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DUTSE JOURNAL OF AGRICULTURE AND FOOD SECURITY (DUJAFS)

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DUTSE JOURNAL OF AGRICULTURE AND FOOD SECURITY

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Saleh M. K (2003). Agro-forestry diagnostic survey in the semi-arid areas of Yobe State of Nigeria, *Nigeria Journal of Agricultural Extension*, 14(2): 59-69.

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COMPARATIVE ANALYSIS OF VALUE ADDITION WITHIN THECATTLE VALUE CHAIN IN MAIDUGURI METROPOLIS, BORNO STATE, NIGERIA

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Abstract
The study examined value addition within the cattle value chain in Maiduguri Metropolis, Borno State, Nigeria. The study used primary data collected from 201major cattle value chain actors namely fatteners, traders, retailers and processors. Simple random sampling technique was used to select 41 fatteners, 60 traders, 23 retailers and stratified random sampling was used to select 77 processors. Descriptive statistics and value added analysis were used to analyse the data. The findings on socio-economic characteristics of the cattle value chain actors revealed that all the fatteners, traders, retailers and 76.6% of processors were male with majority (73.2% fatteners, 70% traders, 86.9% retailers and 72.8% processors) within the age bracket of 31-50 years. Majority of the actors were married (95.1% of fatteners, 95% of traders, 91.3% of retailers and 81.8% processors) with low educational qualification as 61% of fatteners, 58.3% of traders, 65.2% of retailers and 53.2% of processors had only Qur'anic education. The findings further revealed that majority of the actors (78% fatteners, 93% traders, 87% retailers and 96.1% processors) had family size of up to 10 persons with over 10 years of experience. Results for the value addition revealed that the processors had the highest added cost (79.7%) with a corresponding highest profit (71.3%) in the entire chain. Added cost for the other actors were 8.1%, 1.8% and 10.4% for the fattener, trader and retailer respectively with a corresponding profit of 3.2%, 8.6% and 16.9%. The study established that there was an uneven distribution of profit in the cattle value chain with the processors making the highest profit. It was recommended that use of improved technology should be encouraged in the value chain so as to ease activities and reduce cost of production. Also, value addition for fatteners can be increased by increasing the number of cattle fattened by coming together to enjoy economies of scale.

Keywords: Cattle, Value addition, Value chain, Stratified random sampling, Maiduguri

Introduction

The demand for animal protein in Nigeria, like in many developing countries of the world is far from being met. Nigeria has 1.2 million tons of unmet demand for meat which represents more than 70% of the total of 1.7 million tons of unmet meat demand in the West African sub-region (Nyager, 2013). Products from cattle are the most commonly consumed source of animal protein (Emokaro and Amadasun, 2012). The country largely depends on beef as it accounts for about 70% of total national meat supply (Mafimisebi *et al.*, 2013). The demand for cattle and their products have been increasing while the supply has not been able to keep up with the demand (Tibi and Aphunu, 2010). The domestic production and noted importations are together still not enough to meet more than 60% of the actual demand (Mbanasor, 2000). The strong rise in demand which is likely to double in the near future is stimulated by a combination of population growth, urbanization and income growth (FAO, 2006). Cattle are found throughout Nigeria but are commonest in the northern parts. They are the most predominant and valued livestock with a population of about 16 million (Federal Livestock Department, 2012), 99% of which are managed traditionally (Tibi and Aphunu, 2010). Borno state has the highest population of cattle in Nigeria with an estimated population of about 2 million heads (Ministry of Animal Resources and Fisheries Development, 2011). The sector provides means of livelihood for a significant proportion of the participants in the value chain although studies have shown that the sector is dominated by traditional systems of production (Umar *et al*., 2014), processing (Iliyasu, 2005) and marketing (Bulama, 2004). Aside creation of employment and income, cattle help in the provision of meat, milk, manure, draught power, skin, hooves and horns. It is also used as insurance and for socio-cultural purposes.

Cattle in the study area pass successively through a number of actors and a series of links in the value chain before it reaches the end-users. These participants include producers, marketers, transporters, processors, feed millers and input suppliers. The long chain of traditional intermediate processes are characterised by low value additions at some points. Aside low value additions, it has been observed that generally, the livestock industry in Nigeria is beclouded with limitations ranging from poor management and inefficient marketing (Okeoghene and Idoge, 2013), high marketing cost and margins (Emokaro and Amadasun, 2012). It is a known fact that the high rate of spoilage of cattle by-products, arising from poor storage and transportation facilities impedes the total supply reaching the consumers' table. Cattle products as most agricultural products are bulky and perishable but with value addition through processing and transportation, the shelf life of such products could be improved.

Value addition refers to the process of changing or transforming a product from its original state to a more valuable state (Boland, 2009). It is the difference between the value of goods and the cost of materials or supplies that are used in producing them (Oni, 2013). For cattle, value addition can be looked as the contribution to the final product by each actor in the production, marketing and delivery process of cattle products. This can be achieved through processing, storage, transportation and ownership.

Most studies on cattle in the study area emphasised on the actors individually. Such studies were on economics of production (Umar *et al.*, 2014), marketing (Bulama, 2004), processing (Iliyasu, 2005) and consumption/demand (Zongoma, 2003; Maina, 2012). The sources and extent of imperfections in the cattle value chain would only be known if the actors are studied collectively considering the interdependence among them along the chain. This study was carried out with a view of understanding the contributions of each actor within the cattle value chain.

Methodology

The study was conducted in Maiduguri Metropolis, Borno State, Nigeria. The area lies between latitudes 11^0 54^I and 11^0 45^I N and longitudes 13^0 08^I and 13^0 14^I E with a population of 732,696 people (NPC, 2006). The climate is hot with temperatures ranging between 35ºC and 40ºC for a greater part of the year. It has a short rainfall period of three months that lasts from July to September with an average of 647mm per annum (Lake Chad Research Institute, 2007).

Maiduguri Metropolis which is also referred to as Maiduguri Urban comprised Maiduguri Metropolitan Council (MMC), Jere Local Government Area (LGA), some parts of Konduga LGA and to a lesser extent parts of Mafa LGA (Kawka, 2002). Major occupations of the people include civil service, trading as well as farming. Major crops cultivated include maize, millet, groundnut, cowpea and vegetables. The main products traded in Maiduguri include groundnuts, hides and skins, beans and Gum Arabic. Livestock reared include cattle, sheep, goat and poultry. It is the largest source of cattle in Nigeria as a large number of cattle coming from the neighbouring countries (Chad, Cameroon and Niger Republic) get into the country through Maiduguri.

It is the custodian of a large livestock market, K*asuwan Shanu*, which serves as producing, trading as well as transit centre for livestock especially cattle (Bila and Bulama, 2007). Most of the cattle consumed in Nigeria are traded through the market. With about 2,000,000 herds of cattle in Borno and millions of sheep and goats, this has stimulated trade in livestock as well as the establishment of a modern abattoir in Maiduguri, capable of handling 400 cattle a day (Mayomi and Mohammed, 2014). Cattle enterprise provides employment for a large number of people as producers/ fatteners, traders, brokers/dealers and processors both within and outside the market.

Simple random sampling and stratified random sampling techniques were used to select the research subjects. Lists of producers (fatteners), marketers (wholesalers and retailers) and processors from their associations were used as sampling frames and 20% were proportionately selected from each. From the sampling frames, 41 fatteners, 60 wholesalers and 23 retailers of cattle products were randomly selected. The selection included fatteners as producers, marketers of live animals as wholesalers and marketers of beef and offal as retailers. The sampling frame of processors was stratified according to the products they process and random sampling was used to select 77 processors comprising 35 *Tsire* makers, 27 *Kilishi* makers and 15 food sellers. T*sire* is roasted, boneless peppered meat arranged on sticks which is placed around a glowing fire while *kilishi* is thinly sliced, roasted, boneless, peppered meat which is first dried then roasted. A total of 201 respondents were selected for the study.

Primary data were used for this study which was collected through the use of structured questionnaires administered by trained enumerators. Analytical techniques used include frequencies, percentages and value added model.

Value Added Analysis

Value added is the amount of wealth added by a player. It represents the value a particular agent has added during the accounting period (Adeoye *et al.,* 2013; Oni, 2013). It was calculated using the model used by Making Markets Work Better for the Poor (M4P) (2008) as follows:

Table 1: Computational Procedure for Value Added Analysis

Cost					**Revenue**	**Profit**	
	Unit Cost (₦)	Added Unit Cost (₦)	Total Unit Cost (₦)	% Added Cost	Unit Price (₦)	Unit Profit (₦)	% Total Profit
Actors	A	B	C	D	E	F	G
Total	H	I	J	K	L	M	N

Source: Adapted from M4P (2008) Where:

A = Cost per Unit of Output

B = Added Unit Cost (added cost at each stage of production net of the procurement cost from previous stage)

C = Total Unit Cost incurred by the Actors D = % Added Cost = B/J × 100

E = Price per Unit of Output (₦)

F = E- C (₦) i.e Unit Price - Total Unit Cost

G = $\frac{F}{M} \times 100$

Results and Discussion

Socio-economic Characteristics of Cattle Value Chain Actors

The socio-economic characteristics of the cattle value chain actors studied include sex, age, marital status, educational qualification, household size and years of experience. Table 1 presents information on the socio-economic characteristics of the value chain actors.

Sex

The distribution of sex of the respondents shows that all the producers, traders and retailers were male. About 76.6% of the processors were also male indicating that the cattle value chain was male dominated. Females were found only in processing as restaurants owners. The *Kilishi* and *Tsire* processing activities were strictly male affair. In the study area, it is common to see differences in the roles and responsibilities of men and women. The male dominance in the value chain could be due to culture which restrict female's involvement in some outdoor and strenuous activities and thus classified some categories of activities to either male or female. Generally, in northern Nigeria, cattle business from fattening to processing is usually a family lineage occupation whereby most of the participants inherit the businesses from their forefathers. Only the males are involved in the outdoor activities. Females do not feature prominently; they are usually involved in some home front activities.

Table 2: Socio-economic Characteristics of Cattle Value Chain Actors

Socio-economic characteristic	Producers (n=41)		Traders (n=60)		Retailers (n=23)		Processors (n=77)		Total (N=201)	
Sex	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Male	41.0	100.0	60.0	100.0	23.0	100.0	59.0	76.6	183.0	91.0
Female	0.0	0.0	0.0	0.0	0.0	0.0	18.0	23.4	18.0	9.0
Age (year)										
<20	0.0	0.0	0.0	0.0	1.0	4.3	1.0	1.3	2.0	1.0
20-30	3.0	7.3	5.0	8.3	1.0	4.3	10.0	13.0	19.0	9.5
31-40	13.0	31.7	12.0	20.0	11.0	47.8	29.0	37.7	65.0	32.3
41-50	17.0	41.5	30.0	50.0	9.0	39.1	27.0	35.1	83.0	41.3
51-60	5.0	12.2	11.0	18.3	1.0	4.3	8.0	10.4	25.0	12.4
Above 60	3.0	7.3	2.0	3.3	0.0	0.0	2.0	2.6	7.0	3.5
Marital status										
Divorced	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.3	1.0	0.5
Married	39.0	95.1	57.0	95.0	21.0	91.3	63.0	81.8	180.0	89.6
Single	2.0	4.9	3.0	5.0	2.0	8.7	5.0	6.5	12.0	6.0
Widow	0.0	0.0	0.0	0.0	0.0	0.0	8.0	10.4	8.0	4.0
Educational qualification										
No education	0.0	0.0	0.0	0.0	2.0	8.7	1.0	1.3	3.0	1.5
Primary	10.0	24.4	9.0	15.0	5.0	21.7	18.0	23.4	42.0	20.9
Secondary	5.0	12.2	14.0	23.3	1.0	4.3	15.0	19.5	35.0	17.4
Tertiary	1.0	2.4	2.0	3.3	0.0	0.0	2.0	2.6	5.0	2.5
Qur'anic studies	25.0	61.0	35.0	58.3	15.0	65.2	41.0	53.2	116.0	57.7
Household size										
1-5	16.0	39.0	29.0	48.3	12.0	52.2	50.0	64.9	107.0	53.2
6-10	16.0	39.0	27.0	45.0	8.0	34.8	24.0	31.2	75.0	37.3
11-15	8.0	19.5	4.0	6.7	3.0	13.0	2.0	2.6	17.0	8.5
16 and above	1.0	2.4	0.0	0.0	0.0	0.0	1.0	1.3	2.0	1.0
Years of experience										
<5	6.0	14.6	8.0	13.3	2.0	8.7	11.0	14.3	27.0	13.4
5-10	12.0	29.3	15.0	25.0	4.0	17.4	17.0	22.1	48.0	23.9
11-15	11.0	26.8	18.0	30.0	7.0	30.4	24.0	31.2	60.0	29.9
16-20	6.0	14.6	13.0	21.7	4.0	17.4	16.0	20.8	39.0	19.4
Above 20	6.0	14.6	6.0	10.0	6.0	26.1	9.0	11.7	27.0	13.4

Source: Field Survey, 2015

Age

Table 2 reveals that 73.2% of the producers were within the age bracket of 31-50 years; only 7.3% were below 30 years of age. The Table also shows that 70% of the traders, 86.9% of the retailers and 72.8% of the processors were also within the age range of 31-40 years. Only 8.3% of the traders, 8.6% of the retailers and 14.3% of the processors were less than 30 years of age. The results show that majority of the actors in the cattle value chain in Maiduguri were within their active age, capable of handling the strenuous work associated with the cattle enterprise. The implication of the presence of few young actors (below 30 years of age) could be that they are possibly in school as it is within the school going age or they are not interested in the cattle business. There is a possibility of improvement in the value chain with introduction of new technologies if the young persons return to the business after their schooling. On the other hand, if they do not return or their absence is because they are not interested in the cattle business, the implication is that the family lineage that characterise cattle business will gradually slip to extinction.

Marital status

Majority of the participants of the cattle value chain in the study area (95.1% of fatteners, 95% of traders, 91.3% of retailers and 81.8% of processors) were married. This shows that the chain was dominated by participants that have social obligations and responsibilities. Marriage is a cherished custom in the study area as it is encouraged by both culture and religion. It is one of the factors influencing participation in income generating activities as both partners mostly engage in some activities in order to meet up family responsibilities. Informal discussions revealed that most of their wives carry out some activities at the home front that help out in catering for their families.

Educational qualification

The educational qualifications of the respondents were also examined. The findings on educational qualification revealed that 61% fatteners, 58.3% traders, 65.2% retailers and 53.2% processors had Qur'anic education. Only 2.5% of the entire chain had up to tertiary education. The educational attainment of the respondents can thus be described as low. The implication of this finding is that low educational attainment of the participants in the cattle value chain could be the reason why most activities within the chain were traditionally managed. This may hinder their acceptance of new innovations or technology. People with high educational attainments were found to be more able to interpret agricultural information (Muchara, 2011).

Household size

Information on household size revealed that 78% of fatteners, 93.3% of traders, 87% of retailers and 96.1% of processors had family size of up to 10 persons. This shows that majority of the respondents had large family size. Large households could be attributed to the polygamous custom in the study area which could be associated with culture and belief. It can be an added advantage if the household consist of economically active workers as it can be used to supplement labour. Large household size can also make the actors take their jobs with all the seriousness it deserves because of family responsibilities.

Years of experience

The distribution of years of experience of the respondents indicates that fattening, marketing and processing of cattle and its products have been age long occupations. Table 2 reveals that 56%, 61%, 73.9% and 63.7% of fatteners, traders, retailers and processors respectively, had above 10 years' experience. Only 14.6%, 13.3%, 8.7% and 14.3% respectively, had less than 5 years' experience. The findings suggest that majority of the respondents were well experienced hence capable of handling their businesses professionally and can perform well. This is not surprising as the cattle business is a family lineage occupation that had been within families for long. Most of the participants may have either inherited the business or may have joined at an early age.

Value Addition in Cattle Value Chain

Estimates of weight of cattle were obtained from Animal Science Department, University of Maiduguri using the value of cattle fattened and sold. The amount spent per kilogram (kg) weight of cattle was established by taking average of the number of cattle handled, their corresponding weights and cost of handling. Table 3 presents summary of unit cost, unit revenue and unit profit per actor. At each stage of the chain, the value of the product increases as the product becomes more suitable to the end users.

Fattener

The fatteners cost of purchasing a head of cattle was approximately ₦74,800.0 weighing about 195kg which could sell for up to ₦120,900.0 weighing about 245kg at the end of the fattening period. Variable cost of handling a bull through the fattening period of 3 months which includes feeding, watering, labour and medication was about ₦11,280.0 (₦46.0/kg). This low handling cost could be because they buy feeds (which are bulk of the cost) during the glut period when the prices are low as observed by the study. Fixed cost which mainly comprises feeders, drinkers and shade was ₦3,789.9 per bull (₦15.5/kg). Table 3 reveals that the fatteners' cost in purchasing a bull was ₦383.6/kg while cost of fattening was ₦61.5/kg. Cost of fattening which was the additional cost incurred by the fattener was 8.1% of the total. This implies that the fatteners' share of added cost was 8.1% of the total additional cost incurred by the value chain actors. Price per kg of cattle sold was ₦493.5 with a profit of ₦48.4/kg. The fattener's share of profit in the chain was 3.2%. As the producer, this profit is very low considering that the fattener started the chain and has to handle the animal for a long period before disposing.

Table 3: Distribution of Value Addition within the Cattle Value Chain

	Cost (₦/kg)				Revenue (₦/kg)	Profit (₦/kg)	
Value Chain Actors	**Unit Cost**	**Added Unit Cost**	**Total Unit Cost**	**% Added Cost**	**Unit Price**	**Unit Profit**	**%Total Profit**
Fattener	383.6	61.5	445.1	8.1	493.5	48.4	3.2
Trader	307.3	13.7	321	1.8	450.3	129.3	8.6
Retailer	387.5	79.7	467.2	10.4	721.4	254.2	16.9
Processor	522.3	608.8	1131.1	79.7	2,206.6	1,075.5	71.3
Total	**1,600.7**	**763.7**	**2,364.4**	**100.0**	**3,871.8**	**1,507.4**	**100.0**

Source: Computed from Field Data, (2015)

Trader

The traders' cost of purchasing a head of cattle was about ₦63,000.0. It was envisaged that the traders' cost of purchasing a cow/bull would be higher than that of the fattener considering that the fatteners could sell to the traders. However, the findings revealed that this was not the case. Majority of cattle handled by the traders are bought from herdsmen or agents. The trader handles more animals of different sizes, ages and weights than the fattener who handles just a few at a time. A cow/bull bought at ₦63,000.0 could sell for up to ₦92,308.0 with just about ₦2,185.0 (₦10.7/kg) spent on variable cost which includes transportation, feeding and watering of the cattle while in the traders' custody. Fixed cost which mainly comprises feeders and drinkers was about ₦620.3 per cow (₦3.0/kg). From the table, the traders' share of added cost was 1.8% (₦13.7/kg) with a corresponding profit of 8.6% (₦129.3/kg) in the chain. The traders' share of added cost was lower than that of the fattener but with a higher profit. This lower added cost could be because the traders do not handle the animals for long before selling off unlike the fattener who keeps it for a longer period and thus higher profit.

Retailer

The retailer buys a kilogram of beef and offal at an average of ₦387.5/kg (a kg of beef was bought at about ₦500.0 and offal at about ₦275.0). The retailer, who sells in units, has an added cost of ₦79.7/kg (10.4%) which was higher than both the fatteners' and traders added cost. The bulk of variable cost (₦24.1/kg) was on transportation and storage. The retailer buys from the abattoir in bulk and breaks the bulk by selling in smaller units. A kg of beef is sold at about ₦892.8 and offal at about ₦550.0. Taking an average, price for a kg of beef and offal was ₦721.4 which was much higher than that of the traders' (₦450.3) because they sell in smaller units. The retailers' percentage profit was 16.9% which was higher than that of the fatteners' and traders'. For a kg of beef and offal, a retailer makes up to ₦254.2 profit.

Processor

The processor had the highest added cost of ₦608.8/kg (79.7%) in the chain with a corresponding highest profit of ₦1,075.5/kg which was 71.3% of total profit in the chain. Variable costs (₦335.0/kg) include that of firewood, spices and vegetables while fixed costs (₦273.80/kg) include stall/shop, rent, tables and chairs/mats and utensils. The high added costs and profit could be explained by the utility derived from their products as they provide ready-to-eat products directly to consumers. Although the processors' added cost was higher than that of the other actors, the profit obtained makes the processor the highest beneficiary in the chain. The fattener who starts the chain ended with a minute share of profit while the processor who is at the end of the chain gets the lion share of profit. One may think that the processor handles just a few kg at a time while the fattener handles the whole cow at a time, so the fatteners' profit in the long run will be higher than the processors'. On a closer look, the processor handles a few kg daily which at the end of 2 months will be much higher than the fatteners' who handles a larger quantity but will take up to 2 months before disposal. In 2 months, the processor would have handled more than the quantity handled by the fattener which justifies the higher profit.

Conclusion and Recommendations

The study has shown that the cattle value chain in Maiduguri Metropolis, Borno State, was male dominated majority of who had low level of educational attainments, large family sizes and many years of experience. Although value addition revealed profits were generated at all stages of the chain, its distribution was not even. Processors made the largest share of profit compared to other actors. The profits generated within the chain shows that there are opportunities in the value chain. The study recommends that use of improved technology should be encouraged in the value chain so as to ease activities and reduce cost of production. Also, Fatteners should increase the number of cattle fattened by coming together through their associations to enjoy advantages of access to credit and economies of scale in buying of inputs like feed and feeder cattle. This will eventually reduce cost of production and increase value addition for fatteners.

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GROWTH AND INSTABILITY IN YAM PRODUCTION IN NIGERIA: AN INTER STATE LEVEL ANALYSIS

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Abstract

The study aimed at assessing the growth pattern and instability in area, production and productivity in yam (tuber crop) in Nigeria from 1960-61 to 2015-16 using time series data. To achieve this objective, the exponential growth model, Quadratic function in time variable, coefficient of variation, Coppock's instability index and Hazell's decomposition analysis were employed. The findings revealed that the crop recorded significant increase in production largely due to expansion in area rather than yield growth per hectare implying that yield induced investments were grossly undermined. Highest production (14.27%) and area (11.77%) growth was achieved during the economic diversification period; and productivity growth was highest during SAP period. However, accelerated growth has not been achieved during the periods of the study. Instability was generally low for area, production and productivity in selected states in terms of CII and moderate in terms of CV. Change in mean area was the dominant source of change in average of yam production whereas changes in residuals and change in area-yield covariance were identified as the major sources of instability of change in variance of yam production. The study recommends investment in the direction of yield increase as there is limit to area expansion.

Keywords: Decomposition analysis, Growth, Instability Index, Nigeria, Yam production

Introduction

Food security has been an issue of concern in the context of growing population in developing countries. In Nigeria, the food crop sub sector comprising cereals and root and tuber crops dominate the agricultural sector contributing over 30% of the agricultural Gross Domestic product (GDP). Yam is an important tuber crop in Nigeria rank second to cassava and serves as a source of income, food consumption and employer of labour. Nigeria is the largest producer of yam in the world accounting for two - thirds of global production (Verter and Vera, 2015; NBS, 2012; Fu *et al.*, 2011; IITA, 2009).

The economic and cultural value of this crop makes it important in Nigeria and other African countries for instance, it contributes a nutritional value of more than 200 calories daily for more than 150 million people in yam producing zone of West Africa comprising of Nigeria, Benin, Togo, Ghana and Cote d' Ivoire. This zone produces more than 90% of the total world production. The crop contains high value starch and minerals and form part of religious, traditional, cultural and ritual heritage and ceremonies in many communities (Izekor and Olumese, 2010; Fu *et el*., 2011; Babaleye, 2003 in Ibitoye and Onimisi, 2013).

Over the past 50 years' yam production trend in Nigeria has shown a tremendous improvement from 3.2 million tonnes per annum in 1960 to 26.2 million tonnes in 2000 to 45 million tonnes in 2014 (FAO, 2014). Similarly, area under yam cultivation from available data seems to increase from 1.3 million hectares in 1990 to 2.6 million hectares in 2000 and to 5.4 million ha in 2014. Increase in production can however be attributed to increase in hectares of land planted to yam than to increase in productivity especially looking at the declining and fluctuating trend of the yield during the study period. IITA (2009) also reported that yam production is declining in some traditional producing areas due to declining soil fertility, increasing pest pressures and high cost of labor and observed that small holders need access to innovations to reduce labor and improve productivity.

In Nigeria, numerous combination of institutions, agricultural policies and programmes were developed to support and stimulate agricultural growth in the face of low and declining yield of crops. Some of the research institutes and programmes by the government were: Root and Tuber Crops Extension Programme in 2003, credit policies in form of inputs through NACRDB and Agricultural Credit Guarantee Scheme Fund (ACGSF) of Central Bank of Nigeria, National Root Crops Research Institute (NRCRI), International Institute of Tropical Agriculture (IITA) for research on improved yam seed technology, National Special Programme for Food Security Programme (NSPFS), Fadama World Bank project and other interventions. Moreover, efforts to increase yield through these programmes and policies proved abortive especially with the persistent scarcity and high cost of seed yam, on-farm harvest and post-harvest losses and high labour demand for production (Shimada, 1999; Fu et al., 2011). In view of the above background, this study was designed to analyze the growth and instability in area, production and productivity of yam in Nigeria within the purview of different policy regimes.

Research Methodology

The study used time series data which covered a period of 56 years from 1960-61 to 2015-16 the period was further sub-divided into four period on the basis of policy regimes following the works of Sanyal and Babu (2010), Iwuchukwu and Igbokwe, (2012) and Udah *et al.* (2015). Period I from 1960-61 to 1970-71 (period of policy of economic diversification); it's the period when the nation got independence characterized by era policies of export-led growth and diversification of resources to encourage industrialization. Period II from 1971-72 to 1985-86 (period of rehabilitation, reconstruction and stabilization); this era corresponds to the period after the civil war, oil boom and first democratic dispensation. Various policies were implemented in the face of the decline in agricultural performance. Period III from 1986-87 to 1999-2000 was the period of structural adjustment programme (SAP) which marked the beginning of a deregulated economy. Policy instruments of SAP were design to influence the sector indirectly or directly through fiscal policies, monetary and trade and foreign exchange rate policies. Period IV from 2000-01 to 2015-16 (period of liberalization) this period marked the beginning of a new democratic dispensation and consists of several programmes and policy with the aim of attaining food self-sufficiency, increase processing and export of commodities and creation of more agricultural and rural employment. Sources of instability (component of change in average production and variance of production) were estimated between two periods; Structural Adjustment Period (1986/87 to 1999/2000) and liberalization period (2000/01 to 2015/16). Computations at zonal and states levels however, were carried out for the period between 1994-95 and 2015-16 due to dearth of data. Three states were purposively chosen from each zone based on level of production. Similarly, estimation of quadratic function in time variable on production data was from 1960-2015. The data sources were FAOSTAT, National Bureau of Statistics (NBS) and National Agricultural Extension Research Liaison Services (NAERLS). Data was converted to natural log and analyzed using exponential growth model, Quadratic function in time variable, Coppock's instability Index, Coefficient of Variation and Hazell's, 1982 decomposition analysis.

Model specification

1. **Exponential growth model**

The exponential form of the model of the following type was used in the analysis to measure the growth rate of the crop during the periods of study. Ammani, (2012), Maikasuwa and Ala, (2012), Igwe, *et al*, (2014), Isah *et al*, (2015) used similar model as follows,

$$Y = ab^t + \varepsilon \qquad (1)$$

Upon logarithmic transformation, the function is converted to linear form

$$l \quad = a + b \; + \; \varepsilon \qquad (2)$$

Where,

Y =Area, production and productivity of the selected crops

t = Time variable in years (1, 2, 3… n)

a = Intercept (constant)

b = Time trend coefficient

ln = Natural logarithm, ε = Summation

Thus, the compound growth rate (r) in percentage is given by;

*r = exp (b-1)*100* ………(3)

Where, r = compound growth rate, exp = exponential (2.71828) and b = estimated coefficient of time trend.

2. Instability Analysis

Instability in area, production and productivity was measured using Coefficient of Variation (CV) and Coppock's Instability Index (CII). While CV is the most commonly used index because of its easy interpretation, it only measures the overall variation in the data but does not take into account any trends of the data and therefore can over estimate. Coppock's Instability Index (CII) on the other hand explained the average year to year percentage variation adjusted for trend.

Coefficient of Variation (CV)

CV is standard deviation expressed as a percentage of mean value and is most popular measure which indicates the extent of instability. It is defined as;

$$C \quad = \frac{\sigma_i}{\bar{x}_i} \qquad (4)$$

Where,

C = Coefficient of variation

σ_i = Standard deviation of the ith variable in the jth crop

$\bar{x}_i$ = Arithmetic mean of the ith variable in the jth crop

Coppock's Instability Index (CII)

Coppock's Instability Index as noted earlier, unlike coefficient of variation give close approximation of the average year to year percentage variation adjusted for trend. It was employed by Narinder and Singhal (1988); Rama Rao (2003) and Samarphita, (2013).

CII is specified as,

$$CI. = \left(A \qquad \sqrt{l} \quad - 1\right)\times 100 \qquad (5)$$

$$l \quad = \sum(l \quad X_{t+1} - l \quad X_t - M)^2/N - 1 \quad (6)$$

$$M = (l \quad X_{t+1} - l \quad X_t)/N - 1 \qquad (7)$$

Where,

X_t = Area/production/productivity in the year t,

N = Number of years

M= Arithmetic mean of the difference between the logs of X_{t+1} … etc

Log V = arithmetic variance of the series

For the purpose of this study, both CV and CII were used to estimate the magnitude of instability of yam within the study periods. For easy understandings, their values were categorized representing different range of instability as follows;

i) Low instability = between 0 to 20
ii) Moderate instability = greater than 20 and lower than 40
iii) High instability = greater than 40

Sihmar (2014) used similar categorization while studying instability in Haryana state, India

3. Quadratic function in time variable

The present study assessed agricultural policies under different regimes within the study period by fitting quadratic equation in time trend variable on production data to make inference about the pattern of growth whether it is acceleration, deceleration or stagnation as follows.

$$Q_t = \beta_0 + \beta_1 t_i + \beta_2 t_i^2 + U_t \qquad (8)$$

Where,

Q_t=Quantity of output in different period of policy regime as follows,

Q_t1 = Period I from 1960-61 to 1970-71-period of policy of economic diversification

Q_t2 = Period II from 1971-72 to 1985-86 - period of policy of reconciliation, rehabilitation, reconstruction and stabilization

Q_t3 = Period III from 1986-87 to 1999-2000 - period of structural adjustment programme (SAP)

Q_t4 = Period IV covers from 2000-01 to 2015-16 - period of liberalization.

The linear and quadratic time terms indicate the circular path in the dependent variable (Qt) and the quadratic time variable (t^2) allows for the possibility of determining whether there is acceleration, deceleration or stagnation in production growth during the study periods.

$\beta_0, \beta_1, \beta_2$ Are parameters to be estimated and consideration is on β_2 which is the coefficient of time trend squared (t^2) that reveals the measure of the growth pattern. The conclusion is that;

If $\beta_2 > 0$ and statistically significant, then there is acceleration in growth,

If $\beta_2 < 0$ and statistically significant, then there is deceleration in growth,

If β_2 is positive or negative but not statistically significant, then there is stagnation in growth

The model had been used by many authors including; Sawant, (1983), Oyenweanku, (2004), Maikasuwa and Ala, (2012), Sadiq, (2014), Udah *et al.* (2015) and Isah *et al.* (2015).

4. Hazell's Decomposition analysis

Sources of instability were captured using the above technique. According to Hazell (1982) agricultural production is a combined result of area and yield. If there is variability in area and yield growth, there will be change in output growth. A change in these components will lead to change in variance of production. The objective of the decomposition analysis therefore, is to partition the changes in variance of production and average production between chosen periods into constituent parts. Liberalization period (2000/01 to 2015/16 over the structural adjustment period (SAP) from 1986/87 to 1999/2000 were considered. Rama Rao (2003), Ganesa, (2015) and Pradeep, (2015) has employed this model.

Method of decomposition of change in average production

Change in average production of the crop is affected by changes in the covariances between area and yield and also by changes in mean area and mean yield, expressed as;

$$E(P) = \bar{A}\,\bar{Y} + C \quad (A \quad) \quad (9)$$

Where;

$E(P)$ = average/mean production,

$\bar{A}$= average/mean area,

$\bar{Y}$= average/mean yield and

$C \quad (A \quad)$= covariance between area and yield respectively.

To differentiate the changes in E(P) average production between two periods, let average production in first and second period be;

$$E(P_1) = \bar{A}_1\bar{Y}_1 + C \quad (A_1Y_1) \quad (10)$$

$$E(P_2) = \bar{A}_2\bar{Y}_2 + C \quad (A_2Y_2) \quad (11)$$

Taking the first period as base year, each variable in the second period can be expressed in terms of its counterpart in the second period plus the change in the variable between the two periods. The change in average production $\Delta E(P)$is then obtained by subtracting equation (10) from equation(11)as follows:

$$\Delta E(P) = E(P_2) - E(P_1) = \bar{A}_1\Delta\bar{Y} + \bar{Y}_1\Delta\bar{A} + \Delta\bar{A}\,\Delta\bar{Y} + \Delta C \quad (A, Y) \ldots\ldots \ (12)$$

There are four (4) sources of change in average of production from above equation. The first two terms represent change in mean area and change in mean yield which are called 'pure effects' and existed even if there were no other source of change. The third term is an interaction effect, which arise from the simultaneous occurrence of changes in mean yield and mean area. The fourth term in the equation represents interaction between area and yield covariance. Thus, the component of change in average production taking the first period as base period after de-trending the data can be arranged as shown in Table 1 below.

Table 1: Components of change in average production measured in percentage

Sources of change	Symbols	Components of change
Change in mean area	$\Delta\bar{A}$	$\bar{A}_1\Delta\bar{Y}$
Change in mean yield	$\Delta\bar{Y}$	$\bar{Y}_1\Delta\bar{A}$
Interaction between changes in mean area and mean yield	$\Delta\bar{A}\,\Delta\bar{Y}$	$\Delta\bar{A}\,\Delta\bar{Y}$
Changes in area – yield covariance	$\Delta C\quad(A,Y)$	$\Delta C\quad(A,Y)$

Sources: Hazell, (1982).

Methods of decomposition of change in variance of production

In this the variance of production was decomposed into its sources, viz., area variance, yield variance, area-yield covariance and higher order interaction between area and yield. A change in any one of these components will lead to change in variance of production, it is expressed as;

$$V(P) = \bar{A}^2.V(Y) + \bar{Y}^2.V(A) + 2\bar{A}\,\bar{Y}C\quad(A,Y) - C\quad(A,Y)^2 + R \qquad (13)$$

Where,

$V(Q)$ = Production Variance
$\bar{A}$ = Mean Area
$\bar{Y}$ = Mean Yield
$V(Y)$ = Yield variance
$V(A)$ = Area variance
$C\quad(A,Y)$ = Area - Yield covariance
$CO\ (A,Y)^2$ = Higher order covariance between area and yield
R= Residual term

Using first and second periods, variance of production can be partition into its constituent parts as;

$$V(P_1) = \bar{A}_1^2.V(Y_1) + \bar{Y}_1^{\,2}.V(A_1) + 2\bar{A}_1\bar{Y}_1C\quad(A,Y) - C\quad(A_1,Y_1)^2 + R1 \qquad (14)$$

Second period is,

$$V(P_2) = \bar{A}_2^2.V(Y_2) + \bar{Y}_2^{\,2}.V(A_2) + 2\bar{A}_2\bar{Y}_2C\quad(A,Y) - C\quad(A_2,Y_2)^2 + R2 \qquad (15)$$

Variables in the second period can be expressed in terms of its counterpart in the first period plus the change in the variable between the two periods as follows and the final equation having ten sources is summarized and explicitly presented in Table 2. Excel version of the soft ware was used to obtained the results in percentage.

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Table 2: Components of change in variance of production

Sources of change	Symbols	Components of change (%)
Change in mean area	$\Delta\bar{A}$	$2\bar{Y}_1\Delta\bar{A}\,C\quad(A_1,Y_1)+\{2\bar{A}_1\Delta\bar{A}+(\Delta\bar{A})^2\}V(Y_1)$
Change in mean yield	$\Delta\bar{Y}$	$2\bar{A}_1\Delta\bar{Y}C\quad(A_1,Y_1)+\{2\bar{Y}_1\Delta\bar{Y}+(\Delta\bar{Y})^2\}V(A_1)$
Change in area variance	$\Delta V(A)$	$\bar{Y}_1^{\,2}\Delta V(A)$
Change in yield variance	$\Delta V(Y)$	$\overline{A_1^2}\Delta V(Y)$
Interaction between changes in mean area and mean yield	$\Delta\bar{A}\,\Delta\bar{Y}$	$2\Delta\bar{A}\,\Delta\bar{Y}C\quad(A_1,Y_1)$
Changes in area-yield covariance	$\Delta C\quad(A,Y)$	$\{2\bar{A}_1\bar{Y}_1-\ 2C\quad(A_1,Y_1)\}\Delta C\quad(A,Y)-\{\Delta Cov(A,Y)$
Interaction between changes in mean area and yield variance	$\Delta\bar{A}\,\Delta V(Y)$	$\{2\bar{A}_1\Delta\bar{A}+(\Delta\bar{A})^2\}\Delta V(Y)$
Interaction between changes in yield and area variance	$\Delta\bar{Y}\Delta V(A)$	$\{2\bar{Y}_1\Delta\bar{Y}+(\Delta\bar{Y})^2\}\Delta V(A)$
Interaction between changes in mean area and mean yield and changes in area- yield covariance	$\Delta\bar{A}\,\Delta\bar{Y}\Delta C\quad(A,Y)$	$(2\bar{A}_1\Delta\bar{Y}+2\bar{Y}_1\Delta\bar{A}+2\Delta\bar{A}\,\Delta\bar{Y})\Delta C\quad(A,Y)$
Changes in residual	ΔR	$\Delta V(A\quad)$ - sum of other components

Hypothesis: There is significant growth rate of area, production and productivity.

Production growth was a function of area rather than productivity growth.

Results and Discussion

Growth in area, production and productivity of yam

Analysis from Table 3 revealed that productivity growth rate of yam ranges from as low as -3.42% in period II to as high as 2.90% in period III. Productivity growth during the whole period of study was also very low (0.3%) but statistically significant at 10% level of significance. Unlike productivity, area growth showed remarkable growth. For instance, during period I a growth rate of 11.77% was achieved which was statistically significant at 1% level. A gross decline was then observed in period II (1.82%) though still positive it has not upset the decline in productivity during that period so production maintained a negative growth rate. Area growth during period IV and overall period were; 5.29 and 4.24 percent respectively. Growth in yam production like other crops seemed to be more of a function of area growth and this corroborates with the report of Nwosu and Okoli, (2010) as cited in Nsikak-Abasi *et al*. (2013). Period I and II recorded higher production growth of 14.27% and 13.38% respectively, while growth in overall period was 4.59 percent statistically significant at one percent level of significance. Results of interstate analysis showed that seven out of 15 states exhibited negative growth rate of productivity, this ranges from -3.11 % in Oyo state, -2.85% in Anambra and -1.9% in Imo state. Among the states that showed positive growth, Adamawa recorded the highest growth rate (3.89%) then closely followed by Cross River state (2%). There was remarkable increase in area growth under yam during the period of study especially when compared to yield growth. As can be seen area growth ranges from 8.19% in Anambra state to 0.13% in Benue state. Negative growth rate of area was observed in only three states; Adamawa, Kwara and Enugu states. Analysis further revealed that, majority of the states recorded positive growth of production implying that effect of negative growth rates of productivity was cancelled by increased in area during the period of study, meaning that area growth contributed more to production growth. Likewise, at the zonal level area growth was higher in south east zone (4.17%), productivity and production growth were highest in north east and north central zones respectively. The hypothesis that there is significant growth in area and production is hereby accepted.

