the values of the intercepts (a) and slope (b). Variation observed in the monthly mean values on weight (g) and total length (cm), slope (b) and condition factor (*K*) for each treatment was tested to determine the significant difference ($P<0.05$) level. The results revealed negative allometric growth and are incredibly above the reference value of "3" with *Heterobranchus longifilis* (T2) having the highest (4.097). The "*r*" values obtained showed that *Clarias gariepinus* (T1) and *Heterobranchus longifilis* (T2), had 0.939 and 0.934 respectively. The values of "a" and exponent "b" for the two groups of fish in this study were within the recommended limits. The *K* values obtained were generally close to the recommended value of "1" for healthy fishes. The results also showed that, there is significant difference ($p< 0.05$) in *K* among the treatments examined. Water quality parameters were observed to be within the acceptable limit for optimum performance of studied fish species. This study has affirmed that the juveniles of *Clarias gariepinus* (Burchel, 1822) and *Heterobranchus longifilis* (Valencinnes, 1840) exhibited good growth ratio. However, there were variabilities between the condition factors measured that may have resulted by several environmental and technical differences.

Keywords: Length-weight, condition factor, *Clarias gariepinus, Heterobranchus longifilis,* Allometric

INTRODUCTION

The African Catfish (*Clarias gariepinus*) and Bighead catfish (*Heterobranchus longifilis*) are the most common farmed fresh water fish; These fish are considered as the most important animal source protein food valued for their nutritional qualities, especially in Africa. Generally, catfishes have contributed to fish production in Africa (Satia, 2017), being the second most cultured fish in Africa. The *C. gariepinus* are being intensively explored for food and aquaculture in Africa. *C. gariepinus*, leads the group of catfish species mostly cultured due to their hardiness, wide acceptability and high market value (Oyakhilomen and Zibah, 2013; Ozigbo, *et al.*, 2014).

The culture of the African Catfish is advancing in most West African countries including Nigeria. Meanwhile, field experiences have revealed the general need for proper management of the diverse catfish resources in the culture environments for sustainable fish production and conservation of fish species in African countries. Growth is an important trait in fish production. Hence, there is always the need to establish growth pattern in economically important fish species such as *C. gariepinus* and *H. longifilis*. Meanwhile, there is need for increased supply of juveniles with desirable growth rate for table size production. The length-weight relationship (LWR) is an important tool used in fishery assessment for predicting weight from length required in yield assessment and in calculation of Biomas (Keyombe et al., 2015).

Knowledge on relationship between weight and length is important for establishing production and biomass estimations of a species (Ogunola et al., (2018); Olopade et al., 2018). Beyer (1987) reported that Length–Weight Relationship of fishes are important in fisheries biology because they allow the estimation of the average weight of fish of a given length group by establishing a mathematical relation between the two. The study of LWR of fish species allows the inter-conversion of length and weight parameters. It also enhances morphometric comparisons between species and populations. Furthermore, LWR allows the health status or condition of fish to be estimated.

The relationship between the length (L) and weight (W) is usually expressed as $W=aL^b$. where a is the intercept and b is the allometry coefficient. Values of the exponent b provide information on the fish growth. When $b = 3$, increase in weight is isometric, and when the value of b is other than 3, weigh increase is allometric (negative if $b < 3$, positive if $b > 3$). Important information on the structure and function of fish population are provided by Length weight relationships. One of the benefits of estimating LWR is the ability to apply the length and weight data for prediction of well-being of studied population through the estimation of condition factor (K).

The condition factor often referred to as "K" provides information on the wellbeing of a fish and is usually influenced by the fish, sex, season, maturity stage etc. (Anyanwu, et al. 2007). K= 100w/L3 was proposed by Fulton (1902) as the mathematical formula for quantifying or estimating the condition of fish. The role of the condition indices as stated by Stevenson and Woods (2006) is to quantify the health of individuals in a population or to tell whether a population is healthy relative to other populations. Anwa-Udondiah and Pepple, (2011) reported that fish of a given length exhibits higher weight and better condition. The relationship of length-weight can be used to estimate condition factor of fish species (Fishbase, 2013). Knowledge of growth pattern and well-being of fish species is of importance in fish production as it affords the opportunity of precision in utilization of the fish population. Such knowledge would assist in proper management of the fish progenies in either

capture or culture environment. However, the dynamics of growth and condition factor could vary across strains of fish species. The length-weight relationship, size at first maturity and condition factor of African Catfish have been reported from several water bodies of Nigeria (Tesfaye and Seifu, 2016). However, there is no compiled information on the length-weight relationship from juvenile stage to first maturity and the condition factor of *C. gariepinus* and Bighead catfish (*Heterobranchus longifilis*), in Aquaculture. Therefore, this study aimed to evaluate the Length-weight relationship and condition factor of African Catfish (*Clarias gariepinus*) and Bighead catfish (*Heterobranchus longifilis*) juveniles under Laboratory condition in Jos, Plateau State. Nigeria.

MATERIALS AND METHODS

Study Area

The study was conducted in Jos. Plateau State, Nigeria at the Hydrobiology and Aquaculture laboratory of the Department of Zoology, University of Jos Nigeria and the Federal College of Land Resources Technology, Kuru, Jos. Plateau State.

Experimental Procedure

The experimental trial was conducted in two phases: Artificial induced breeding of African Catfish (*C. gariepinus*) and Bighead catfish (*Heterobranchus longifilis*) using Ovulin synthetic hormone administered at 0.5ml/kg b/wgt, and rearing of the fish hatchlings to 9 weeks and rearing of the 9 weeks juveniles for 24weeks. Sixty (60) fish juveniles. Thirty (30) each of African Catfish (*C. gariepinus*) and Bighead catfish (*Heterobranchus longifilis*) of 34.06g and 42.66g mean weight respectively, were randomly selected and stocked into 6 transparent 65L plastic bowls at 10 fish/bowl. The bowls were filled with water and maintained at 40L. Three (3) of the bowls stocked with African Catfish were designated as Treatment 1(replicated) and the other Three (3) stocked with Bighead catfish were designated as Treatment 2 (replicated). The fishes were fed Alltech Coppens (45%cp) feed at 4% body weight. Feed was adjusted and administered weekly for 24 weeks. Samples of 10 individuals from each treatment were used to determine the lengths and weights of the progenies. Fish samples were weighed weekly to the nearest grams (g) using electronic weighing balance and total length (distance from the tip of the snout to the tip end of the caudal fin) was measured using a measuring rule. The length increases and weight gain, growth rate, specific growth rates and condition factors were determined as reported in Okomoda *et al*. (2018).

Breeding/Crosses and Experimental Design

Parental crossing of *Clarias gariepinus* and *Heterobranchus longifilis* were carried out as presented below. The experimental trial consisted of 2 treatments, and each of the treatment was replicated.

Treatment	Crosses
$T_1(R_1)$, R_2, R_3	♂Cg X ♀Cg (*Clarias gariepinus*)
T_2 (R_1), R_2, R_3	♂Hl X ♀Hl (*Heterobranchus longifilis*)

Keys: Hl: (*Heterobranchus longifilis*), Cg: (*Clarias gariepinus*), ♂(Male), ♀(Female)

Determination of Length-Weight Relationship and Condition Factor

Length-weight Relationship: this was determined using the equation

$W = aL^b$

Where: W = weight of fish in (g), L = total length (TL) of fish in (cm), a = constant, b = the length exponent.

Condition Factor (K): This shows the degree of wellbeing of the fish in their habitat, and this was determined using (Le Cren, 1951).

$$K = \frac{100 \times W}{L^b}$$

Survival rate (SR, %)

Survival was calculated using the formula below:

$$survival\ rate\ , SR(\%) = \frac{total\ number\ surviving\ at\ end\ of\ experiment}{total\ number\ stocked\ at\ the\ start\ of\ the\ experiment} x100$$

Water Quality Parameter Test

The physicochemical parameters were determined based on the procedures outlined in AOAC (2012). The determination of physicochemical water quality parameters was carried-out weekly for a period of 24 weeks. The water samples were collected in test bottles. The temperature of the water sample was taken immediately using the clinical mercury-in-glass thermometer. Other water quality parameters; pH, Ammonia and Dissolved oxygen were analyzed using a TestLab water quality test kit (JBL, GmbH & Co. KG, 67141,Neuhofen, Dieseletrabe 3, Germany) immediately after collection.

Data Analysis

Data collected on the body weight (g) and total length (cm) for relationships between body weight and total length were subjected to Analysis of Variance. Correlation and regression were used to estimate the values of the intercepts (a) and slope (b) for weight and length relationship. Variation observed in the monthly mean values on weight (g) and total length (cm), slope (b) and condition factor (*K*) for each progeny was tested to determine the significant difference (P>0.05) level.