Table 3: Compound annual growth rates of area, production and productivity of yam in Nigeria 1960-61 to 2015-16 (%)

Period	Area	Production	Productivity
Period I (1960/61-70/71)	11.77***(0.00274)	14.27***(0.00236)	2.56***(0.00319)
Period II (1971/72- 85/86)	1.82***(0.00153)	-4.34***(0.00255)	-3.42**(0.0071)
Period III (1986/87- 99/2000)	8.69***(0.00479)	13.38***(0.00735)	2.90**(0.00524)
Period IV (2000/01-2015/16)	5.29***(0.00439)	2.85***(0.00237)	-2.23**(0.00392)
Overall Period (1960/61-2015/16)	4.24***(0.00111)	4.59***(0.00082)	0.34*(0.00082)
States and Zones 1994/95-2015/16			
Kaduna state	2.3***(0.00676)	3.43***(0.00735)	0.98***(0.0234)
North West Zone	2.29***(0.004)	-1.12 NS(0.009)	-3.28***(0.008)
Adamawa state	-5.3***(0.01653)	1.91*(0.0106)	3.89***(0.00644)
Taraba state	5.29***(0.0506)	5.4***(0.00595)	0.15 NS (0.0044)
North East Zone	3.73***(0.0079)	5.31***(0.0061)	1.04 NS(0.0087)
Benue state	0.13 NS (0.00122)	-1.21**(0.0056)	-1.33**(0.00534)
Niger state	3.12*(0.01704)	2.57 NS(0.018)	0.52 NS(0.00417)
Kwara state	-2.64**(0.0111)	-4.25***(0.00857)	-1.65**(0.00623)
North Central Zone	2.36***(0.0060)	2.41***(0.0074)	1.09 NS(0.0042)
Ondo state	3.84***(0.00288)	4.62***(0.00441)	0.75***(0.00275)
Ogun state	5.42***(0.00574)	7.36***(0.00691)	1.84***(0.00266)
Oyo state	1.89***(0.00556)	-1.28**(0.00585)	-3.11***(0.00560)
South West Zone	0.04 NS(0.0112)	-2.46**(0.0099)	-2.49***(0.0068)
Rivers state	1.04 NS(0.00832)	-1.0 NS(0.00704)	-1.78***(00.00312)
Cross River state	2.19***(0.00404)	4.27***(0.00416)	2***(0.00308)
Delta state	7.55***(0.00576)	7.04***(0.00861)	-0.47 NS(0.00658)
South South Zone	2.37***(0.0028)	2.30***(0.0062)	-0.075 NS(0.0055)
Anambra state	8.19***(0.00559)	5.11***(0.00544)	-2.85***(0.00758)
Enugu state	-0.14 NS(0.00632)	1.23**(0.00523)	1.37***(0.00356)
Imo state	2.55***(0.00481)	0.61*(0.00322)	-1.904***(0.0435)
South East Zone	4.17***(0.011)	1.26 NS(0.0010)	-2.79***(0.0095)

Note: *, ** and *** indicates significant at 10%, 5% and 1% probability level respectively, NS denotes non- significant, while figures in parenthesis are standard errors

Instability pattern in area, production and productivity

Period III exhibited the highest yam productivity instability (CV 29.55%, CII 22.94%) and was noticed to be higher than the instability obtained for the whole period of study (1960/61 -2015/16) as presented in Table 4. Area instability for the periods seemed to be higher than yield instability. The lowest instability was recorded during period II in terms of CV (27.661%) and period I in terms of CII (10.54%). There was high area variability during the overall period (75.61%) as per CV and moderate as per CII. Production instability recorded its highest values in period I and III, which might be linked with the influenced of both area and yield instability. Period I recorded highest CV, while period III registered highest CII. The most stable periods were period IV in terms of CV and period I in terms of CII. Similarly, Overall period had high production instability by way of CV

(74.56%) and low instability in terms of CII (16.35%). As seen from the results production instability was accounted more to area variance than productivity. Ongoing analysis further revealed stable nature of yam productivity; about twelve out of fifteen states studied had low instability score (0-20%), three states had moderate score (20-40%) and none had high instability. Area instability varied as four states recorded high instability in terms of CV and two states in terms of CII. Majority of the states however scored moderate instability as per CV while in terms of CII low instability dominated. Highest area instability was recorded in Niger state (148% CV and 68.23% CII), whereas, Benue state registered the lowest area variability (CV 3.64%, CII 6.25%). Production instability ranges from as low as 10.52% in Imo state to 147% in Niger state in terms of CV, and 9.73% in Ondo state to 73.21% in Niger state in terms of CII. High and low instability in the states may not be unconnected with growth trends in area, production and productivity. According to Sen (1967) increase in rate of growth is accompanied by an increase in instability if the growth comes about mainly as a result of extension of average area and increase in inputs like fertilizer rather than improvements in skills, unless sufficient corrective measures are taken concurrently. While Das (1978) is of the view that dependence of agriculture on precarious rainfall, extension of area under crops cultivation, use of fertilizers, inadequate irrigation facilities and absence of better farming methods were factors responsible for instability, Ray (1983) and Hazel (1984) attributed instability to yield fluctuations.

Instability at zonal level were generally low following pattern of growth, highest instability in area was observed in south east zone in terms of CV and CII, whereas, the lowest was noticed in south-south zone. Conversely, productivity variability was highest in terms of CII in north-central zone indicating high growth rate. In terms of instability in production however, south east and north-west zone recorded higher values. It could be inferred that instability in yam area, production and productivity was moderate on average and production variability was more as a consequence of area instability ostensibly because policies do not seem to capture or impact positively on increase in yield per hectare during the study periods.

Table 4: Instability in area, production and productivity of Yam in Nigeria -1960-61 to 2015-16 (%)

Period	**Area**		**Production**		**Productivity**	
	CV	CII	CV	CII	CV	CII
Period I (1960/61-70/71)	38.11	10.54	44.48	7.48	11.21	12.02
Period II (1971/72- 85/86)	27.76	24.98	23.64	13.60	29.55	22.94
Period III (1986/87- 99/2000)	37.66	14.28	43.11	19.46	17.65	13.46
Period IV (2000/01-2015/16)	30.13	12.13	17.27	12.83	18.57	19.39
Overall Period (1960/61-2015/16)	75.61	20.03	74.56	16.35	21.34	17.91
States and Zones 1994/95-2015/16						
Kaduna state	22.74	23.94	28.28	27.16	8.97	7.54
North West Zone	12.96	25.09	18.46	16.17	20.95	15.07
Adamawa state	66.11	60.24	15.25	32.65	27.55	23.15
Taraba state	32.47	15.55	33.11	17.76	12.39	16.28
North East Zone	29.61	14.39	26.68	14.20	19.05	17.49
Benue state	3.64	6.25	16.18	16.78	16.18	15.39
Niger state	148.0	68.23	147.5	73.21	12.97	15.01
Kwara state	37.15	32.39	39.27	24.62	18.85	22.07
North Central Zone	18.12	8.84	19.28	11.98	8.34	10.20
Ondo state	26.16	7.08	32.52	9.73	9.58	8.84
Ogun state	37.50	15.73	50.17	18.04	14.86	8.64
Oyo state	21.75	20.73	19.17	23.09	24.51	16.96
South West Zone	21.88	12.85	24.95	14.90	17.71	17.86
Rivers state	25.91	25.14	27.57	27.37	14.34	10.91
Cross River state	18.42	13.11	28.48	14.02	16.49	10.68
Delta state	50.11	15.92	48.20	21.18	18.58	16.95
South South Zone	13.37	6.99	18.49	18.47	12.17	15.13
Anambra state	56.37	15.64	30.43	13.54	24.99	17.11
Enugu state	17.31	18.34	17.27	11.45	17.31	15.53
Imo state	22.95	11.87	10.52	13.68	16.03	6.56
South East Zone	29.97	25.09	20.89	16.17	20.53	15.07

Source: Author's computation

Results of Sources of Instability

Change in average of yam production was decomposed into its components and the results were presented in Table 5. It was observed that of the four components, change in mean area was the major source of variability at the states level constituting ten states out of 15 studied while change in mean yield was responsible in the remaining 5 states. In Kaduna, Taraba, Niger and Ondo states, the change in mean area was high ranging from 77% to 100% and was followed by change in mean yield, whereas in Delta and Ogun states interaction between change in mean area and yield was followed next as a dominant source of change in average production. The highest change in mean area among the states was recorded in Imo state (312.34%) while the lowest was noticed in Adamawa state (-999.66%). The percentage proportions of contribution of change in mean area and change in mean yield in relation to change in average yam production was not much in Cross rivers state (48.09 and 40.37 % respectively) whereas in Kwara, Anambra and Imo states all other components were negative except change in mean area. Implying that instability in those states were totally due to interventions geared toward area expansion.

States where change in mean yield became the major source of change in average production were: Adamawa state (2282.38%), Benue state (106.65%), Oyo state (259.42%), Enugu state (66.47%) and Rivers state (364.7%). With the exception of Enugu state, interaction effect between change in mean area and mean yield was found to be next contributing factor after change in mean yield. The highest change in mean yield among the states was observed in Adamawa (2282.38%) and the lowest was recorded in Imo states (-147.37%) respectively. At the level of zones, a change in mean area dominates in four zones (north-east, north- central, southeast and south-south whereas change in mean yield was the main source in the remaining two zones (north-west and south-west). In north east zone change in change in mean area constitutes 69.18% as the major source while change in mean yield is seen as another contributor with 23.10 %. Similar pattern follows in north-central and south-south (77.24 and 19.77 % and 91.44 and 6.16 %). In the south-east, all component was negative except change in mean area. Interaction between mean yield and mean area and change in mean area were the next sources of change after change in mean yield in north-west and south-west respectively. At all Nigeria level, result indicated that change in mean area was the dominant source of change (110.96) in average yam production during liberalization period over structural adjustment period. Change in mean yield, interaction between changes in mean yield and mean area and changes in area –yield covariance were virtually less important (negative) and acted to reduce the positive growth.

Table 5: Result of sources change in average of yam production (%)

States, Zones and National	Change in mean Area $\Delta\bar{A}$	Change in mean Yield $\Delta\bar{Y}$	Interaction between changes in mean Yield and mean Area $\Delta\bar{A}\,\Delta\bar{Y}$	Changes in Area - Yield covariance $\Delta C\ (A, Y)$
Kaduna	96.72	6.75	3.18	-4.42
Adamawa	-999.66	2282.38	-1125.22	-69.13
Taraba	97.61	2.55	1.56	-1.24
Benue	-8.30	106.65	1.51	0.10
Kwara	145.28	-28.99	-12.54	-2.52
Niger	100.70	0.95	0.99	-2.67
Oyo	-237.04	259.42	78.81	-0.84
Ogun	64.57	17.47	17.59	0.37
Ondo	77.53	14.10	8.64	-0.20
Anambra	178.43	-28.69	-42.45	-6.92
Enugu	25.86	66.47	3.68	2.64
Imo	312.34	-147.37	-53.37	-11.73
Rivers	-353.65	364.7	88.9	0.97
Cross Rivers	48.09	40.37	12.07	-0.35
Delta	96.38	2.44	3.55	-2.22
North West zone	-298.27	318.85	76.69	1.61
North East zone	69.18	23.10	8.03	-0.17
North Central zone	77.24	19.77	3.86	-0.79
South West	17.32	75.71	-2.12	7.68
South East	276.87	-121.01	-43.67	-10.89
South South	91.44	6.16	1.12	0.96
All Nigeria level	110.96	-0.90	-0.98	-7.43

Source: Author’s computation using excel.

Components of change in variance of yam production

The results of components of change in variance of yam production indicated that change in area variance was the major cause of instability in majority of the states under the periods studied (Table 6). Change in area variance and change in residuals were recorded as dominant source of variability in Kaduna state (53.09%), Taraba state (78.23%) and Kwara state (84.08%) respectively. Other states where change in area variance exerts much impact were Niger, Enugu, Imo Rivers and Cross rivers states. The highest and the lowest contribution of instability by change in area variance were observed in Imo and Anambra states accounting for 25776.04 and -211.01 percent respectively. On the other hand, a change in yield variance was seen to dominate only in Benue state (84.08%) whereas change in residuals had more impact in Oyo and Ogun states accounting for 180.24 % and 113.17 % respectively. In Anambra state, a change in area yield covariance and interaction between changes in mean area and mean yield and changes in area- yield covariance were the dominant sources of change in variance of yam production (188.15 and 162.70 % respectively. Furthermore, interaction between changes in mean area and yield variance and interaction between changes in mean area and mean yield and changes in area- yield covariance were also observed to be major source of variability in Adamawa state (1344.87%) and Delta state (241.41%) respectively.

At the zonal level the results showed that change in variance of yam production between the studied periods were as a result of change in area variance in northeast (95.63%) and north- central (168.9%) zones, whereas in northwest and south-south, variation is due to change in residuals (136.30 and 68.44 % respectively). Similarly, change in area yield covariance was the main source responsible for the change in variance of production in southwest and southeast zones (74.72 and 107.72 % respectively). The overall results at all Nigeria level confirmed the dominance of interaction between changes in mean area and mean yield and changes in area- yield covariance (89.71%) and changes in area-yield covariance (84.89%) as major sources of change in variance of yam production during the study period.

Conclusively, sources of instability in average of yam production indicated that, among the components, change in mean area and interaction effect were the major sources of change in average production, whereas, change in area variance, change in yield variance, change in mean area and interaction between changes in mean area and mean yield were major sources of instability resulting from change in variance of yam production.

Results of Quadratic function in time variable

The result of quadratic function is presented in Table 7. Policy status recorded in period I shows a stagnating growth considering the positive but non-significant coefficient of time trend squared variable. The empirical result shows that policies within this period did not translate to achieve the expected growth. The basic frame work of these policies under the first national development plan controlled by regional government centered on establishment of plantations, farm settlements primarily for cash crop and infrastructures, however production of yam continued in the southern and middle belt zone until late 1960s. The compound annual growth rate of yam production during this policy phase was positive (Table 3) and higher when compared to population growth. Period II witnessed stagnation growth. The empirical result revealed that there was gross under performance of the policies. Negative growth rate of production and productivity was observed during this policy regime (Table 3) confirming minimal or no policy impact. Possible reasons may not be far from neglect as a result of oil revenue, labour shift because of industrialization policy and the effect of civil war from 1970 to 1977. However, increased in area growth was noticed from available data, this may be linked to a move from communal land ownership to private ownership and the 1978 Land Use Act policy, Operation Feed the Nation (OFN) and Green Revolution (GR) programmes.

Period III was observed to record deceleration growth as shown by the negative significant coefficient of time trend squared (Table 7). This period was marked with so many programmes which seemed to impact positively on yam production as (CAGR) compound annual growth rate of area, production and productivity were all positive (Table 3). Deceleration growth looking at (β_2) was not unexpected because agricultural output rose slowly due to inadequate transportation and power networks, lack of appropriate technology and ineffective application of rural credit. Table 7 further showed that coefficient of time trend for yam function was positive and statistically not different from zero implying that, the crop suffered a stagnation growth between 2000 - 2015 (Liberalization period). The result may be connected to negative growth in yield (-2.23%) recorded during this period.

However, positive growth rate was achieved during this period which may be ascribed to policies and programmes like Root and Tuber Crops Extension Programme in 2003, credit policy through NACRDB, and research on improved yam seed technology by NRCRI and IITA. Production growth was (2.85%) mainly due to area expansion (5.29%). Moreover, efforts to increase yield through these programmes proved abortive especially with the persistent scarcity and high cost of seed yam, post-harvest losses and high demand of labour. From above findings and in the context of quadratic function in time variable, yam production has not recorded acceleration growth from 1960 to 2015 and SAP period was the only period attributed with deceleration growth of production (Table 7).

Table 6: Sources of change in variance of yam production (%)

	Sources/ Components of change									
States, Zones and National	Change in mean Yield $\Delta\bar{Y}$	Change in mean Area $\Delta\bar{A}$	Change in area variance $\Delta V(A)$	Change in yield variance $\Delta V(Y)$	Interaction between changes in mean area and mean yield $\Delta\bar{A}\Delta\bar{Y}$	Changes in area-yield covariance $\Delta C\ (A, Y)$	Interaction between changes in mean yield and area variance $\Delta\bar{Y}\Delta V(A)$	Interaction between changes in mean area and yield variance $\Delta\bar{A}\Delta V(Y)$	Interaction between changes in mean area and mean yield and changes in area-yield covariance	Changes in residual ΔR
Kaduna	-27.78	-19.19	53.09	6.70	-0.37	24.43	3.55	7.81	12.83	38.92
Adamawa	-107.11	262.66	-91.15	-1810.17	-182.43	1041.6	-320.70	1344.87	78.70	-116.30
Taraba	-12.93	-7.55	78.23	0.25	-0.10	13.63	2.52	0.41	8.71	16.83
Benue	-8.99	-3.15	0.49	84.08	0.02	10.54	-0.16	2.39	-1.79	16.57
Kwara	3.11	-6.16	76.54	1.00	0.44	12.51	-12.64	1.05	3.88	20.29
Niger	-0.11	4.67	113.26	-1.40	0.00	-6.67	2.24	-4.43	-6.99	-0.56
Oyo	-137.35	19.0	-78.80	-21.50	9.26	115.48	43.68	-15.05	-14.97	180.24
Ogun	2.31	0.00	17.78	4.55	0.00	18.78	11.01	13.01	28.82	3.25
Ondo	-108.84	-78.16	-59.55	19.15	-4.90	112.97	-14.01	30.65	89.52	113.17
Anambra	9.65	-46.55	-211.01	-24.06	6.77	188.15	88.45	-123.91	163.70	48.82
Enugu	23.20	2.72	265.82	7.12	0.82	-106.45	81.06	0.81	-21.83	-153.28
Imo	-747.11	596.14	25776.04	10281.85	40.63	-31683.7	-8056.76	8796.74	-4071.42	-832.41
Rivers	54.66	1.24	94.48	-1.01	-0.34	3.03	-41.53	-0.55	-0.21	-9.77
Cross Rivers	-131.61	-39.91	110.93	-60.21	-5.17	67.82	62.66	-41.37	42.42	94.44
Delta	-25.76	-53.23	-97.70	-27.82	-1.12	158.37	-7.33	-139.51	241.41	52.70
North West	-37.71	-41.49	77.90	-35.69	4.52	54.59	-34.91	-19.23	-4.29	136.30
North East	15.09	11.35	95.63	-8.62	0.50	-8.19	23.50	-7.04	-4.14	-18.08
North Central	10.57	9.97	168.9	-15.76	0.10	-51.73	17.31	-6.76	-13.19	-19.41
South West	-14.96	1.24	13.05	-8.94	-0.09	74.72	-3.00	0.49	-10.95	48.44
South East	-7.74	-14.70	4.99	-29.83	1.40	107.72	-1.45	-25.41	15.69	49.33
South South	-40.20	1.47	19.43	-20.23	-0.09	65.80	0.48	-8.04	12.93	68.44
All Nigeria	-34.47	-70.61	-57.53	-4.98	0.34	84.89	1.01	16.58	89.71	65.12

Table 7: Output (production) growth of Yam showing acceleration, deceleration and stagnation during policy regimes

Regimes	Time trend Coeff (β_2)	R^2	Std Error	F stat	Policy Status
Period I (1960/61-1970/71)	0.0008 NS	0.987	0.0008	29.71***	Stagnation
Period II (1971/72-1985/86)	0.0006 NS	0.825	0.0007	28.28***	Stagnation
Period III (1986/86- 99/2000)	-0.0065***	0.969	0.0009	172.9***	Deceleration
Period IV (2000/01 – 2014/15)	0.0002 NS	0.824	0.0005	30.42***	Stagnation

Note: ** and *** indicates significant at 5% and 1% probability level respectively while NS implied non-significant

Conclusions and policy implication

The study attempted to determine the growth and instability in area, production and productivity in yam (tuber crop) in Nigeria from the period 1960-61 to 2015-16 using time series data. Annual compound growth rate, Coefficient of Variation, Coppock's Instability Index and Hazell's decomposition analysis were employed to achieve this objective. From the findings yam was noticed to have recorded a significant growth in both area, production and productivity in the overall study period even though there were fluctuations when inter period analysis was considered. Production growth rate was more as a result of area expansion rather than yield per ha, implying that investments in policies and programmes that stimulate yield growth were grossly undermined. Similarly, quadratic function in time variable indicated that yam has not registered accelerated growth and SAP period had the most unfavourable policy structure which resulted in deceleration growth. The study therefore recommends strategic revisit of the policies and programmes with emphasis on focusing increase in yield through improve cultural practices, high yielding seed varieties, adequate inputs and effective extension delivery system.

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MOISTURE RETENTION CHARACTERISTICS OF ALFISOLS TREATED WITH DIFFERENT TYPES AND RATES OF ORGANIC MATERIALS

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Abstract
This study was aimed at assessing soil moisture retention characteristics of Alfisols treated with different types and rates of organic matter. The study was conducted in the screen house of the Department of Soil Science, Ahmadu Bello University, Zaria. Treatment consists of soils in plastic pots treated with three types of organic matter (poultry litter, cow dung and compost) and at four rates; (0 t/ha, 16.5t/ha, 22t/ha and 27.5t/ha); in a factorial combination laid out in complete randomized design and replicated three times. 36 pots containing the samples were saturated and covered overnight until free drainage ceases. The weights of the pots were subsequently taken at 1, 2, 3, 5, and 7 days after saturation while left uncovered. These processes were repeated twice (two cycles). Moist soil cores were sampled for determination of moisture contents at 0, 0.3, 5, and 15 bar pressure. Results showed moisture retention increased with increasing rates of organic material with a highly significant difference ($P<0.001$) when poultry litter was added to the soil at 27.5t/ha on the 7^th^ day. The same was observed for moisture contents at 0.3, 5, and 15 bar as in the former. Compost treated soil had significantly ($P<0.001$) higher moisture content at 16.5 t/ha than at the same rates with poultry litter and cow dung at saturation and field capacity, and at first day of the first week and 1st, 5th and 7th day of the second week. Thus, application of 27.5 t/ha of poultry litter or 16.5t/ha of compost will significantly influence soil moisture retention in the savanna Alfisols at longer periods of irrigation schedule and/or rainfall event. However, this may depend on availability and cost of the selected organic material.

Key words: Alfisols, Compost, Field capacity, Organic amendment, Soil moisture

Introduction

Projections of climatic change in the last decades have shown potential impacts on agriculture for food supply and food security (IPCC, 2007). This effect may be more profound in one agro-ecological zones compared to another. The arid and semi-arid zones are characterized by erratic rainfall distribution (Owunubi *et al*., 1991) and soils with low organic carbon content and poor water holding capacities (Odunze, 2003). Climate change is projected to make arid and semi-arid agroecological zones drier from IPCC report (2007) and necessitates climate-smart strategies such as the use of organic amendments to increase soil organic carbon and increase water holding capacity as adaptation or coping strategies.

Soil water is essential for the germination of seeds, the growth of micro-organisms, and a major factor in determining crop yield in the semi-arid region (Addina, 2000). Soil moisture is an expedient factor in crop production because the growth and survival of plants depend to a large extent on its availability (Brady and Weil, 2014). Soil moisture content is an expression of the amount of moisture in the soil (Klute, 1986). Data on soil moisture retention are used in research and applications in hydrology, agronomy, meteorology, ecology, environmental protection and other soil related fields, and is a major soil hydraulic property that governs soil functioning in ecosystems and greatly affects soil management (Adeoye, 1983).

Savannah soil have low fertility status, weak aggregation, low water holding capacity, shallow depth and low organic matter content (El-Swaify *et al*., 1997). To ameliorate these problems for the purpose of sustainable yield and productivity, farmers are faced with the challenges of providing solutions to mitigate these effects of soil degradation. This may therefore require the application of organic material such as crop residues, animal waste and where available, compost. Recently, compost is also used due to constraints of high cost and shortage or late availability of inorganic fertilizer (Mohammed *et al*., 2004).

The use of organic materials to improve the soil is often considered more beneficial than inorganic fertilizer because of its potential to modify the physical condition of the soil such as; water holding capacity, aeration, drainage, bulk density and aggregation of soil particles which enhance infiltration rate (Brady and Weil, 2014). Moreover, water retention curve gives the relationship between water content (θ) and the soil water potential (ψ). It helps to determine the amount of water retained in a soil under equilibrium at a given matric potential (Gao and Liu, 2010). This curve is characteristic for different types of soil, and is also called the soil moisture characteristic/retention curve. Alongside saturated hydraulic conductivity, water content is a basic function in several numerical modeling of water flow and solute transport in soils (Van Genuchten, 1980; Simunek *et al*., 2006).

Studies have shown the positive benefits of using organic amendments on soil structure and water retention (Mba and Mbagwu, 2006) for sustainable crop production. Moreover, there is a need for climate-smart strategies for improved moisture retention in soils with poor water holding capacity. Few studies exist on the effect of soil organic amendments especially compost, and their rates on soil moisture retention. This study was aimed to determine the moisture retention properties of different types and rates of organic material in Alfisols, northern Guinea savanna of Nigeria.

Materials and Methods

Description of Study Location

The study was conducted at the Institute for Agricultural Research (IAR), Ahmadu Bello University, Samaru, Zaria situated in the Northern Guinea Savanna (Latitude 11^{o} 10’ 30.40” N and Longitude 007^{o} 36’ 42.9” E) on an Altitude of 701 m above sea level. The rainfall distribution is mono-modal, with rains starting in May, peak in August and ends in September/October and ranges from 950-1270 mm with annual mean of 1110 mm (Garba, 2010). Daily maximum temperature is in the high twenties and the annual mean of 25^{o}C. The predominant soil type in the area is mainly Alfisol (Garba, 2010).

Collection and Preparation of Samples

Soil samples were collected with an auger from five random spots at 0-15 cm depth from the experimental farm of the Institute for Agricultural Research, Zaria and made into a composite sample. The field has been under natural fallow for more than two years. Three replicate core samples (5cm x 5.2cm) were also taken at the same sampling spots and depth for determination of soil bulk density and hydraulic conductivity. Bulk soils (324kg) for pot experiment were collected and transported to the Soil Science Department of Ahmadu Bello University (A.B.U.), Zaria, Nigeria. Organic materials (Cow dung and Poultry litter) were obtained from the Department of Animal Research and Teaching farm, A.B.U. Zaria; while compost was obtained from the Department of Soil Science, A.B.U Zaria. The soil sample and organic matter samples were air dried under laboratory temperature (32^{o}C) for two weeks, after which the samples were thoroughly mixed and crushed. Composite soil sample and organic materials were sieved through 2mm sieve followed by storage in cartons with proper identification labels prior to chemical analysis and addition to soils. Bulk soils were sieved through 5mm sieve and packed in experimental pots.

Treatments and Experimental Design

Thirty-six (36) experimental 10-litre-capacity pots containing 5mm sieved soils (9 kg) were then mixed in factorial combination with 3 different organic materials (poultry litter, cow dung and compost) and 4 varying rates; 0, 16.5, 22 and 27.5t/ha respectively replicated 3 times (3x4x3) and kept in the screen house of the Department of Soil Science, A.B.U. Zaria. The experiment was set up in a complete randomized design (CRD). Water was added to the pots to saturation and covered with the lid to prevent evaporation. The set up was left to allow for free drainage for 24 hours and the lids were removed. The weights of the pots were taken. Subsequent weights were taken at 1, 2, 3, 5, and 7 days after the first weighing. These processes were repeated twice (two cycles). Weights of empty pots, weight of water retained in the soils was determined. After the second cycle, soil was moistened to aid collection of soil core samples at 0-5 cm depth from each of the experimental pots for moisture extraction using the pressure plate apparatus at 0, 0.3, 5, and 15bar respectively.

Composite soil sample and organic materials were subjected to routine analytical methods for determination of soil pH, organic carbon, total nitrogen, available phosphorus, exchangeable bases. Particle size distribution of the composite soil was also determined using the method of Gee and Bauder (1986), while bulk density and hydraulic conductivity were determined by the methods of Blake and Hartge (1986) and Klute and Dirksen (1986) respectively.

Data Analysis

Data on soil moisture content collected at different days under the various treatments were subjected to the analysis of Variance (ANOVA) using Statistical Analysis System Institute Package (SAS Inc. 2011) and mean values were compared using Least Significant Difference (LSD). Data from pressure plate apparatus was used to plot the soil moisture retention curves for the different types and rates of organic materials using the Microsoft Office 2010 Excel program (Microsoft Inc. 2010).

Results

Physical and chemical properties of soils and organic materials

Particle size distribution of the studied soil is presented in Table 1. The percentage value of sand, silt, and clay indicated a loamy soil texture. Mean dry soil bulk density was 1.2 Mg m^{-3} and saturated hydraulic conductivity was 0.49 cm s^{-1} indicating a moderately rapid conductivity. Values of organic carbon content, total nitrogen and exchangeable bases of the soil was low, as compared to those of organic materials. Amongst the organic materials, poultry litter had the highest value of organic carbon of 80.16 g kg^{-1} and total nitrogen (37 g kg^{-1}).

Effects of organic material on soil moisture content at week 1

Table 2 represents the gravimetric moisture content obtained at the end of the first week (Week 1). Soils treated with cow dung retained the most moisture from the first day to day 5 and statistically differ ($p<0.05$) from all the other treatments through all these days. However, compost and poultry manure and control treatments retained statistically similar ($p>0.05$) moisture content. At day seven, soils with poultry litter and compost retained the highest moisture followed by soils treated with cow dung and the least being the control, although the cow dung treatment did not differ statistically with moisture retained by the control. The difference in moisture content of the treatments were highly significant ($p<0.01$) at days 1, 2, 5 and 7 except for day 3, which was significant at $p<0.05$.

The interaction between types of organic materials and their rates on soil moisture content was significant ($p<0.05$) only at day 1 of week 1 as shown in (Table 2). Cow dung treated soils retained statistically higher moisture at 22t/ha which differ from soils treated with poultry manure and compost, the latter two being statistically similar (Figure 1). At 27.5 t/ha, similar moisture was retained by compost and cow dung treated soils, while at 16.5 t/ha, all treatments retained statistically different moisture contents with highest moisture retained by cow dung treatment.

Soils treated with poultry litter at all the rates had the least moisture retention in the interaction.

Effects of organic material on soil moisture content at week 2

By the end of the second cycle, the results obtained showed that soils treated with poultry litter retained the highest moisture at day 7 followed by cow dung treatment (Table 3). Cow dung treated soil retained most moisture from day 2 through day 5 than poultry litter treatment. The difference in the means of all the treatments were highly significant ($p<0.001$). Although, Table 3 showed the control had the highest moisture retained in the first 2 days, and in some cases the same with compost (day 2), soil moisture in the control was observed to suddenly decline from day 3 and had the least moisture retained at day 7. The highest moisture was retained at the rate of 27.5 t/ha from day 3 to day 7, followed by 22 t/ha at days 1 and 2. The interaction between moisture content and rates of the different organic materials was highly significant at day 1 and 5 and significant at day 7. At day 7, there was significant difference ($p<0.05$) with moisture retained by the three type of organic materials (Figure 2). At 22 t/ha, cow dung treatment retained the most moisture which is statistically similar ($p>0.05$) with the same rate of poultry litter, and both differ with moisture retained by compost. At 27.5 t/ha, poultry litter retained the highest moisture, which statistically differ ($p<0.05$) with the other treatments, while compost retained most moisture at 16.5 t/ha (Figure 2).

Effects of organic material at various suction points on moisture content

The values of moisture content at different suction points as given in Table 4, shows that soils with poultry litter retained most moisture and statistically differ ($p<0.001$) from soils treated with cow dung and control at 0.3 bar to 15 bar. However, moisture retained by poultry litter treatment did not differ statistically ($p>0.001$) at all suction points with compost treatment. At field capacity, 22 t/ha and 27.5 t/ha retained statistically similar moisture contents and both differ significantly ($p<0.01$) from 16.5 t/ha. Although at saturation, similar trend as with field capacity was obtained but 27.5 t/ha retained statistically similar moisture with 16.5 t/ha.

Soil moisture retention curve shows poultry litter retained most moisture from field capacity to PWP, although water retained by compost and poultry litter treatment at 15 bars was similar at the same rate (Figure 3). From the curve, at the same rate, the order of water retention through suction points from field capacity to PWP was PL>CP>CD>CT.

Discussion

In this study, application of different types and rates of organic materials improved soil water retention. Organic materials have been found to improve soil structural properties and water movement (Eusufzai and Fujii, 2012) and increasing soil organic matter and crop yields (N'dayegamiye and Augers, 1990). This may be directly related to increase in size and number of soil water retention pores due to additions of organic materials (Mbagwu, 1992; Mba and Mbagwu, 2006). Adeleye *et al.* (2010) reported increased water holding capacity in soils amended with poultry manure as well as improvement in other physical and chemical soil properties. Report have also shown the ability of cow dung to increase water retention in soils with a clay content of <15% (MacRea and Mehuys, 1985). Evanylo (1996) also found a direct relationship between rates of organic material and moisture content. This work shows poultry litter to retain most water at the highest rate (27.5 t/ha). This could be due to the high organic carbon content of poultry litter (Table 1) that gives it the ability to absorb much moisture compared to the other treatments. This is why the highest rate was seen to retain water at 7 days after saturation, which implies that for these Alfisols with low water retention and with moderately rapid hydraulic conductivity, longer irrigation period could be scheduled with application of poultry litter. This result coincides with the research carried out by Omale (2014) and Ekwue (1990), who observed a direct relationship between the level of poultry litter and moisture content. Brye *et al.* (2003) and Aluko (2003) also found that poultry manure application rates had a greater effect on soil moisture retention. Compost was found to increase water retention at 16.5 t/ha at 7 days from saturation and retained water similar to 22 t/ha and 27.5 t/ha of poultry manure. The use of compost was reported by the extension unit of Michigan State University to increase water holding capacity by 2.5 times that of a native sandy soil in the US and provided plant available water for up to 7 days, and was also found to reduce moisture stress of crops during summer droughts (Charles, 2015). Composted wastes or materials have been shown to improve soil physical and chemical properties (Adugna, 2016), as well as enhance water retention and enhance crop productivity (Mohammed *et al*., 2004; Nguyen, 2013, Yáñez-Chávez *et al.*, 2014).

From the soil water extraction data, at saturation, control soil had the highest soil moisture content than in all the treatments but, suddenly declined at bars 0.3 to 15 bar. Soils treated with organic materials may have higher water transmission properties than the control (Eusuzai and Fujii, 2012), and thus drainage may have started at saturation. The difference between the treatments means could be attributed to the high organic carbon content in the organic materials, and where their application improved soil moisture content (Kwari and Balbinu, 2010).

Conclusion

In this study, applications of 27.5 t/ha of poultry litter or 16.5t/ha of compost were found to significantly influence soil moisture retention in a northern guinea savanna Alfisol at longer periods of time. This has a great implication to water management and irrigation scheduling especially with competing uses of limited water reserves in semi-arid regions. However, availability and cost of organic material are factors to consider in selecting suitable climate-smart strategy to enhance soil water retention.

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Table 1: Physical and Chemical properties of the Soil and organic materials used in this study.

	SL	PL	CD	CP
Physical properties				
Bulk density (Mg m^{-3})	1.20			
Saturated Hydraulic conductivity (cm s^{-1})	0.49			
Soil moisture content (g g^{-1} at 0.3 bar)	0.15			
Particle size distribution				
Clay (g kg^{-1})	80			
Silt (g kg^{-1})	440			
Sand (g kg^{-1})	480			
Chemical properties				
Organic carbon (%)	0.80	80.16	55.70	43.00
Total Nitrogen (g kg^{-1})	0.50	3.70	1.30	1.70
Total Phosphorus (mg kg^{-1})	52.30	133.50	596.60	397.70
pH (water)	7.50	7.30	8.60	7.90
pH ($CaCl_2$)	6.60			
Exchangeable bases ($cmol_{(+)}$ kg)				
K	0.10	2.97	2.66	1.28
Na	0.09	0.62	0.20	0.14
Mg	6.29	12.01	10.33	11.00
Ca	13.79	40.28	21.05	23.59

SL=soil, PL=poultry litter, CD=cow dung, CP =compost.

Table 2: Effect of different organic matter (OM) and OM rates on soil moisture content at week 1

Treatments		Moisture content (g/g)			
	Day 1	Day 2	Day 3	Day 5	Day 7
Organic matter (OM)					
PL	0.282^{c}	0.242^{b}	0.225^{ab}	0.165^{b}	0.145^{a}
CP	0.292^{b}	0.242^{b}	0.217^{bc}	0.182^{a}	0.145^{a}
CD	0.310^{a}	0.262^{a}	0.228^{a}	0.185^{a}	0.135^{ab}
CT	0.295^{b}	0.245^{b}	0.215^{c}	0.165^{b}	0.125^{b}
LOS	****	***	*	****	***
Rates (t/ha)					
16.5	0.29	0.240^{b}	0.213^{b}	0.165^{b}	0.128^{b}
22	0.29	0.249^{ab}	0.229^{a}	0.180^{a}	0.144^{a}
27.5	0.29	0.254^{a}	0.223^{a}	0.178^{a}	0.141^{a}
LOS	NS	**	***	***	***
Interactions					
OM*Rates	*	NS	NS	NS	NS

Values followed by the same letter(s) within a column and treatment are not significantly different ($P \leq 0.05$)

PL = poultry litter,
CD = cow-dung,
CP = compost,
CT = Control,
LSD = Least significant difference,
LOS= level of significance
NS=not significant,
*=significant at 0.05,
** =significant at 0.01,
*** =significant at 0.001,
**** =significant at <0.0001.

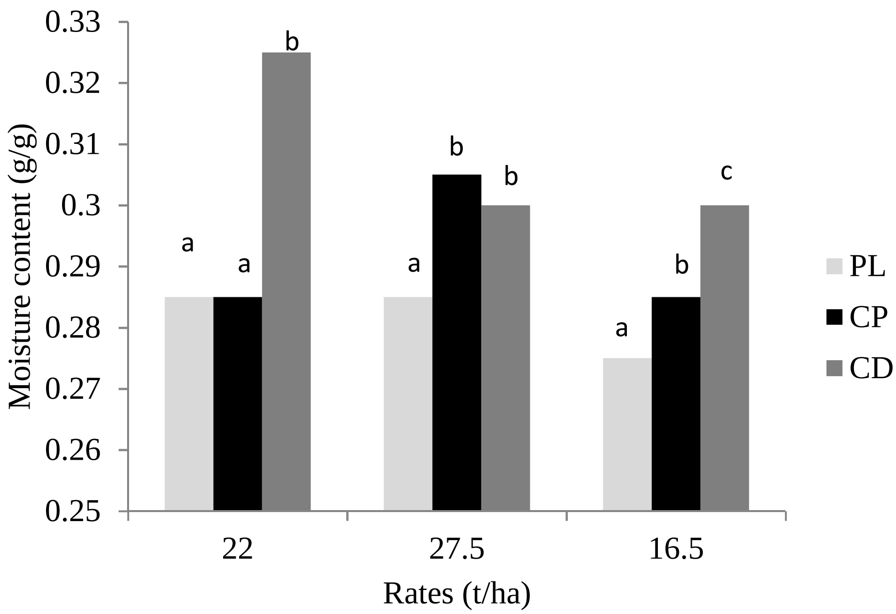

Figure 1: Interactions between poultry litter, compost and cow dung at varying rates at day 1of the first week. Bars with the same letters are statistically the same (LSD >0.05).

Table 3: Effect of different organic matter (OM) and OM rates on soil moisture content at week 2

Treatments	Moisture content (g/g)				
	Day 1	Day 2	Day 3	Day 5	Day 7
Organic matter (OM)					
PL	0.273^{b}	0.233^{b}	0.212^{c}	0.160^{b}	0.140^{a}
CP	0.273^{b}	0.240^{b}	0.223^{b}	0.138^{c}	0.118^{c}
CD	0.278^{ab}	0.252^{a}	0.232^{a}	0.180^{a}	0.145^{a}
CT	0.285^{a}	0.248^{a}	0.223^{b}	0.163^{b}	0.133^{b}
LOS	**	***	****	****	****
Rates (t/ha)					
16.5	0.271^{b}	0.240^{b}	0.216^{c}	0.156^{b}	0.121^{c}
22	0.284^{a}	0.240^{b}	0.223^{b}	0.158^{b}	0.131^{b}
27.5	0.278^{ab}	0.246^{a}	0.229^{a}	0.168^{a}	0.140^{a}
LOS	***	NS	***	***	***
Interactions					
OM*Rates	**	NS	NS	***	*

Values followed by the same letter(s) within a column and treatment are not significantly different ($P \leq 0.05$)

PL = poultry litter, CD = cow-dung, CP = compost, CT = Control, LSD = Least significant difference, LOS= level of significance, NS=not significant, *(significant at 0.05), ** (significant at 0.01), *** (significant at 0.001), **** (significant at <0.0001).

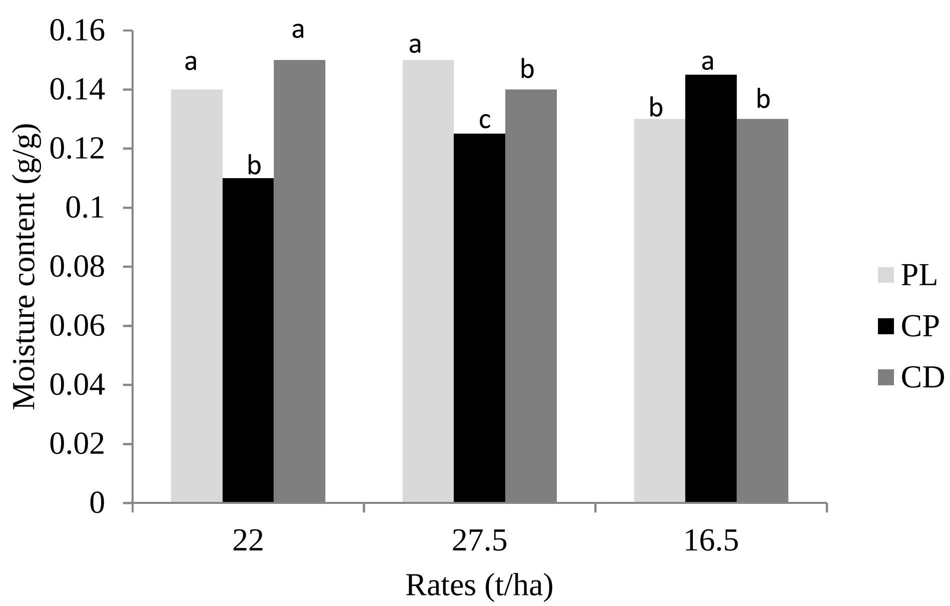

Figure 2: Interactions between poultry litter, compost and cow dung at varying rates at day 7 of second week. Bars with the same letters are statistically the same (LSD >0.05).