RESULTS AND DISCUSSION

Length-Weight Relationships and Condition Factor

The total length-weight relationships of all individual and groups were separately evaluated (figure 1 and figure 2).

The Length weight relationship parameters, a and b, the coefficient of determination, r^2 and the condition factor (*k*) are presented in Table 2. Information on the pattern of growth (allometric or isometric) is fully furnished. From the results as presented in table 2, most of the fishes recorded negative allometric growth and are incredibly above the reference value of "3" with T2 having the highest (4.097) and T1 the lowest (3.042) respectively. The "*r*" values obtained showed that T1 and T2, had 0.939 and 0.934 respectively. The length-weight data obtained from this study showed different values for each of the treatments studied. The values of "a" and exponent "b" for the two groups of fish in this study were within the recommended limits reported by (Okomoda et al., 2018); (Froese 2006); (Pervin and Mortuza 2008).

From the result of the present study, most of the fishes had a negative allometric growth which came incredibly close to the reference value of "3" (b = 3.042, 4.097).

According to Riedel et al., (2007), when fish becomes tinnier as it increases in weight; it implies a negative allometric growth. An isometric length-weight relationship on the other hand implies that the weight of these fishes increases at approximately the same rate as the length (Olufeagba et al., 2016).

However, variations in the value of "b" between the treatments could be linked to so many factors. Some of which includes differences in

the physiology of different fishes and feeding rate (Tarkan et al., 2006), degree of stomach fullness (Hossain et al., 2009; 2012), sexes, sensitivity to water quality parameters (Khallaf et al., 2003), differences in the observed length ranges of the specimens sampled (Wooten 1998), or behaviour (Muchlisin et al., 2010). It could be rightly said that one or more of these factors must have interplayed to cause the current observation made on the length-weight relationship in this study. There was no consistency in the condition factor obtained for treatments in this study, even though values recorded were desirable.

However, T2 exhibited the highest mean *K* value of 0.605 than values observed in T1. The *K* values obtained in this study were generally close to or above the recommended value of "1" for healthy fishes. The results also showed that, there is significant difference ($p< 0.05$) in *K* among the treatments examined which could be associated to the different species used.

According to Khallaf, et al., (2003) condition factor of fish are affected by many factors resulting to the variations in the values of "b" in this study (i.e. strain, species, stress, sexes, availability of feeds, water quality etc.). Hence, this could justify the differences between the observation of the present study and those of previous studies on different fishes under different experimental conditions (Tsoumani et al., 2006; Karakulak et al., 2006; Fontoura et al., 2010; Solomon, et al., 2012; Olufeagba et al., 2016; Solomon et al., 2017; Rodriguez et al., 2017; Freitas et al., 2014).

Water Quality Parameters

The water quality parameters results obtained during the 24 weeks culture period of *Clarias gariepinus* (Burchel, 1822) and *Heterobranchus longifilis* (Valencinnes, 1840) juveniles are presented in Table 3. The mean pH values ranged between 6.55 and 6.80. The pH value at week 12 (6.55) was significantly lower compared to other weekly mean data obtained, while week 24 (6.80) was significantly higher $p < 0.05$ than other weeks. The temperature was observed to decrease from the initial value of 25.50 to the minimum of 22.25 in week 20. However, the values obtained for temperature were observed to be within the acceptable limit recommended for catfish. The values recorded for dissolved oxygen indicated that week 8 (8.13 mg/l) was significantly higher than other weeks. Dissolved oxygen values obtained (Table 3) revealed that the oxygen was sufficient for the optimum performance for the fish species studied. The ammonium values obtained in this study showed that ammonium level was maintained within the optimal limit and this ranges from 0.17 to 0.20 throughout the 24weeks experimental period.

Table 1: Nutrient composition of commercial feed (CATCO FISH CONCENTRATE -COPPENS) fed to Juveniles of *Clarias gariepinus* (Burchel, 1822) and *Heterobranchus longifilis* (Valencinnes, 1840)

Nutrient	Composition (%)
Crude protein	56.0
crude fibre	10.9
Crude fat	15.0
Ash	10.9
Phosphorus	8.0
Energy	3400Kcal/kg

*****Each kg of the diet contains 300mg vit C, 200mg vit E, 22,500 IU vit A, 2,500 IU vit D_3, 5mg Cu, E280 preservatives and E 324 antioxidants

Plate 1: Experimental set-up showing the rearing units

Plate 2: Juveniles of African Catfish (*C. gariepinus*) and Bighead catfish (*Heterobranchus longifilis*) used for the study

Table 2: Length – weight relationships and condition factors of *Clarias gariepinus* (Burchel, 1822) and *Heterobranchus longifilis* (Valencinnes, 1840) juveniles reared under laboratory condition for 24 weeks

Parameter	T 1 (*Clarias gariepinus*)	T 2 (*Heterobranchus longifilis*)	p-value
A	-2.199	-3.680	-
B	3.042	4.097	-
r^2	0.939	0.934	-
K	0.587±0.02[a]	0.605±0.02 [a]	0.001

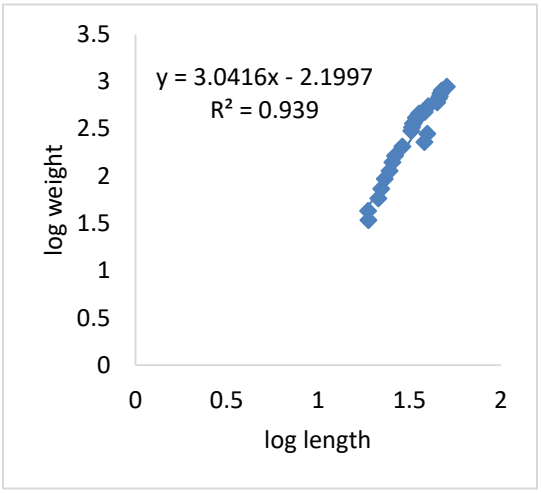

Figure 1: Length-weight relationship of *Clarias gariepinus*

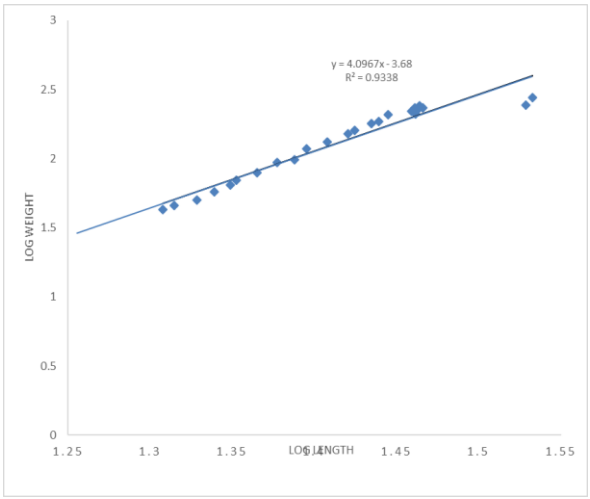

Figure 2: Length-weight relationship of *Heterobranchus longifilis*

Table 3: Mean weekly water quality parameters evaluated during the 24 weeks experimental trial

Parameters	Initial	12 weeks	16 weeks	20 weeks	24 weeks
pH	7.60±0.06[b]	6.55±0.06 [b]	6.70±0.09 [b]	6.80±0.05 [b]	6.80±0.06
Temperature(°/c)	25.50±0.09 [b]	24.25±0.05 [b]	24.13±0.05 [b]	22.25±0.04 [a]	22.88±0.06
Dissolved Oxygen (mg/l)	8.20±0.15 [b]	6.25±0.18 [b]	6.88±0.20 [b]	7.70±0.15 [b]	7.13±0.25
Ammonium (mg/l)	0.20±0.05 [b]	0.20±0.05 [b]	0.21±0.7 [b]	0.17±0.06 [b]	0.17±0.05

Mean with different superscripts (a, b) along the rows are statistically significant (P<0.05)

CONCLUSION

This study revealed a positive growth performance for the juveniles of *Clarias gariepinus* (Burchel, 1822) and *Heterobranchus longifilis* (Valencinnes, 1840) reared for 24 weeks. Experimental fishes were also observed to have high Survival (%) for all treatments during the study period. The length-weight relationship revealed a strong positive correlation as expected, that as the fish grow in length, the weight also increases i.e. the fish became heavier with increase in length. The regression analysis showed that the fish exhibited isometric growth. The value of the exponent b indicated that all treatments showed a negative allometric growth which implies that the fish is becoming tinnier as it increases in weight; hence, the fishes become slender. Water quality parameters were observed to be within the acceptable limit for optimum performance of studied fish species. This study has affirmed that the juveniles of *Clarias gariepinus* (Burchel, 1822) and *Heterobranchus longifilis* (Valencinnes, 1840) exhibited good growth ratio. However, there were variabilities between the condition factors measured that may have resulted by several environmental and technical differences.

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