Table 4: Effect of different organic matter (OM) and OM rates on soil Moisture content at various suction points

Treatments	0 bar	0.3bar	5 bar	15 bar
Organic matter (OM)				
PL	0.262[ab]	0.172[a]	0.154[a]	0.139[a]
CP	0.255[b]	0.152[ab]	0.137[ab]	0.136[ab]
CD	0.260[ab]	0.149[b]	0.124[b]	0.118[bc]
CT	0.282[a]	0.128[c]	0.099[c]	0.096[c]
LOS	***	***	***	***
Rates (t/ha)				
16.5	0.251[b]	0.142[b]	0.122	0.115
22	0.275[a]	0.153[a]	0.130	0.125
27.5	0.264[ab]	0.152[a]	0.132	0.124
LOS	**	**	NS	NS
Interactions				
OM*Rates	**	*	*	NS

Values followed by the same letter(s) within a column and treatment are not significantly different (P≤0.05)
PL = poultry litter, CD = cow-dung, CP = compost, CT = Control, LSD = Least significant difference, LOS= level of significance, NS=not significant, *(significant at 0.05), ** (significant at 0.01), *** (significant at 0.001).

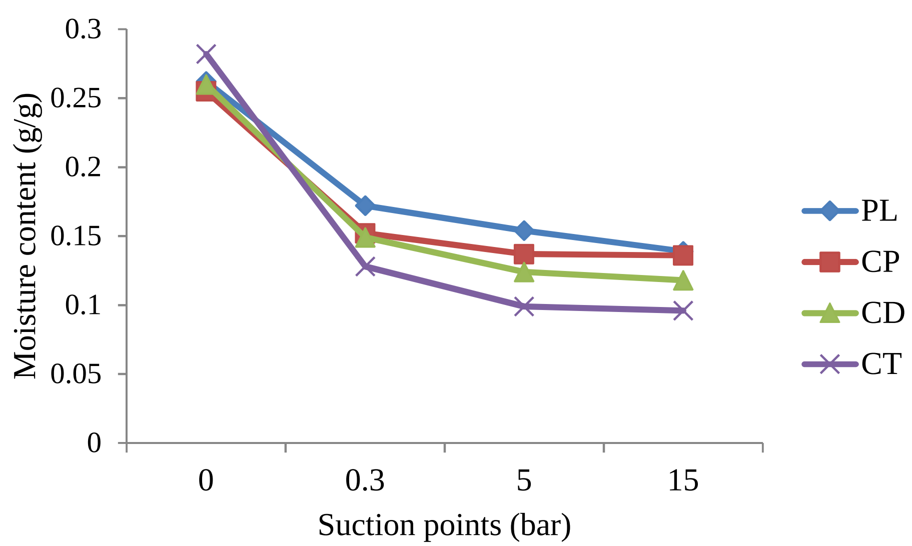

Figure 3: Moisture retention curve affected by Organic matter addition at different suction points. PL = poultry litter, CP = compost, CD = cow-dung, CT = Control.

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EFFECT OF FANASAN D AGAINST SEED-BORNE INFECTION BY *Collectotrichum destructivum* ON GROWTH AND YIELD OF COWPEA *(Vigna unguiculata* L Walp*)* IN MUBI, ADAMAWA STATE, NIGERIA.

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Abstract
This study was carried out at the Teaching and Research Farm of the Department of Agricultural Technology, Federal Polytechnic Mubi **(***Longitude* 10^0*11N and latitude* 10^0 *6'N and* 13^0 *16'E, at an altitude of 696m) during 2012 cropping season to investigate the effect of Fanasan D as seed dressing chemical against Collectotrichum destructivum on growth and yield of cowpea (Vigna unguiculata L. walp) in Mubi North, Adamawa, Nigeria. The trial consisted of four treatments: 0g Fanasan D. (*T_1*), 2g Fanasan D. (*T_2*), 3g Fanasan D. (*T_3*) and 4g Fanasan D. (*T_4*). The experiment was laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The chemical (Fanasan D.) was properly mixed with cowpea 100 seeds in each case prior to planting. Data collected includes: Establishment count, vine length, number of leaves per plant, days to 50% flowering, days to 50% podding, 100 seeds weight and yield per plot. Data collected were subjected to Analysis of Variance (ANOVA). Means were separated using Least Significant Difference (LSD) at 5% probability level. On the effect of Fanasan D against Collectotrichum destructivum to cowpea growth parameter, the results showed that, vine length increase to the greater height of up to 58.87cm as quantity of Fanasan D increase to 4g (*T_4*) and length reduced to 47.87cm when seeds are untreated (*T_1*). On the response of Fanasan to the yield and its components, the finding revealed that Fanasan D significantly influenced 100 seeds weight and yield per plot with the highest mean scores (14.98 and 70.74g) obtained from* T_4 *while* T_1 *gave the lowest values of 12.67 and 42.54g. Despite the variation in the quantity of Fanasan D applied plant height, days to 5o% flowering and podding were not significantly affected. But slight differences among the treatment mean were observed: establishment count 16.00 (*T_2*), number of leaves 39.00* $T_{3,4}$*, days to 50% flowering 60 days* T_4 *accordingly.* T_4 *(4g Fanasan D) was observed as the best treatment in this experiment therefore, recommends for as seed treatment for cowpea against Collectotrichum destructivum to farmers in the study area. Further trials could also be carried out in other locations on the effect of this chemical and its doses against the pathogens.*
Keywords: Cowpea, Fanasan D., Collectotrichum destructivum and Yield.

Introduction

Cowpea *(Vigna unguiculata* L. walp*)* is one of the most important food crops in semi-tropical region of Africa (Jackai and Adalla, 1997). The crop potential yields of about (3000kg/ha) have been reported (Rusoke and Rubaihayo, 1994). However, the average cowpea grain yields in Uganda were found to be 200-400kg/ha (Omanga *et al.*, 1997), similarly an average yield of 200-300kg/ha in Nigeria was reported by Alghali, (1992). Nigeria accounts for about 58% of the world's total production of cowpea and is also the major consumer, (IITA, 2009). Studies by Singh (1997) showed that cowpea is an important crop to millions of households. Benefits derived include: food, animal feeds and income with spill over benefit to farm lands. Being rich in protein and containing many other nutrients, it is known as vegetable meat. On dry matter weight, basis cowpea grains contain 23.4% protein, 1.8% fat and 60.3% carbohydrates. It is also a rich in source of calcium and iron. It is used for both human consumption and as a concentrate feed for livestock (Chidda *et al*., 2006; Anyam, 1998). It was also revealed that cowpea is a source of fibre and medicine which is used to treat swellings, skin infection tooth ailments, antidote for snake bite, epilepsy, chest pain, constipation etc. The plant has ability of fixing atmospheric nitrogen through its nodules (Madamba and Grubben, 2006).

However, like any other agricultural enterprises, cowpea production is considered as a high-risk venture because of the prevalence of pest and diseases which limits its yield potential. Mafimisebi, (2004) indicated that, reduction in farm yield and income, natural hazards such as pest and diseases, flood, fire, drought, lightening, and windstorm have considerably reduced the quantum of investment in farming enterprises. Losses of cowpea grains due to pest and disease infestation range from 20-100% annually (Kamara, 2007). Important diseases of cowpea which have being found to limit its production include cercospora leaf-spots and damping-off diseases. Amotobi *et al.* (2005) indicated that the use of plant materials, synthetic chemicals and biological controls have been experimented by many researchers to control this diseases and insect pests in cowpea production in recent years. Seed treatment with chemicals such as insecticide dusts or slurry are applied as toxic barrier on seeds or growing crops in order to provide protection against infection by pathogenic organisms which reduce seed and seedling losses due to seed borne and soil borne disease. It is against this background that the study was undertaken to assess the effects of Fanasan D. seed treatment chemical at variable rates on growth and yield of cowpea in Mubi, Adamawa state, Nigeria.

Materials and Methods

Mubi is located in the Northern part of Adamawa state, at Longitude 10^0 11’ N and latitude 10^0 6’N and 13^0 16’E, at an altitude of 696m above sea level located in the Northern Guinea Savannah of Nigeria. (Nwagboso and Uyanga, 1991), with an annual rainfall of 750mm and 13% relative humidity (Tekwa and Usman, 2006). The experiment was laid out in a Randomized Complete Block Design (RCBD), consisting of four treatments: 0g Fanasan D. (T_1), 2g Fanasan D. (T_2), 3g Fanasan D. (T_3) and 4gFanasan D. (T_4), replicated three times. An hour to sowing little water was applied to the seeds just to enable the chemical attached to the seeds. The experimental site was harrowed with a tractor and soil particles were later tilled, levelled and marked using hoe, rake, meter tape, page and shovel. Being a raining season, twelve raised beds were constructed each measured 3m × 3m (9m) with 1m walk space and 0.5m between plots. Early maturing variety of cowpea seeds (Ife brown) were selected for this trial, 3 seeds were sown per hole (which were later thinned to 2 seedlings per stand 3 weeks after sowing) at the depth of 2-3cm, spaced 60cm×50cm between crop row and crop stand accordingly. Weeds were controlled manually by hand picking and hoeing 2 times during the growing period at an interval of two weeks. Harvesting was done manually when the crops were completely dried. Pods from each bed were collected separately and threshed by beating lightly with stick and finally winnowed.

Data collection began three weeks after sowing where four seedlings were randomly selected from the centre of each bed, tagged and data was collected regularly at 15 days’ interval on the following parameters: Establishment count, vine length, number of leaves per plant, days to 50% flowering, days to 50% podding and 100 seeds weight and yield per net-plot at harvest. Data collected was analyzed using analysis of variance (ANOVA) techniques following the procedure of Gomez and Gomez (1984) while least significant difference (LSD) was used to separate means at 5% level of significance.

Results and Discussion

Growth Parameter

The results for the effect of Fanasan D seed dressing chemical on cowpea growth parameters are presented in Table 1. The result obtained indicated that (Fanasan D) significantly ($P \leq 0.05$) affected vine length, which led the vine length to reach the highest length of 58.87cm at T_4 while the least cowpea vine length of 47.87cm recorded from T_1. But establishment count and number leaves per plant were not significantly ($P \geq 0.05$) influenced by treatment with Fanasan D at all levels. Nevertheless, differences in the mean values among treatment levels were observed. Highest values of 16 established seedlings and 39 leaves numbers per plant generated from T_2 and T_3/T_4 and the lowest mean score 14 seedlings and 37 leaves generated from T_1 accordingly.

Table 1: Effects of Fanasan D seed dressing chemical on the growth of cowpea in Mubi.

Treatments	Establishment count	Vine length (cm)	Number of leaves per plot
T_1(0g)	14.00	47.87^c	37.00
T_2(2g)	16.00	51.91^b	38.00
T_3(3g)	15.00	57.06^a	39.00
T_4(4g)	15.00	58.87^a	39.00
LSD (5%)	-	2.20	-
Level of Significant	NS	**	NS

MB: ******= highly significant, NS= not significant, means bearing the same letters in a column are statistically non-significant.

Significant response shown by vine length in this trial might not be unconnected to the level of Fanasan D at T_3 and T_4 which in turn provides protection against soil micro-organisms and other insect pests for not only the seeds but also the young growing seedlings. Studies revealed that seed treatment with chemicals such as insecticides, dusts or slurry are applied as toxic barriers on seeds or growing crops in order to produce protection against infestation by pathogenic organisms (Amotobi *et al.*, 2005). Application of Captan, Pentacgloronitrobenze and Apron on soybean (Glycine max) seeds, reducedthe viability of Bradyrhizobium japanicum (Revellin, et al (1993)

The non-significant difference (P≥0.05%) in the establishment count and number of leaves per plant recorded in this study disagreed with the findings of Rusoke and Rubaihayo (1994) how discovered that seeds dressed with chemical recorded higher establishment count (35 seedlings) compared to the undressed seeds which had the least estimates (26.75 seedlings). On the other hand, Dugji *et al.* (2009) reported that insect pests such as *Callobrucus maculatus, Aphids craccivora army worm Sepdotora species* are major constraints to cowpea production in West Africa; the crop is severally attacked at every stage of its growth by a myriad of insects which make the uses of tolerant varieties and insecticides spray imperative. Singh *et al* (1997) added that damage by beetles, leaf hoppers, bee-flies and birds could cause poor plant stands when seeds are not treated with dressing chemicals. Yellamanda ans Sankara, (2013) reported that seed treated with chlorphriphos at 6ml/kg of groundnut seed reduces the population of white grub.

Yield Parameters

The results of yield and yield components of cowpea crop as affected by Fanasan D presented in Table 2. The data showed that, days to 50% flowering and days to 50% podding were not significantly (P≥0.05) affected by Fanasan D. Nevertheless, differences in mean scores among the treatments were observed where least (60 and 73days) to 50% flowering and podding recorded at T_4 while, the highest (64/75 days) to produced 50% flower/podding obtained from T_1 and T_2.But 100 seeds weight and yield per plot significantly (P≤0.05) influenced by Fanasan D seeds dressing chemical where highest 100 seeds weight of 14.98g and yield per plot (70.74g) were obtained from T_4 on average, compared with 12.67g and 42.54g at T_1 being the least.

Table 2: Effect of Fanasan D seed dressing chemical on the yield and yield components of cowpea in Mubi

Treatment	Days to 50% flowering	Days to 50% podding	100 seeds weight (g)	Yield per plot (g)
T_1 (0g)	64	75	12.67^c	42.54^c
T_2 (2g)	64	75	13.37^b	47.25^b
T_3 (3g)	63	74	12.85^c	59.84^c
T_4 (4g)	60	73	14.98^a	70.74^a
LSD (5%)	-	-	0.51	9.81
Level of Significant	NS	NS	**	**

Means bearing the same letters in a column are statistically non-significant.

The non-significant response by days to 50% flowering and podding might not be unconnected to toxic substances induced by insect pests at the initial growth of cowpea seedlings that resulted to poor response of Fanasan D or not given at the corrected dose thereby affecting the general performance of the crop. IITA, (2009) reported that, cowpea plant is attacked by pests during its life cycle. For example, aphid extracts juice from its leaves and stems while the crop is still at seedling stage and spread cowpea *mosaic virus*. Flohr *et al* (1994) added that seeds that are not treated with chemical, during reproductive growth reduce flower and pod production and thus seed yield.

The significant performance of 100 seeds weight and yield per plot proved the effectiveness of Fanasan D as a strategy for managing the pathogens. Seed treatment is considered to be a cheap and highly effective means of managing seed-borne diseases in crops. Global losses of grain and pulse crops after harvest is estimated to be 10% and this is mainly by insect pests and it is very serious in developing countries (Boxall, et al (2002).

Conclusion and Recommendation

This research investigated the effect of Fanasan D against seed borne infection by Collectotrichum destructivum on the growth and yield of cowpea in Mubi Adamawa. The findings revealed that Fanasan D applied to cowpea seeds prior to sowing significantly influenced vine length, 100 seeds weight and yield per plant whereas establishment count, number of leaves per plant, days to 50% flowering and poddind were not significant. Seed treatments with Fanasan D at the rate of 4g per 100 seeds provide protections

against cowpea seed-borne insect pest, it is therefore recommended to farmers within Mubi and its environment. There is also need for more investigation of this nature to provide more option to the farmers in the study area.

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COMPOSTERS' PERCEPTION ON THE HARMFUL EFFECTS OF PESTICIDES SPRAYED ON HOMEMADE COMPOST IN LONDON BOROUGH OF NEWHAM UNITED KINGDOM

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Abstract
This study assessed composters' perception on the harmful effect of pesticides sprayed on homemade compost that are subsequently used in growing consumable vegetables. 96 respondents interviewed through questionnaire were selected through Multi-stage sampling procedure. Data were collected on selected personal characteristics, the type of materials composted, respondents' level of involvement in composting, level and frequency of use of pesticides and respondents' perception of the harmful effect of pesticides on compost. Data were analysed using descriptive statistics. The study revealed that a high proportion (36.46%) of the respondents fell in the age category of 41 to 50, half (50%) of the respondents were male and own gardens respectively. The study also revealed that 90% of the respondents' compost, more than half (54.17%) admittted to the use of pesticides, with 42.71%, and 30% admitting to use always and rarely respectively while 10.42% did not use. Respondents' perception on the harmful effect of pesticides sprayed on compost was low (54.2%). The study concludes that respondents' perception on the harmful health effect of pesticides sprayed on compost was low. It is therefore recommended that an enlightenment campaign be embarked upon to intimate people on the impending dangers associated with the use of pesticides. Also, people should be encouraged to use non-chemical based alternatives. Residents should endeavor to position the compost bin in strategic locations where it will not constitute a nuisance.

Keywords: Composters; pesticides; compost; chemicals and compost bins

Introduction

The most understandable route by which pesticides make their way into compost is through the composting of pesticide-treated plants (CIWMB, 2002). Every year in the UK, pesticides amounting to 23,504 tons are produced which literarily make 420g of these chemicals available for use by every man, woman and child in the UK (WDDTY, 2009). For many reasons, majority of the people that compost their general kitchen or garden wastes adopt the use of different pesticides so as to keep their homes free of flies and guide against or neutralize odours emanating from the compost bins. These reasons are fair enough if there are no dangers associated with the usage of the various pesticides currently in use in many homes and gardens where such is practiced in the UK.

It is essential to note that majority of the people that douse their homes with pesticides barely read the instructions written on the labels thereby using it indiscriminately (PAN-UK, 2001). However, mismanagement and abuse of pesticides usage and many chemicals can lead to infiltration of the residues into surface water, groundwater and huge volume of soil (Castillo *et al*. 2008). It was revealed in a study conducted by Davis *et al.* (1992) on the usage of pesticides in the United States of America, that nearly all the families interviewed used pesticides at least one time in a year and two thirds reportedly used pesticides more than five times in a year in their households. Generally, the remains or residue of pesticides that can be detected in a compost sample depends largely on the contamination level of pesticides present in the compost and the types of pesticides used (CIWMB, 2002). In a report released by Hiroyuki *et al*. (1984), pesticides that are frequently employed to control household and agricultural pests are pin pointedly alleged as endocrine disrupting chemicals. These authors further reported that the ever-present nature of the usage of these chemicals without precautions has led to the contamination of the place of work, food and the environment laying claim to reports that have shown that many pesticides exercise anti-estrogenic and anti-androgenic actions in the course of interacting with estrogen and androgen receptors. However, so many researchers have reported the devastating health effects associated with the interference of pesticides with wildlife and humans. Numerous endocrine disrupting chemicals have been detected in men and women reproductive tissues (Thomas and Colborn, 1992).

According to WHO (2013), recent scientific reviews and reports published by the Endocrine Society, the European Commission and the European Environment Agency illustrate the scientific interest in and complexity of this issue. These documents concluded that there is emerging evidence for adverse reproductive outcomes (infertility, cancers, malformations) from exposure to Endocrine Disruptive Chemicals (EDCs), and there is also mounting evidence for effects of these chemicals on thyroid function, brain function, obesity and metabolism, and insulin and glucose homeostasis. It is against this backdrop that this study seeks to ascertain composters' perception on the harmful effects of pesticides used on homemade compost that are subsequently used to grow vegetables. The study therefore looked into the following objectives: These were to specifically:

i. identify some selected socioeconomic characteristics of respondents;
ii. investigate the types of materials used for compost
iii. ascertain respondents' frequency of composting;
iv. determine respondents' use and frequency use of pesticides
v. investigate respondents' perception on the harmful effect of pesticides sprayed on homemade compost.

Materials and Method

Description of study area

London Borough of Newham is a region of Greater London that is situated in the capital city of England and it is 5 kilometers away from the city of London and north of Thames. The Borough lies between Latitude 51.8038 and Longitude -2.4494 (Mapawi.com, 2016). Centre on Dynamics of Ethnicity (CoDE) (2013) reported Indians found in East Ham, Green Street East and Green Street West wards as the largest ethnic minority group making 14% of the entire population while Africans which are regarded as the second largest ethnic minority group that are found almost everywhere in the Borough grew in population by one and three quarters between 1991 and 2011.

Study Design

In other to get a clear understanding of the respondents' perceptions with respect to composting and pesticides-related issues, a multistage sampling procedure was used. The first stage involved the use of snowball sampling technique to generate a list of household involved in composting thereafter; simple random sampling was used to select a total of 96 respondents for this study. Structured questionnaire was used to elicit information on selected personal characteristics, the type of materials composted, frequency of compost making, use and frequency of use of pesticides and respondents' perception of the harmful effect of pesticides sprayed on compost. Respondents' perception was measured on a 5 point likert type scale of strongly agree, agree, undecided, disagree and strongly disagree with scores of 5, 4, 3, 2 and 1 respectively. The mean was computed and used to categorize respondents' perception into low and high. Descriptive statistics such as bar graphs, pie-charts and frequency tables were used to summarize the results.

Results and Discussion

Age

Table 1 shows that a larger proportion (36.46%) of the respondents fell between the age range of 41 to 50 years while the least proportion (1.04%) ranged from 1 to 20 years. This implies that majority of those involved in compost making belonged to the active working age category. This is consistent with the submission of Frerick and Maier (2012) that active working age in the UK is between 16-60 years of age

Sex

Table 1 shows that 50% of the respondents were males while the other 50% were females. This suggests that both male and female were actively dominant in composting activities in the study area.

Ownership of garden

Table 1 shows that half of the respondents (50%) had gardens, 32% had no gardens while 18% had no response. This implies that majority of the respondents had gardens, suggesting that residents had begun to yield to the directive to maximize the utilization of their household waste with a view to cutting down the quantity of waste sent to the landfills and further minimize hazardous effect of gaseous buildup.

Table 1: Selected personal characteristics of respondents (n=96)

Variables	Percentage (%)
Age	
1-20	1.04
21-30	4.17
31-40	26.04
41-50	36.46
≥51	32.29
Sex	
Male	50
Female	50
Ownership of garden	
Yes	50
No	32
No response	18

Frequency of compost making

Figure 1 indicates that 61% of the respondents were always involved in making compost, 30% of the respondents were rarely involved while 9% had no response. This implies that majority of the households in the study area were always involved in compost making. It also implies that respondents complied significantly enough with the directives of local council to convert households' wastes to compost so as to reduce the pressure on landfills.

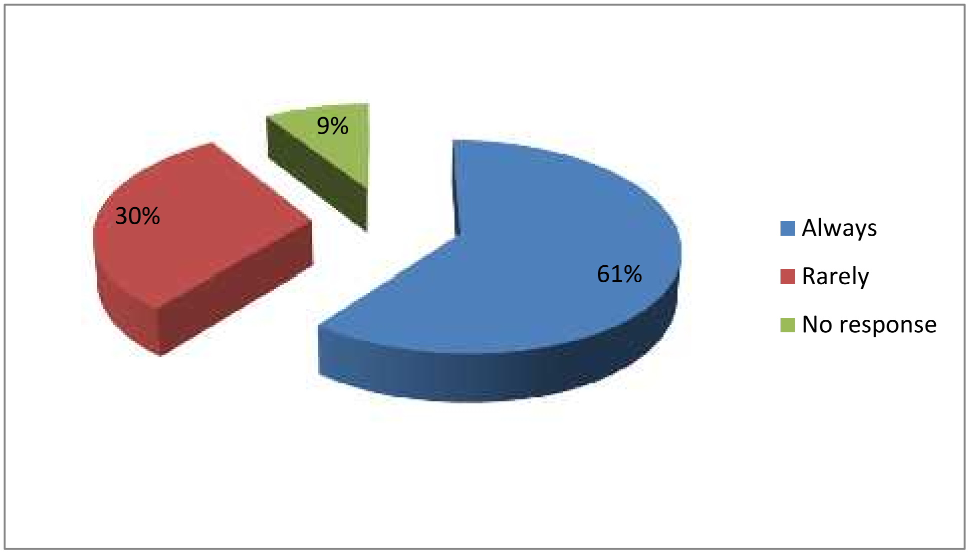

Figure 1: Distribution of respondents on frequency of composting

Type of materials used for compost
Figure 2 shows that 35.42% of the respondents composted garden waste only, 20.10% of the respondents composted general kitchen waste only, 30.46% of the respondents composted both garden waste and general kitchen waste while 14.03% had no response. The respondents composted general kitchen waste, garden waste and the combination of these with a view to taking part actively in the initiative of the council as regards efforts to reduce the amount of waste being sent to the recycling plant situated in Jenkins Lane.

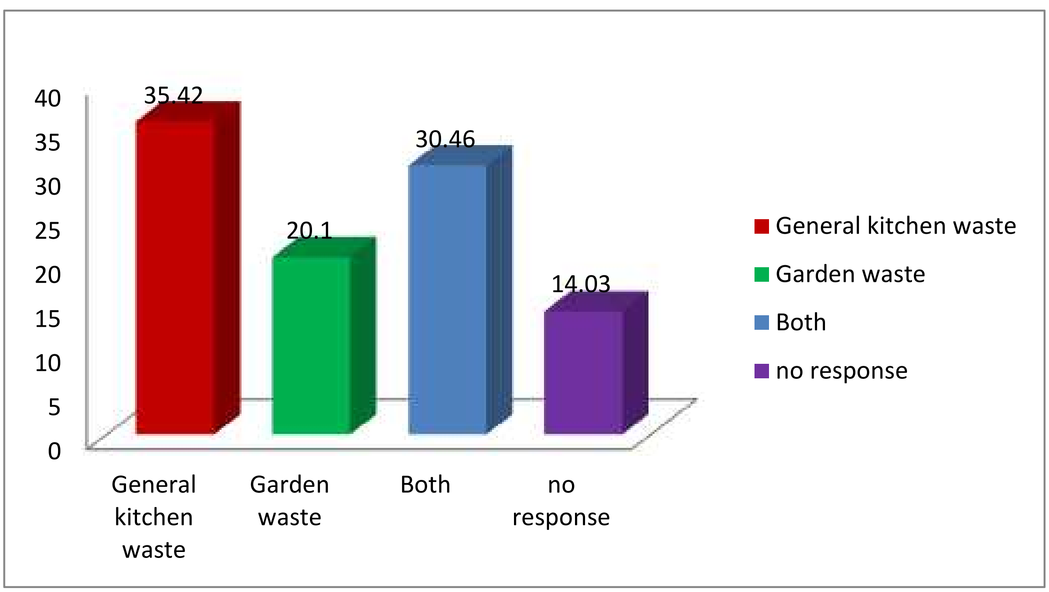

Figure 2. Distribution of respondents on types of waste composted

Use and frequency of use of pesticides

Figure 3 shows that 54.17% of the respondents sprayed pesticides on their compost while 12.50% did not. This implies that majority of the respondents used pesticides on their compost bins. This suggests that majority of the respondents in the study area employed the use of pesticides to rid their compost free of flies. The result corroborates the position of Steer *et al* (2006) that over 90% of household in America and UK use pesticides for this same purpose.

Regarding the frequency of spray of pesticides as shown on Figure 4, 42.7% admitted to spraying always, 30% rarely sprayed, 10.42% did not spray and 16.88% had no response. This infers that majority of the respondents always sprayed pesticides on their compost to rid off flies.

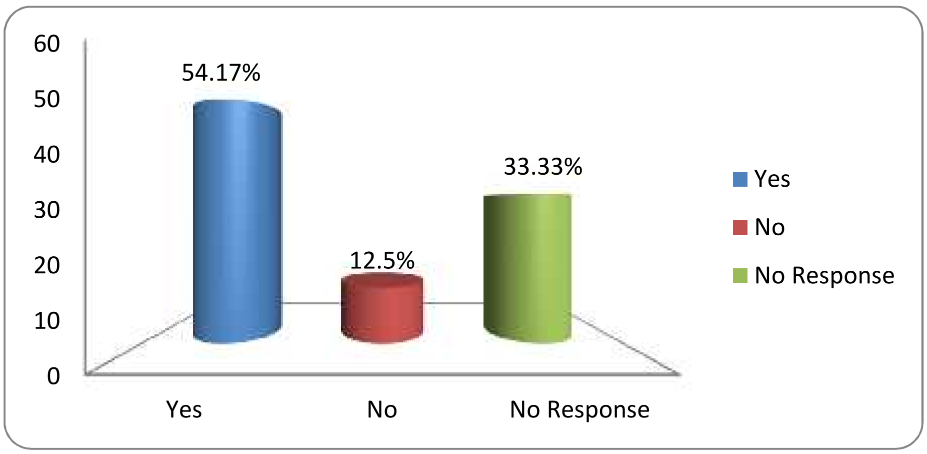

Figure 3: Distribution of respondents on use of pesticides

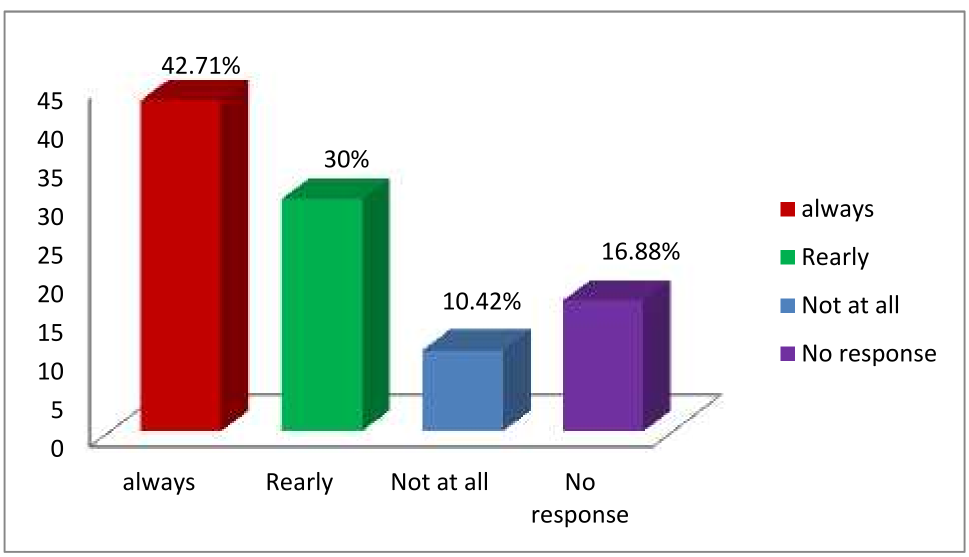

Figure 4: Distribution of respondents on frequency of pesticide use

Perception on the harmful health effect of dousing compost with pesticides

Figure 5 shows that more than half (54.17%) of the respondents either disagreed or strongly disagreed with the statement that compost doused with pesticide is a potential cause of endocrine disruption, on the other hand, 12%, 10% strongly agreed and agreed respectively with the statement while 23% of the respondents were undecided. The result on the categorization of respondent's level of perception (Table 2) also showed that respondents perception on the selected health implication of pesticides sprayed on compost was low (54.2%). The result implies that majority of the respondents were ignorant of the impending danger that dousing of compost with pesticides can present. The result corroborates a related study by Rahman (2003) where a significant proportion of farmers interviewed on the harmful effects of pesticides, did not see it as harmful.

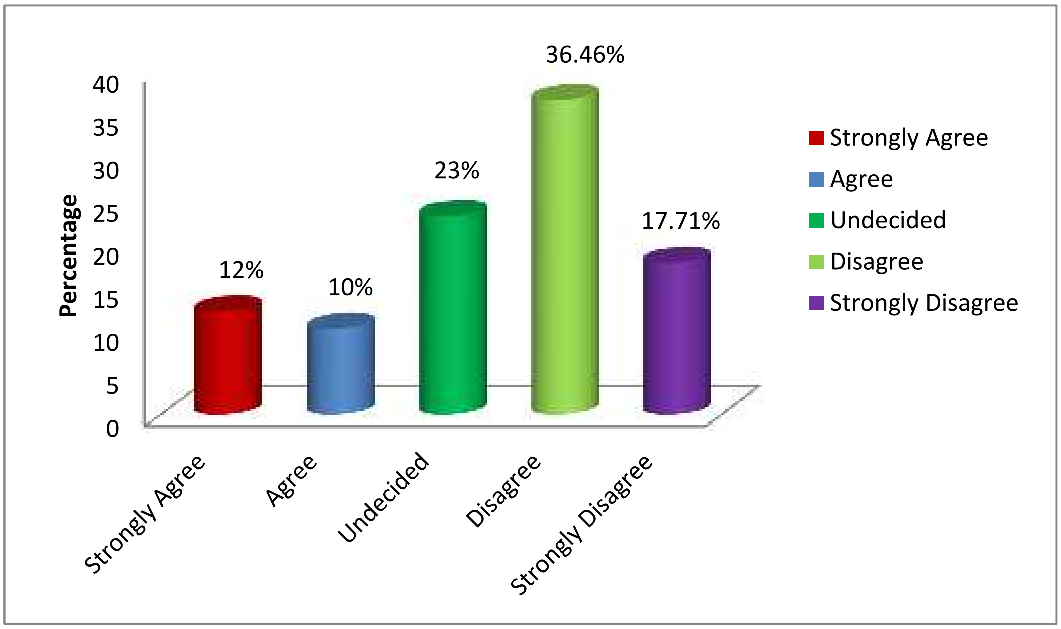

Figure 5: Distribution of respondents according to their Perception on the harmful effects of pesticides sprayed on compost

Table 2: Categorisation of respondents' level of perception on the harmful effect of pesticide sprayed on compost

Level of perception	Scores	Frequency
High	2.60-5.0	54.2
Low	1.0-2.59	45.8

Conclusion and Recommendation

The study concludes that both male and female were actively involved in composting with a high frequency. The use of pesticides on compost by respondents was equally high and respondents' ownership of garden was fairly high too. Respondents' perception on the harmful health effects of pesticides sprayed on compost was low. It is therefore recommended that an enlightenment campaign should be embarked upon to intimate people on the impending dangers that the use of pesticides may present. Respondents should also be encouraged to use non-chemical based alternatives. Instead of dousing compost bins with pesticides with a view to making their homes fly and odour free, residents should endeavour to position their compost bins in strategic locations where it will not constitute nuisance.

Acknowledgement
We thank the Recycling outreach team (Rufino Mbuandi, Kamil Murawski and Badshah Khan) for aiding the collection of the survey data used in this study and the entire Recycling team made up of Tim Woolven, Joy Ekhator, Femi Idowu-Ajibogun, Rita Nganwa and Linda Gillie all of London Borough of Newham, United Kingdom.

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APPROACH TO DEVELOPMENT AND PROSPECTS OF CLUSTER FARMING IN JIGAWA STATE, NIGERIA

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Abstract
Cluster Farming focuses on enabling lasting and sustainable agribusiness; it aims to contribute to sustainable productivity, income improvement, increased education and training. Cluster Farming is the best practice for encouraging and empowering people to grow food everywhere through a self-sufficient farming model. Cluster Farming is the sustainable producer of food, fibre, plant and animal products using farming techniques that protect the environment, public health, human communities and animal welfare, while making home-grown agricultural products more accessible. Clusters are based on common technologies or know how, commodity or service linkages and competitive advantages. Cluster farming is the coming together of agricultural entrepreneurs in an area forming cluster so as to synergistically enjoy one economic benefit or a burden which if faced individually may be an obstacle to their profitability. Benefits of cluster farming include sharing of recent agricultural technology developed by research institutions; easy access to credit, farm inputs such as seeds, breeds of livestock, fertilizer, pesticides and herbicides; marketing and distribution chain, as well as extension services. Cluster farming strategy was developed in Jigawa state in 2015 with the aim to achieving food security and transforming the current agricultural practices from subsistence farming to commercial agriculture. Under this system, clusters were developed in each of the four zones of Jigawa Agricultural and rural development authority (JARDA). In each of the local government area, 50 hectares of farmlands were provided as a cluster with 20 to 30 farmers organized into a cluster depending on their farm sizes. Cluster farmers were then facilitated with farm inputs on loan (insecticides, fertilizer, improved seeds / seedlings and training) to achieve a minimum target per hectare. Some of the challenges to cluster farming includes: poor management, inconsistent and poorly implemented government policies, lack of basic infrastructure, Competition and the desire to work together, Poor Entrepreneurship Development, weak linkages between Agriculture / input dealers and Poor Marketing system. It is therefore recommended that politicians be encouraged to have farmer support Programme to provide support, to promote economic and market development, to sustain adequate on-farm incomes which promotes stability, competitiveness, growth and transformation in the agricultural sector of Jigawa state in particular.

Keywords: Development, Prospects, Challenges and Cluster Farming.

Introduction

Cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities (Teshome, 2008). The geographic scope of clusters ranges from a region, a state, or even a single city to span nearby or neighboring countries. Clusters are based on common technologies or know how, commodity or service linkages, competitive advantages etc (Onwualu, 2010).

Cluster farming is the coming together of agricultural growers in an area and forming a cluster so as to synergistically enjoy one economic benefit or a burden which if faced individually may be an obstacle to profitability. Benefits of cluster farming include sharing of recent agricultural technologies developed by research institutions; easy access to credit, farm inputs such as seeds / seedlings, breeds of livestock, fertilizer, pesticides and herbicides; marketing and distribution chain, as well as extension services among others.

Cluster farming has recorded a success story in countries like, India, Sri-lanka, Malaysia, Philippines, Japan, Norway and Ghana. Cluster Farming focuses on enabling lasting and sustainable agribusiness entrepreneurship in Africa and aimed at contributing to sustainable productivity, income improvement, increased education and training. Nigeria currently has a number of industrial clusters which have high promise for driving agriculture and industrial development (Oyelaran, et al., 2007; Eboh, 2012). These include Otigba Computer Hardware Village, Ikeja Lagos, Nnewi Automotive Cluster, Kano Leather Cluster, Aba Leather and Footwear Cluster, Aba Fashion and Garment Cluster, Abeokuta and Oshogbo Tie and Dye Clusters (Oyelaran, et al., 2007). Others are Rice Processing clusters in Ebonyi, Benue, Niger and Anambra States, Wood and Furniture Processing Clusters in FCT, Edo and Oyo States, Cashew Processing Clusters in Kogi, Enugu and Abia States, Sheabutter Processing Clusters in FCT, Niger and Kwara States, and Fish Processing Clusters in Borno, Kebbi, Rivers, Cross River, Akwa Ibom and Kogi States (Onwualu, 2010).

Cluster Model was introduced in 2015 with the aim to achieving food security and transforming the current agricultural practices from subsistence farming to commercial agriculture. Under this system, clusters were developed in each of the 287 political wards in the 27 local government areas of the state as demonstration farms. In each of local government, 50 hectares of farmlands were provided as a cluster with 20 to 30 farmers organized into a cluster depending on their farm size. Cluster farmers were then facilitated with credit and farm inputs (insecticides, fertilizer, improved seed / seedlings) on loan and training to achieve a minimum target per hectare. Extension workers were also deployed across the 20,000 hectares' demonstration farms to provide expertise to these local farmers with the focus of producing the following crops rice, sesame, and groundnut. It was estimated that with the introduction of this scheme, average yield per hectare in the state will reach 10 tonnes per hectare for rice in the next five years. Therefore, cluster farming can be considered as the solution for empowering people to grow food everywhere through a self-sufficient farming model. Cluster Farming is the sustainable producer of food, fibre, plant and animal products using farming techniques that protect the environment, public health, human communities and animal welfare, while making home-grown agricultural products more accessible (Oyelaran, et al, 2007, Onwualu, 2010, RMRDC, 2010 and Onwualu, 2011). The objective of this study is to review the approach to cluster farming in Jigawa state.

Characteristics of Agricultural Clusters

Agricultural clusters have some characteristics based on the type of products and services they produce, their location, development stage, and the business environment that surrounds them, membership of associations, common interest, farming experience, household size and level of education. In Jigawa state groundnut and rice farm clusters were formed with aim to achieving commercial agriculture

An agricultural cluster may have the following characteristics:

a. Common needs and interests

Farmers may cluster around types of needs and interests. There are clusters in tree crops, in fisheries, in agro processing activities, cereal crops, in livestock and many more. More recent research on clusters indicated that even within a given field here is room for many different successful clusters, each taking a unique individual role. Clusters are differentiated by their specialization in a particular stage of their fields and value chain, by their focus on specific geographic areas, or by targeting selected customers' needs or market demand.

b. Interdependent and overlapping

Farmers can be in more than one cluster, depending on whether the relationships are similar, commonalities, or complementarities. The ongoing convergence of technologies is making it even more difficult to pigeonhole a particular cluster. Flour Mills Company could be considered part of design, sourcing, and financers of wheat farmer's clusters. A winery could be included in food processing, tourism, or biotech clusters.

c. Talent and creativity

Clusters also depend on talent and creativity. In today's global economy, farmers depend more than ever before on highly proven technology while educated farmers are getting more involved in agriculture. Educated people, scientists or researchers, civil servants, tend to choose to be near others with common interests and lifestyles and where cultural and recreational amenities are plentiful.

d. Technology adoption

Technology adoption and entrepreneurship are the main drivers for competitive agricultural clusters. Usually, the success of members of a cluster depends on their ability to protect their own technological advancement, new products, or value chain. However, the success of the cluster in which it operates may depend on widespread diffusion and adoption, access to extension services and formation of new enterprises.

Elements of Cluster Farming and Development

Cluster Farming and development must be private-sector driven; government agencies play a core partnership role in the process of cluster development. This strategic planning process may include, but is not limited to the following elements and approaches

i. Legitimacy

Cluster initiatives need both leadership (provided mostly by private sector) and legitimacy (provided mostly by public sector). Government may legitimize a cluster initiative; it needs to guarantee the quality of the cluster farming development process, in the sense of openness, transparency, and democracy.

ii. Cluster facilitator

Cluster Facilitators (Extension workers) can play an active central role in the process of cluster farming development. Cluster farmers can be identified by the extension workers, providing their integrity, honesty and trust-worthiness are evident. It may take a considerable time before the spark turns into a self-sustainable process of cluster farming and development, especially in clusters that are more traditional and conservative in character.

iii. Association

Association encourages and facilitates agribusiness networks and cluster-specific enterprise, by supporting facilitators and collaborative projects. It assumed that firms operating in a strong associational environment will discover shared interests and competencies, will aggregate their resources and collectively express their needs, while their scale will give them greater visibility as a cluster farmers.

iv. Support

Establishing integrated public sector support for a cluster is not an easy achievement. This alignment may need to reach across functional agencies (including export development, investment attraction, Research and Development, education) and across local, regional and national agencies. Further, the private sector needs to earn the control position and by so doing separate government agencies do not have to individually second guess the cluster's priorities.

v. Specialization

Most clusters have been boosted by some variation on specialization strategies. The "specialization," influences the use of public or private sector resources or services in ways that make them more directly relevant to a particular kind of industry. Specialization affects business and technical assistance, research and development, market assistance and information, and often most importantly education and training, shaping it to the particular needs of the companies in the cluster. The export specialization of the cluster needs to be highlighted at an early stage in the cluster development process. For example, rather than 'timber processing' focusing on 'outdoor furniture'; not 'horticulture' but 'organic kiwifruit'; not 'biotech' but 'animal remedies'. The initial scoping of a clustering initiative may well start at the broader 'engineering' level, but subsequently a core competency in 'automotive engineering' highlighted the cluster development initiatives that follows then focusing on the specific corner of the broader engineering cluster.

vi. Collaboration

Clustering is one form of collaborative engagement. Complementing this within clusters are other forms including soft and hard networks, and value/supply chains. With some clusters the initial opportunities for collaboration may well not be at the cluster level, but lower down, e.g. in developing a common pack house, or encouraging a group of saw millers to co-invest in a processing plant for export. These other forms of collaboration also benefit from having a neutral facilitator.

Advantages of agricultural Cluster

The cluster farming model prospects can be summarized as follows:

1. Clusters are defined by interdependencies and are inclusive of other economic development approaches.

2. Cluster farming drive innovation and adoption drives productivity. Adoption of new technology takes place disproportionately in clusters.

3. Cluster farming provides mutual understanding and cooperation between members through interaction among the participants. Farmers have all the necessary skills to shift their attention from subsistence agriculture to commercial agriculture by themselves, therefore farming in cluster, rather than single farmer, can be a source of income, jobs and export growth.

4. Cluster farming provides benefits to all involved. Farming in a cluster enables members to have easy access to all production resources (credit, extension services and farm inputs). It provides them with access to all players, attracting brainpower, expertise and local suppliers. In turn, it makes the farming more attractive and easy to adopt technology and enables them to develop and export unique products and services.

5. Cluster farming is attractive for many reasons. It catalyzes economic transformation. Cluster farming drives growth and enhances stability. Once they are rooted, they are remarkably self-generating.

Limitations/ constraints of agricultural cluster farming

Despite all the laudable programmes promoted by various governments, agriculture has suffered from years of poor management, inconsistent and poorly implemented government policies, and the lack of basic infrastructure.

1. **Rivalry** (competition) and the desire to work together.

Effective clusters involve a combination of pressure (competition) and support.

2. **Lack of Basic Physical Infrastructure and Essential Services**

Basic infrastructural facilities like electricity, irrigation water and transport that are critical for agricultural development are lacking.

3. **Lack of Appropriate Technology and Machinery for Production and Processing of Agricultural Products.**

The absence of appropriate processing technology and the obsolete nature of existing machinery and equipment constitute great hindrance to agro raw materials processing in the country. Most of the processing equipment are outdated and lack the necessary spare parts for their maintenance. Consequently, the efficiency and product quality of the industries are greatly affected. This often contributes to the frequent break down and closure of such industries.

4. **Apathy towards Investment in the Agricultural Sector**

There is great apathy towards investing in the agricultural sector of the economy. Preference is rather given to trade than real sector. This is because of the get-rich-quick attitude of the people at the expense of enduring and sustainable economic ventures like agro industrial processing (value addition).

5. **Poor Entrepreneurship Development**

The entrepreneur is the central actor in the process of change. There is a dearth of well trained and experienced human resource in the various fields of agricultural development. This has negatively affected the level of activities in the full exploration and exploitation of the abundant agricultural resources.

6. **Weak Linkages between Agriculture and Input dealers and Poor Marketing system**

One of the constraints to the development of agricultural resources in Jigawa state is the inability of the Agricultural sector to harness the Research and Development results coming out of research centres into innovations. Most research findings in Jigawa state and Nigeria at large do not get to the intended users because there is a very weak link between research and implementation.

Conclusions

Cluster-based strategies have proven effective in improving the clusters' ability to compete and, in many instances, have influenced regional and local growth patterns. Innovation is most likely to occur where talent, skills, technology and businesses are clustered and are organized to respond to competitive forces and to take advantage of opportunities.

Recommendations

Generally, it is recommended that government be encourage to have farmer support Programme to provide support, to promote economic and market development, to sustain adequate on-farm incomes which promotes stability, competitiveness, growth and transformation in the agricultural sector in Nigeria. The following are solutions recommended for different constraints of small- scale farmers in Jigawa state:

1. **Ensure cluster Farmers' Access to Inputs and to Markets for Outputs:** The private sector should be encouraged to participate in the supply of inputs to cluster farmers. It should also be the main driver of competitive commodity value chains and the promoter of farmer group/out-grower marketing schemes, with Government providing an enabling environment for commercial operations.
2. **Public-Private Partnerships:** Such partnerships would ensure an integrated approach to producer, processor, trader and marketer arrangements. The most successful precedents in Nigeria have involved clusters of farmers being organized around major agro-based industries, notably in the supply of rice and other cereals for processing and food manufacture.
3. **Agricultural Credit:** Agricultural lending institutions should ensure that increased efficiencies are realized at every step. There should be provision of a system through which small farmers can improve efficiencies in all areas, including accessing inputs, improving yields, making linkages, infrastructure development and skills transfer. The Central Bank of Nigeria (CBN) has recently initiated a new agricultural financing paradigm called Nigeria Incentive-based Risk Sharing System for Agricultural Lending (NIRSAL) that took off in 2012. This paradigm aimed at providing farmers with affordable financial products, while de-risking agriculture and unlocking the access of input suppliers, farmers, agro-processors and product marketers in the agricultural value chain financing from financial institutions. It is suggested that with the government of the day already implementing several programmes aimed at promoting best practices in agricultural development, including cluster farming, anchor Brower and others farmers should get closer to the relevant authorities to know how they can fit in and subsequently benefit from the schemes.
4. **Agricultural Technology:** Nigerian governments should encourage research institutes and universities to carry out more researches and equip the extension system more to disseminate the research findings effectively to farmers.
5. **Extension Education:** Extension agents need to intensify their efforts in educating farmers to increase their level of awareness. Of all the existing channels of agricultural communication, Nigerian farmers

ranked extension highest in terms of providing credible information and advice, especially on agricultural technology (FAO, 2012). A major function of extension is to get the farmer into a frame of mind and attitude conducive to accepting technological change.

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IRRIGATION AND INCOME-POVERTY REDUCTION: AN ASSESSMENT STUDY OF RIVER BASIN DEVELOPMENT AUTHORITY'S IRRIGATION SCHEME IN DADINKOWA, GOMBE STATE, NIGERIA

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Abstract
Irrigation has been identified to be a key part in optimizing agricultural production for self-sufficiency in food production and poverty reduction in most developing countries in the world. The study was carried out to assess the role of Upper Benue River Basin Development Authority`s (UBRBDA) irrigation scheme on the poverty status of rice farmers in Dadinkowa, Gombe State, Nigeria. Data were collected using well-structured questionnaire from 157 respondents out of which 82 were registered rice farmers and 75 were Non-registered. The study used descriptive statistics to examine the socio-economic characteristics of the respondents and supports received from the authority. Foster-Greer-Thorbecke (FGT) model was used to examine the incidence, gap and severity of poverty among the sample respondents. Logistic regression model was used to identify factors that influence poverty status. The budgetary analysis compared the costs and returns of the farmers. Results showed that majority of the farmers were male and married, in active labour age with a non-formal education and adequate farming experience who worked as small scale farmers with small sized farmlands. Some were full-time while others had other off-farm work. Water supply had the highest level of farmer's satisfaction among all the supports received while fertilizer supply was the least in terms of farmers` satisfaction. The poverty incidence was 57% and 64% for registered and non-registered rice farmers respectively. The poverty gap was 34% and 46% for both the registered and non-registered respondents. Poverty severity was also high among non-registered farmers (21%) and 12% for Non-registered. Household size, farm size, farm income and age of the household head were the factors that influence poverty status. The study also revealed N 107,262.20/ha and N 97,513.04/ha gross revenue and N 53,320.87/ha and N 47,547.52/ha gross margin for registered and non-registered farmers, respectively. In conclusion, the study revealed that UBRBDA`S irrigation scheme play a role in reducing the level of poverty among the registered respondents. The study therefore recommends improvement in the area of inputs such as fertilizer, improve seeds in addition to increasing the size of farmland allocated to each individual farmer which would go a long way in improving the authority`s irrigation scheme and also encourage more farmers to registered into the irrigation scheme.
Key words: Irrigation, poverty, assessment, rice farmers

Introduction
One of the major problems confronting most developing countries today is how to improve the quality of life and reduce the level of poverty (Adamu, 2013). Poverty in Nigeria is not only a state of existence but also a process with many dimensions and complexities (Khan, 2000). However, statistics from the National Bureau of statistics indicate a worsening poverty situation in the country and a cause for concern (Ayanwale and Alimi, 2004). The report of the 2006 Nigerian Core Welfare Indicator (CWI) on the poverty profile in the country stated that the dependency ratio, which was defined as the total number of household members aged 0-14 years and 65 years and above to the number of household members aged 15-64 years, was 0.8% (Central Bank of Nigeria, 2005). This indicated almost a one-to-one dependency ratio, and reflected the high population growth rate in the country. There is also large income inequality with the top 10% of the income bracket accounting for close to 60% of total

consumption of goods and services (Ayanwale, 2004).

Over 65 per cent of Nigerians are now classified as poor, and 35 per cent of them live in absolute poverty. Poverty is mostly severe in rural areas, where majority of the population lives below the poverty line and social services and infrastructure are limited. The country's poor rural women and men depend on agriculture for food and income (Olawuyi *et al.*, 2013).

Food and Agricultural Organization has consistently listed Nigeria among countries that are technically unable to meet their food needs from rain- fed agriculture because of low level of inputs. The report further emphasized the expansion of food production from rain-fed to include irrigation (Adeoye, 2010).

One of the goals of irrigation farming is the provision of right amount of water at the right time for plant growth and development. Consequently, it ensures sustainable agriculture with its economic benefits (Oriola, 2014). Farmers are usually less busy on the farm during the dry season; therefore, provision of irrigation facilities that offer all-year-round farming serves as an alternative employment and additional source of income throughout the year.

The federal government of Nigeria created the River Basin Development Authorities (RBDAs) in 1976 (eWASH, 2009). The aim of the RBDAs is to harness the country's water resources and optimize its agricultural resources. The Upper Benue River Basin Development

Authority (UBRBDA) is one among the eleven River Basin Development authorities that operates in all the geographical areas of all the major tributaries of the Benue River upstream including the Gombe State (Mu'azu, 2011). It supplies irrigation water to registered farmers; provide about 19 million gallons of potable water to the state and its environs (Suleiman. 2011).

In this regard, the study was to assess Upper Benue River Basin Development Authority's' (UBRBDA) Irrigation scheme on the poverty status of rice farmers in Dadinkowa, area of Gombe State, Nigeria with a view of comparing between registered and non-registered rice farmers`. The specific objectives are to

(i) describe the socio-economic characteristics of the respondents.
(ii) examine the incidence, depth and severity of poverty among registered and non-registered rice farmers; and
(iii) examine the determinants of poverty among the respondents.

Research Methods

Study Area

The study was conducted in Dandikowa area of Gombe State. Dadinkowa is a town located in Yamaltu-Deba Local Government Area of Gombe State in north eastern Nigeria. It is about 35km away from the state capital. It is situated within Latitudes 90^0 30' - 12^0 30' North of the Equator and Longitudes 80^0 45' - 110 45' East of Greenwich meridian. The average rainfall is between 800 – 900 mm per annum, mean temperature ranges from 30 – 32^0C and it experiences a relative humidity of 17 – 90 per cent. The people in the area are predominantly small-scale farmers and rice and vegetables are the major crops grown in the area (Gombe State Government, 2009).

Data Collection and Sampling Procedure

A two-stage sampling procedure was used for this study. The first stage involved the use of stratified sampling technique. The respondents were divided into two strata; registered and non-registered rice farmers. In the second stage, 82 registered rice farmers were randomly selected from a sampling frame of 310 registered rice farmers which were obtained from Upper Benue River Basin Development Authority(UBRBDA) and 75 non-registered rice farmers were also selected randomly from four villages in Dadinkowa namely (Hina, Gwani, Kinafa and Difa) with 25 respondents from each village. Therefore, a total number of 157 respondents were used for this study.

The data used for the study were obtained with the use of structured questionnaire coupled with interview schedule.

Data Analysis

Both descriptive and inferential statistics were used to analyses the data. Descriptive statistics used include mean and percentages. The Foster, Greer and Thorbecke (1984) class of weighted poverty measures were also used to find out the poverty incidence, depth and its severity on the households. The formula is given as follows:

$$F \quad T_{\alpha} = \frac{1}{N}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right)^{\alpha} \qquad \text{(I)}$$

Where:

Z = the poverty line defined as 2/3 of mean per capita income

N = total number of respondents

Y_i= Per capita income of the ith respondents – poverty indicator

q = Number of poor households in the population of size N,

α = the degree of poverty aversion; α=0; is the headcount index (P_0) measuring the incidence of Poverty (proportion of the total population of a given group that are poor, based on poverty line). α =1; (P_1) is the poverty gap index measuring the depth of poverty, that is on average how far the poor is from the poverty line; α = 2, (P_2) measures the severity of poverty, giving more weight to the poorest. The closer the FGT index is to 1, the greater the poverty level.

Logistic regression model was also used to examine the determinants of poverty among the respondents. These factors could have positive or negative impact on household poverty status. The model was specified as follows:

$$Yi = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, U,) \qquad \text{(II)}$$

Where,

Yi = (1 if respondent is non-poor and 0 if poor)

Explanatory variables;

X_1= Farming experience (years)

X_2=Membership of farmer's group (1 if member, 0 if otherwise)

X_3=Educational level (number of years of formal Education)

X_4 = Household size (Persons)

X_5= Access to credit (1 if yes, 0 if otherwise)

X_6= Farm size (ha)

X_7=Age of the household head (years)

X_8 = Farm income (Naira)

X_9 = Secondary income (Naira)

U = Error term

Results and Discussion

Socio-economic characteristics of the Respondents

Table1 shows socio-economic characteristics of the respondents. The mean age for registered and non-registered farmers was 40.0 and 47.8 respectively. These results suggest that both the registered and non-registered farmers were within their active/productive age. Meanwhile (92.7%) registered farmers were male while 7.3% were female. On the other hand, 94.7% of the non-registered farmers were male while 5.3% were female. This is in line with the study carried out by Sulaiman (2011) that male dominating rice farming in northern Nigeria. Most of the farmers (87.8% and 93.3% registered and non-registered farmers respectively) were married. Distribution of the respondents according to their level of educational attainment shows that more than half of registered and non–registered farmers have non-formal education, and this was followed by farmers with primary and secondary education. While very few farmers have post-secondary education. It has been observed that illiteracy militates against adoption of recommended packages of innovation and modern farming techniques. Adamu and Bakari (2015) also stressed that farmers with a high level of education earn a higher profit than those with low literacy.

About 37.8% registered farmers had household size between 1 -5 while 30.7% non-registered farmers had household size between11-15. Furthermore 30.5% and 17.3% registered and non-registered farmers respectively had the same household size between 6 –10. Moreover 29.3% non – registered farmers respectively had household size of greater than 15 as against 8.5% registered farmers.

Table 1. Socio-economic Characteristics of the Respondents

Variables	Registered ($n_1 = 82$)	Non-registered ($n_2 = 75$)
Age (years)		
25-35	20.7	17.3
36-45	41.5	17.3
46-55	25.6	48.1
>55	12.2	17.3
Mean	**40.0**	**47.8**
Gender		
Male	92.7	94.7
Female	7.3	5.3
Marrital Status		
Married	87.8	93.3
Single	7.3	4.1
Divorce	3.7	1.3
Widowed	1.2	1.3
Educational Status		
Non-formal Education	57.3	52
Primary Education	13.4	29.3
Secondary Education	25.6	16
Tertiary Education	3.7	2.7
Household Size(Persons)		
1-5	37.8	22.7
6-10	30.5	17.3
11-15	23.2	30.7
>15	8.5	29.3
Years of Experience (Years)		
1-5	7.3	1.3
6-10	25.6	18.7
11-15	30.5	24
>15	36.6	56
Mean	**15.4**	**18.5**
Farm Size(ha)		
≤ 1.0	40.24	58.67
1.1-2.0	59.76	41.33
Mean	0.33	0.31
Secondary Occupation		
Artisan	25.6	22.7
Civil Service	11	9.3
Trading	24.4	21.3
Farming	39.0	46.7
Estimated Income from Another Source(₦)		
≤ ₦ 5,000	12.2	20
₦ 5001 – 10,000	24.3	22.7
₦ 10,001 – 15,000	48.8	46.7
> ₦ 15,000	14.6	10.7
Mean	**10,500**	**9,800**

Membership of Cooperative Society		
Yes	61	14.7
No	39	85

Source: Field Survey, 2015

Mean farming experience for registered farmers was 15.4 years while that of non-registered was 18.5 years. This suggests that irrigation farming is an age-long venture to both groups of farmers. In the study of Adamu and Bakari (2015), farmers with more years of experience operate at the high level of profit efficiency. The average farm size of registered and non-registered farmers was 0.35 and 0.31 hectares. This indicates that the farmers' production is at small scale level. Nmadu and Garba (2013) showed a positive relationship between farm size and profit efficiency. About 39% and 46.7% registered and non-registered farmers respectively were full time farmers, while the remaining was artisan, traders or civil servant. Average monthly incomes from non-farm source for registered and non-registered farmers were ₦ 10,500 and ₦ 9,800. Ojo et al. (2011) found that part-time farmers tend to augment their income from other off-farm work. Majority (61%) registered farmers had no access to credit while the rest had access. On the other hand, the distribution of respondents based on membership of cooperative societies shows that 61% registered farmers were members of cooperative societies while only 14.7% non-registered farmers were members.

Costs and Return Analysis of the Registered and Non-Registered Respondents

Table 2, shows the variation in the gross revenue, gross margin as well as the structure of farm expenditures between the registered and non-registered respondents. The analysis of costs and returns shows the average gross revenue of ₦ 107,262.20 and ₦ 97,513.04 for registered and non- registered respondents and a gross margin of ₦ 53,320.87/ha and ₦ 47,547.52/ha for both registered and non-registered respondents. Labor costs constitute the highest among all the variable cost components. This result is in line with the report by Mohammed (2011), that labor cost has the highest among all the variable costs in rice production. The difference in gross margin between these two categories of farmers could be as a result of the impact of the scheme.

Table 2. Costs and Return Analysis of Registered and Non-Registered Farmers

Variables	Registered	Non-registered
Gross Revenue	**107,262.20**	**97,513.04**
Seeds	3,440.85	2,810.00
Chemicals	2,323.17	2,160.00
Fertilizer	16,473.17	14,500.00
Transport	2,836.46	1,956.33
Hired Labour	22,215.24	19,680.19
Irrigation Cost	6,652.44	-
Fuel Cost	-	8,860.00
Total Variable Cost	**53,941.33**	**49,965.52**
Gross Margin	**53,320.87**	**47,547.52**

Source: Computation from Field Survey Data, 2015

Poverty Profile among Registered and Non-Registered Farmers

Table 3 shows a poverty profile among registered and non-registered rice farming households in the study area. The results revealed a poverty line of ₦ 3,643.57 and ₦ 3,391.45 for the registered and non-registered rice farming households which were calculated from the two-third (2/3) monthly Mean Per Capita Households Income (MPCHI). Households with MPCHI below the poverty line were classified as poor, while those with a

higher MPCHI were classified as non-poor. Based on their respective poverty line, 57% of registered farmers were classified as poor while 43% were classified as non-poor. Meanwhile 64% of non-registered farmers were classified as poor, while 36% of them were classified as non-poor. Therefore, this could be as a result of the impact of the irrigation scheme in the study area. The poverty gap or income shortfall of the poor households is 34% from the respective poverty line for registered households and 46% for the non-registered households. The results further revealed that 12% and 21% of the households for registered and non-registered respectively were severely poor. Comparison of the poverty status of registered and non-registered reveals that, the poverty level is higher by 7% among non-registered households. The percentage of income shortfall (gap) is also higher among non-registered households as compared to their counterpart registered households. However, poverty severity follows the same pattern. Adenuga et., al (2013) also show that incidence, gap and severity of poverty is significantly lower among beneficiaries of fadama Ш programmed than non-beneficiaries in Patigi Local Government Area of Kwara State, Nigeria.

Table 3. **Poverty Profile among Registered and Non-Registered Farming Households in the Study Area**

Variables	Registered %	Non-registered %	% Difference
P_0	57	64	7
P_1	34	46	12
P_2	12	21	9
MPCHI	₦ 5,465.36	₦ 5,087.17	
PL	₦ 3,643.57	₦ 3,391.45	

Source: Computation from Field Survey Data, 2015

Determinants of Poverty in the Study Area

Table 4 presents the factors influencing poverty status among the respondents in the study area. The result shows that all the variables except access to credit and secondary income improves the model and if included would add to the predictive power of the model. Therefore, it become necessary to drop the other independent variables since they have less effect on the predictive power of the model.

Table 4. Determinants of Household Poverty Status

Variables	Coefficient	Standard error	t-value
Household size	0.092	0.045	2.044444
Farm Size	-0.137	0.057	-2.40351
Farm Income	-0.252	0.071	-3.5493
Education	-0.751	0.546	-1.37546
Experience	-0.228	0.601	-0.37937
Membership	-2.382	0.748	-3.18449
Age	0.038	0.23	0.165217
Constant	44.752	5.671	7.891377

-2 log likelihood = 104.67; Cox and snell R^2 : 0.467; Nagelkerke R^2 - 0.542

Source: Analysis from Field survey data, 2015

The coefficient of household's size and age exert a positive effect indicating that the higher the household size and age the higher the poverty level, this is probably due to the fact that larger household size consumed more of their farm produce rather than selling for income. Farm size and farm income exert a negative effect indicating that the higher the farm size and the farm income the lower the poverty level, this is because higher farm size is assumed to have higher output with translates to higher income which conforms to a prior expectation.

The age of the household head exerts a positive coefficient which is also logical, as the age increase the tendency of having more children to cater for increase which translate to increase in the level of poverty.

Assessment of Supports Received from UBRBDA

Table 5 shows farmers' response towards the support they received from Upper Benue River Basin Development Authority. This is as shown below.

Table 5. Assessment of Supports Received from UBRBDA

Variables	Satisfied	Undecided	Not-satisfied	Ranking
Water supply	65(79.27)	0(0.00)	17(20.73)	1st
Canal maintenance	59(71.95)	10(12.20)	13(15.85)	2nd
Land preparation	53(64.63)	17(20.73)	12(14.64)	3rd
Farm land	40(48.78)	8(9.76)	34(41.46)	4th
Improve seeds supply	32(39.02)	15(18.29)	35(42.69)	5th
Fertilizer supply	31(37.80)	9(10.98)	42(51.22)	6th

Source: Field survey, 2015

Table 5 shows the support received from UBRBDA by the registered farmers. The results depict that all the support rendered by the scheme, water supply had the highest level with (79.27%) of farmer`s satisfaction. This was followed by canal maintenance (71.95%), and land preparation (64.63). This shows that majority of the respondents were okay with the water supply, canal maintenance and land preparation of the scheme. Contrastingly, up to (51.22%) of the respondents were not satisfied with the fertilizer supply support of the scheme. This was follow by seeds supply with (42.68%) and the third important problem of the registered farmers was the smallness nature of the farmland allocated to them where up to (41.46%) expressed their non-satisfaction. And this is in line with the findings of Bamire et.al., (2007) who found that reduce land holding per respondents was the major problem of rice farmers in Osun state.

Conclusion and Recommendations

The findings of this study revealed that poverty incidence, depth and severity were higher among non-registered rice farmers in the study area. Furthermore, the study revealed some factors that influence poverty status in the study area to include; household size, farm size, farm income, age and membership of cooperative society. Therefore, based on these results, the followings recommendations were made:

There is need to expand the area covered by the authority's irrigation scheme in addition to increasing the size of farmland allocated to each individual farmer. This will help in increasing farm output thereby reducing the level of poverty.

The management of the authority should reduce the cost of rendering services so as to accommodate more farmers into the scheme and should also improve in the area of fertilizer and improve seeds supply. This will also enhance the farm income of the registered farmers there by encouraging more farmers to join the scheme.

Farmers should be encouraged to come together and form cooperative group. This will serve as a means of passing requisite information to them about the scheme as well as providing other source of credit facilities.

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EFFECT OF TIME OF SOWING ON THE GROWTH AND YIELD OF COWPEA (*Vigna unguiculata (*L) walp) INTERCROPPED WITH MAIZE (*Zea mays* l.) IN JALINGO, TARABA STATE

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Abstract
Field experiment was conducted at research farm of the Taraba state college of agriculture, Jalingo to study the effect of time of sowing on the growth and yield of cowpea (Vigna unguiculata (L) Walp) intercropped with Maize (Zea mays L.) in Jalingo, Taraba state. The experimental layout was a Randomized Complete Block Design (RCBD) which consisted of four (4) treatments: Cowpea sown the same day with Maize (0 WAS), Cowpea sown 1 week after sowing Maize (1 WAS), Cowpea sown 2 weeks after sowing Maize (2 WAS), Cowpea sown 3 weeks after sowing Maize (3 WAS) replicated three times accordingly. Data were collected on: plant height, number of branches, days to 50% flowering, number of pods, 100 seeds weight and grand weight per plot. Data collected were subjected to Analysis of Variance (ANOVA). Means were separated using Least Significant Difference (LSD) at 5% probability level. On the effect of time of sowing to the growth and yield parameters, the results indicated that time of sowing had significantly ($P \leq 0.05$) increased number of branches with up to 6 branches per plant when sowing of cowpea was delayed for 2 weeks after sowing maize. On the response of sowing time to yield parameters, the findings revealed that highest values of 103.3 pods per plant, 34 g weight of 100 seeds, 3.3 kg weight of yield per plot as well as the least 63.3 days to 50% flowering recorded in this research were obtained when cowpea sown 2 weeks after sowing maize (2 WAS). It was observed that cowpea sown 2 weeks after sowing maize (2 WAS) appeared the best treatment among others, therefore recommended for adoption by farmers in Jalingo and its environment.

Keywords: Date, Planting, Maize, Cowpea and Intercrop.

Introduction

Cowpea (*Vigna unguiculata* (L) Walp) is an annual, drought and warm-weathered crop, requiring a rainfall of 500-1200mm per year and soil temperature of 21^0-30^0C for excellent germination and growth (Abiodun, 1998). It performs in most soils with more than 85% sand, less than 0.2% organic matter and low levels of phosphorus. It is a shade tolerant crop and is compatible as an intercrop with the maize, millet, sugarcane and cotton as well as several plantation crops (Anon, 2008). It is used as pulse, a fodder and green manure crops. Being rich in protein and containing many other nutrients, it is known as vegetable meat. On dry matter weight basis cowpea grains contain 23.4% protein, 1.8% fat and 60.3% carbohydrates. It is also rich in source of calcium and iron. It is used for both human consumption and as a concentrate feed for livestock (Chhidda *et al*., 2006a). Studies by Philips and Blaster, *et al*. (2007) showed that more than 80% of Nigerians consumed cowpea in one form or the other every day.

Maize (*Zea mays* L.*)* is one of the most important cereal crops in the world of agricultural economy both as food for human and feeds for animals. It is a miracle crop. It has a very high yield potential, there is no cereal crop on the earth which has so immense potentiality than maize and that is why it is called 'queen of cereals'. It ranks below wheat and rice but considerably above rice in nutrition. Maize grain contains about 10% protein, 4% oil 70% carbohydrate, 2.3% crude fiber, 10.4% albumin ides, 1.4% ash. Maize grain also has significant qualities of vitamin A, nicotinic acid and riboflavin and vitamin E but low calcium, fairly high phosphorus (Chhidda, *et al*., 2006b). Intercropping is the practice of growing two or more crops in proximity crops (Wikipedia, 2014), intercropping of legumes and cereals is an old practice in tropical agriculture that dates back to an ancient time civilization. The main objective of intercropping has been to maximize use of resources such as space, light, and nutrients (Li, *et al* 2003a) as well as improve crop quality and quantity (Mpairwe, *et al*., 2002; Moreira, 1989). Olukosi, *et al* (1991) reported that growing crops in a mixture is a common feature of growing crops in Nigerian Savannah and on the average 60-70% of crop lands are devoted to growing crop in mixture but it is not uncommon to see combination of cereal/legume. Most studies on intercropping have focused on resource utilization, including water (Snaydon and Harris, 1981; Sheckle and Hall (1984), light (Donald, 1985 and nutrients Li, *et al* 2003b) resulting in substantial yield advantage compared with sole cropping. research or information on the appropriate time to introduce legume into cereal (cowpea/maize) is either lacking or scarce. This experiment was therefore designed to determine the suitable time to introduce cowpea into maize such that productivity of both crops used will improved drastically.

Materials and Method

The study area

The study was conducted at the Crop Science Department research farm of the Taraba State College of Agriculture Jalingo during the 2006 cropping season. Jalingo is a City in North-Eastern Nigeria which lies at latitude: 8’ 9, Longitude: 11’3667 111 N 8 54’ 0”, E 11 22’ 0” of the Greenwich meridian, and it has a. Sandy-loamy type of soils (Anon, 2017).

Field experimental procedure

The experiment was a combination of cowpea intercropped with maize sown at four sowing dates: cowpea sown simultaneously on the same day with maize (0 WAS), cowpea sown 1week after sowing maize (1 WAS), cowpea sown 2 weeks after sowing maize (2 WAS) and cowpea sown 3 weeks after sowing maize (3 WAS), arranged in a Randomized Complete Block Design (RCBD) replicated three times. Maize variety ACR-95 DT collected from Taraba State Agricultural Development Program (TSADP) and cowpea variety locally known as ‘Yar-Malasia’ spreading type collected from Jalingo main market were used for this trial. The experimental field was prepared manually. Twelve (12) plots were constructed, each measured 3 * 2 m (6^2 m) with 1 m work space both between plots and replications. First set of sowing was done with both cowpea and maize simultaneously sown on 4th June, 2006. Each crop variety sown on separate row, cowpea was sown at a distance of 65 * 65 cm and 40 *40 cm between crop stand/row with 2 seeds per stand. On the other hand, maize was sown at a spacing of 45 *45 cm crop stand and 40 * 40 cm between crop rows with 2 seeds per hole at the depth of 3 cm in each crop accordingly. The same pattern of sowing was adopted for 1, 2 and 3 WAS (on 11th, 18th, and 25th June, 2006) accordingly. Basal application of fertilizer (NPK 15:15:15) foe maize crop was done 3 weeks after sowing at the rate of 200 kg/ha, this followed by the application of urea as side dressing at the rate of 100kg/ha at 6 weeks after sowing.

Data collection

Data taken included: plant height, number of branches per plot, days to 50% flowering, number of pods per plant, 100 seeds weight per plot and grand weight per plot. Five (5) seedlings were randomly selected from the center of each plot, tagged, and data collected regularly at 15 days’ interval. Weight of 100 seeds per plot was determined after harvesting and processing the output of each plot separately by randomly selecting 100 grains weight measured using electrical weighing balance and recorded. In order to obtain the grand weight per plot, total output of each sub plot merged together with the 100 grains in each case, measured, result properly taken and recorded.

Data Analysis
Data collected from the farm were analyzed using the Analysis of Variance (ANOVA). Means were separated using the Least Significant Difference (LSD) at 5% probability level.

Results and Discussion
Growth parameter
Table 1 showed the effect of time of sowing cowpea intercropped with maize on plant height and number of branches per plant of cowpea at 0, 1, 2, and 3 WAS respectively. The result showed that time of time of sowing had no significant (P≥ 0.05) effect on the plant height. However, slight differences among treatment levels observed where the highest length of 29cm recorded at 2 WAS while the lowest mean values (24cm) obtained at 0 WAS accordingly. Meanwhile, variation in the time of sowing had significantly affected (P≤ 0.05) number of branches per plant which led to the production of greatest number of 6 branches per plant on average basis also generated from 2 WAS whereas the total number of 4.3 branches being the least recorded at 0 WAS.

Table 1: Effect of time of sowing on the growth of cowpea intercropped with maize:

Treatments	Plant height(cm)	Number of branches/plot
0 WAS,	24	4.3^b
1WAS,	27	4.7^b
2WAS	29	6.0a
3 WAS	28	5.7^a
LSD	-	0.98
Significance	NS	*
CV	8.9	10.2

NB=WAS= means week(s) after sowing maize, ** =highly significance and * =significance

In their earlier study by Hamd, et al (2014) reported significant increase of plant height (127.68) and 12.14 number of branches per plant in maize cowpea intercrop. This remarkable performance might not be unconnected to the agronomic advantages of introducing legume (cowpea) being a nitrogen fixing crop in to cereal (maize) which high amount of NPK thereby creating enabling environment for the crops. FAO, (2003) Stated that intercropping increases the efficiency of land use, enhancing the capture and use of light, water and nutrients, controlling weeds, insects, diseases and increasing the length of production cycle. Similarly, Terao *et al*, (1997) observed that light in the early stages of development will influenced branching patterns, which in turns determine the source and sink of the plant. Similarly,

Yield parameters
Table 2 presents the results for the effect of time of sowing cowpea intercropped with maize, the findings showed that number of pods per plant, 100 seeds weight, grand weight per plot and days to 50% flowering were significantly affected (P≤0.05) by time of sowing. Days to 50% flowering which resulted to the record of 63.3 and 65.3 as the minimum and maximum days for cowpea to reach 50% flowering generated from treatment 2 and 3 WAS respectively. Significant differences (P≤0.05) also was observed in the number of pods per plant with 2 WAS having the greatest mean score of 101.3 pods whereas 88 pods being the least values obtained from 0 WAS accordingly. Furthermore, the highest weight (34g) of 100 seeds per plot and 3.3kg weight of grand yield per plot also recorded at 2 WAS.

Table 2: Effects of time of sowing on the yield of cowpea intercropped with maize:

Treatments	Days to 50% flowering	Number of pods per plant	100 seeds weight per plot (g)	Grand weight per plot (kg)
O WAS,	65[a]	88[c]	31[c]	2.4[d]
1 WAS,	64.3[b]	88.7[c]	32.3[b]	2.8[c]
2 WAS,	63.3[c]	101.3[a]	34[a]	3.3[a]
3 WAS,	65.3[a]	96[b]	32.3[b]	3.1[b]
LSD	0.69	5.3	1.27	0.2
Significance	*	*	**	**
CV	0.6	3.7	1.2	0.2

This performance might not be unconnected to the benefits of introducing cowpea after sowing maize. The earlier studies of Blade *et al*. (1993) revealed that, later planting of cowpea may reduce the competition with cereal to ensure that the high priority cereal yield are not reduce, cowpea is also able to take an advantage of late season residual moisture and additional light which influence both growth and biomass production. OMAFRA (2014) pointed out that delayed planting may reduce the vegetative growth period resulting to produce shorter plants thereby reducing the total number of pods per plant because of the shorter flowering period.
This implies that intercropping cowpea with maize had a greater influence on the yield of cowpea especially when sowing of cowpea is done 2 WA as it was revealed in this experiment. Studies on cowpea/millet by N'tare (1990); N'tare and Williams (1992) and N'tare *et al*. (1993) showed that the yield of intercropped cowpea depends on planting time of cowpea relative to millet. This was further confirmed by Chhidda*et al*. (2006) who stated that any marked delay in sowing cowpea is likely to result in low yield, but Blade *et al*. (1992) having conducted a research on millet/cowpea viewed it from different angle that delaying cowpea planting by 2-3 weeks resulted in cowpea grain yield reduction of over 50% in comparison to simultaneous millet/cowpea plants. However, simultaneous millet/cowpea plant reduced grain yield (715kg/ha), in comparison to 940kg/ha when cowpea was planted 3 weeks after millet. Henceforth, the highest weight of cowpea recorded is an indication of suitability of crops involved in the intercrop which might have resulted possibly because the mixture was subjected to less competition during flowering, podding.

Conclusion

Delayed time of sowing cowpea in to maize for 2 weeks had significantly ($P \leq 0.05$) the production of more branches of cowpea since it stayed only for a brief period of time with maize, thus able to made efficient utilization of the available resources in the soil. Evidence of this tremendous achievement portrayed by all the yield parameters used as delayed sowing of cowpea for 2 weeks after significantly ($P \leq 0.05$) affected Days to 50% flowering, number of pods per plant, 100 seeds weight and grand weight per plot over simultaneous sowing of cowpea with maize as lowest performance of obtained from it. This research therefore, recommends sowing of cowpea 2 weeks after sowing maize as the most appropriate time for intercropping cowpea with maize in Jalingo area of Adamawa state.

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COMPARATIVE YIELD PERFORMANCE OF MILLET (SOSAT) BEFORE AND AFTER ADOPTION OF SG 2000 TECHNOLOGIES IN JIGAWA STATE, NIGERIA

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Abstract
This study was carried out to compare the yields performance before and after adoption of SG, 2000 Millet (SOSAT) production technologies among farmers in Jigawa state, Nigeria. To draw out the respondents for this study, a multi - stage sampling technique were used. In the first stage, 4 zones of the Jigawa Agricultural and Rural Development Authority (JARDA) were purposively selected namely; Birninkudu zone, Gumel zone, Hadejia zone, and Kazaure zone. At the second stage, 2 LGA$_S$ were randomly selected from each zone. Birninkudu and Dutse, from Birninkudu zone, Gumel and Garki, from Gumel zone, Hadejia and Kafin- Hausa, from Hadejia zone, Kazaure and Roni from Kazaure zone. This gave 8 LGA$_S$ and at the third stage, 20 respondents were randomly selected from each LGA from a list of SG, 2000 participating farmers in each of the selected LGA, provided by the Jigawa Agricultural and Rural Development Authority (JARDA) head - quarters totaling 160 respondents for this study. Data were analyzed using descriptive statistics and t-test analysis. The result revealed that 81.25% of the respondents were married and 100% attained one form of education or the other. Majority (98.8%) were males, average age range was 31-50years (63.8%), household size of 1-20 persons (78.5%) and farming experience of 5-20 years (81.1%). The result also shows that 89.37% of the respondents had access to extension agents. T-test of yield before and after adoption indicated significant difference in yield ($p < 0.001$). It is therefore recommended that: To enhance adoption of SOSAT millet production SG, 2000 technologies in order to reach more farmers in the study area. Extension agents should intensify their effort in disseminating SG, 2000 production technologies on SOSAT millet in Jigawa state.

Keywords: Comparative, Analysis, Yield, SG, 2000 and SOSAT

Introduction

Agriculture plays a vital role in meeting the food and fibre needs of Nigeria's growing population, contributing about 41.5% to the nation's Gross Domestic Product (GDP), Food and Agricultural Organization (FAO, 2009). Agriculture also provides about 70% employment of the labour force although about 70% of Nigerians live below the poverty line. Nigeria is a country with a population of over 140 million people, and is the most populous black nation in the world. To bring about rapid agricultural growth, the country has since independence in 1960, embarked on various projects and programmes in agriculture and rural development, including agricultural extension. Therefore, existing low levels of productivity and low use of modern farming practices hinder efforts to achieve progress in this direction. Various efforts by non-governmental organizations (NGOs) have been made to raise agricultural productivity by providing farmers with better production technologies. A prominent example has been the Sasakawa Global 2000 (SG 2000) agricultural programme which featured a strong extension component directed at dissemination of improved technologies to small - scale producers and the improvement of farmer practices (Langyintuo, 2004, Garba,2014 and Garba et al,2015).

SG 2000 is an example of the donor organization in Nigeria. SG 2000 is a non-profit organization established to develop programmes for technology demonstration in various African countries in cooperation with national extension services (Dowswell and Russel, 1991[a]). Since 1986, SG 2000 has helped African farmers to improve their livelihoods through better farming practices. The programme is aimed at increasing and improving Agricultural production in Africa. It focuses on the production of wheat, rice, millet (SOSAT), sesame, cowpea, maize (QPM), groundnut and addressing conservative tillage.

The SG 2000 programme is based on the principle that agricultural development cannot be achieved unless farmers have greater access to science-based knowledge and technology, namely, improved varieties, chemical fertilizers, crop protection products, and improved crop management practices (Dowswell and Russel, 1991[a]). The main features of SG 2000 programme are as follows; close collaboration with partner country's Ministry of Agriculture, Direct farmer participation in technology transfer, and promotion of agricultural intensification with appropriate financially viable technology.

Historically, SG 2000, started in Nigeria in March, 1992, aimed at improving agricultural productivity and food marketing. It involves states and federal agencies. It operates in six states in Northern Nigeria, of Kano, Kaduna, Jigawa, Katsina, Bauchi and Gombe states (Idi, 2002). This study was aimed at comparing the yield performance before and after adoption of SG, 2000 Millet (SOSAT) production technologies among farmers in Jigawa State, Nigeria.

The study area

Jigawa state is one of the 36 States that constitute the Federal Republic of Nigeria. It is situated in the north-western part of the country between latitude 11.00^0 N, to 13.00^0N and longitudes 8.00^0E to 10.15^0 E. Kano State and Katsina State border Jigawa to the west, Bauchi State to the east and Yobe State to the north east. To the north, Jigawa shares border an international border with Zinder in the Republic of Niger, which is a unique opportunity for cross-border trading activities (JARDA, 2005). The state had a population of 4,348,649 persons (National Population Commission, 2006). It has a land area of approximately 22,210 km^2 or about 2.2 million hectares. Most part of the state lies within the Sudan vegetation zone. On some parts of the southern boundaries, some traces of Guinea Savannah exist. The rainfall is higher in the southern part of the state. Jigawa has an average of about 700mm annual rainfall, (JARDA, 2005). The rainy season periods lasts between May to October in the south and in the north, it lasts from June to September (Garba *et al.*, 2011).

The state is considered to be agrarian as more than 90 percent of the working adults engage in agriculture as a means of livelihood (JARDA, 2005). Popular rain fed food crops are millet, sorghum, beans and rice. Crop production during the rainy season is mainly for subsistence with farmers averagely cultivating about 2.5 hectares (Ado, 2012). Major cash crops include: sesame, cowpea, groundnut, Bambara nuts, pepper, bitter melon, and water melon (JARDA, 2005). Livestock such as cattle, sheep, goats, poultry and donkeys are very common in the state.

Millet varieties grown in the state are; SOSAT, Ztiiv, Zango, Lake chad, Ex- borno and late millet (maiwa).

Sampling technique and sample size

Jigawa State is made up of 27 Local Government Areas (LGA_S) which are grouped into four agricultural zones. To draw out the respondents for this study, a multi - stage sampling technique were used. In the first stage, 4 zones of the Jigawa Agricultural and Rural Development Authority (JARDA) were purposively selected namely; Birninkudu zone, Gumel zone, Hadejia zone, and Kazaure zone. At the second stage, 2 LGA_S were randomly selected from each zone. Birninkudu and Dutse, from Birninkudu zone, Gumel and Garki, from Gumel zone, Hadejia and Kafin-Hausa, from Hadejia zone, Kazaure and Roni from Kazaure zone. This gave 8 LGA_S and at the third stage, 20 respondents were randomly selected from each LGA from a list of SG, 2000 participating farmers in each of the selected LGA, provided by the Jigawa Agricultural and Rural Development Authority (JARDA) head - quarters totaling 160 respondents for this study.

Data collection method
Data were collected primarily from the respondents. From the primary source, information collected was through the use of structured questionnaires, administered to the respondents. The secondary source of data were journals, published books, articles, magazines, seminar papers and newsletters.

Analytical technique
The data were analyzed using both descriptive inferential statistics. The descriptive statistics was used include frequency and percentages, on the other hand inferential statistics, student t-test were used.

Results and discussion
The result in table 1 showed that most 98.75% of the respondents were male. This is similar with the result of Yakubu (2010) who reported that, majority of his respondents in Jigawa state who adopted Purdue improved cowpea storage technology were male. The implication is that process of Millet (SOSAT) SG 2000 production technology adoption, male farmers should be first targeted in Jigawa state as first contact group. The result also revealed that 63.75% of the respondents were within the age bracket of (31-50) years. This implies that Millet (SOSAT) farmers in Jigawa state were at their active and most productive stage in life and has a high risk bearing ability. Yakubu (2010) reported that compared with younger farmers, the probability of adopting new technology was lower among older farmers, because of their shorter planning horizons. Similarly, Usman (2009) stated that people with age bracket of (30-50 years) were more able and willing to take risk in expectation of profit than older farmers (above 50 years) who were risk aversive. The result also, shows that 58.49% of the respondent had between 5-20 years of farming experience. Also, 81.25% of his respondents were married where as 15.62% were single and 3.12% were divorced. This is similar with the result of Yakubu (2010) who reported that (95.9%) of the respondents were married. The result also shows that majority (78.48%) had between 1-20 family members; also, 68.75% of the respondents were small scale farmers, having farm sizes of between 0.5-4.00 ha. Therefore, based on these findings the bulk of the farming activities in the study area are carried out by small holder farmers. This means the SG 2000 millet development programmes should be targeted at this group.

The result in table 2 showed that most, 88.75% of the Millet (SOSAT) Farmers in Jigawa state do not use the recommended varieties and planting spacing in millet (SOSAT) production, only 11.25% of the respondents used the recommended varieties and planting spacing in millet (SOSAT) production. This reveals that most of millet (SOSAT) farmers in the study area do not adopted the recommended technology of SG 2000.

Table 3 showed the result of the t-test for yields of millet (SOSAT) before and after adoption of SG, 2000 production technologies. Majority (97.5%) of the respondents before adoption of the technology had yield of between 1-10 bags of millet, 1.9% of the respondents had yields ranging from 11-20 bags of millet while the rest 0.6% of the respondents had yield ranging from 21-30 bags. The mean yields was 4.59 bags, variance (S_1^2) was 11.31 and standard deviation (SD_1) was 3.36. The mean yield before adoption was 4.59 bags when compared with mean yield after adoption (7.63), showing that there was a difference of 3.04 bags. This implies that when the farmers subjected their land to good SG, 2000 for millet SOSAT production technologies, the productivity will increase. The result further disclosed that 75% of the respondents after adoption got yield of 1-10 bags, followed by those who got yields ranging from 11-20 bags representing 21.9% of the respondents. The mean yield was 7.63 bags, variance (S_2^2) was 23.08 and standard deviation (SD_2) was 4.8 standard error of the difference (SED) was 0.464.

From the average yield farmers after adoption of SG, 2000 extension technologies on millet (SOSAT) production when compared to the mean yield before adoption, there was a difference of 3.04 bags. This implies that with the adoption of SG, 2000 millet (SOSAT) production technology there was a significant yield increase. Result of the student t-test for yield before and after adoption indicated that t-calculated was 6.53 which is greater than t-tabulated indicating a significant difference ($p \leq 0.001$).

Conclusion and recommendation

Findings revealed that there was an increase in yield when the farmers used and adopted the recommended varieties and planting spacing. However, both small and large - scale farmers easily adopted SG 2000 millet (SOSAT) production technology in the study area. Though the participating farmers were not fully encouraged by the extension agents in the area of inputs supply more especially fertilizer and agrochemicals while non-participating farmers complain that they were not carried along since from the initial stage or take up of the programme. Therefore, SG, 2000 is a promising rural development strategy through agriculture there is the need to carry all categories of farmers along from the planning to final stage to encourage participation of farmers in the development planning. However, it recommended that government should employ more Extension agents and trained to intensify efforts in disseminating SG 2000 production technologies on SOSAT millet. Similarly, the use of herbicides and improved millet should be encouraged to promote food security.

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

A. Gender	**Frequency**	**Percentage**
Male	158	98.7
Female	02	1.2
Total	**160**	**100**
B. Age (years)		
< 20	16	10.0
21-30	22	13.7
31-40	54	33.7
41-50	48	30.0
51 and above	20	12.5
Total	**160**	**100**
C. Marital Status		
Married	130	81.2
Single	25	15.6
Divorced	5	3.2
Total	**160**	**100**
E. Household Size		
Less than10	71	44.9
10-20	53	33.5
21-30	24	15.2
31 and above	12	7.5
Total	**160**	**100**
F. Farming Experience		
Less than 5 years	16	10.0
5-10 years	49	30.8
11-20 years	44	27.6
21-30 years	36	22.6
31 and above	15	9.3
Total	**160**	**100**
G. Educational Level		
Qur'anic school	69	43.6
Adult literacy	29	18.3
Primary school	11	6.8
Junior secondary school	10	6.3
Senior Secondary school	10	6.3
Tertiary education	31	19.6
Total	**160**	**100**
H. Farm size (ha)		
Less than 5	110	68.7
5-10	28	17.5
11 – and above	22	13.7
Total	**160**	**100**

Table 2: Distribution of the respondents according to use of recommended SOSAT varieties / planting spacing

Index	**Frequency**	**Percentage**
Do not adopt the recommended technology	142	88.8
Adopt the recommended technology	18	11.2
Total	**160**	**100**

Table 3: Yield of respondents before and after adoption of SG 2000 production technology on SOSAT millet.

Yield in bags	Frequency before adoption	Class mid-point	FX	%	Frequency After Adoption	%	FX	t value
1-10	156	5.5	858	97.5	120	75	660	6.53*
11-20	3	15.5	46.5	1.9	35	21.9	542.5	
21-30	1	25.5	25.5	0.6	4	2.5	102	
31-40	-	35.5	-	-	1	0.6	35.5	
TOTAL	160		930	100	160	100	1340	

Source: Field survey,2014

$\overline{X}_1 = 4.59$ $\overline{X}_2 = 7.63$

$S_1^2 = 11.31$ $S_2^2 = 23.08$

$SD_1 = 3.36$ $SD_2 = 4.80$

SED = 0.464

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COST AND RETURNS ANALYSIS OF MAIZE MARKETING IN GOMBE METROPOLIS, NIGERIA

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Abstract
The study examined costs and returns of maize wholesaling in Gombe metropolis, Nigeria. Using questionnaire, primary data were collected from 120 randomly sampled wholesalers and the data were analyzed using descriptive statistics, correlation and net farm income analyses. Results showed that 99.1%, 98.2% and 65.4% of sampled traders were male, married and had farming as secondary occupation respectively. Similarly, their average age, marketing experience, household size and capital level were 39.5 years, 12.6 years, 9 persons and ₦ 422,500.00 respectively. Further, it was found that respondents' socioeconomic characteristics were significantly correlated with one another except between education and capital level. Furthermore, the marketing margin, net income and return per each Naira invested were found to be ₦503.84, ₦227.00 per 100 Kg and 0.06 respectively, while the efficiency value was 181.99%. Finally, while maize marketing in the study area was found to be profitable and efficient, there is need for further improvement, such as in the area of traders' education.

Key words: Maize, costs and returns, marketing margin, net income, Gombe.

Introduction

Maize is a staple food of great importance in the sub-Saharan Africa. It is one of the most important crops in Nigeria and its dual role of feeding a fast-growing population and supporting a potentially buoyant agricultural industrialization is well recognized (Awotide and Ajala, 2007; Awotide *et al.*, 2008). In Nigeria, it is not only a major cereal crop but is regarded as one of the major staples (Ojo, 2000a; and Ojo, 2000b). Maize which is being cultivated in both the forest and savannah zones of Nigeria has been in the diet of Nigerians for centuries. It started as a subsistence crop and has gradually become a commercial crop on which many agro-based industries depend for raw materials (Iken and Amusa, 2004). Owing to the suitability of the northern guinea savannah of Nigeria, there has been expansion in the production of maize and its uses are equally increasing (Odojoma, 1990; Awotide and Ajala, 2007), where it is consumed in one form or the other throughout the country (Yusuf *et al.*, 2006). Nwanna (2009) observed that though maize's contribution to Nigeria's Gross Domestic Product (GDP) was low, its average annual production was 7.1 million tons. Globally, maize is the third most important cereal grain after wheat and rice, providing nutrients for humans and animals and serving as a basic raw material for the production of starch, alcoholic beverages, food sweeteners and more recently bio-fuel (FAO, 1992; Okoruwa, 1992; Alabi and Adebayo, 2008)).

The main thrust of Nigeria's agricultural trade policy is to, among other things; stimulate growth through remunerative prices to farmers and at the same time protecting consumers' interest. Verily, this can be achieved through, among other things, investigating the operation of farm produce marketing (Musa, 2003). This is because if prices of commodities are too low, farmers would be discouraged from production, and consumers from consumption if reverse is the case.

The objectives of the study were to identify the socioeconomic characteristics of maize wholesalers in the study area, examine the profitability and efficiency of maize wholesaling in the area. The study will increase the volume of reference material to the existing literature in the field for producers, marketers, researchers and policy makers. The findings of the study will provide new challenges and / or prospects in the field of food grains marketing and distribution in Nigeria.

Methodology

The Study Area

Gombe is located in the Northern Guinea Savannah agro-ecological zone of Nigeria within Latitude 9^0 30' and 12^o 30' North of the Equator and Longitude 8^0 45' and 11^0 45' East of Greenwich meridian (Gombe State Government, 2009). It occupies a total land area of 20,265 square kilometers (Mohammed *et al.*, 2005) and has a population of 261,536 people (NPC, 2006). The area experiences distinct wet and dry seasons. Gombe metropolis has a rainfall distribution which ranges from 970.7 mm to 1,142mm annually, with a mean of 1,009.4mm. The rain falls from month of April to October. It has mean maximum and minimum temperature of 32.8^0C and 18.3^0C respectively. The coldest months are from November to January while March – May are the hottest (Gombe State Government, 2009).

The popular Gombe grains market is where a variety of tons of assorted cereals are marketed and transported to different parts of the country in their raw forms (Mohammed *et al.*, 2005). The Gombe grains market receives its grains supply from far and nearby smaller and weekly village markets. Other grains brought to the market apart from maize include millet, sorghum, rice, cowpea, ground nut etc.

Sampling procedure

Simple random sampling technique was employed to select maize wholesalers on the ground that the researcher wanted to give all wholesalers an equal chance and opportunity of being selected as reported by Ladele (2004). This, in turn, gives an opportunity for broad generalization of the outcome of the research. A sample is a subset of a population that shares the same characteristics as the population," opined Runyon *et al.* (1996); while a sample size refers to the number of units selected out of the population that an investigator determines to use in a study (Ladele, 2004). To this end, ten traders each engaged in maize wholesaling were selected each month using a list of wholesalers collected from the traders' association in the area and table of random numbers. Thus, this makes 12 field-visits leading to a total of 120 interviews for the study.

Method of Data Collection

Using prepared questionnaire, an interview schedule technique was employed in eliciting relevant information. Interview or recording schedule refers to a situation in which an interviewer asks questions and records the answers (Awolola, 2004). Data were collected once each month for a period of twelve calendar months and during each visit, 10 wholesalers were randomly sampled for an interview. The data included information on traders' socio-economic characteristics such as age, gender, other occupations, highest educational attainment and household size. According to Nasiru *et al.* (2005), socio-economic characteristics of respondents play a vital role in shaping the level of their activities. Sani (2000) reported that age is an invaluable consideration in decision-making as it affects risk bearing and availability of family labour. Further, Haruna *et al.* (2002) and Abdu (2006) opined that old age is aversive to risk bearing and limits availability of human labor. Similarly, Murtala *et al.* (2004) stressed that household size is an important factor that affects the entire life of an individual especially his decision-making. In their contribution, Asumugha *et al.* (2000) observed that the larger the family size the lesser the expenditure on hired labour. Other forms of collected data were information relating to marketing costs and prices of maize in the study area.

Method of Data Analyses

Descriptive statistics

Descriptive statistics such as percentage, mean, standard error of the mean and frequency distribution were used to describe the socio-economic characteristics of the respondents. According to Salvatore (1982), descriptive summarizes a body of data with one or two pieces of information that characterize the whole data. It deals with describing a sample without making any generalization. Frequency distribution breaks up a data into groups or classes and shows the number of observations in each class. In their contributions, Adamu and Johnson (1997) stated that, frequency distribution is the tabulation of a given collection of data in an order with frequency attached to each value or group of values. Another descriptive tool employed was standard error of the mean.

Correlation analysis

Correlation analysis was used in the study to determine the relationships existing among selected socio-economic characteristics of the respondents such as age, household size and length of marketing experience. Others were capital level and years of formal educational. The model as used in the study is given by the formula:

$$r_{xy} = \frac{\sum x_i y_i}{\sqrt{\sum x_i^2}\sqrt{\sum y_i^2}}$$

$$where: \qquad (1)$$

$$r_{xy} = correlatio \quad ncoefficie \quad nt$$

$$x_i = X_i - \overline{X}_i$$

$$y_i = Y_i - \overline{Y}$$

The correlation co-efficient is a measure of the degree of co-variability of the variables X and Y. The values that correlation coefficient may assume vary from -1 to +1. Thus:

- When r is positive, X and Y increase or decrease together i.e. positive correlation.
- When r = +1, it implies perfect positive correlation between X and Y
- when r is negative, X and Y move in opposite directions i.e. inverse correlation
- when r = -1, there exists a perfect inverse correlation between X and Y (Koutsoyiannis, 2006).

Marketing margin

Marketing margin, according to Kohls (1985), Musa, (2003), Olukosi *et al.* (2005) and Murtala, (2009), is the difference in price paid for a commodity at different stages of time, form, place and possession as the commodity moves from the primary producer to the ultimate consumer. The marketing margin model, as used in this study is expressed as:

$$\text{Marketing margin} = \frac{S \quad P - S \quad P}{S \quad P} \text{ X } 100$$

Mm = Sp – Pp (2)

Where:
Mm = Marketing margin of 100 Kg of maize
Sp = Average selling price of 100 Kg maize
Pp = Average purchase price of 100 Kg maize

Based on the model, as was also applied by Ekunwe *et al.* (2008), it follows that traders' margin equals traders' selling price per unit minus trades' purchase price per unit. This also represents the opinion of Awotide and Ajala (2007).

Net income

This refers to the average net returns in Naira accruing to a trader for a 100 Kg bag of maize grains traded. The net income model as used in this study is expressed as:

NI = Sp – (Pp + Mc)...............................(3)

Where:
NI = Average net income for 100 Kg bag of maize grains traded
Sp = Average selling price for 100 Kg bag of maize grains traded
Pp = Average purchase price for 100 Kg bag of maize grains traded
Mc = Average marketing cost for 100 Kg bag of maize grains traded

Similarly, the net income or profit accruing to the trader is the difference between the marketing margin and the marketing cost (Awotide and Ajala, 2007).
The economic decision rule is that if: NI > 0,
Then the enterprise was profitable and worth undertaking, otherwise not. Contrastingly, if: NI < 0,
Then the enterprise yielded loss or negative profit otherwise not

Return on investments

This was captured as return per Naira invested and it measured the net return accruing to a trader for each ₦1 expended in the business. The model is expressed as:

RNI = NI / TC.................................. (4)

Where:
RNI = Average net return per Naira invested in maize grains marketing
NI = Average net income per Kg or net returns from sales of 100 Kg of maize grains
TC = Average total costs due to marketing 100 Kg of maize grains

The economic decision rule is that if: RNI > 0,
Then the business yielded positive rewards and hence worth undertaking; and if on the other hand, RNI < 0
Reverse was the case, ie the venture yielded negative rewards (loss) and not worth undertaking. On the other hand, if

RNI = 0

The business breaks even, meaning that no profit and no loss recorded. Thus, the model specifies that the higher the value of RNI the better the business.

Marketing efficiency

The marketing efficiency formula used was stated by Olukosi and Isitor, (1990) as:
Marketing efficiency = Value added by marketing/Marketing cost X 100
= Marketing margin/Marketing cost X 100
A value >100 is desirable otherwise not. The higher the value, the better the business.

Results and Discussion

Respondents' Selected Socio-economic Attributes

Table 1 shows that 99.1, 98.2 and 65.4 percent of the respondents were male, married and farmers respectively. The dominance of male and married traders was not unexpected since the socio-cultural living of the people of the area encourages early marriage of both sexes and also women to remain in-door in their houses to take care of children. Further, respondents with secondary, primary and adult education were represented by 32.5, 37.5 and 22.5 percent respectively while only 6.7 percent had never attended school. This implies that majority of the respondents were literate and hence would be able to cope with some challenges of their marketing businesses.

Table 1: Socio-economic Characteristics of Maize Traders in Gombe Grains Market

Variables	Frequency	Proportion (%)
Gender		
Male	114	99.1
Female	1	0.9
Marital status		
Married	112	98.2
Single	2	1.8
Educational level		
Never attend school	8	6.7
Adult education	27	22.5
Primary school	45	37.5
Secondary school	39	32.5
Tertiary institution	1	0.8
Secondary occupation		
Farming	68	65.4
Civil service	4	3.8
Others	32	30.8

Source: Field survey, 2010

Respondents' Age, Marketing Experience, Household Size and Capital

Table 2 shows that the minimum values of respondents age, marketing experience, household size and level of capital were 24 years, one year, one person and ₦10,000 respectively. The respective maximum values of these variables, on the other hand, were found to be 65 years, 40 years, 27 persons and ₦6, 000,000. Similarly, the average age, marketing experience, household size and level of capital for the respondents were 39.5 years, 12.6 years, 9 persons and ₦ 422, 500.00 respectively. Thus, it can be concluded that traders in the market were not only experienced and in their active ages but also possessed a very reasonable level of capital base, the characteristics that favour high level of success in their businesses. However, those respondents with up to 65 years of age were not likely to be very productive in their businesses because, age, according to Adesina and Kehinde (2008), is a vital determinant of an individual capacity in most endeavors such as marketing, farming and so on. This is because elderly traders / businessmen are less likely to physically perform field operations and hence more likely to rely on hired labour or depend on family labour.

Table 2: Distribution of Respondents According to Age, Marketing Experience, Household Size and Capital Level in Gombe Metropolis (n = 120)

Variable	**Minimum**	**Maximum**	**Mean**	**Standard**	
				Error	**Dev.**
Age (Years)	24.0	65.0	39.5	0.95	10.22
Marketing exp. (Years)	1.0	40.0	12.6	0.85	9.14
Household size (No.)	1.0	27.0	8.8	0.53	5.75
Capital level ('000 ₦)	10.0	6,000.0	422.5	73.00	799.60

Source: Field Survey, 2010.

Correlation between Selected Socio-economic characteristics of respondents

Table 3 depicts how the socio-economic variables of respondents correlated with one another. To this end, while respondents' age was found to be positively correlated with years of marketing experience ($p<0.001$), capital level ($p<0.01$) and household size (p<0.001), its relationships with educational attainment was negative (p<0.001). Respondents' years of marketing experience was also found to have significant positive correlation with household size (p<0.001) and capital level (p<0.01) but negative with education (p<0.001). Finally, other important significant correlations included those of household size with capital level and education. However, there was no significant correlation found between education and capital level and this did not support the *a prior* expectation that respondents educational level would be highly correlated with capital level.

Table 3: Correlation between Selected Socio-economic Variables of Respondents (n=120)

	Age	Marketing Experience	Capital Level	Educ. Level	Household Size
Age	1				
Marketing Exper.	. 693***	1			
Capital Level	.244**	.308**	1		
Education Level	-.454***	-.346***	-.023 NS	1	
Household Size	.771***	.702***	.192*	-.477***	1

* = significant at 0.05 ** = Significant at 0.01 **** = Significant at 0.001
Source: Field Survey, 2010.

Costs and Returns Analysis of Maize Marketing in Gombe Metropolis Grains Market

The results in Table 4 shows that the average purchase cost and the marketing cost of each 100 Kg bag of maize is ₦3, 464.00 and ₦276.84 respectively. This resulted to a total cost of ₦3, 740.84. Further, the purchase and the marketing costs constituted 87.30% and 6.98% of the total cost of each bag respectively. However, with an average gross income of ₦3, 967.84 per 100 Kg, the marketing margin and the net income were found to be ₦503.84 and ₦227.00 respectively. The marketing margin and the net income constituted 12.70% and 5.72% of the gross income. According to Kirimi *et al.* (2011), marketing margins should reflect the cost of moving a good from surplus to deficit areas as well as the costs of storage and processing from one stage to the next in the value chain. Hence, when a reduction in margin is observed, this could naturally follow from a reduction in the cost of transportation or transformation. Since the net income was more than zero, then maize wholesale enterprise in the area was profitable and hence worth undertaking. Similar finding was reported by Obasi *et al.* (2012) where he discovered that maize marketing in Aba Local Government Area of Nigeria was profitable.

Table 4: Marketing Margin and Income of Maize Marketing in Gombe (₦ / 100Kg)

Variable	Value (₦)	Percentage
Purchase cost	3,464.00	87.30
Marketing cost	276.84	6.98
Total cost	3,740.84	94.28
Gross income	3,967.84	100.00
Marketing margin	503.84	12.70
Net income	227.00	5.72
Efficiency (%)	181.99	-
RNI	0.06	-

Source: Field survey, 2010

According to Obasi *et al.* (2012), one of the food problems is the inefficiency of the marketing system from production to consumption for agricultural commodities in most developing economies. Analysis of maize wholesaling efficiency in the study area was thus investigated and the result showed 181.99 percent efficiency which implies that value addition through marketing was 81.99 percent more than the cost incurred in the process of the marketing. This contradicts the finding of Obasi *et al.* (2012) who discovered that maize marketing efficiency was only 117.31 percent in Aba. The lower efficiency value in Aba could be interpreted to mean an inefficient marketing system. Scarborough *et al*. (1992) noted that marketing efficiency value ranges from zero (0) to infinity. If marketing efficiency is less than 100 percent, it indicates inefficient market whereas if the marketing efficiency is greater than 100 percent there is excess profit. Finally, return per Naira invested (RNI) in the marketing process was found as 0.06 implying that for each one Naira spent, six kobo were realized as net profit. Since RNI value is greater than zero, it can be deduced that the business yielded positive rewards and hence worth undertaking.

Conclusion and Recommendations

Based on the findings of the study, it can be concluded that with respective marketing margin, net income and return per each Naira invested of ₦503.84, ₦227.00 and 0.06 per 100 Kg, maize grains wholesaling in Gombe metropolis was profitable in addition to being efficient. Finally, despite this, there is need for further improvement in the areas of shortcoming, such as in the area of traders' education.

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ANALYSIS OF ORGANIC FERTILIZER USAGE AMONG FARMERS IN ONDO STATE, NIGERIA

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Abstract
Usage of organic fertilizer can help maintain soil fertility and reduce the effect of climate change on soil. This study therefore assessed the use of organic fertilizer among farmers in Ondo State, Nigeria. Multistage sampling procedure was used to select 250 farmers and interview schedule was used to source information from the respondents. Data collected were analysed using descriptive and inferential statistics. The results show that majority (78.0%) of the respondents had formal education; and a mean of 28 ± 16.62 years of farming experience. Majority of the respondents (73.6%) had, at least, 1hectare of land. Majority (70.8%) of the respondents practised both arable farming and tree cropping and many (64.4%) of them earned about ₦300,000 annually from farming activities. The organic fertilizer types known to majority of the respondents were green manure (79.2) and mulching (69.2%). Most (95.2%) of the farmers had poor knowledge of organic fertilizer; and had low level of organic fertilizer usage (82.2%). Years of farming experience ($\beta = 0.262$) and farmers' knowledge on organic fertilizer usage ($\beta = 0.630$) had relationships with farmers' usage of organic fertilizer at $p \leq 0.01$. The study recommended that extension agents should make farmers aware of the types of organic fertilizers available in their environment and train them on how to use these organic fertilizers types effectively.

Keywords: Organic, Fertilizer, Usage, Green manure, Knowledge

Introduction

According to Miller (1995), soil plays a vital role in sustainable human welfare and assures future agricultural productivity and environmental stability. It is a dynamic, living system which supports life and keeps balance on earth (Hons *et al.*, 2013). It is the major resource that every farmer exploits every season in order to meet the increasing basic needs of the society. This same soil is expected to play a major role in solving the problem of poverty in the rural areas, since agriculture is the major occupation in many rural communities, and lead to development if properly managed. It has been realized that poverty, environmental degradation, and population growth are inextricably related and that none of these fundamental problems can be successfully addressed in isolation. It is either a complete success or a complete failure (World Commission on Environment and Development, 1986). This justifies that food security depends on finding the solution to soil degradation and ensuring that there is a balance between population growth and soil health. Sustainable food security and poverty alleviation for an ever-increasing population can therefore be achieved only when the environment, including the soil, remain healthy and balanced.

Soil has the ability to sustain its productivity indefinitely through management that often includes addition of nutrients, organic materials and water (Hons *et al.*, 2013). On cultivated lands, man plays a major role in managing the soil's productivity. His choice of management practice can improve and maintain soil productivity or have a negative effect on the soil in the form of soil degradation. Soil degradation has become a global issue in the 21st century (Eswaran *et al.*, 2001). Its impact is difficult to reverse, especially if severe, hence, early intervention in the rehabilitation of degraded soils is very important (Agbede and Ojeniyi, 2009). The avoidance of soil degradation is even more important to combat low agricultural production, food insecurity and the rapid increase in level of poverty (Ehui and Pender, 2005). Several management practices have been employed over the years to ensure sustainable soil productivity. These practices are either inorganic or organic in nature.

Organic fertilizers are nutrient sources of organic origin either natural or processed (FAO, 2010). The use of organic fertilizer in farming helps avoid and sequester Green House Gases (GHG) and return carbon to the soil (Kotschi and Müller-Samann, 2004). According to International Federation of Organic Agriculture Movements (IFOAM) (2006), Small Planet Institute (2008) and Gaynor (2009); organic fertilizer offers permanent cropping systems with sustainable productivity. It can therefore be said that organic fertilizer can ensure sustainable development by not endangering the natural systems that support life on earth but detoxifying it. Organic fertilizer plays a major role in keeping the soil healthy. According to FAO (2010), most of the organic fertilizer types in Nigeria are important primarily because of their organic matter content. The organic matter / humus supplied by organic fertilizer acts as a carrier of utilisable energy and nutrients for the soil organisms, improves soil structure and porosity, increases water-holding capacity of soils, improves aeration, reduces soil temperature fluctuations, stores nutrients in exchangeable form and provides nutrients to crops (Suzuki, 1997). Organic fertilizer, according to McCausland (2013) rejuvenates poor soils, allows excess water to drain away while leaving enough moisture for roots, and retains nutrients until feeder roots need them. This and many other functions make organic fertilizer a necessity to sustainable soil productivity.

According to Daramola *et al.* (2010), the soils in Ondo state are naturally of high agricultural value for both tree and arable crops. Many farmers migrate to the state to avail themselves of the opportunity. But over the years, in most parts of the state, the soils and natural vegetation have been very much degraded as a result of human activities, the major of which is based on the rotation of bush fallow system. As a result, the original forest is now restricted to forest reserves (Daramola *et al.*, 2010). Ogunbadewa (2012) reported that of the state’s total land area, 74.78% was intensively cultivated with annual crops and was being poorly managed thereby increasing land degradation so that farming types were unsustainable without the application of fertilizer. This trend can be effectively reversed by using organic fertilizer in rehabilitating the degraded soil in Ondo state. The state naturally possesses a vast array of organic materials that can be used to maintain the soil fertility. Also, the state has an industry that produces pure organic and organo-mineral fertilizers. But the extent to which the farmers are using these organic fertilizer types to improve soil fertility is not known. The study was therefore conducted to find out farmers’ level of organic fertilizer usage in Ondo state. The specific objectives were to identify the known organic fertilizer types in the study area; determine farmers’ level of knowledge on organic fertilizer application; and determine the level of organic fertilizer usage in the study area. The study also tested hypotheses to know whether socioeconomic characteristics were predictors of the level of organic fertilizer usage and whether the level of knowledge on organic fertilizer application was a predictor of the level of organic fertilizer usage in the study area.

Methodology

The study was conducted in Ondo State, Nigeria. A multi-stage sampling procedure was used to select respondents for the study. At the first stage, five Local Government Areas (LGAs) were proportionately selected from the two Agricultural Development Programme (ADP) zones; two LGAs were selected from the 8 LGAs in Owo Zone (25%) while 3 LGAs were selected from the 10 LGAs in Ondo Zone (25%). At the second stage, 5 farming rural communities were proportionately selected from each of the

LGAs and 10 respondents were selected from the communities using Simple Random Sampling Technique. In all, 250 farmers were selected for the study.

Relevant information regarding farmers' level of organic fertilizer usage, types of organic fertilizer known to farmers in the study area and farmers' knowledge of organic fertilizer application were collected from the farmers using interview schedule. Descriptive statistical techniques such as frequency counts, percentages, mean score and standard deviation were used to analyse the data collected. However, to determine the relationship between dependent variable and independent variables, correlation and multiple regression were used.

Results and Discussion

Socio-economic characteristics

Results in Table 1 show that 35.2% of the respondents had only primary education, 33.2% had secondary education, 22.0% had no formal education while 9.6% had post secondary education. This implies that majority (78.0%) of the respondents had formal education and were therefore literate. This finding is in contrast with the result of Akinbile and Odebode (2007) that most farmers were non-literates but supports the report of Solomon (2008) and Oyeshola and Obabire (2011) that present day farmers had formal education and so, the level of literacy among farmers was high.

The results in Table 1 also show that 43.2% of the respondents had at most 20 years of farming experience, 35.6% of the respondents had 21 to 40 years of farming experience, 20.8% had more than 40 years of farming experience. This means that more than half of the respondents (56.4%) had more than 20 years of farming experience. The mean years of farming experience was 28.32 ± 16.62 years. This is not too far from the mean years of farming experience of farmers using organic fertilizer in Bauchi which was 18 years as stated by Omotesho *et al.* (2010). The results imply that most farmers had quite an experience in farming and must have had experiences in the use of different types of practices including organic fertilizer.

Furthermore, the results show that 45.2% of the respondents had between 1 to 4 hectares (ha) of farm land, 22% had less than 1 ha, 20% had between 5 and 8 ha, while 8.4% had more than 8 ha of farm land. Majority of the respondents (73.6%) had, at least, 1hectare of land. This is in contrast with the findings of Fasina (2013) and Omotesho *et al.* (2010) that farmers had less than one hectare of land for farming in Bauchi and Oyo respectively. The mean land size cultivated by the respondents was 3 ± 2.58 hectares. This implied that the respondents had an appreciable size of farmland and a lot of organic fertilizer would be needed to fertilize the whole of such a size of farmland. Majority (70.8%) of the respondents practised both arable farming and tree cropping while 29.2% of the respondents practised only arable farming. This implies that majority of the respondents had access to more organic fertilizer types of plant origin than respondents who practised only arable farming.

Results in Table 1 further show that 35.6% earned less than ₦100,000 as income from farming, 28.8% earned between ₦100,001 and ₦300,000, 10% earned ₦300,001 to ₦600,000, while 5.6% earned more than ₦600,000 as their annual income. This implies that many (64.4%) of the respondents earned, at most, ₦300,000 annually as income from their farming activities. This supports the findings of Uwagboe *et al.* (2014) that farmers' revenue from farming activities was, at most, ₦300,000 annually but disagrees with the discovery of Adekunle *et al.* (2005) that most farmers earned more than ₦300,000 annually. The divergence might be as a result of the fact that most farmers in Katsina (study area of Adekunle *et al.*, 2005) also had livestock rearing as part of their farming activities. The mean income of the respondents was ₦254,500 ± 249,157 which translates to a monthly income of about ₦21,208.

Table 1: Distribution of respondents by economic characteristics

Variables	Frequency	Percentage	Mean	SD
Educational level				
Non literate	55	22.0		
Primary	88	35.2		
Secondary	83	33.2		
Post-secondary	24	9.6		
Farming experience (years)				
≤ 20	108	43.2	28.32	16.62
21-40	89	35.6		
≥ 41	52	20.8		
Farm size (Hectares)				
No response	11	4.4		
< 1	55	22		
1-4	113	45.2	3	2.58
5-8	50	20		
> 8	21	8.4		
Type of farming practised				
Arable	73	29.2		
Both arable and tree cropping	177	70.8		
Income (₦)				
≤ 100,000	89	35.6		
100,001-300,000	72	28.8	254,500	249,157
300,001-600,000	25	10		
≥ 600,000	14	5.6		

Source: Field Survey

Types of organic fertilizer known by the respondents

Results in Table 2 show that 79.2% of the respondents were aware that green manure was a type organic fertilizer; mulch was known to 69.2%; and poultry droppings was known to 41.6% as organic fertilizer types. Also, 37.2% were aware of cocoa pod husk as an organic fertilizer type; cow dung was known to 36.8%; and goat /sheep dung was known to 28.0%. Furthermore, 22.4% were aware that swine dung was a type of organic fertilizer; sawdust was known to 16.4% as an organic fertilizer type; 7.6% were aware of compost; 6.4% were aware that urine was an organic fertilizer type; 4.8% were aware of seaweed as organic fertilizer types; 4.8% were aware of organomineral fertilizer and bagged compost as organic fertilizer types; 3.6% were aware of blood meal; 3.6% were aware of feather meal; 3.2% were aware of ashes; while 2% were aware of horn/hoof meal as organic fertilizer types. It can therefore be inferred that the organic fertilizer types known to majority of the respondents were green manure (79.2%) and mulching (69.2%).

The study area is in a rain forest zone where vegetation (trees, shrubs, grasses) is abundant and could be viewed as one of the naturally endowed resources of the study area especially during the rainy season. This vegetation could provide materials that could be used as green manure and most of the farmers were aware of this. Mulching (ìlédân) was specifically associated with late yam planting and known as a means of protecting the yam sprout from being scorched by intense sunlight. Majority of the farmers are therefore aware of only a few of the organic fertilizer types in their environment.

Table 2: Farmers' awareness of organic fertilizer types

Organic fertilizer types*	Frequency	Percentage
Green manure	193	79.2
Mulch	173	69.2
Poultry dropping	104	41.6
Cocoa pod husk	93	37.2
Cow dung	92	36.8
Goat / sheep dung	70	28
Swine dung	56	22.4
Sawdust	41	16.4
Blood meal	23	9.2
Compost	19	7.6
Bone meal	16	6.4
Urine	16	6.4
Seaweed	12	4.8
Organo-mineral fertilizer	12	4.8
Bagged compost	12	4.8
Feather meal	9	3.6
Ashes	8	3.2
Horn / hoof meal	5	2

Note: * - Multiple responses
Source: Field Survey

Knowledge on organic fertilizer application

Knowledge of organic fertilizer application among the respondents was measured by asking questions related to application of organic fertilizer. Questions were asked to test respondents' knowledge on necessary precautions to be taken when using certain organic fertilizer types, when to apply certain organic fertilizer types and possible negative effects of wrong organic fertilizer use. The highest obtainable score was 20 and the lowest was 0. Equal interval approach was used to divide the scores and group the respondents' knowledge into poor (scores less than 7), fair (7 – 14) and good knowledge (scores above 14) categories.

Results in Table 3 show the aspects of farmers' knowledge of organic fertilizer application that were tested and the mean scores. The results show that a larger proportion of the respondents knew which parts of crops that could be used as green manure (0.74) and what stage of growth plants were more suitable for use as green manure (0.63). A fair fraction of the respondents (0.48) knew that human excrement was not appropriate as organic fertilizer for crops meant for human consumption. Also, some of the respondents knew that plant parts and old manure could be used as mulches. The farmers realized the fact that non-fibrous plant parts, if left on the soil, would decay and nourish the soil.

Furthermore, the results show that a non-significant fraction of the respondents had knowledge on the aspects relating to application of manure, compost, seaweed, urine and blood meal. This implies that most of the farmers were only knowledgeable on the aspects pertaining to organic fertilizers sourced from plant parts (except seaweed) and were not knowledgeable about issues relating to application of organic fertilizer types sourced from animal by-products and processed organic fertilizer.

Results in Figure 1 show the overall knowledge level of the respondents on organic fertilizer application. The results show that most (95.2%) of the respondents had low knowledge level while the remaining 4.8% of the respondents had fair knowledge level of organic fertilizer application. The mean knowledge score was 3.32 ± 2.12. The result implies that the respondents had poor knowledge on issues relating to organic fertilizer application. This result is close to the report given by Ajayi *et al.* (2010) that farmers in Oyo state were fairly knowledgeable about organic fertilizer but diverges from the report of Obinne *et al.* (2008), Oyesola and Obabire (2011) and Umar and Ibrahim (2011) that farmers were highly knowledgeable about organic fertilizer in Benue, Ekiti and Nasarawa states respectively.

Table 3: Tested knowledge on organic fertilizer application

Aspects of organic fertilizer application tested	Highest obtainable	Mean
Plant parts for green manuring	2	0.74
Plants' stage of growth for green manuring	1	0.63
Inappropriateness of human excrement for crops for human consumption	1	0.48
Types of mulching materials	2	0.47
Best state of mulching materials	1	0.41
Best form of manure when cultivating crops for human consumption	1	0.34
Indicators of compost maturity	3	0.14
Knowledge that manure use has guiding regulations	1	0.03
Knowledge that fresh manure poses threat to humans	1	0.02
Preparation of seaweed for application	1	0.02
Prescribed interval between application of fresh manure and crop harvesting	1	0.01
Inappropriateness of fresh urine for crops	1	0.01
Best way for storing blood meal	1	0.01
Threat of fresh manure to man	1	0.01
Threat of fresh manure to crops	1	0.01
Dilution of urine for application to crops	1	0.00
Grand	**20**	**3.32**

Source: Field Survey **Mean = 3.32 ± 2.12**

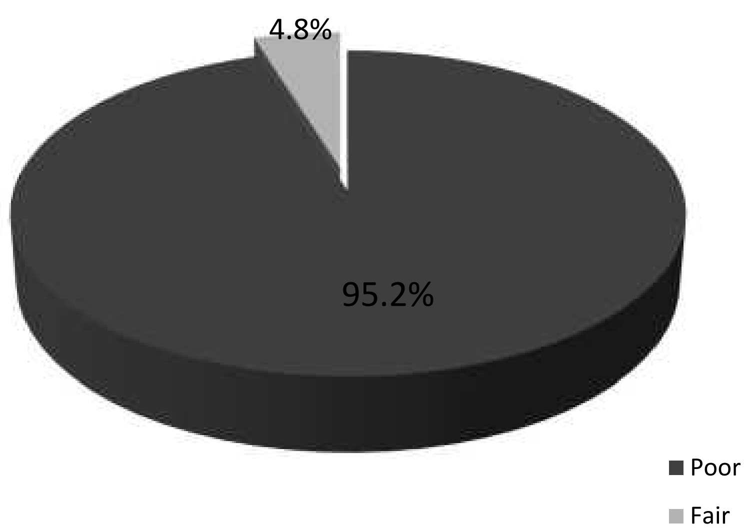

Fig. 1: Farmers' level of knowledge on organic fertilizer application

Level of organic fertilizer usage by respondents

The dependent variable was the level of organic fertilizer usage. This was measured using a usage score which was calculated following the pattern established by Ajayi *et al.* (2010). The score was gotten from the summary of the farmers' responses to selected questions relating to organic fertilizer usage. Each type of organic fertilizer used was scored 1; years of experience in using organic fertilizer were grouped into ≤10, 11-20, 21-30, 31-40, 41-50, >50years and scored 1, 2, 3, 4, 5 and 6 respectively. Frequency of use was scored: rarely -1, annually -2, twice a year -3, quarterly -4, monthly -5, fortnightly -6 and weekly -7. Also, past usage of organic fertilizer was scored 1, current usage of organic fertilizer was scored 1 and the intention to continue the use of organic fertilizer was scored 1. The maximum usage score was therefore 33 and the minimum was 4. Equal interval approach was used to group the respondents into low (4 – 13), moderate (14 – 23) and high (24 – 33) usage level categories.

The results in Table 4 show the aspects of organic fertilizer usage that were examined and the mean scores. The results show that an average farmer used organic fertilizers twice a year (2.81) and had 11 – 20 years of experience using organic fertilizer (2.26). All the farmers had used organic fertilizer before (1), most of them also are still using organic fertilizer (0.86) and intend to continue using them (0.92). The results further show that the organic fertilizer used by majority of the farmers was green manure (0.79) followed by cocoa pod husk (0.37) and mulch (0.34). This implies that only green manure was used by majority of the farmers. In practicing, green manuring, some of the farmers ploughed the plant parts into the soil while others left them on the soil after weeding. Cocoa pod husks were not used by many farmers because they were usually termite infested and were not available in sufficient quantities especially for large farm lands. Also, mulching seemed to be used exclusively for yam and since it is the practice in the study area to plant yam in cocoa farms so that the cocoa trees acted as shades for the sprouting yam seedlings, mulching was mainly used by farmers who planted dry season yam on open fields to protect the sprouting yam from being scorched by intense sunlight. Furthermore, poultry farms were not close to farm camps and keeping of free ranging animals was not a common practice in most of the farming communities in the study area since most cocoa farmers spread their cocoa beans on the floor to dry and these could be eaten or polluted by free ranging animals.

Farmers in Ondo state used their naturally endowed resources, i.e. abundant vegetation, more in their quest to improve soil fertility; hence, the use of plant originated organic fertilizers (green manure, cocoa pod husk and mulch). This finding is in consonance with the opinion of Nwaiwu *et al.* (2010) that the use of organic products as fertilizer depends on local availability and acceptance. This might be the major reason for the contrast between the most common fertilizer types used in this study area and the study area of Omotesho *et al*. (2010), Bauchi state (savanna), where cow dung was the most common organic fertilizer type used, followed by goat droppings, sheep droppings, ashes and poultry droppings.

Results in Figure 2 show the distribution of respondents based on their total organic fertilizer usage score. The results show that majority (82.2%) of the respondents had low level of organic fertilizer usage, while 16.8 per cent of the respondents had moderate level of organic fertilizer usage and the mean score was 10.44 ± 3.30. This implies that majority of the respondents (82.2%) used organic fertilizer on a low level. This is in agreement with the reports of Obinne *et al.* (2008), Ajayi *et al.* (2010), Umar and Ibrahim (2011) and Nnamonu and Ali (2013) that farmers in Benue, Oyo, Nasarawa and Benue states respectively used organic fertilizer on a low level. Also, this finding buttressed the point made by Olayide *et al.* (2011) that organic fertilizer usage level in Nigeria, as a whole, was low. This means that the low level of organic fertilizer usage was not restricted to Ondo state.

Table 4: Organic fertilizer usage among respondents

Aspects contributing to level of organic fertilizer usage	Mean score
Frequency of use	2.81
Years of usage	2.26
Ever used	1.00
Intention to continue usage	0.92
Still in usage	0.86
Green manure usage	0.79
Cocoa pod husk usage	0.37
Mulch usage	0.34
Poultry dropping usage	0.22
Cow dung usage	0.18
Goat / sheep dung usage	0.18
Sawdust usage	0.12
Swine dung usage	0.11
Compost usage	0.05
Bone meal usage	0.04
Ashes usage	0.03
Blood meal usage	0.03
Feather meal usage	0.03
Seaweed usage	0.02
Urine usage	0.02
Horn / hoof meal usage	0.02
Organo-mineral fertilizer usage	0.02
Grand mean of usage	**10.44**

Source: Field Survey

Mean = 10.44 ± 3.30

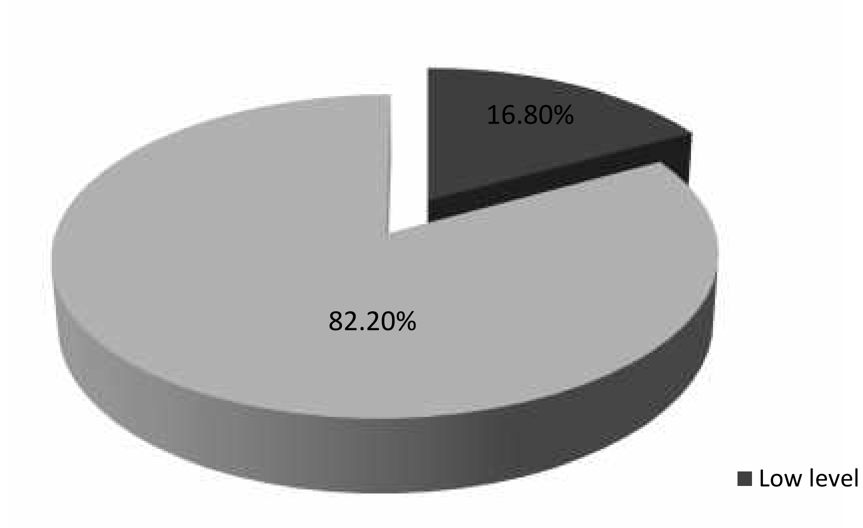

Figure 2: Distribution of respondents based on the Level of organic fertilizer usage

Testing of Hypotheses

The data collected were subjected to correlation and multiple regression in order to establish the existence of relationship between the two variables investigated and the usage of organic fertilizer in Ondo State. The results in Table 5 show that all the 4 variables correlated with organic fertilizer usage at $p \leq 0.01$. The variables were therefore subjected to multiple regression. The results in Table 6 show that two of the four variables subjected to multiple regression were found to be statistically significant predictors. These variables were years of farming experience and farmers' knowledge of organic fertilizer usage. The multiple correlation coefficient (R) value for the regression was 0.688 indicating that a strong association exists between the combination of independent variables and farmers' organic fertilizer usage, R^2 value was 0.473 and adjusted R^2 value was 0.464 which means that the regression model accounted for 46.4% variation in farmers' usage of organic fertilizer. The F-value was 54.922 and was significant at $p \leq 0.01$ which means that the variables explained by the regression model were not due to chance. The beta coefficient for the years of farming experience was 0.262 at $p \leq 0.01$; the beta coefficient for farmers' knowledge of organic fertilizer usage was 0.630 at $p \leq 0.01$. This indicated that the more the years of farming experience and the better farmers' knowledge on organic fertilizer usage, the higher the level of organic fertilizer usage and vice versa.

Table 5: Correlation result

Variable	**Correlation coefficient (r)**	**Coefficient of determination (r^2)**
Farm size**	0.175	0.0306
Income**	0.168	0.0282
Years of farming experience**	0.241	0.0581
Knowledge of organic fertilizer usage**	0.624	0.3894

** - Significant at $P \leq 0.01$ level
Source: Field Survey

Table 6: Result of multiple regression analysis

Model	**B**	**Std. Error**	**β**	**t**
(Constant)	4.949	0.439		11.268
Farm size	-0.001	0.035	-0.002	-0.035
Income	3.587E-7	0.000	0.080	1.605
Years of farming experience**	0.054	0.010	0.262	5.486
Knowledge of organic fertilizer usage**	0.225	0.017	0.630	13.376

Multiple R-value = 0.688
R^2 value = 0.473
Adjusted R^2 = 0.464
F value = 54.922 at $P \leq 0.01$
** - Significant at $P \leq 0.01$ level
Source: Field Survey

Conclusion and Recommendation

Based on the results of the study, it was concluded that farmers used organic fertilizer at a low level. With respect to their socio-economic characteristics, most farmers were formally educated, had over 20 years of farming experience, had, at least, one hectare of land for farming, and realized a mean annual income of ₦254,500. The organic fertilizer type known to majority of the respondents were green manure and mulching. Farmers' knowledge of organic fertilizer usage was poor and their level of organic fertilizer usage was low. Farmers' usage of organic fertilizer was significantly related to years of farming experience and knowledge of organic fertilizer usage.

From the findings and conclusion of this study, it is recommended that extension agents should make farmers aware of the types of organic fertilizers available in their environment and train them on how to use these organic fertilizers types.

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MARKET PERFORMANCE ALONG THE VALUE CHAIN OF RICE IN NGOKETUNJIA DIVISION OF NORTH-WEST REGION OF CAMEROON

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Abstract
This study investigated the market performance of rice value chain actors in Ngoketunjia Division of Cameroon. The objective of the study was to identify the value chain actors and to determine the market performance of the value chain actors identified. Structured questionnaire was used to collect data from 165 respondents randomly selected from the study area. The data were analyzed using value chain mapping, economic evaluation of value chain using market margin, net returns, frequency tables and percentages. The results showed that value chain actors were made up of producers, assemblers, processors, wholesalers, retailers and consumers. The results also revealed that rice marketing in the study area has two main channels. The major marketing channel had 5 value chain actors and therefore more efficient. The producers made up 51.5% of value chain actors, assemblers 10.9% and processors 20%. Estimations using Net Returns (NR) revealed that all the value chain actors were benefiting profitably from the sale of rice. The retailers were making the highest profit of 61.1 FCFA per kg ($ 0.12), the wholesalers were realizing 57.4 FCFA per Kg ($ 0.11) while the assemblers had the lowest profit of 29.6 FCFA per kg ($ 0.05). While the producers and the processors create utility of form, the wholesalers and the retailers create utility of space and time through transportation and storage. The major constraints to rice marketing in the study area were inadequate credit, low fertilizer supply, high labour cost and poor extension coverage. It was recommended that rice value chain actors should organize themselves into cooperatives to enable them obtain credit and have access to improved seeds, agro-chemicals, fertilizer, farm implements and processing equipment at subsidized rates. The government should construct farm-to-market roads to ease movement into and out of rice fields.

Keywords: Assemblers, consumers, processors, producers, Ngoketunjia division, value chain,

Introduction

Rice contributes a significant proportion of the food requirements of the Cameroonian population. Despite the huge potential and widespread interest on rice cultivation in the country, average development and farm productivity remains low (Ngome *et al*., 2015). Many authors have observed that the value of rice produced (at constant prices) increased from 1960s to the end of the 1980s. However, the increase in demand had been more than increase in production. Molua (2010) observed that the value of rice output in the 1970s was about 1.6 billion FCFA, which more than doubled to 5.4 billion in 1980, increasing to 7.3 billion in 2000. Despite all that has been done to attain self-sufficiency, Cameroon still satisfies only about 28.8% of demand via local production (Bime *et al*., 2015). The result of this is an endless importation to meet growing demand. Goufo (2008b) observed that about 400 thousand tons of rice is imported yearly, accounting for 87% of the country's needs. Despite this large shortfall, the demand-supply gap can be shortened or bridge by increasing the development and productivity of the sector.

One method that could be adopted to contribute to the productivity and development of the rice sector in the area is an improvement in rice marketing through value chain Value chain is a framework for understanding how a product moves from the producer to the customer. According to Webber and Austin (2005), the value chain perspective provides an important means to understand the business-business relationships, mechanisms for increasing efficiency, and ways to enable business to increase productivity and add value. Analysis of value chain is needed to obtain knowledge that can be applied to upgrade marketing activities. Value chain for agricultural commodities can function more efficiently when small-scale farmers develop relationships with suppliers of inputs and services with entities that market and process their output (Westlake, 2014). It identifies the set of actors and activities that bring commodities from production in the field to the end consumer, where at each stage value is added (Bidogeza, 2016). Value chain analysis extends traditional supply chain analysis by locating values at each stage of the chain. It involves processing, packaging, storage, transport and distribution. Value chain participants, can provide farmers with information, training, inputs and finance among others.

Rice production operators had been directly or indirectly involved in production, processing and marketing activities. However, these operators had not been clearly identified and characterized (in any previous study in the area). A well-functioning value chain where actors mutually support one another is capable of improving competitiveness of the entire value chain, from the time the rice leaves the farm gate until it arrives to the hands of an ultimate consumer (Bidogeza, 2016). Given the important role rice value chains play in alleviating poverty and improving nutritional status (through value addition at each stage of the chain), there is a need to objectively assess the potentials and critical bottlenecks of specific nodes in the chains to identify the strategies that will maximize the net benefits of all actors. This study aims at raising the awareness of decision-makers in Ngoketunjia Division of Cameroon on the importance of adopting a strategy for the development of the rice sector based on the value chain approach. Against this background, the paper intends to analyze the effect of economic variables on the profitability of rice marketing in Ngoketungia division of the North-West Region.

The specific objectives are to;

(i) map out the rice value chain,

(ii) identify value chain systems for rice and analyze inter-linkages among different stakeholders,

(iii) determine the profitability of value chain actors,

(iv) identify opportunities and constraints of rice value chains, and

(v) identify appropriate policy interventions.

Methodology

The study was carried out in Ngoketunjia Division of the North-West Region of Cameroon. The division is made of three sub-divisions: Ndop central, Balikumbat and Babessi subdivisions. It is located between latitude 5°37'N to 6°14'N of the equator and longitudes 10°23'E to 10°33'E with a surface area of about 17,910 km^2 (Ngome *et al.*, 2015). The area has an altitude of 1150 meters above sea level (Fonteh *et al*., 2013). The climate of the area is characterized by a dry season that starts from November to mid March and the rainy season from mid March to October. Rainfall is the sub equatorial monsoon type which varies from 1300–3000 mm annually with a mean at 2000 mm (Ngome *et al*., 2015). Rice is grown in the study area mainly on hydromorphic soils using continuous flooding methods as in most of sub-Saharan African countries. The minimum and maximum temperatures are 15.5^{0}C and 24.5^{0}C respectively, with an annual average of 21.3^{o}C. The population of the area is estimated at 128.432 inhabitants and 70% are involved in activities like agriculture (Bime *et al*., 2015). Apart from rice, other major crops cultivated in the area are: maize, tubers, and vegetables like okra, pepper, onion, tomato, carrot, and cabbage. The upper Noun Valley Development Authority (UNVDA) intervenes in rice production in the study area by offering production servicess.

Sampling Technique and Sample Size

Multi-stage sampling technique was employed in selecting the respondents for the study. In the first stage, five villages namely Bamunka, Bamali, Bangolan, Babessi and Babungo were purposively selected on the three sub-divisions that make up Ngo-ketunjia division. These areas have irrigation facilities and experienced rice production farmers. The selection of these communities was therefore based on intensive rice production activity in these villages. The Second stage involved a simple random selection of 165 respondents in the five villages using random sampling technique as indicated in Table 1. Thus, the lists of rice farmers were obtained from cooperatives. Numbers were written and place in a basket. These names were randomly picked to identify the sampled farmers.

Table 1: Distribution of Sample Size

Sub-division	Village	Sample frame	Sample size	Percentage
Ndop Central	Bamunka,	4350	97	58.78
	Bamali	150	8	4.84
Balikumbat	Bangolan,	950	20	12.13
	Babessi	980	22	13.34
Babessi	Babungo	780	18	10.91
	Total	**7210**	**165**	**100.00**

Field survey, 2016

Data Collection

Data for this study were collected from primary source with the aid of structured questionnaires designed in both open and close ended formats. The data were collected by the researcher and agricultural students trained on data collection activity. The data collected were on marketing activities, average weekly sales, prices, type of marketing services and their costs.

Analytical Techniques

Data for this study were collected and analyzed quantitatively. A qualitative analytical method involves using descriptive statistics such as frequency, mean and percentage. Marketing margin was used to compute gross margins. Market margin represents the farm-to-retail price spread. It shows payments for all assembling, processing, transporting, and retailing charges added to farm products. As given by Olukosi *et al.* (2007), marketing margin can be calculated using the following model:

$$\text{Marketing margin} = \frac{\text{Selling price} - \text{Supply price}}{\text{Selling price}} \text{ X } 100$$

Thus, using the above formula the marketing margin per value chain actor was calculated. Analysis of Net Returns (NR) aimed to assess market performance. It is expressed as:

$$N = \sum P_1 V_1 \text{-TC}$$

Where:
NR = Net Returns (FCFA);
P_1 = price of rice (FCFA/kg) per value chain actor;
V_1 = amount of rice sold by an actor in kilograms;
TC = Total costs (included cost of purchase and marketing cost) (FCFA);
FCFA = the monetary unit used in the study area ($ 1= 500 FCFA at the time of the study).

Results and Discussion

Rice value chain actors and their functions

The study has discovered that the principal actors of the rice value chain were producers (rice farmers), assemblers, processors, wholesalers, retailers and consumers. Figure 1 shows that rice marketing in the study area has two main channels. The first channel is identified as the one where major marketing functions hold, whereas in the other channel, the products were sold directly to the consumers and in some cases through other chain actors. The most important channel starts with the producers who sell to the rural assemblers in the local markets of the production areas. The rural assemblers collect the produce and sell to the wholesalers who may come from distant places to purchase the product. The assemblers also purchase in large quantity from different rural assemblers and sell in large quantities to processors. The processors (millers) after processing to different rice products sell to wholesalers (mainly from Bamenda and other big towns). The wholesalers in turn sell to retailers who mostly serve the ultimate consumers on daily basis. It is important to note that a certain proportion of the retailer's paddy go to local processors for milling before finally reaching the ultimate consumers. The minor channel is where other value chain actors sell the produce directly to consumers. This happened mostly in the production areas where rice processors purchase directly from the producers at harvest. Some studies had similar results. Katanga *et al*. (2016) in their study on cowpea marketing channel in Kiyawa, Jigawa State of Nigeria observed that there were two channels of cowpea marketing; the main channel and smaller channels. Saleh *et al*. (2015) on their study on profit and market efficiency of small-scale groundnut oil processing of two main groundnut varieties in Gombe metropolis identified five distributions. They grouped the channels into; very important channel, the important channel, the less important channel, the very less important channel and the insignificant channel based on the volume of business activity.

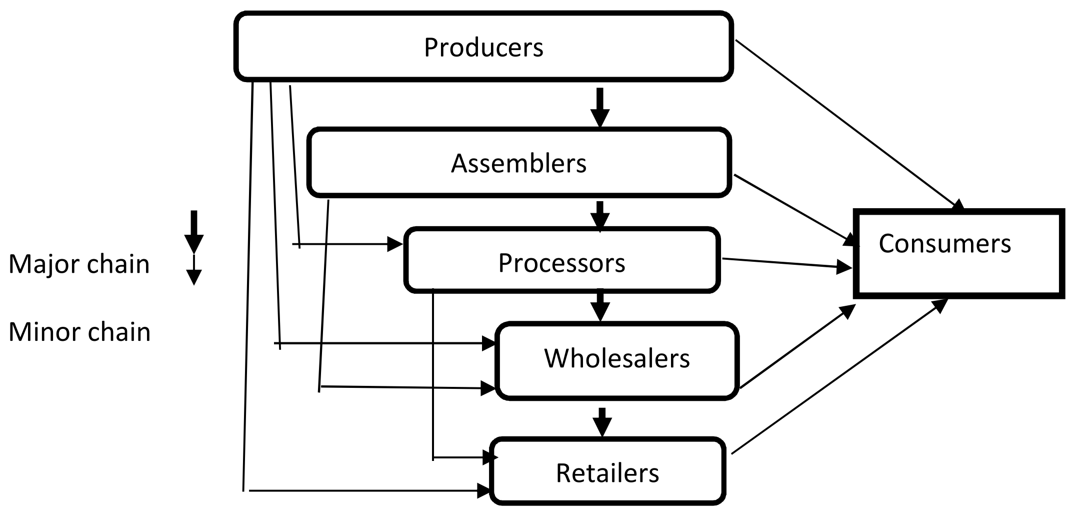

Figure 1: Rice value chain mapping

Value chain actors of rice in the study area
Value addition to agricultural products is the process of increasing the economic value and consumer appeal of an agricultural commodity. Several value chain actors were identified based on the role they performed along the value chain of rice in the study area. A total of 165 value chain actors were identified in the study area (Table 2). The results indicate that 51.5% were producers, 10.9% were assemblers, 8.5% were wholesalers, 20.0% were retailers and 9.1% were processors. The results show that producers and retailers play a greater role in creation of utility in the rice value chain more than other participants.

The producers: There were 85 households that were producing rice making 51.5% of total rice operators in the study area. About fifty-six of these respondents were in Bamunka, three of them in Bamali, ten of them in Bangolan, nine of them in Babessi and seven of them in Babungo. The high percentage value for producers shows the importance of rice production in the area. These farmers grow mainly *nerica* rice, *tainans* (T5) (Thailand rice), VARIETE 14 (V14) and *Tox* (long grain) (Chindong, 2008), certainly because of high yield. However, some farmers were growing different varieties of rice in different areas depending on the types of soil, the general access to seeds and the local habits. Paddy was stored in local storage facilities (baskets, tarpaulin, jute bags farm houses) on the farm. These facilities do not protect the paddy from rodents and moisture leading to depreciation in the value. In some cases, the need for immediate cash to pay for household’s daily expenses may compel farmers to sell their rice as paddy at the farm’s gate directly to local traders. Some areas do not have access to a milling machine that can process large quantities. According to Ian and Elepu (2014) individual farmers in most cases do not have the liquidity to pay for transportation from the farm to the mille. Some of the farmers may use the services of producers’ cooperatives. Such cooperatives provide the farmers with fertilizers, seeds, herbicides, insecticides and jute sacks. The cooperatives take care of the rice to buyers through their network of warehouses and in return receive fees from the sale. They use part of these fees to build storage facilities on farms and to provide their members with other services such as the management of their savings and credit for growing rice. Some of these groups of farmers venture into the processing of paddy locally, in spite of the challenges of this type of processing. According to Bime *et al.* (2015) paddy in the study area is affected by pre-harvest and post harvest losses and these losses ripples through factors including labor, water, seeds, time and fertilizers. Farmers favour milling before selling to increase substantial value to the commodity.

Assemblers: many assemblers were found all over the study area. About nine assemblers were found in Bamunka, one of them in Bamali, two of them in Bangolan, three of them in Babessi, and three of them in Babungo. Assemblers made up 18.9% of the total number of operators in the study area. The assemblers go around the inaccessible areas and collect paddy directly from farm gates and stores. The paddy which is collected is then bulked and sold to the wholesalers, cooperatives or the processors. They often work independently but sometimes for middlemen and/or cooperatives. Some large scale processors may offer credit facilities, input supply and transportation services. Some of the assemblers have large ware houses and may determine paddy supply to the processors.

Processors: Most of the processors are located mainly in Bamunka where eight are found, one of them are found in Bamali, two of them in Bangolan, two of them in Babessi, and two of them in Bamungo. These processors operate in marketing centres where farmers and traders meet and sell/buy paddy and/or rice. The work of the processors at the first level is limited to parboiling the paddy up to the level of milling. The second stage of processing requires more rigorous application of hygienic standards. The transformations at the second level begin with the milling of the paddy and end with sorting into different grade for packaging. In general, the processors can be classed into small, medium and large businesses. The small transformers may produce for local markets, while the large-scale transformers (like UNVDA factories) produce for local, regional and international markets. Most of the processing entrepreneurs are young men who provide milling services to smallholder rice farmers for a fee (based on the quantity milled). The quantity processed for a customer varies from one kilogram to several tons. The diffusion of milling had been a purely private sector undertaking involving the artisans, milling business owners and rice producers. Its use has been augmented by increasing production of paddy, which is receiving public sector support.

Wholesalers: About 7 wholesalers are located in Bamunka, 1 in Bamali, 2 in Bangolan, 2 in Babessi and 2 in Babungo. Wholesalers make up 8.5% of value chain operators in the study area thus constituting the lowest value chain actors. While some wholesalers can provide services to farmers such as information, training on farming practices, some grant access to loans and provide transportation to the warehouse. The wholesalers may sell directly to rural retailers located in the rural markets and trading centres. Wholesalers can regulate market prices by holding stock of rice during harvest and releasing during off season.

Retailers: The retailers are the second largest group of value chain operators after the producers.

About seventeen retailers were found in Bamunka, two of them in Bamali, four of them in Bangolan, six of them in Babessi and four in Babungo. Milled and branded rice from processors can be sold on local markets mainly by retailers. Rice retailers are available throughout the country in sales outlets, warehouses, road stands, stores, groceries, and supermarkets. Street sellers may packaged and sell rice on the roadside or at the traffic lights. They often work independently, but sometimes for middlemen. They provide utility to the consumers by selling in small quantities. Umar and Sulumbe, 2015) had similar results in their study.

Table 2: Distribution of rice Value Chain Actors

Actors	Bamunka	Bamali	Bangolan	Babessi	Babungo	Total	Percentage
Producers	56	3	10	9	7	85	51.5
Assemblers	9	1	2	3	3	18	10.9
Processors	8	1	2	2	2	15	9.1
Wholesalers	7	1	2	2	2	14	8.5
Retailers	17	2	4	6	4	33	20.0
Total	97	8	20	22	18	165	100.0

Field survey, 2016

Costs and returns along the value chain of rice

The profits which market participants make give an indication of market performance. Therefore, the costs incurred and returns realized by rice value chain actors were estimated and presented in Table 3. The analysis was based on the volume of rice handled by each value chain actor. The Table shows that producers handled 13.8% of the weekly quantity of rice traded. Total Revenue (TR) of the producers was 313440 FCFA ($ 626.88) while Total cost (TC) was 202243 FCFA ($404.48). A Net Revenue (NR) of 111197 FCFA ($ 222.39) was realized which translates to a NR of 42.6 FCFA ($ 0,08) per Kg. The assemblers handled 19.1% of the quantity traded weekly. A TR of 430440 FCFA ($ 860.88) was realized, while the TC was 324132 FCFA ($ 648.26). A NR of 106308 FCFA ($ 212.61) was realized. The value of TC realized by the assemblers may be due to cost incurred in collecting and bringing the paddy to a central warehouse. The cost of transporting paddy on bad roads and lost on transit reduces the NR of assemblers. The wholesalers realized a TR of 863880 FCFA ($ 1727.76) and the TC was 623264 FCFA ($ 1246.52) while NR realized was 240616 FCFA ($ 481.23). The wholesalers traded at 22.3% of the weekly sales. The value of 57.4 FCFA ($ 0.11)/Kg obtained as NR could be explained in terms of the ability of the wholesalers to keep the product in their warehouses and sell at such a time prices rise. According to Umar and Sulumbe (2015), this occurs during the harvesting season when producers do not have much bargaining power, they accept what is offered. The retailers traded at 17.4% of the weekly trade making a NR of 201016 FCFA ($ 402.03) which translated to 61.6 FCFA ($ 0.12) per Kg. The high returns in NR per Kg may be because of the ability of the retailers to break bulk and sell in smaller measures. The processors' share of the weekly trade was 27.4% of paddy realizing a NR 215728 FCFA ($ 431.45) of the weekly sales that translated to 42 FCFA ($ 0.08) per Kg. This may be as a result of modern processing facilities in the study area. The analysis shows that the marketing intermediaries are getting a larger share of the benefit generated through the marketing of rice in the study area than the producers who initiate the rice production process. The producers have less control over price thus; they obtain a lower share of the benefits generated.

Table 3: Net returns of value chain actors for weekly sales of rice

Actor	$\sum V_1$ (Kg)	Percentage $\sum V_1$	$\sum P_1 V_1$ (FCFA)	TC (FCFA)	NR (FCFA)	NR/Kg (FCFA)
Producer	2612	13.8	313440	202243	111197	42.6
Assembler	3587	19.1	430440	324132	106308	29.6
Wholesaler	4193	22.3	863880	623264	240616	57.4
Retailer	3261	17.4	503160	302144	201016	61.6
Processor	5142	27.4	617040	401312	215728	42.0
Total	**18795**	**100.0**	**2017320**	**1853095**	**874865**	**233.2**

Source: Field survey, 2016
1$ (USD) = 500 FCFA

Marketing Margin

Marketing margins obtained by paddy producers, processors, assemblers, wholesalers, retailers and processors were computed based on the price information collected during the study and is presented in Table 4. According to Norwood and Lust (2008), the money spent on taking farm produce, processing it into a consumer product and marketing the product is referred to as the marketing margin. Therefore for every amount of money consumers spend on food, a portion goes to the farmer and the remainder is spent on food processing and marketing. Therefore identifying margins distributed across the actors in the value chain is important to advice if actors can improve their position in the chain by making the chain more efficient through increase in value. According to Umar and Sulumbe (2015), marketing margin is the percentage of the final weighted average selling price taken by each stage of the marketing chain. The results show that the retailers obtained a marketing margin of 26.4% while the wholesalers had a margin of 24.6%. The producers have a marketing margin of 18.3% and processors 18%. The assemblers had the lowest marketing margin is of 12.7%. The table also shows that the marketing margin of retailers in rice value chain was more than that of the producers, assemblers, wholesalers and the processors. A low marketing margin for producers may suggest that they depends on other value chain actors for inputs and provision of financial services where they could be exploited.

Table 4: Marketing Margin of rice Value Chain Actors

Value chain actor	Marketing margin (%)
Producers	18.3
Assemblers	12.7
Wholesalers	24.6
Retailers	26.4
Processors	18.0

Source: Field survey, 2016

Value chain addition

Value chain describes the full range of activities required to bring a product or service through the different phases of production, including physical transformation, the input of various producer services, and response to consumer demand (Webber and Austin, 2005). The value created by the actors along the value chain of rice is presented in Table 5. The table shows that producers and processors created the utility of form to rice while assemblers, wholesalers and retailers create utility of space and time. The producers obtain a low returns per kilogram which did not commensurate with the magnitude of the utility they have created. This can be attributed to exploitation as the retailers and wholesalers had higher returns per kilogram. During harvest, other value chain actors will be able to buy at low prices and improve the value for a higher price. The results is similar to that of Umar and Sulumbe (2015b) who had similar results.

Table 5: Value adding activities of rice value chain actors

Value chain actor	Value adding activity	Utility added
Producers	Production activities	Form
Assembler	Gathering packaging	Space and time
Processor	Process to different forms	Form
Wholesalers	Packaging and warehousing	Form, time and space
Retailer	Transporting, packaging and storage	Time and space

Source: Field survey, 2016

Constraints associated with rice production

The results in Table 6 show the major constraints militating against rice production in the study area. The result revealed that 21.09% of the respondents complained on inadequate credit as their main problem on rice marketing. During land preparation and planting, there is need to increase labour supply to prepare the seed bed, the rice fields and purchase of inputs like improved seeds, fertilizer, pesticides and herbicides. This is easy only when there is access to finance. In the study area, there are no banks or financial institutions to make funds available to farmers to use in their production activity. The implication of this finding is that these farmers may operate at a very low profit margin that could discourage them from engaging in further production. According to (Nsoh, 2011) the poor who constitute the majority of farmers producing the bulk of the national food supply with the least support should be granted access to credit. This will guarantee their access to food. Inputs were used in production and marketing, however, the supply was low as 18.6% of the respondents complained of shortage of inputs. Generally in Cameroon, low soil-fertility is a major constraint on crop production. Under these conditions, an increasingly important impact of fertilizer on food-crop yields can be expected particularly with rice which requires a high level of soil fertility for good yields. According to Nsoh (2011) the economic crises in the mid 1980s pushed the Government to drop subsidies on fertilizers and other farm chemicals. This coupled with a poor and insufficient system of subsidies to farmers, had a great impact on their yields and engagement in agriculture. Respondents in the study area observed that high labour cost (15.83%), incidence of pests and disease attack (13.48%) and poor extension coverage (12.5%) were identified as constraints to rice output. Folorunso and Okoroji (2015) identified similar constraints in their study and recommended that cost of inputs should be subsidized and efforts should be made to make credit accessible to farmers. Other factors that had a negative influence on the rice marketing chain were low market information and prices (11.32%) and poor infrastructural facilities like storage and road linkages (7.62%).

Table 6: Constraints to rice marketing chain among respondents

Constraints	Frequency	Percentage (%)	Rank
Inadequate credit	108	21.09	1
Low fertilizers supply	93	18.16	2
High labour cost	81	15.83	3
Incidence of pests and disease attack	69	13.48	4
Poor extension coverage	64	12.50	5
Low market information and prices	58	11.32	6
Poor storage and road linkage	39	7.62	7
Total	*512	100.00	8

Source: Field survey, 2016 * Multiple responses were obtained

Conclusion and Recommendation

Analysis of the study shows that many actors were involved in rice value chain. The producers provide the paddy to initiate the value chain process. The assemblers, retailers and the wholesalers provide an important service of marketing transforming the paddy to rice at the time the consumers require it. Based on the findings it is observed that the Total Revenue was 2017320 FCFA while Total cost was 1853095 FCFA. The net revenue was 874865 FCFA. Further analysis showed that net revenue per Kg of paddy was 233.2 FCFA. Thus, rice production was profitable among the value chain actors in the study area.

Based on this study, it was recommended that rice value chain actors should organize themselves into cooperatives to enable them obtain credit from formal institutions. Cooperatives can also help them to access improved seeds, agro-chemicals, fertilizer and farm implements and processing equipment at subsidized rates. Rice value chain actors should be educated on the need to use small-scale processing equipment and adequate technology which could add value thereby increasing their revenue. There should be provision of market information and the government should construct farm to market roads to ease movement into and out of rice farms.

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ASSESSMENT OF FARMERS' STORAGE AND PRESERVATION TECHNIQUES ON ONION (ALLIUM CEPA) IN JIGAWA STATE, NIGERIA

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Abstract
The study examines the storage and preservation techniques of Onion farmers in Jigawa State, Nigeria. A total of one hundred and twenty respondents (120) were interviewed through a focus group discussion to elicit information for the study. Majority (96.7%), were Males, married (90.8%) with Household size of 6-10 persons (81.70%, X═8 persons) and age range of 31-50 years (90.9%, X=41 years) No formal education (72.5%), average monthly income is ₦31, 000-40,000 (67.5%, X ₦35,825.00). average farming experience is 6-15year (85.0%, X═14years) and farm size of 1-5 hectares (85.5%, X=4hectares). Family source of labor usage (69.2%) with system of land ownership through personal purchase (66.7%) and source of finance from personal saving (84.2%). Annual output of 0-2 tons (94.2%) and source of input through self-findings (65.0%). Improved storage and preservation which are; refrigeration, canning, green house drying, infrared drying and use of suppressants (X═3.000) were not adopted by the respondents while indigenous storage and preservation like timing of planting (X═1.017), hanging small bunches (X═1.117), free air drying (X=1.000), quick selling (X=1.110), sorting (X=1.058) and spreading under shed (X=1.000) were very much used. Major constraints identified were lack of improved technologies, inadequate information and transportation/road networks, and inadequate market (100%). The result of Chi-square analysis showed positive relationship between the average monthly income, educational level, household size and farming experience (p≤0.05) on adoption of improved storage and preservation techniques. It was recommended that government should train more extension personnel and deploys them to the study area; formulate good policies in favor of onion storage and preservation, and provide improved technologies.

Keywords: Vegetable Cultivars, Technology, Onion, Storage, Preservation

Introduction

The food problem in Nigeria and most of the Third World countries is fast becoming an alarming one, prices of food commodities are increasing daily because of scarcities which often do not emanate from underproduction but which are offshoot of lack of awareness and availability of adequate post-harvest technologies/ equipment, and practices to preserve these commodities when they are in season and of utmost economic importance (Agbo, et.al., 2015). The common dry onion (*Allium cepa*), is a member of the Amaryllidaceae family, originated in mid-Asia in what is now northwestern India, Afghanistan, Tajikistan, and Uzbekistan.

It was reported in the sixteenth century that onions were among the most common vegetables used at that time. They occurred in red and white varieties and were sweet, strong, or intermediate in flavor (Micheal et.al, 2016). Mitra et.al (2011) posited that, onion is the most commonly used vegetable in the world food preparations especially in the tropical countries. Although, it is classified as vegetable, it has special qualities, which add to taste and flavor in food. Besides adding a delicious taste and flavor, onion serves as a good medicinal plant for the treatment of cataract, cardiovascular disease and cancer due to its hypocholesterolemic, thrombolitic and antioxidant effects as stated by Block (1985), Block et al. (1997), Stavric (1997), Nuutila et al. (2003) and Vidyavati et al. (2010).

Several antioxidant compounds, mainly polyphenols such as flavonoids and sulfur-containing compounds, have been described in onion and garlic by the researchers namely Kourounakis and Rekka (1991), Horie et al. (1992), Yamasaki et al. (1994), Prasad et al. (1995), Block et al. (1997), Suh et al. (1999), Banerjee et al. (2002), Nuutila et al. (2003), Gorinstein et al. (2005) and Ly et al. (2005). According to the latest information available from United Nations Food and Agriculture Organization (FAO 2009), the world production of onion is 64.48 million tons from 3.45 million ha. Approximately 8% of this global onion production is traded internationally. Productivity of onion is highest in Ireland (58 tons/ha), followed by Korea Republic (57 tons/ha), USA (55.88 tons/ha), Spain (52 tons/ha), Chile (48.50 tons/ha), and Australia (49 tons/ha) while India has a productivity of 13.20 tons/ha (NHRDF 2009). The production as well as market value of this potential vegetable is increasing day by day, therefore a country endowed with the natural ability must at best consider effective storage and preservation of this vegetable product (Mitra et.al, 2011).

In terms of composition as a beneficial and economic vegetable Onions are low in calories (50 kcal/100 g) yet add abundant flavor to a wide variety of foods. It is also known for its nutritional value and for the utility as herbal medicine in many countries. It has moderate amounts of protein, fat, fibre and good amounts of calcium, phosphorous and potassium, vitamin C and B_6. Apart from onion as such even the stalk is edible. The stalk contains good amount of carotene and iron. Onion has both glucose (reducing sugar) and sucrose (non-reducing sugar). The pungent taste of onion is due to volatile oil Allyl-propyl-disulphide present in it. Onions also contain significant amount of a flavonoid called quercetin, which is also available in tea and apples, earlier research proved that absorption of quercetin from onions is twice that from tea and more than three times that from apples (Singh et.al, 2006).

Onions are stimulant and mild counter irritant. Crushed raw onion can be applied on the forehead to get relief from headaches. Red small onions can be used as an expectorant. Eating raw onions help to reduce cholesterol levels because they increase levels of high-density lipoproteins. It is advisable to include raw onions in the salads daily, to controlling coronary heart disease, thrombosis, and blood pressure. Onion can cause migraine in some people and flatulence. Eating raw onion can also lead to bad breath. Sulphur compounds present in onion will help to prevent the growth of cancer cells. Onions are also used in the treatment of anemia, urinary disorders, bleeding piles and teeth disorders. Anti-tumor and anti-cancer effect, platelet-anti-aggregating agent, anti-hypercholesterolemia, anti-ulcer and anti-gastric cancer agent activity of onion are also found by several researchers (Mitra et.al, 2011)

Dehydration of food is aimed at producing a concentrated product, which when adequately packaged has a long shelf life, after which the food can be simply reconstituted without substantial loss of flavor, taste, color and aroma. Several types of dryers and drying methods, each better suited for a particular situation are commercially used to remove moisture from a wide variety of food products including fruits and vegetables. Factors, on which the selection of a particular dryer or drying method depends, include the form of raw material and its properties, desired physical form and characteristics of the product, necessary operating conditions and operating costs. The most commonly adopted drying practices for onion are sun drying or solar drying, convective air drying, green house drying and infrared drying (Mitra et.al, 2012). In Nigeria, there is relatively no improved storage and preservation technologies for onion as most peasant farmers resort or use whatever familiar techniques availed to them. It is on this premise that the research is sought to provide relevant answers to the following research questions;

1. What are the socio-economic characteristics of the Onion farmers in the study area?
2. What are the farmers' existing storage and preservation technologies on Onion?
3. What are the indigenous technical knowledge of the Onion farmers on its preservation and storage?
4. What are the constraints to enterprise production and management of Onion farming?

Objective of the study

The general objective of the study is to analyses the storage and preservation techniques of arable crop farmers on Onion cultivation in Jigawa State, Nigeria.

The specific objectives are to:

1. Determine the socio-economic characteristics of the arable Onion farmers.
2. Identify the farmers existing preservation and storage technologies on Onion.
3. Determine the available indigenous technical knowledge on the preservation and storage of Onion.
4. Examine the constraints to enterprise formation on Onion farming.

Hypothesis

Ho1: The socio-economic characteristics of the Onion Farmers significantly affect their storage and preservation techniques.

Methodology

Study Area

The study was conducted in Jigawa State Nigeria. Jigawa State is one of thirty-six states that constitute Federal Republic of Nigeria. It is situated in the north-western part of the country between latitudes 11.00°N to 13.00°N and longitudes 8.00°E to 10.15°E. The state has a total land area of approximately 22,410 square kilometers with twenty-seven (27) Local Government Areas (Jigawa Wikipidia, 2014 and National Population Commission, NPC, 2006). The topography is characterized by high land areas which is almost 750meters. Soil tends to be fertile ranging from sandy-loamy with many pockets of Fadama and alluvial plains suitable for the cultivation of different crops. The state share common boundaries with three (3) states and Niger Republic. There are usually two seasons in the state viz the rainy season lasting from June through October and dry season spanning from November to May (Jigawa Wikipidia, 2014).

The mean temperature ranges from 35°c in October to about 50°c in May, while mean annual rainfall varies from 700mm to over 1000mm and can last up to 200days in some lowland parts of the state. The months of November to March are particularly cold due to dry harmattan wind. Jigawa state is predominantly an agrarian state with over 80% of the population involved in Agriculture. Jigawa State is blessed with large expanse of agricultural land, rivers and flood plains, suitable for crops, livestock and fish production. Based on this over 80% of the State's total land mass is considered arable, which makes it one of the most agriculturally endowed States in Nigeria. The major Cultivated crops in Jigawa State are the rainy and dry season crops. Rain fed crops include millet, sorghum, cowpea, groundnuts, sesame, rice, maize, sweet potatoes, Bambara nuts, water melon, cassava, cotton, okra, Roselle. The dry season farming production include tomatoes, pepper, onions, wheat, sugarcane, carrots, cabbage, lettuce, maize and a host of other leafy vegetables like Amaranthus spp (MTSS, 2016). The major rivers in the state that provide water for irrigation activities are the Hadejia and Katagum rivers. The Hadejia-Nguru river has the largest fadama area in Nigeria (Jigawa Wikipidia, 2014). Jigawa state is divided into four ADP Zones 1, 2, 3 and 4

- Zone 1. With headquarters in Birninkudu comprises of Dutse, Kiyawa, Jahun, Buji, Birninkudu, Gwaram, and Miga, Local Government Areas.
- Zone 2. With headquarters in Gumel comprises of Gumel, Maigatari, Ringim, Taura and Gagarawa, Local Government Areas.
- Zone 3. with headquarters in Hadejia comprises of Birniwa, Kirikasamma,

Kafin-Hausa, Auyo, Guri, Malammadori, Kaugama and Hadejia, Local Government Areas.

- Zone 4. With headquarters in Kazaure comprises of Kazaure, Yankwashi, Gwiwa, Roni, Suletankarkar, Babura and Garki, Local Government Areas

Data Collection

The population for the study comprises of all the vegetable Onion farmers in the state who are the sampling frame. A three-stage sampling technique was employed for the study. The first stage was a random selection of two local governments from the ADP Zones as follows: Zone 1; Dutse and Jahun, Zone 2; Gumel and Gagarawa, Zone 3; Kirfin-Hausa and Hadejia and Zone 4; Kazaure and Roni respectively. The second stage was also a random selection of three communities each from the local governments selected in the state. The third stage was the random selection of five onion farmers from each of the communities to give a sample size of 120 respondents for the research. The statistical analysis that was employed were; Descriptive statistics (percentages, mean, frequency counts, standard deviation) and Mean Scale. The hypothesis was tested using Chi-square analysis.

Results and Discussions

Socioeconomic Characteristics of the Onion Farmers

Table 1, shows that majority of the onion farmers (90.9%, X= 41 years) were within the age range of 31-50 years meaning that they were still in the active productive age range, males (96.7%), married (90.8%) with household size of 6-10 persons (81.7%, X=8 persons), no formal education (72.5) as only 19.2% were with primary education, meaning that they were not really educated and farm size of 1-5 hectares (82.5%, X=3.6ha). The farming experience of the respondents is 6-15 years (85.0%, X= 13.6). Average monthly income is N31,000-40,000 (67.5%, X=N35,825.00), showing that they have favorable proceeds from onion farming. Main source of labor is family (69.2%) with system of land ownership being through personal ownership (66.7%), followed by inheritance (25.0%) and source of finance for onion farming is through personal savings (84.2%). Average annual output from onion is 0-2 tons (94.2%, X=1.2tons), with source of input from personal sourcing around (65.0%) and other farmers (28.3%).

Table 1: Socioeconomic Characteristics of the Onion Farmers.

Variables	Frequency	Percentage	Mean ± S.D
Age (Years)			
≤ 30	2	1.6	41.2± 8.9
31- 40	62	51.7	
41- 50	47	39.2	
51- 60	5	4.2	
61- 70	2	1.6	
71- 80	1	0.8	
≥ 81	1	0.8	
Sex			
Male	116	96.7	
Female	4	3.3	
Marital Status			
Singled	7	5.8	
Married	109	90.8	
Divorced	2	1.6	
Separated	1	0.9	
Widow	1	0.9	
Household Size			
0-5	13	10.8	7.8 ± 2.4
6-10	98	81.7	
11-15	8	6.7	
≥ 15	1	0.8	
Educational Qualification			
No Formal Education	87	72.5	
Primary Education	23	19.2	
Secondary Education	8	6.7	
Tertiary Education	2	1.6	
Farm Size (Ha)			
1-5	99	82.5	3.6 ± 2.4
6-10	19	15.8	
11-15	2	1.7	
≥ 16	0	0.0	
Farming Experience			
1-5	15	12.5	13.6 ± 4.9
6- 10	44	36.7	
11-15	58	48.3	
16-20	1	0.8	
≥ 20	1	0.8	
Average Monthly Income (N)			
1-10,000	2	1.6	35,825.00±7,215.62k
11,000-20,000	2	1.6	
21,000-30,000	10	8.3	
31,000-40,000	81	67.5	
41,000-50,000	24	20.0	
≥ 51,000	1	0.8	
Source of Labor			

Family	83	69.2	
Hired	14	11.6	
Both	23	19.2	
Land Ownership			
Lease	9	7.5	
Inherited	30	25.0	
Owned	80	66.7	
Communal	1	0.8	
Source of Finance			
Commercial Bank	1	0.8	
Cooperative Society	2	1.6	
Money Lenders	4	3.3	
Relatives	12	10.0	
Personal Savings	101	84.2	
Output or Yield/Annum (Ton)			
0-2	113	94.2	1.2 ± 0.7
3-4	6	5.0	
5-6	1	0.8	
Source of Planting Materials			
JARDA	7	5.8	
ADP	1	0.8	
Personal	78	65.0	
Other Farmers	34	28.3	

Source: Field Survey, 2017.

Available Technologies of Onion Storage and Preservation

As depicted in table 2, the onion farmers used sun drying or solar drying simply because it is cheap, readily available and bears no cost. Curing and drying of onion bulb, windrowing under favorable weather conditions: is cheap and used mostly by the onion farmers, and covering with soil to avoid scalding (X=1.000). Convective air drying which is also available naturally are cheap to the respondents (X= 1.042) and harvesting between 90-150 days of sowing (1.050). Finally, drying on the field for 8-10 days to allow for optimum reduction in moisture content before taking away from farm (X=1.117). The respondents were indifferent in their views in maintenance of appropriate condition of humidity and temperature recommendation of 30^0c, 60-70^0rh and $150m^3h^{-1}$ for mechanical drying of onion (X= 1.867) and sorting/grading by size for storage (X= 2.000) because their own goal is to harvest and sell, that is why onion in the market are of various sizes and colors because cognizance is not given to sorting and grading. The implication of this is that the respondents were ignorant due to lack of education to specify the optimum condition to be used in the study area, since all their major styles of storage are through sundrying (mechanical) means. On opposite, refrigeration method, processing into paste and canning, green house drying, infrared drying and use of suppressants (X= 3.000) were not used by the respondents, meaning that these techniques were not familiar to them in the study area.

Table 2: Available Technologies of Onion Storage and Preservation

Variable	VMU	U	NU	Mean (X)	Ranking
Sun Drying and Solar Drying	120(0.0)	0(0.0)	0(0.0)	1.000	1
Curing and Drying Bulb Onion	120(100)	0(0.0)	0(0.0)	1.000	1
Windrowing under favorable weather condition	120(100)	0(0.0)	0(0.0)	1.000	1
Covering with soil to avoid of Scalding	120(100)	0(0.0)	0(0.0)	1.000	1
Convective Air Drying	116(96.7)	3(2.5)	1(0.8)	1.042	5
Harvesting between 90-150 after sowing	116(96.7)	2(1.6)	2(1.6)	1.050	6
Drying on field for 8-10 days	110(91.7)	6(5.0)	4(3.3)	1.117	7
Adequate temperature/humidity (30^0c,60-70rh,150m^3h^{-1}	16(13.3)	104(86.7)	0(0.0)	1.867	8
Sorting and Grading by size for Storage	0(0.0)	120(100)	0(0.0)	2.000	9
Refrigeration Method	0(0.0)	0(0.0)	120(100)	3.000	10
Processing into Paste and Canning	0(0.0)	0(0.0)	120(100)	3.000	10
Green House Drying	0(0.0)	0(0.0)	120(100)	3.000	10
Infrared Drying	0(0.0)	0(0.0)	120(100)	3.000	10
Use of Suppressants Anti-sprout like Maleic Hydrazite	0(0.0)	0(0.0)	120(0.0)	3.000	10

Source: Field Survey, 2017.

The available technologies on storage and preservation of Onion being within the post-harvest technologies were measured using a mean scale of Very Much Used (VMU=1), Undecided (U=2) and Not Used (NU=3). The mean score X=2 on the continuum indicated that values below the mean signifies very used while values above the mean signifies not used.

Indigenous Technical Knowledge on Storage and Preservation of Onion

Table 3 shows that onion farmers highly practiced spreading onions under shed on racks, trays free from direct impact of sun and moisture and free air drying by allowing constant passage of air under shed (X= 1.000), followed by proper timing of planting to coincide with dry season when storage and preservation are easier (X=1.017), then manual removal of bad/ damaged bulbs from healthier once (sorting, X=1.058). They highly practiced quick selling after harvesting to prevent spoilage when the environmental condition is unfavorable and this also allows them to sell their products at ridiculous prices to end users and middle men (X=1.100), onion may be stored by hanging small bunches tied together by plaiting the top on pole under shed (Natural drying, X=1.117). They were having mixed opinion on biological storage technique with the use of plants like Neem leaves during packaging (X= 2.000).

Table 3: The Respondents' Indigenous Technical Knowledge on Onion Storage and Preservation.

Variables	HP	U	NP	Mean	Ranking
Spreading under Shed on racks, tray free from Sun& Moisture	120(100)	0(0.0)	0(0.0)	1.000	1
Manual removal of bad damaged Bulbs (Soating)	100(83.3)	3(2.5)	7(5.8)	1.058	4
Quick selling after harvesting to prevent spoilage	110(91.7)	8(6.7)	2(1.7)	1.100	5
Free Air Drying by allowing constant Air passage under Shed	120(100)	0(0.0)	0(0.0)	1.000	1
Hanging small bunches tied together by plaiting the top on pole	110(91.7)	6(5.0)	4(3.3)	1.117	6
Proper timing of planting to coincide with dry season	119(99.2)	0(0.0)	1(0.8)	1.017	3
Biological Storage by the use of Neem leaves etc during package	0(0.0)	120(100)	0(0.0)	2.000	7

Source: Field Survey, 2017. The Knowledge was measured on a mean scale of Highly Practiced (HP=1), Undecided (U=2) and Not Practiced (NP=3), Mean X=2. Values below 2 is very practiced while above is not practiced.

Onion Farmers' Constraints to Storage and Preservation of Onion

The farmers identified the following as their major constraint to storage and preservation of onion: lack of improved technologies on storage and preservation of onion, lack of information channel and flow on preservation and storage, sustainable market outlet and transportation/ road networks as major bottleneck (100%), followed by lack of capital to procure all the necessary facilities and equipment required for storage and preservation of onion (97.5%), lack of extension services delivery which is the linkage between the farmers and research and lack of facilities/equipment for storage and preservation (95.8%). Socioeconomic factors like education, Cosmo-politeness (91.7%) was also identified as limiting the effectiveness of farmers to improved storage and preservation and lack of improved varieties of onion e.g. the white local type (51.7%).

Table 4: Constraints of the Farmers to Storage and Preservation of Onion.

Variable	Frequency	Percentage	Ranking
Lack of Capital	117	97.5	2nd
Lack of Improved Technologies	120	100	1st
Lack of Extension Service Delivery	115	95.8	3rd
Lack of Information	120	100	1st
Lack of Facilities and Equipment	115	95.8	3rd
Socioeconomic factors: Education, Cosmo-politeness	110	91.7	4th
Transportation and Road Networks	120	100	1st
Problem of sustainable market outlets	120	100	1st
Lack of Improved /variety of Onion (white type)	62	51.7	5th

Source: Field Survey, 2017.

Chi-square Analysis between the Socio-economic Characteristics and the Storage and Preservation Techniques on Onion.

It can be seen from table 5 that educational qualifications, average monthly income, farming experience and household size showed positive significance with improved storage and preservation techniques on onion cultivation. The implication of this is that the higher the educational qualification, average monthly income, farming experience and household size the higher will be the level of understanding, financial power, labor availability and exposure to improved onion storage and preservations techniques in the study area. With more monthly income accrued from the sales of onion the higher the financial power and wilingness to store and adopt improved storage and preservation techniques of onion. The higher the educational level the more their understanding of improved technicalities on onion storage and preservations. The result of the study shows that the higher the household size the more the available man power for improved storage and preservation activities. Finally, in the same vein the higher the farming experiences the more the awareness and readiness to adopt improved storage and preservation techniques of onion. This is in line with the findings of Sharada (1999), who opined that there is great scope for increasing productivity through higher levels of formal education, despite the traditional nature of rural farming. He further stated that formal education is thought to be particularly important in terms of enhancing the spread of innovations and helping to extend the limit of the frontier including outputs. Agbo et.al., (2015) and Umunna (2010), in the same opinion also agreed level of education, household size, off-farm income and farming experience had significant relationship for farmers productivity, storage and preservations knowledge in Owerri Agricultural Zone of Imo State, Nigeria. Debashis and Kanungo (2016) posited that a good number of socioeconomic variables such as Cosmo politeness, land size, income, had positive significant impact on the adoption level of farmers regarding various production related technologies in agriculture.

Table 5: Chi-square Analysis between the Socio-economic Characteristics and the Storage and Preservation Techniques on Onion.

Variables	X2-value	d.f	P-value	Remarks
Average Monthly Income	0.311 *	5	0.032	Significant
Educational Qualification	0.302 *	4	0.043	Significant
Household Size	0.228 *	3	0.037	Significant
Farming Experience	0.129 *	4	0.039	Significant
Age	-0.113	3	0.477	Not Significant
Marital Status	-0.223	3	0.565	Not Significant

Source: Field Survey, 2017 $P \leq 0.05$

Conclusion and Recommendations

Due to the ability of onion to grow in the tropical and temperate regions, the growing and handling of onion for storage and preservation needs considerable attention in the study area as the respondents were not aware of most improve storage and preservation technique. They only relied on their indigenous technical skill to store and preserve onions. The research therefore recommended that:

1. Capacity building training programmes from all tiers of government and NGOs through the ADP is needed to help the respondents understand and adopt other improved methods.
2. Biological storage techniques should be introduced and stepped down to the respondents by way of advisory services so that they can be abreast of the technique through employment and deployment of more extension agent to the study area.
3. Proper synergy must be in place to improve the farmers to extension agent relationship as this is very crucial for the flow of information from research to farmers and vice versa. This means that adequate capacity building training is

needed by the farmers in this area and transmission of farmer's problems to research center through extension agents which are lacking in the study area.

4. Institutional framework like farmers' information tracking systems must be put in place to provide constant and adequate information to onion farmers, sustainable market networks and transportation to help the farmers in improved storage and preservation.
5. Government should at the same time provide policies that would be favorable to improved storage and preservation of onions to help avert wastage of the crop and livelihood assets of the farmers.

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QUALITATIVE AND QUANTITATIVE DETERMINATION OF PHYTOCHEMICALS AND LEVELS OF SOME HEAVY METALS (PB, CD AND CR) PRESENT IN THE LEAVES EXTRACT OF *Cassia tora.*

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Abstract

The aim of this study is to determine the phytochemicals and some heavy metals present in the leaves of Cassia tora. Phytochemical screening was conducted using standard procedure. The level of some heavy metals present in leaves of Cassia tora were determined at different wavelengths using Atomic absorption spectrophotometer (AAS). The results of phytochemical screening indicated the presence of most phytoconstituents except alkaloids and saponin while the Atomic Absorption Spectroscopy revealed the presence of some haevy metals Pb (15.01 $\pm$ 0.31), Cd (1.14 $\pm$ 0.01) and Cr (5.56 $\pm$ 0.11) which are significantly ($P < 0.05$) lower than the the practically toxic range. Therefore, the results of this study further justify the traditional use of Cassia tora as food and in the treatment of variety of disease conditions. The Cassia tora collected in the study area is toxicologically safe for both human and animal consumption.

Key words: Atomic Absorption Spectrophotometer, *Cassia tora*, Phytochemical Screening,

Introduction

It has been estimated that 80% of the world's population is still dependant on traditional medicines for maintaining their health and combating various diseases (Ahmad *et al.,* 2008). Besides, 56% of world's populations in the rural areas rely chiefly on herbal medicine and supplementation for their primary health care needs (Planta *et al.,* 2000). Today, microbial infections, malaria and cancer are the common health problems in rural communities throughout the world. A huge number of traditionally important medicinal Plants have been known to be biologically effective against these diseases (Pinn, 2000). One of such potential plant is *Cassia tora* Linn., which is a small semi-wild annual herb belonging to the family Caesalpinaceae. The plant is native to Africa , South-East Asia, Northern Australia, and Latin America. *C. tora* is commonly known as "Tafasa" in "Hausa tribe" of northern Nigeria. *C. tora* is a stout, erect, smooth, half-woody annual herb which is one meter or less in height (Shakywar *et al.,* 2011). The Leaves are alternate, even-pinnate, 1-2 cm long; leaflets in 2-4 pairs, oblong-ovate to obovate, 3-4 cm long, obtuse, attenuate at base; stipules linear lanceolate, falling early. The leaves are furnished with glands on the main rachis between the leaflets. The flowers are grouped 1-2 in leaf axils, showy, nearly regular, five merous, yellow; ten stamens with seven fertile and three abortive anthers in pairs, in the axils of the upper leaves about 1.5 cm across (Soni and Pal, 1996). Fruits are linear pods, 4-angled, up to 10 cm long with thick (3-4 mm) margins (Takahashi and Takido, 1973). The seeds are flattened in the same direction as the pods are composed of hull (27%), endosperm (32%) and germ (41%) (Shakywar *et al.,* 2011). Although heavy metals are naturally present in the soil, geologic and anthropogenic activities increase the concentration of these elements to amounts that are harmful to both plants and animals (Raskin *et al.,* 1994). Some of these activities include mining and smelting of metals, burning of fossil fuels, use of fertilizers and pesticides in agriculture, production of batteries and other metal products in industries, sewage sludge, and municipal waste disposal (Shen *et al.,* 2002; Chatterjee and Chatterjee, 2000). Growth reduction as a result of changes in physiological and biochemical processes in plants growing on heavy metal polluted soils has been recorded (Öncel *et al.,* 2000; Oancea *et al.,* 2005; Marques *et al.,* 2009) . In present study the phytochemicals and some heavy metals present in leaves of *Cassia tora* were evaluated.

Material and Methods

Plant Collection, Identification and Preparation.

Fresh leaves of *Cassia tora* were collected within the premises of Binyaminu Usman Polytechnic Hadejia (old campus).The plant was Authenticated at the Herbarium of the Department of Forestry, Binyaminu Usman Polytechnic Hadejia with a voucher number 002, deposited by Malam Sani Musa . The fresh leaves of *Cassia tora* were air-dried at room temperature and grinded into powder using mortar and pestle.

Extraction of the Leaves of *Cassia tora*

About 500 g of the powdered leaves of *Cassia tora* was extracted with methanol by cold maceration using a 1-litre capacity separating funnel. The extraction was carried out at room temperature for 48 hours. The initial extraction was done with 1.5 liters of methanol and the process was repeated twice using 750 liters of methanol in each extraction. The extracts obtained during the 3 phases of extraction were pooled together and concentrated under reduced pressure between 50-55 ºC, and then stored in a vacuum dissector. Stock solution of the extract at concentration of 1 g/ml were prepared and stored at 4 ºC for phytochemical test.

Phytochemical Screening

The methanol leaves extract of *Cassia tora* were screened for the presence of flavonoids, carbohydrates, tannins, alkaloids, saponins, glycosides and sterols triterpens using methods described by Brain and Turner (1975).

Determination of Heavy Metals

Atomic Absorption Spectroscopy was used to determine the amount of some common heavy metals (lead, cadmium and chromium) present in the methanol leaves extract of *Cassia tora*, using Atomic Absorption Spectrophotometer (Shimazu A6800).

Sample Preparation for Atomic Absorption Spectroscopy

One (1g) of the powdered *Cassia tora* was transferred into clean beaker containing 15 ml of trioxonitrate (v) acid (HNO_3) and tetraoxochlorate (vii) acid ($HClO_3$). The beaker was then placed on copper hot plate and heated to boiling point for 45 to 60 minutes. After boiling, the beaker was allowed to cool for 20 minutes, the contents of the beaker was separated using filter paper and separating funnel placed on conical flask and finally the filtrate were used for Atomic Absorption Spectroscopy (AAS).

Results

Extract yield

Following extraction, the percentage yield of the dried methanol leaves extract of *Cassia tora* was 32.67 %.

Phytochemical Screening

The results of phytochemical screening are presented in Table 1.

Table 1: Phytochemical screening results of crude Methanol Leaves Extract of *Cassia tora*

Compounds	Inference
Carbohydrate	+++
Glycosides	+
Anthraquinones	+++
Cardiac glycoside	+
Saponins	-
Steroids	+
Triterpenes	++
Flavonoid	+++
Tannins	++
Alkaloids	-

***Key**: +++=Highly present, ++=moderately present, +=faintly present, -=not present*

Atomic Absorption Spectroscopy

The results of atomic absorption spectroscopy are presented in table 2.

Table 2: Mean ± SEM of Atomic absorption spectroscopy of the leaves of *Cassia tora* .

Elements	Concentration (mg/kg)
Lead (Pb)	15.01 ± 0.31
Chromium(Cr)	5.56 ± 0.11
Cadmium(Cd)	1.14 ± 0.01

Discussion

Current world-wide interest in traditional medicine has led to rapid development and studies of remedies employed by various ethnic groups of the world for treating different disease conditions. Herbal medicine is used by up to 80 % of the population in the developing countries. Despite the widespread use, few scientific studies have been undertaken to ascertain the safety and efficacy of traditional remedies (Tahraoui *et al.,* 2010). The methanol leaves extract of *Cassia tora* contains flavonoids, tannins, sterols, cardiac glycoside, triterpenes, Anthraquinones, Carbohydrates and steroids. Flavonoids have been shown to possess an antioxidant as well as anti-inflammatory and analgesic properties due to their inhibitory effects on the production of chemical mediators of pain ,histamine and bradykinins (Choi *et* al., 2005). Similarly, saponins and sterols (Choi *et al.*, 2005), tannins (Besra *et al.*, 1996) and cardiac glycosides have been reported to possess anti-nociceptive and/or anti-inflammatory activities (Ma *et al*., 1998).

Many species of plants were able to absorbe heavy metals such as lead, cadmium, chromium, arsenic and various radionuclides from soils (Katz and Salem, 1992). The only solution to this problem is the capability of plants to remove these heavy metals from soil via their ability to take-up metals which are essential for their growth (Fe, Mn, Zn, Cu, Mg, Mo, and Ni). Some metals with unknown biological function (Cd, Cr, Pb, Co, Ag, Se, Hg) can also be accumulated (Oancea *et al.*, 2005). It is important to note that *Cassia tora* has ability to tolerate high concentration of some heavy metals in their environment. Blaylock *et al.*, (1997) reported three mechanisms on how plants are able to tolerate heavy metals namely, exclusion: restriction of metal transport and maintenance of a constant metal concentration in the shoot over a wide range of soil concentrations, inclusion: metal concentrations in the shoot reflecting those in the soil solution through a linear relationship, and bioaccumulation: accumulation of metals in the shoot and roots of plants at both low and high soil concentrations. Plants are the main way of cadmium (Cd) and lead (Pb) transfer from contaminated soils to humans. In a contaminated soil, Cd and Pb are accumulated in different parts (edible) of the plant (Lin et *al.*, 2004). Estimated Daily Intake (EDI) as a common index for metal transfer from plant to humans were calculated and used for *Cassia tora* in some studies (Lin *et al.*, 2004). In total, averages normal value of Cd and Pb concentrations in *Cassia tora* are 60 and 440 µg/kg, respectively (Horiguch *et al.*, 1978). Jung (1995) also reported that Cd and Pb concentrations in plant grown in various countries were in the range of 10–50 µg/kg and 1–500 µg/kg, respectively (Jung, 1978). The results obtained from atomic absorption spectroscopy indicated the concentration of lead (Pb) and cadmium (Cd) in *Cassia tora* fell within the tolerable range. However, The World Health Organization maximum allowable concentration in food and drinking water for chromium (VI) as 0.05 milligrams per litre (WHO, 2014). In the body, chromium

(VI) is reduced by several mechanisms to chromium (III) already in the blood before it enters the cells. The chromium (III) is excreted from the body, whereas the chromate ion is transferred into the cell by a transport mechanism, one by which sulfate and phosphate ions also enter the cell (Dayan and Paine, 2001). The chromium (VI) has due strong oxidative properties, when it reaches the bloodstream, it damages blood cells by oxidation reactions, leading to haemolysis, and subsequently kidney and liver failure eventually results from this damage (Dayan and Paine, 2001). Therefore the results obtained from atomic absorption spectroscopy indicated that the concentration of chromium in *Cassia tora* falls within WHO maximum allowable concentration in food and drinking water.

Conclusion and Recommendations

The findings of this study suggest that methanol extract of *Cassia tora* contains bioactive constituents. It also suggests that the concentration of heavy metals was within WHO allowable concentration. Further work to evaluate the pharmacological and toxicological activities of the phytoconstituents and heavy metals present in the leaves of *Cassia tora* would be worthwhile.

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EFFECT OF INCORPORATED LEGUMES, NPK 20-10-10 AND THEIR COMBINATION ON SOIL CHEMICAL PROPERTIES OF PEARL MILLET GROWN SOIL (*Pennisetum glaucum* (L.))

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Abstract
Soil properties as influenced by incorporated legumes, NPK 20-10-10 and their combination were studied at the Teaching and Research Farm of the Leventist Training School, Tumu. The treatments consist of Centrosema; Centro + N_{30} P_{15} K_{15} kgha^{-1}; Lablab; Lablab + N_{30} P_{15} K_{15} kgha^{-1}; Mucuna, Mucuna + N_{30} P_{15} K_{15} kgha^{-1}; Sesbania; Sesbania + N_{30} P_{15} K_{15} kgha^{-1}; control and N_{60} P_{30} K_{30} kgha^{-1} laid out in a RCBD with three replicates. Auger was used to collect soil samples at 0-30cm before sowing and during harvesting for soil properties determination. Data were subjected to analysis of variance (ANOVA) using SAS package of statistical analysis and means were separated using Duncan's Multiples Range Test (DMRT). Result indicated that incorporation of green manure alone significantly ($P<0.05$) increased organic C, total N, Mg^{2+}, K^+ and CEC but invariably lower soil pH, while application of green manure combined with N_{30} P_{15} K_{15} kgha^{-1} improved soil available P and Ca^{2+}. However, application of N_{60} P_{30} K_{30} kgha^{-1} alone significantly increased Na^+ and K^+ while application of N_{60} P_{30} K_{30} kgha^{-1} alone, green manure alone or in combination significantly increased K^+ compared to control. This study showed that addition of organic manure to soil in combination with N_{30} P_{15} K_{15} kgha^{-1} positively influenced the chemical properties by improving soil fertility and soil quality

Keywords: Soil, Pearl millet, Incorporation, Green manure, Application

Introduction

Pearl millet (*Pennisetum glaucum* (L) R. BR. EM end Stunz) locally known as gero and cultivated for its grain and as forage (Tabosa *et al.*, 1991; Ali 2010). However, the crop is a dual purpose and drought tolerant crop grows with annual mean rainfall of 200mm, compared to maize and sorghum (Tabosa *et al.*, 1991; Ali 2010). Despite all benefits, farmer's yields are low and range between 450 – 1400kgha^{-1} (FPDD, 2011). However, crop yields reduction was attributed to low fertility status due to continuous cropping without proper soil management, pest and diseases problems as well as unfavorable weather conditions Odo and Bibinu (1998). In recent times, many soil fertility restoration techniques have been recommended Busari *et al.* (2005) which included adoption of appropriate and adequate fertility approach involving the use of organic and inorganic fertilizer as well as planting at the right time. A combination of both organic and inorganic amendments has been reported to improve crop yield, soil fertility levels or both (Vanlauwe *et al.*, 2002; Odunze *et al.*, 2012).

The current practices of continuous cultivation with excessive use of chemical substances do alter the soil physical and chemical properties, leadings to increase in production cost and environmental risk (Juo *et al.*, 1995).

There is scarcity of information as regards the changes in soil chemical properties upon incorporation of green manure and inorganic fertilizer on soils cultivated to pearl millet (*Pennisetum glaucum* (L.)) in Gombe State, Nigeria. Hence, the objective of this study was to investigate the effect of combined application of green manure and N_{30} P_{15} K_{15} (inorganic fertilizer) on pearl millet cultivated soils.

Materials and Methods

The study area

Field experiments were carried out in the wet seasons of 2015 and 2016 at the Teaching and

Research farm of the Leventist Farm, Tumu Akko local Government area, Gombe State located on Latitude 9^0 55N and Longitude 10^0 58E at an altitude of 325m above sea level. The geology of the area is said to be of tertiary continental sandstone to the west of the Kari Keri escarpment, clay and siltstone Mustapha *et al.* (2011). According to annual rainfall recorded at federal university Kashere meteorological station for the duration of the study in 2015 and 2016 were 369.4mm and 2183.2mm respectively. Annual mean minimum and maximum temperatures were 30^0C and 32^0C respectively. According to Ojanuga (2006) the study area is characterized by dry sub humid zone. The economic activities of local communities of the study area are mixed farming system that involve arable crops production and in animal production.

Soil Sampling and Analysis

Soil sampling and analysis were done twice: before planting (initial) and two years after harvesting millet. Before planting of millet, soil samples were collected from five randomly selected spots on the field at the soil depth of 0 – 30 cm using a soil auger and bulked together. Random samples were taken at the establishment of the 2015 experiment to determine initial physico-chemical properties of the soil. Subsequent soil sample collections from the depth of 0 – 30cm were taken in each plot according to treatments at harvest of millet in 2015 and 2016. Such initial and after harvest samples were air dried and ground to pass through a 2 mm sieve for soil parameters to analyze their physicochemical properties.

The processed soil fractions were subjected to laboratory analyses according to the procedure outline by Page *et al*. (1982). Texture was analyzed using Bouyoucos hydrometer (Day, 1965). Soil pH was determined in water at a 1:1soil to water ratio using glass electrode pH meter. Organic carbon was determined using the wet oxidation method (Walkley and Black, 1934). Micro-Kjeldhal digestion method (Juo, 1979) was used to determine total N and available P was analyzed by extraction with Bray II method (Bray and Kurtz, 1945) using 0.03 M NH4F and 0.10 M HCl solution. The exchangeable Ca, Mg, K and sodium (Na) were extracted with 1 M NH4OAc at pH 7 by which exchangeable Ca and Mg in extracts were analyzed using atomic absorption spectrophotometer, while Na and K by flame photometer Rowell (1994). The CEC was determined by saturating the soil with 1NNH4AC solution, and all the cations displaced into the soil solution were summed up.

Total land area of 810m^2 was marked out and divided in to 30 plots of 20 m$^{2\ with}$ 1m spacing between plots. The experiment consisted of ten treatments laid out in a randomized complete block design (RCBD) and replicated three times. The treatments comprised of Centro alone; Centro + N_{30} P_{15} K_{15} kgha^{-1}; Lablab alone; Lablab + N_{30} P_{15} K_{15} kgha^{-1}; Mucuna alone; Mucuna + N_{30} P_{15} K_{15} kgha^{-1}; Sesbenia alone; Sesbenia + N_{30} P_{15} K_{15} kgha^{-1}; recommended N_{60} P_{30} K_{30} kgha^{-1} fertilizer and Control

Sowing of Centro, lablab, Mucuna and Sesbenia at two seeds per hole were done at spacing of 37.5cm x 25cm and incorporated in to soil at six weeks after sowing. A week after incorporation, Seeds of pearl millet variety SOSAT-C-88 seeds were dressed with Apron Star 42 WS at the rate of 10 g sachet per 4 kg seeds for protection against soil and seed borne pests and diseases, and was sown at the rate of two seeds per hole at spacing of 25cm within ridges. The seedlings were thinned to one plant per stand at two weeks after sowing (WAS). NPK fertilizer (20-10-10) was applied two weeks after sowing (2WAS) at a rate of N_{60} P_{30} K_{30}kgha^{-1} in plots treated with fertilizer only and N_{30} P_{15} K_{15} kgha^{-1} in plots treated with green manure and fertilizer. Weeds were controlled using Paraquat (Gramaxone) at 3 litres ha-1 to kill weeds that were not properly incorporated and hoe weeding was done at 6WAS.

All data collected were subjected to Analysis of Variance (ANOVA) using SAS package version 9.0 of Statistical Analysis Software package as described by SAS institute, (2002). Differences between treatment means were compared using Duncan Multiple Range Test (DMRT) at 5% level of probability Duncan (1955).

Table: 1 Laboratory analysis of the shoot of the green manure crops used in the experiments

	Description				
Plants	N%	P%	K%	C%	C: N
Centrosema					
2015	1.33	0.38	1.20	18.4	14
2016	1.37	0.33	1.23	20.9	15
Lablab					
2015	2.96	0.49	1.35	29.4	10
2016	3.61	0.53	1.22	38.9	11
Mucuna					
2015	2.07	0.37	1.05	18.6	9
2016	2.74	0.49	0.87	36.3	13
Sesbania					
2015	3.25	0.43	1.25	29.4	9
2016	3.44	0.38	1.36	36.8	11

Results and Discussion

Initial Soil Properties

The results for soil laboratory analysis which were done before planting of millet are presented in Table 2. According to the initial soil laboratory test results, the soil is sandy loam in texture, very strongly acidic in pH, low in OC, total N, available P, K^+, Na^+, and CEC but medium in Ca^{2+}, and Mg^{2+}. These low contents of available P, total N, OC and other nutrients could be attributed to the effects of intensive and continuous cultivation that may aggravate OM oxidation and their consequent leaching/erosion Habtamu (2015). Similar low values of organic C, total nitrogen and available phosphorus were reported by Mustapha and Nnalee (2007) for soils in the guinea savanna zones of Nigeria. Similarly, Negassa and Gebrekidan (2003) reported that cultivation of land results in the reduction of OC and total N.

Table: 2 Pre-planting soil physical and chemical properties of the experimental site

Parameters	Description
Sand	76.5
Silt	12.5
Clay	11.0
Soil texture	Sandy Loam
pH (H_2O)	5.00
Org. C (gkg^{-1})	5.40
Total N (gkg^{-1})	0.04
Available P (mg kg^{1})	6.80
Exchangeable cations (cmol kg^{-1}):	
K^+	0.15
Ca^{2+}	2.32
Mg^{2+}	0.50
Na^+	0.12
CEC (cmol kg^{-1})	4.00

Table 3 shows results of physico- chemical properties of soils. The results indicated that the soil pH varied significantly due to the renewed application of synthetic and organic manures. The highest pH (6.0) was recorded in the treatment T_{10} (control) which was significantly different from all other treatments. This finding was similar to the results of Swarup (1991) and Adesoji *et al.* (2014). The lowest soil pH (4.75) was noted in the treatment T_6 (Mucuna + N_{30} P_{15} K $_{15}$ kgha^{-1}). A reduction in pH in all other treatments corroborates the findings of Mugendi *et al*. (1999) and Mucheru-Muna *et al.* (2013), who elucidated a general reduction in pH after application of fertilizer and legume residues. However, according to Six *et al.* (2000) this decline can be explained by continuous cultivation and crop removal which leads to breakdown of soil aggregates, thus exposing the SOM to decomposition and greater soil acidity. The decrease in soil pH values might be attributed to the decomposition and mineralization of organic matter. In contrast, Njunie (2002) did not record any change in soil pH upon lablab and Clitoria residue incorporation over a 2 years period in a sandy loam soil in the coastal lowlands of Kenya. The decrease in soil pH upon green manure incorporation might be that the decomposition of organic residue released organic acids which probably caused the soil pH reduction.

Incorporation of green manure crops significantly improved soil organic carbon (Table 2). The highest organic carbon (8.5gkg^{-1}) was recorded in treatments T_1 (Centrosema alone). These results were in agreement with the findings of Sharma and Behera (2009); Kalhapure *et al* (2013) and Adesoji *et al.* (2014) who observed that legumes incorporation significantly enhanced soil organic carbon. The lowest value of organic carbon (4.2gkg^{-1}) was noted in the treatment T_{10} (Control) which was significantly lower than all other treatments. The higher values of soil organic C observed under legumes green manure crops incorporation may be attributed to added organic matter residue. Consequently, Amba *et al*. (2011) reported similar results in northern guinea savanna of Nigeria and attributed the increase to the dropping of leaves, which added organic C to the soil.

Total N levels in soil were significantly influenced by various treatments (Table 3). The highest total N (0.46gkg^{-1}) was observed in the treatment T_1 (centrosema alone) which was statistically identical to treatment T_5 (0.46gkg^{-1}) (mucuna alone) which were significantly greater than all other treatments. The findings of this study concurred with those of Waswa (2004), Mucheru (2003), Adesoji *et al.* (2014) and Habtamu *et al.* (2015) who observed a significant increase in total N, compared to other treatments in plots where legumes green manure crops residues were incorporated. The lowest value of total nitrogen (0.19gkg^{-1}) was noted in the treatment T_{10} (Control) which was significantly different from all other treatments. The higher values of soil total N observed under legumes green manure crops incorporation could be attributed to added organic matter residue.

Soil available phosphorus (AP) was significantly influenced by the various treatments used in the experiment (Table 3). The highest available P (10.70mg kg^{-1}) was observed in the treatment T_6 (Mucuna + N_{30} P_{15} K $_{15}$ kgha^{-1}) which was significantly different from all other treatments. Similar findings were also reported by Kalhapure *et al.* (2013) who reported that physico-chemical properties of soil as well as nutrient status of soil were significantly increased due to combined application of organic and chemical fertilizers. The lowest value of available P (7.0 mgkg^{-1}) was noted in the treatment T_{10} (Control) which was significantly different from all other treatments. It was also observed that the application of sole NPK fertilizer (N_{30} P_{15} K $_{15}$ kgha^{-1}) increased soil available p. Zhang *et al.* (1998) postulated that organic manures increased labile, moderately stable and stable organic P contents in soils. Consequently, the higher values of soil available P observed under legumes green manure crops residue might be attributed to addition of P through organic residue and reduction of soil P fixation by organic anions formed during legumes residue decomposition.

Table: 3 Combine effects of treatments on Soil pH, OC, TN and AP in millet grown soil (Pool data)

Treatments	pH	OC(gkg^{-1})	TN (gkg^{-1})	AP ($mgkg^{-1}$)
Centrosema	5.5b	8.5a	0.46a	8.8f
Centro + N_{30} P_{15} K $_{15}$ $kgha^{-1}$	4.9c	7.5d	0.30f	9.1e
Lablab	5.6b	8.2b	0.41b	8.5g
Lablab+ N_{30} P_{15} K $_{15}$ $kgha^{-1}$	5.0c	7.2e	0.34c	9.3d
Mucuna	5.8b	8.1b	0.46a	7.9h
Mucuna+ N_{30} P_{15} K $_{15}$ $kgha^{-1}$	4.8c	6.8f	0.31e	10.7a
Sesbania	5.7b	7.8c	0.41b	9.4d
Sesbania+ N_{30} P_{15} K $_{15}$ $kgha^{-1}$	4.8c	6.9f	0.32d	10.1b
N_{60} P_{30} K $_{30}$ $kgha^{-1}$	5.4b	7.0fs	0.41b	9.9c
Control	6.0a	4.2g	0.19g	7.0i
SE±	0.190	0.010	0.002	0.140

Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of probability using DMRT

Table 4 shows results of soil exchangeable cation, the results show that the treatments had significant influence on the soil exchangeable cations. The highest exchangeable Ca^{2+} (3.76cmol (+) kg^{-1} soil) was observed in plot treated with treatment T_6 (Mucuna + N_{30} P_{15} K $_{15}$ $kgha^{-1}$) which was significantly higher than all other treatments plots. The lowest value of exchangeable Ca^{2+} (2.20cmol (+) kg^{-1} soil) was noted in the treatment T_{10} (Control) which was significantly different from all other treatments. Significant increases in Ca^{2+} was observed when green manure was combined with N_{30} P_{15} K $_{15}$ $kgha^{-1}$. The increase was attributed to the release of Ca^{2+} ions contained in lime through its dissolution, and to mineralization of green manure with release of the mineral nutrients in it. In a similar study Caires *et al*. (2006) reported significant increase of exchangeable Ca^{2+} after application of manure alone or combined with lime and P fertilizer. Similarly, Odedina *et al*. (2011) also observed significant increase in soil exchangeable Ca^{2+} upon application of manure, lime or their combinations.

Soil exchangeable Mg^{2+} was significantly increased as a result of the treatment application (Table 4). The highest soil exchangeable Mg^{2+} (0.91cmol (+) kg^{-1} soil) was observed in the treatment T_1 (Centrosema alone) which was statistically higher than all other treatments. The lowest value of soil exchangeable Mg^{2+} (0.55 cmol (+) kg^{-1} soil) was noted in the treatment T_{10} (Control) which was significantly different from all other treatments. However, when green manure was combined with N_{30} P_{15} K $_{15}$ $kgha^{-1}$ fertilizer, soil exchangeable Mg^{2+} was increased and this was attributed to addition of nutrients to the soil through mineralization.

Application of N_{60} P_{30} K_{30} kg/ha^{-1} fertilizers, green manure alone or in combination recorded the highest significant increase of soil exchangeable K^+ in soil over the control. Similar results were reported by Aspasia *et al.* (2010) and Adesoji *et al.* (2014). According to Vidyavathi *et al*. (2011) increase of soil exchangeable K might be attributed to solubilizing action of organic acids produced during organic matter decomposition and its higher capacity to hold K in available form. Another reason for soil exchangeable K^+ in soil might be due to added K^+ from green manure residue decomposition and mineralization.

Table 4 indicates that significant variations were found in soil exchangeable Na^+. The highest soil exchangeable Na^+ (0.30cmol (+) kg^{-1} soil) was observed in the treatment T_9 (Fertilizer alone) which was statistically identical to the treatments T_2 (0.27cmol (+) kg^{-1} soil) (Centrosema + N_{30} P_{15} K $_{15}$ $kgha^{-1}$), treatments T_6 (0.26cmol (+) kg^{-1} soil) (mucuna + N_{30} P_{15} K $_{15}$ $kgha^{-1}$) and to treatments T_8 (0.27cmol (+) kg^{-1} soil) (sesbenia + N_{30} P_{15} K $_{15}$ $kgha^{-1}$). The lowest value of soil exchangeable Na^+ (0.16 cmol (+) kg^{-1} soil) was noted in the treatment T_{10} (Control) which was significantly different from all other treatments.

However, the study shows that CEC was significantly influenced due to the various treatments used in the experiment (Table 4). The application of treatment T_5 (Mucuna alone) recorded the highest soil CEC values of 5.24 cmol (+) kg^{-1} while the lowest value was recorded in the treatment T_{10} (control). These results corroborate the findings of Ali *et al.* (2009). Norman *et al*. (2000) and Lifeng *et al*. (2006) opined that addition of organic matter into soils in most cases increases CEC due to its humic acids which increase the negative charge.

Table: 4 Combine effects of treatments on Soil Exchangeable bases and CEC (cmol (+) kg^{-1} soil) in Millet grown soil (Pool data)

Treatments	Ca^{2+}	Mg^{2+}	K^+	Na^{2+}	CEC
Centrosema	2.54e	0.91a	0.31a	0.21c	4.93b
Centro + N_{30} P_{15} K $_{15}$ $kgha^{-1}$	3.09d	0.76d	0.31a	0.27a	4.25e
Lablab	2.94d	0.70e	0.28b	0.18c	4.74c
Lablab+ N_{30} P_{15} K $_{15}$ $kgha^{-1}$	2.98d	0.69e	0.32a	0.23b	4.60c
Mucuna	3.44b	0.78c	0.22c	0.20c	5.24a
Mucuna+ N_{30} P_{15} K $_{15}$ $kgha^{-1}$	3.76a	0.70e	0.29b	0.26a	4.61c
Sesbania	2.97d	0.71e	0.20d	0.19c	4.97b
Sesbania+ N_{30} P_{15} K $_{15}$ $kgha^{-1}$	3.26c	0.87b	0.23c	0.27a	4.41d
N_{60} P_{30} K $_{30}$ $kgha^{-1}$	3.06d	0.68e	0.32a	0.30a	4.68c
Control	2.20f	0.55f	0.18e	0.16d	3.73f
SE±	0.090	0.010	0.010	0.010	0.130

Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of probability using DMRT.

Conclusion

Result indicate that incorporation of green manure alone significantly ($P<0.05$) increased organic C, total N, Mg^{2+}, K^+ and CEC but reduced soil pH while application of green manure combined with N_{30} P_{15} K $_{15}$ $kgha^{-1}$ improved soil available P and Ca^{2+}. However, application of N_{60} P_{30} K $_{30}$ $kgha^{-1}$ alone significantly increased Na^+ while application of N_{60} P_{30} K $_{30}$ $kgha^{-1}$ alone, green manure alone or in combination significantly increased K^+ compared to control. Based on the above findings, it is therefore recommended that incorporation of organic manure in combination with N_{30} P_{15} K $_{15}$ $kgha^{-1}$ on pearl millet cultivated soils will greatly enhance the chemical properties of soil and yield.

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ANALYSIS OF PHYSICO-CHEMICAL PARAMETERS OF MOHAMMED AYUBA DAM, KAZAURE, JIGAWA STATE, NIGERIA

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Abstract
This study analyses the physico-chemical parameters of Mohammed Ayuba Dam, Kazaure, Jigawa State, Nigeria. Water samples were collected from four (4) different sites in the Dam (A, B, C and D): The analysis was conducted on Physico-chemical parameters using American Public Health Association (APHA) procedures. The results of the physico-chemical parameters demonstrated that, Temperature ranges between 24 – 31 ^{0}C, Transparency 15 - 97cm, Conductivity 1420 – 3128mg/L, Dissolved Solids (DS) 1.1 – 2.5 mg/L, Suspended Solids (SS) 0–5mg/L, Total Dissolved Solids (TDS) 170 – 2800mg/L, pH 6.5 – 7.8, Salinity 0.1 – 1.6g/L, Total hardness (TH) 0.11 – 4.12 and Biological Oxygen Demand (BOD) 1.0 – 4.9mg/L. The values of Temperature, Transparency Conductivity, Dissolved solids, Suspended solids, Total dissolved solids, pH, Salinity, Total Hardness and Biological oxygen demand were within the acceptable limits set by World Health Organization (WHO) and Federal Environmental Protection Agency (FEPA) of Nigeria. The results of Pearson correlation coefficient, shows that there was positive correlation between Temperature with Transparency a Suspended solids. Conductivity was positively correlated with TDS, pH, TH. Transparency was positively correlated with BOD. Dissolved solids were positively correlated with suspended solids. Total dissolved solids were correlated positively with Salinity.

Keywords: Analysis, Physicochemical, Parameters, Mohammed Ayuba and Dam.

Introduction

Water is one of the abundantly available resources in nature, which man has exploited more than any other resources for the sustenance of life (Shinde *et al.,* 2011). The key to increase human productivity and long life is good quality water (Urbansky and Magnuson, 2002). Water is a precious natural abundant resource for sustaining life and environment. Water is absolutely essential not only for survival of human being but also for animals, plants and all other living being. Water constitutes about 70% of the body weight of almost all living organisms. It exists in three states namely solid, liquid and gas (Thakare *et al*., 2010). Water is the most important substance for human existence next to Oxygen (Melese, 1998). About 97% of earth's water supply is in the ocean which is unfit for human consumption and other uses because of its high salt contents, of the remaining 3% of the water bodies, 2% is locked in polar ice caps and only 1% is available as fresh water in rivers, lakes, dams, streams, reservoirs and ground water which is suitable for human consumption, (Kumar R & Yadav S. 2011) water used by man ranges from purely social needs such as recreation, religious worship, Baptisms and regional/cultural uses such as drinking, cooking, laundry, bathing, waste disposal, to economic needs such as irrigation, fisheries, animal production, electric power generation and navigation. Quality of water plays an important role, whenever it is used for either irrigation or for domestic purpose. Water pollution may change physico-chemical characters of any water, and makes it unfit for any purposes. The degree of pollution is generally assessed by studying physical and chemical characteristics of the water bodies (Duran and Suicmez, 2007). Though physicochemical approach to monitor water pollution is most common and many of information are available on these aspects, it may not provide all the information required at the local level and thus assessment of water quality of all the water bodies becomes essential.

Objectives

i. to determine the correlations between the physicochemical parameters of the dam water
ii. to determine if there is correlation between physicochemical parameters among the four (4) sampling site.

Materials and Methods

The Study Area:

Kazaure is one of the twenty seven Local government areas of Jigawa State, Nigeria. It has about 1780 Square kilometers of land and a population of one hundred and sixty one thousand four hundred and ninety four people 161,494 National Population Commission (NPC, 2006). The ancient city of Kazaure is blessed with many natural elevations, punctuated by hills and bifurcated by the Mohammed Ayuba Dam, with a modern bridge that links the two parts of the city together (Kanti and old Kazaure town).

Mohammed Ayuba Dam is an artificial reservoir situated between old Kazaure town and new town (kanti). The Dam collects its main source of water from three sources (Watari River, in Katsina State, Dambo Dam and Wawan Rafi Dam in Kazaure it also receives rain water as well as waste water from the town and Kanti. The size of the Dam is 15.65m-high earthen-concrete, with active storage capacity of 4,305 m^3. The total volume of the Dam is 299, 500m^3, the area of water is 116 ha, maximum base width 96.32 m and length 1,012 m (WRECA, 1980).

The Dam reservoir was planned as a multi-functional system, with the primary aim of flood control, human consumption, i and fishing, while the secondary benefit is recreation activities. The reservoir has a significant potential for water supply to settlements in Kazaure town. The dam is located on 12^0 39' 10" N and 8^0 24' 43" E with an altitude of 475m.

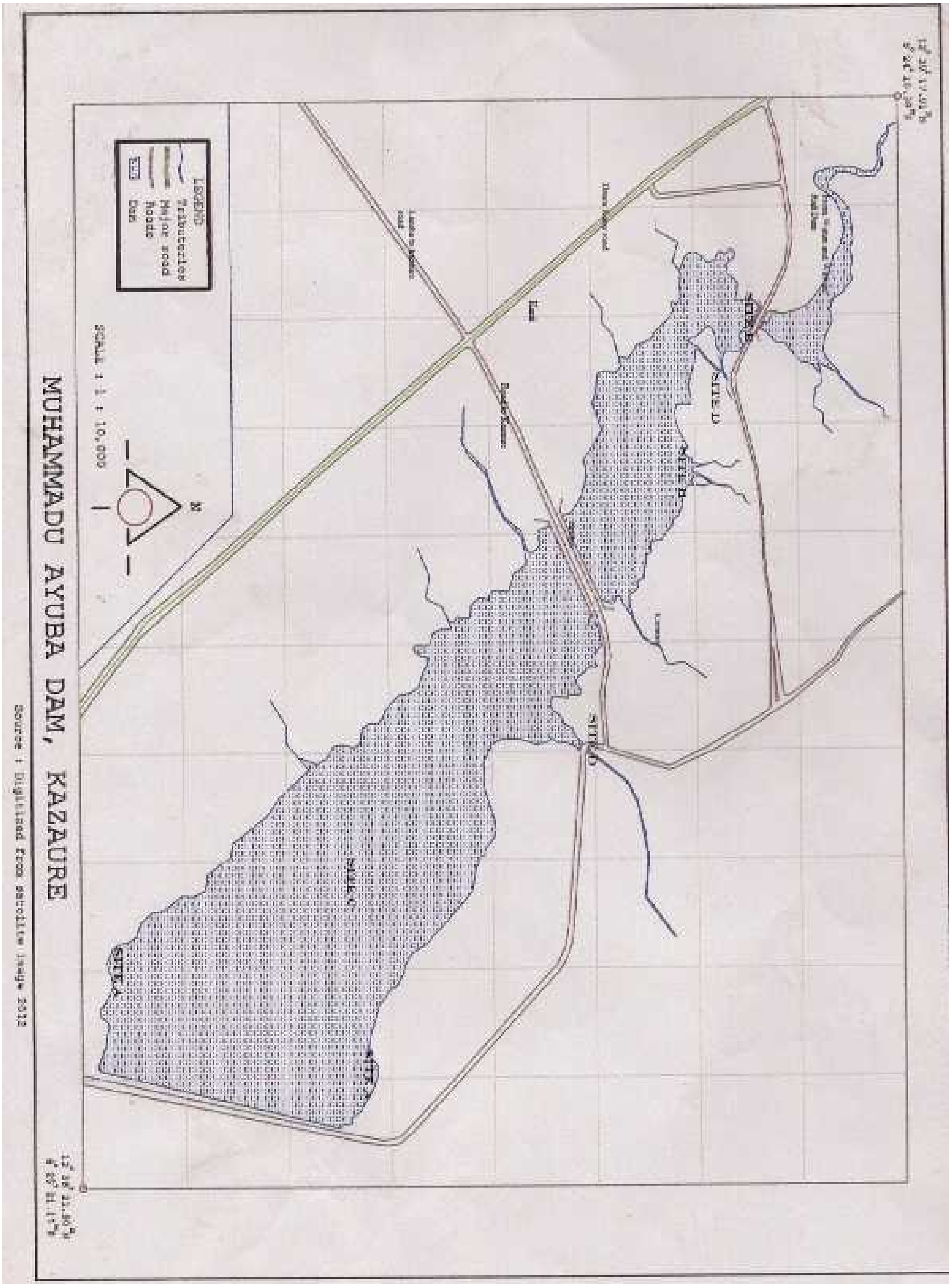

Fig. 1: Map showing the 4 sampling sites at Mohammed Ayuba Dam, Kazaure
(Source: Google earth/Digital from satellite image, 2012)

Sampling and sample Sites

Four sampling sites were selected to represent the water body at different points. These sampling sites (A, B, C and D) were selected based on the rate of human interference and other agricultural activities that have been taking place near the Dam

Site **A,** where anthropogenic activities such as washing of clothes, cars, motor cycles e.t.c taking place.

Site **B,** points where there is inflow of water into the Dam from Wawan Rafi Dam, Watari River and sewage from both Kanti and old Kazaure town.

Site **C** (Middle), the point where human interference was less, and

Site **D,** the point where water was collected from small bore hole at the depth of 9.0 m by the small scale business people at the dam site.

Samples collection

Water samples were collected starting from April, 2012 to February, 2013 (11 Months). The sampling frequencies were carried out on monthly basis between 7:00 a.m. and 10:00 a.m. when most of the human activities were taking place.

Water was collected at approximately l.0m depth by holding the sampler bottle near its base in the hand and plunging its neck downward, below the surface. The bottle was pushed until neck was slightly upward and mouth directed toward the current created artificially by pushing bottle forward horizontally in the direction away from the hand (APHA, 1998). In all cases, the sample bottles were rinsed with the water to be collected 2 - 3 times before final collection. After the water sample was collected, it was stored in cold box to arrest/prevent any chemical reaction in the water sample. Temperature and Transparency of water was measured at the collection site. Water sample bottle were labeled with date, time, sample site and parameters to be analyzed. The water sample was then transported to laboratory for analysis.

Statistical Analysis

Pearson's Correlation coefficients was performed on the data in order to determine the correlations between the physicochemical parameters.

Results and Discussion

The results of the study from table 1 indicated that there is a positive correlation between temperature (T^o) and suspended solids (SS), conductivity and total dissolved solids (TDS), as well as conductivity, TDS and pH at site A. However, there was negative correlation between temperature with total hardness (TH) and TDS. Suspended solids were also negatively correlated with pH. The results in table 2 indicated that temperature was correlated positively with transparency, but negatively correlated with total dissolved solids. Total dissolved solids were positively correlated with conductivity and Salinity. From the same table, conductivity was negatively correlated with temperature and transparency. Positive correlation was also observed between dissolved solids and suspended solids. Temperature was negatively correlated with conductivity. Negative correlation was observed between transparency with conductivity and total dissolved solids. The results in table 3 show that, Temperature was positively correlated with transparency, conductivity with total dissolved solids. However, a negative correlation was observed between temperature with conductivity and total dissolved solids. Transparency was negatively correlated conductivity and total dissolved solids. Salinity was also negatively correlated with dissolved solids.

From table 4, conductivity was positively correlated with SS and TDS. Total dissolved solids were also positively correlated with suspended solids. However, there was negative correlation between salinity with conductivity and dissolved solids. Eight (8) parameters were investigated from Mohammed Ayuba Dam water in Kazaure at four sampling sites (A, B, C and D). The results obtained from site A indicated that, the temperature of the dam water at the site varied from 25^0C in December to 31^0C in July. This rise in temperature in July could be as a result of break in rainfall and increased intensity of sunlight. These results corroborate with the results of Asaolu, (1999), Okonko *et al*. (2008) and National Freshwater Fishing Hall of Fame (2011). The low water temperature of the dam water at site A (November and December) during the dry season could be as a result of changes in air temperatures associated with the cool dry North-East trade winds (Harmattan). It is also agreed with the findings of Oladimeji and Wade (1984); Balarabe (1989); Kolo and Oladimeji (2004) observed low water temperatures in Makwaye Lake, near Zaria and in Shiroro dam during harmattan. Temperature was positively correlated with suspended solids. Conductivity was also positively correlated with total dissolved solids and pH. The higher the total dissolved solids the more the water conducts

The total dissolved solids results indicated that, Total Dissolved Solids values for the dam water at site A showed variations in concentration between dry and rainy seasons. These values varied from 168 mg/L to 450mg/L. However, they were within the allowable limit of 1000mg/L and 500mg/L set by WHO and FEPA respectively.

The pH values of Mohammed Ayuba dam recorded during the study period varied from neutral to slightly alkaline. pH values of most natural water are in the range of 6.5 - 8.5 (Chapman, 1996). At site A pH result ranged between 6.9 and 7.7 in the months of August and February respectively. The obtained values were within the recommended level (6.5 – 8.5) of drinking water sets by World Health Organization. High pH value recorded at site A was associated with water points that received wastes from human activities. Boyd and Lichtkoppler (1979) reported pH range of 6.09 - 8.45 as being ideal for supporting aquatic life including fish. Thus, the pH range obtained in this study was within the acceptable level of 6.0 to 8.5 for culturing tropical fish species (Huett, 1977) and recommended levels of drinking water (WHO, 1984). Federal Environmental protection Agency (FEPA) recommended pH 6.5 – 8.5for drinking and 6.0 – 9.0 for aquatic life. Table 3 indicates a positive correlation between pH with TH. There was a significant difference in pH mean between site D with A, B, and C. However, sites A, B and C were not significant from one another.

The result of total hardness obtained in the study ranged from 0.57 mg/L to 3.94 mg/L $CaCO_3$. Total hardness was higher during the dry season than in the rainy season. This could be as a result of low water levels and high concentration of dissolved ions, and the lower rainy season total hardiness value could be due to dilution of that water body. The finding agreed with the results obtained by Ufodike *et al*. (2001); Kolo and Oladimeji (2004); in Shiroro Lake and Dokowa Mine Lake respectively. Total hardness was positively correlated with pH. Similar observations have been made by Ratushnyak *et al*. (2006). Table 2 and 3 indicated that, Total Hardness was positively correlated with conductivity and pH. However, it showed a negative significant relationship with temperature and transparency. Similar results have been reported by Pawar and Pulle (2005) studied on Pethwadaj Dam, Nanded, India.

The Biological Oxygen Demand values varied from 1.1mg/L in the month of February to 3.6 mg/L in the month of December. Biological Oxygen Demand and salinity was correlated positively. The pH range (6.9 – 7.7) at this site also favoured the growth of these organisms.

Water Temperature is an Important Factor which influences the chemical, Biochemical and Biological characteristics of water body. The variation in the water temperature may be due to different timing of collection and influence of season (Jayaraman *et al*.. (*2*003). This result corresponds with the finding of Parihar *et al.* (2003)**.** Table 2 indicates positive correlation between temperature and transparency at site B.

There was variation in the result of conductivity between dry and wet seasons. The conductivity was higher in the dry season than in the wet season as obtained during the study. This corresponded with the findings of high dry season conductivity values for Shiroro Lake (Ovie and Adeniji 1993; Kolo and Oladimeji 2004). Conductivity was positively correlated with Total Dissolved Solids as observed during the study period.

Conclusion

The physicochemical parameters of water from Mohammed Ayuba Dam, Kazaure, such as Temperature, Conductivity, Dissolved solids, Suspended solids, Total Dissolved solids, pH, Salinity, Total hardness and Biological Oxygen Demand, as indicated by this research are within the recommended level for portable drinking water established by World Health Organization (WHO) and Federal Environmental Protection Agency (FEPA) of Nigeria.

Table 1: Physicochemical parameters of water samples from Mohammed Ayuba dam, Kazaure 2012/13 (site A)

	Temp	Trans	Cond.	DS	SS	TDS	pH	Sal	TH	BOD
Months	(^{0}C)	(cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)		(g/L)	(mg/L)	(mg/L)
April	30	51	249	1.9	1	210	7.4 0.4	0.69	1.3	2
May	29	46	253	1.1	0	176	7.3 0.4	0.81	1.2	2
June	30	30	456	1.3	0	168	7.4 0.3	1.60	2.4	1
July	31	20	243	1.4	2	170	7.1 0.3	0.79	2.3	1
August	30	18	514	1.3	2	360	6.9 0.3	1.18	2.1	1
Sept.	29	18	450	1.1	0	315	7.2 0.2	1.16	2.1	1
Oct.	28	15	457	1.2	1	370	7.4 0.6	1.02	2.7	2
Nov.	26	35	642	1.1	0	450	7.0 1.1	0.57	3.1	5
Dec.	25	43	1157	1.3	0	436	7.3 1.1	1.82	3.6	2
Jan.	26	15	1200	1.3	0	440	7.7 0.1	2.28	2.5	0
Feb.	26	15	1235	1.1	0	410	7.7 0.2	3.94	1.1	4

Keys:
Temp = Temperature   Trans = Transparency   Cond. = Conductivity   DS = Dissolved Solid
SS = Suspended Solids   TDS = Total Dissolved Solids   Col = Colour   Sal = Salinity
TH = Total Hardness   BOD = Biological Oxygen Demand   Site **A**

Table 2: Pearson Correlation Coefficients of Physicochemical Parameters of Mohammed Ayuba Dam, Kazaure at site A

Parameters	Temp	Trans	Cond	DS	SS	TDS	pH	Sal
Temp	1.0000							-0.48752
Trans	0.0556	1.0000						0.48424
Cond	0.86214	-0.27777	1.0000					0.11827
DS	0.40025	0.43409	-0.29248	1.0000				0.09911
SS	0.63671*	-0.22023	-0.47657	0.42594	1.0000			-0.18657
TDS	-0.85089	-0.33084	0.78197*	-0.37283	-0.28481	1.0000		0.38962
pH	-0.39800	-0.13326	0.54123*	0.05393	-0.50465	0.12965	1.0000	-0.37073

Source: field survey, 2013
Key:
Temp = Temperature,   Trans = Transparency,   Cond = Conductivity,   DS = Dissolved Solids,
SS = Suspended Solids, TDS = Total Dissolved Solids, Sal = Salinity,
* indicate positive correlation
Site **A,** where anthropogenic activities are taking place.

Table 3: Physicochemical parameters of water samples from Mohammed Ayuba dam, Kazaure 2012-2013

Months	Temp	Trans	Cond.	DS	SS	TDS	pH	Sal	TH	BOD
	(^{0}C)	(cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(g/L)	(mg/L)	(mg/L)	
April	29	46	420	1.7	1	298	7.0	0.3	0.20	1.1
May	29	51	419	1.9	1	285	6.8	0.3	0.21	1.3
June	28	66	289	1.2	0	275	6.6	0.6	1.35	3.1
July	30	71	400	1.2	0	280	7.3	0.2	0.11	2.2
August	28	74	357	1.3	1	250	7.2	0.3	1.93	4.5
September	28	74	277	1.2	0	208	7.7	0.1	1.1	3.5
October	29	66	289	1.3	1	318	7.8	0.4	1.12	4.2
November	27	53	1028	1.2	0	720	6.7	1.0	0.13	4.5
December	26	48	1200	1.2	1	715	7.0	1.2	1.84	4.1
January	27	41	1154	1.4	0	710	7.7	0.2	4.12	2.2
February	26	41	1068	1.2	0	480	7.1	0.1	3.22	1.0

Keys:
Temp = Temperature Trans = Transparency Cond = Conductivity DS = Dissolved Solid
SS = Suspended Solids TDS = Total Dissolved Solids Col = Colour Sal = Salinity
TH = Total Hardness BOD = Biological Oxygen Demand Site B

Table 4: Pearson Correlation Coefficients of physicochemical Parameters of Mohammed Ayuba Dam, Kazaure at site B

	Temp	Trans	Cond	DS	SS	TDS	pH	Sal
Temp	1.00000							-0.41727
Trans	0.53289*	1.00000						-0.16471
Cond	-0.82031	-0.75709	1.00000					0.43170
DS	0.40213	-0.35036	-0.22065	1.00000				-0.24671
SS	0.21419	-0.02670	0.22170	0.54085*	1.00000			-0.19152
TDS	-0.72854	-0.66999	0.94462*	-0.23076	-0.18378	1.00000		.59910*
pH	0.14321	0.22193	-0.10418	-0.17845	-0.02937	-0.10323	1.00000	-0.49835

Source: Field survey, 2013
Key:
Temp = Temperature, Trans = Transparency, Cond = Conductivity, DS = Dissolved Solids,
SS = Suspended Solids, TDS = Total Dissolved Solids, Sal = Salinity, *indicate positive correlation
Site B,

Table 5: Physicochemical parameters of water samples from site C of Mohammed Ayuba dam, Kazaure Feb. 2012-Jan. 2013

Months	Temp	Trans	Cond.	DS	SS	TDS	pH	Sal	TH	BOD
	(^{0}C)	(cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(g/L)	(mg/L)	(mg/L)	
April	31	76	638	2.2	0	471	7.3	0.2	0.11	1.2
May	30	81	647	2.4	0	458	7.1	0.2	0.13	1.3
June	29	92	532	2.3	1	460	7.0	0.1	1.04	4.5
July	31	97	642	2.3	0	450	7.5	0.1	1.03	3.1
August	27	89	214	2.5	0	280	7.2	0.3	1.09	5.8
September	28	86	142	2.2	1	299	7.3	0.1	1.6	4.7
October	30	89	210	2.1	0	460	7.5	1.2	1.1	5.0
November	26	81	686	2.1	2	480	7.2	1.2	1.0	5.1
December	24	71	1114	2.1	0	699	7.3	0.7	1.7	3.1
January	26	66	1185	2.1	1	690	7.2	0.1	2.1	2.0
February	26	66	1243	2.4	0	870	7.3	0.1	3.7	1.2

Keys:
Temp = Temperature   Trans = Transparency   Cond. = Conductivity   DS = Dissolved Solid
SS =Suspended Solid,   Col = Colour   TDS = Total Dissolved Solids   Sal = Salinity
TH = Total Hardness   BOD = Biological Oxygen Demand   Site **C**

Table 6: Pearson Correlation Coefficients between physicochemical Parameters of Mohammed Ayuba Dam, Kazaure at site C

Parameters	Temp	Trans	Cond	DS	SS	TDS	pH	Sal
Temp								-0.20310
Trans	0.61126*							0.06594
Cond	-0.52339	-0.79614						-0.16769
DS	0.20546	0.24217	-0.16016					-0.54917
SS	-0.30731	-0.00503	-0.02464	-0.43165				0.24814
TDS	-0.50422	-0.79069	0.92679*	-0.18820	-0.11932			-0.04133
pH	0.22515	0.14635	-0.10860	-0.28597	-0.40507	0.044171	.00000	0.28407

Source: Field survey, 2013
Key:
Temp = Temperature,   Trans = Transparency,   Cond = Conductivity,   DS = Dissolved Solids,
SS = Suspended Solids,   TDS = Total Dissolved Solids,   Sal = Salinity.   *indicate positive correlation
Site **C**

Table 7: Physicochemical parameters of water samples from site D of Mohammed Ayuba dam, Kazaure 2012-2013

Months Temp	Cond.	DS	SS	TDS	pH	Sal	TH	BOD
	(^{0}C)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(g/L)	(mg/L)	(mg/L)
April	28	3110	2.1	0	2400	6.90.1	0.13	1.1
May	29	3100	1.9	3	2600	6.80.2	0.21	1.1
June	27	3128	1.5	2	2500	7.00.2	0.41	2.3
July	28	3110	1.5	5	2800	6.60.2	0.18	3.2
August	25	400	1.7	1	1500	7.00.4	0.96	3.1
September	27	315	2.1	1	1221	6.50.2	0.16	2.1
October	27	320	1.6	1	1500	6.81.0	0.18	4.9
November	28	300	1.3	1	1280	6.91.1	0.15	4.7
December	30	557	1.4	0	1780	6.71.6	1.6	3.5
January	29	571	1.8	0	1800	6.90.1	1.0	1.7
February	28	586	1.3	0	1600	6.70.2	3.0	1.1

Keys:
Temp = Temperature   Trans = Transparency   Cond. = Conductivity   DS = Dissolved Solid
SS = Suspended Solids   Site **D**

Table 8: Pearson Correlation Coefficients between physicochemical Parameters of Mohammed Ayuba Dam, Kazaure at site D

Parameters	Temp	Cond.	DS	SS	TDS	pH	Sal
Temp	1.00000						0.29419
Cond.	0.14678	1.00000					-0.53797
DS	-0.12699	0.24112	1.00000				-0.63702
SS	-0.07043	0.60393*	-0.05824	1.00000			-0.49384
TDS	0.27384	0.95445*	0.12537	0.63744*	1.00000		-0.43205
pH	-0.28019	0.12498	-0.08522	0.23929	0.09192	1.00000	-0.15512

Source: Field survey, 2013
Key: Temp = Temperature, Trans = Transparency, Cond = Conductivity, DS = Dissolved Solids, SS = Suspended Solids, TDS = Total Dissolved Solids, Sal = Salinity *indicate positive correlation
Site **D**

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COINTEGRATION TESTS AND SPATIAL PRICE LINKAGES OF REGIONAL TEA MARKETS IN WEST AFRICA

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Abstract
Regional market integration in many agricultural commodities has been extensively studied because of the insight it provides with respect to the function of these markets, given that it provides valuable information about the dynamics of market adjustments, and whether there exists market imperfection which may justify the need for government intervention. The present study used annual producer tea prices of three major tea markets in West Africa region spanning from 1991 to 2013, and empirically determined the degree of temporal price behavior using VAR and ARCH family models. The results showed that the selected regional tea markets were weakly cointegrated in the long-run, indicating low competition which justifies the need for extensive regional bloc government intervention designed to improve competitiveness which will in-turn enhance market efficiency. Furthermore, to achieve the goal of integration of the regional markets, the government should improve the market information and development communication, strengthen the infrastructural facilities of the target markets, and relax some of stringent trade policies, thus, establishing single uniform economic market in the region (West Africa) in particular and Africa in general.

Keywords: Market integration; Cointegration; Price; Tea market; West Africa

Introduction

So long as the farmer produces only for his family, he is least bothered about the type of the marketing system in existence. But if he has a surplus production to exchange for goods which he does not produce, he looks for a marketing system which purchases his products at prices that not only motivate him to continue production but also help increase production *via* investment in new inputs. As the objective of encouraging farmers to produce a larger marketable surplus-not only to meet the growing domestic demand but also to generate exportable surpluses and ensure them a descent standard of living-has assumed importance, the whole issue of the type and efficiency of the marketing system has attracted the attention of all those concerned with the overall development of the West Africa economy. Invariably, market pundits have argued that market reforms are required for achieving efficient agricultural markets, and hence an efficient agricultural production system. Until agricultural markets are integrated, producers and consumers will not be able to realize the potential gains inherent from the common market (Paul *et al.*, 2016). The degree, to which the end users and farmers can benefit, depends on how the domestic markets are integrated with the world markets and how the different regional markets are integrated with each other (Varela *et al.*, 2012).

Most of the literature documented studies on market integration of agricultural commodities concentrated mainly on market intelligence with only a few studies (Sadiq *et al.*, 2016a) which explored both market intelligence and market outlook. Market outlook/market situation that is likely to prevail in the near future is of considerable important to farmers, traders and processors. For example, any information on the prices that is likely to prevail during the forthcoming post-harvest season help farmers in planning their area allocation to an alternative crop. Although, market intelligence is a prelude to market outlook as it helps in building outlook for current and future decision. The issue of market integration is the centre-piece of many contemporary debates regarding market liberalization, price policy and economy reforms in many developing countries. Report showed that African tea prices had plummeted by \$0.5-\$2.8/kg since the commencement of year 2013 from a record hit of \$4.26/kg in year 2012, and was attributed to combination of increased production, fluctuating demand from season and slim end of market buyers, thus, bringing down export by 4% (AFREXIM, 2015). These call for an urgent need to look at how the functioning of tea supply chains can be strengthened to minimize the susceptibility of tea farmers to price fluctuation. Without efficient spatial price integration of markets, price signals will not be transmitted from deficit areas to surplus areas: prices will be more volatile, thus, farmers will specialize according to long-term comparative advantage and the gains from trade will not be realized. Improved market information can greatly assist in identifying the specific measures required to improve the functioning of tea supply chains in this region (West Africa) of Africa. Therefore, the study of market integration becomes imperative in order to investigate temporal price behavior of the revenue generating export commodity (tea) across spatially separated markets in West Africa. The specific objectives were to:-

i. To determine the extent of tea market integration in the region;
ii. To determine the degree of market integration and forecast the future market prices of tea in the region; and,
iii. To determine the price volatility and leverage effect in the regional tea market.

Research Methodology

The study made use of annual price series data of tea spanning from 1991 to 2013 for three major tea markets *viz.* Ivory-Coast, Ghana and Nigeria in West Africa region of Africa. The data were sourced from FAOSTAT database, USDA database, and NBS database. The data were analyzed using inferential statistic. Objective i was achieved using Johansen's cointegration test, objective ii was achieved using VECM, Impulse response function, Granger causality test and dynamic regression model (AR model), and objective iii was achieved using ARCH family model (GARCH).The analytical tools used are given below:

1. Model Selection Criteria

The information criteria are computed for the VAR models of the form:

$Y_t = A_1Y_{t-1} + \ldots.. + A_nY_{t-n} + B_q X_t + \ldots\ldots.. + B_qX_{t-q} + CD_t + \mathcal{E}_t$ (1)

Where Y_t is K-dimensional. The lag order of the exogenous variables X_t, q, and deterministic term D_t have to be pre-specified. For a range of lag orders n the model is estimated by OLS. The optimal lag is chosen by minimizing one of the following information criteria:

$AIC\ (n) = \log\det\{\sum_u(n)\} + (2/T)\ nK^2$ …. (2)

$HQ\ (n) = \log\det\{\sum_u(n)\} + (2\log\log T/T)\ nK^2$ (3)

$SC\ (n) = \log\det\{\sum_u(n)\} + (\log T/T)\ nK^2$ …… (4)

$FPE\ (n) = (T + n^*/T-n^*)^k \det\{\sum_u(n)\}$ ……… (5)

Where $\sum_u(n)$ is estimated by $T^{-1}\sum_{t=1}^{T} U\ U^1t$, n^* is the total number of parameters in each equation of the model when n is the lag order of the endogenous variables, also counting the deterministic terms and exogenous variables. The sample length is the same for all different lag lengths and is determined by the maximum lag order.

2. Augmented Dickey Fuller Test

The Augmented Dickey-Fuller test (ADF) performs the test for the unit root in a time series sample (Blay *et al.*, 2015). The autoregressive formulation of the ADF test with a trend term is given below:

$\Delta p_t = \alpha + p_{t-1} + \sum_{j=2}^{ti} \beta\ \Delta p_{it-j+t} + \mathcal{E}$ ………(6)

Where, p_{it} is the price in market i at the time t, Δp_{it} $(p_{it} - p_{t-1})$ and α is the intercept or trend term.

3. Johansen's Co-integration Test

The Johansen procedure is a multivariate generalization of the Dickey-Fuller test and the formulation is as follows (Johansen, 1988):

$p_t = A_1\, p_{t-1} + \mathcal{E}_t$…………………… (7)

So that

$\Delta p_t = A_1\, p_{t-1} - p_{t-1} + \mathcal{E}_t$…………… (8)

$p_t = (A_1 - I)\, p_{t-1} + \mathcal{E}_t$ ………………(9)

$\Delta p_t = \prod p_{t-1} + \mathcal{E}_t$…………………...(10)

Where, p_t and $\mathcal{E}_t$ are ($n\times1$) vectors; A_t is an (n x n) matrix of parameters; I is an (n x n) identity matrix; and $\prod$ is the (A_{1-1}) matrix.

Using the estimates of the characteristic roots, the tests for the number of characteristic roots that are insignificantly different from unity were conducted using the following statistics:

$ª_{trace} = -T \sum_{i=r+1}^{n} ln\,(1-\lambda_i)$ ……… (11)

$ª_{max} = -T\, ln(1-\lambda_i + 1)$ ……………(12)

Where, λ_i denotes the estimated values of the characteristic roots (Eigen values) obtained from the estimated $\prod$ matrix, and T is the number of usable observations.

4. Granger Causality Test

Granger (1969) causality test was used to determine the order and direction of short-term and long-term equilibrium relationships. Whether market p_1 Granger causes market p_2 or vice-versa was checked using the following model:

$p_t = c + \sum_{i=1}^{n}(¤\, p_{1t-i} + ¢_i\, p_{2t-i}) + \mathcal{E}_i$ (13)

A simple test of the joint significance of δ_i was used to check the Granger causality, i.e.

H_0: $\delta_1 = \delta_2 = ……..\ \delta_n = 0$.

5. Vector Error Correction Model (VECM)

The VECM explains the difference in y_t and y_{t-1} (i.e. Δy_t) and it is shown below (Sadiq *et al.*, 2016a; Sadiq *et al.*, 2016b):

$\Delta y_t = a + «(y_{t-1} - \beta x_{t-1}) + \sum_{i=0}^{i=t} ¢_i\ \Delta x_{t-1} + \sum_{i=1}^{i=t} ¥_i \Delta ¥_{t-1}$ (14)

It includes the lagged differences in both x and y, which have a more immediate impact on the value of Δy_t.

6. Impulse Response Functions

The generalized impulse response function (GIRF) in the case of an arbitrary current shock, δ, and history, $\omega_{t-1}$is specified below (Rahman and Shahbaz, 2013; Beag and Singla, 2014):

$GIRF_Y\,(h, \delta, \omega_{t-1}) = E\,[Y_t + h|\delta, \omega_{t-1}] - E\,[y_{t-1}|\omega_{t-1}]$ (15).

7. Forecasting Accuracy

For measuring the accuracy in fitted time series model, mean absolute prediction error (MAPE), relative mean square prediction error (RMSPE) and relative mean absolute prediction error (RMAPE) (Paul, 2014) and R^2 were computed using the following formulae:

MAPE = $1/T \sum \{A_t - F_t\}$ ……………… (16)

RMPSE = $1/T \sum \{(A_t - F_t)^2 / A_t\}$ …..…. (17)

RMAPE = $1/T \sum \{(A_t - F_t) / A_t\}$ X 100 . (18)

$\mathbf{R^2} = 1 - \frac{\sum_{i=1}^{n} (A_{ti} - F_{ti})}{\sum_{i=1}^{n} A_{ti}}$……………….. (19)

Where,

$\mathbf{R^2}$ = coefficient of multiple determination,

A_t = Actual value;

F_t = Future value, and

T = time period(s).

8. Index of Market Connection (IMC)

The index of market concentration was used to measure price relationship between integrated markets, and the model is specified below:

$P_R = \beta_0 + \beta_1 P_{Rt-1} + \beta_2 \mathrm{a} P_{Ut} + \beta_3 P_{Ut-1} + \mathcal{E}$ (20)

P_{Ut} = interactive market price

P_{Rt}= reference market price

P_{Rt-1} = lagged price of reference market

P_{Ut-1} = lagged price of target market

Ɛ = stochastic/ noise/disturbance term

Δ = difference

β_0 = Intercept

β_1= coefficient of lagged reference market price

β_2 = coefficient of the 1st difference of target market price

β_3 = coefficient of lagged target market price

IMC = β_1/β_3, where $0 \leq$ IMC $\leq \infty$

Where,

IMC < 1 implies high short-run market integration;

IMC > 1 implies low short-run market integration;

IMC = ∞ implies no short-run market integration; and,

IMC = 1 implies moderate short-run integration.

9. GARCH Model

The representation of the GARCH (p, q) is given as:

$Y_t = \alpha + b_1Y_{t-1} + b_2Y_{t-2} + \mathcal{E}_i$

(Autoregressive process) ………… (21)

And the variance of random error is:

$\pm^{2}_{t} = \text{a}_{0} + \text{a}_{1}\text{«}^{2}_{t-1} + \text{a}_{2}\pm^{2}_{t-1}$ ……….. (22)

$\pm^{2}t = \mu + \sum_{i=1}^{p} \beta_i \pm^{2}_{t-i} + \sum_{j=1}^{q} \sim_i \mathcal{E}^{2}_{t-i}$ (23)

Where, Y_t is the price in the i^{th} period of the i^{th} market, p is the order of the GARCH term and q isthe order of the ARCH term. The sum of $(\alpha + \beta)$ gives the degree of persistence of volatility in the series. The closer is the sum to 1; the greater is the tendency of volatility to persist for a longer time. If the sum exceeds1, it is indicative of an explosive series with a tendency to meander away from the mean value.

Results and Discussion

Lag Selection Criteria

Before we construct the conditional mean, the first thing to do is to find the right lag of VAR model in order to ensure that the errors are Gaussian white noise and obtain more interpretable parsimonious results devoid of biases due to sensitive nature of time series data to lag length (Table 1). A reasonable strategy of how to determine the lag length of the VAR model is to fit VAR (p) models with different orders $p = 0,\ldots,p_{\max}$and choose the value of p which minimizes some model selection criteria. Model selection criteria for VAR (p) are based on Akaike information criterion (AIC), Schwarz-Bayesian information criterion and Hannan-Quinn (HQ) information criterion. A cursory review of the results shows that Akaike and Hannan-Quinn information criteria advised for the selection of lag 4 while Schwarz-Bayesian information criterion chose lag 1 as indicated by the asterisks ascribed to the criterion. And by applying democratic principle the decision of two criteria *viz.* Akaike and Hannan-Quinn information criteria supersedes that of the latter, therefore lag 4 was chosen as the optimum lag truncation length that is appropriate for all the models to be used in subsequent analysis.

Table 1: Lag selection criteria

Lag(s)	AIC	BIC	HQC
1	42.88	43.62*	43.01
2	43.09	44.28	43.29
3	43.45	45.09	43.72
4	41.89*	43.98	42.24*

Test of Unit Roots

Before conducting cointegrating tests, there is a need to examine the univariate time-series properties of the data and confirm that all the price series are non-stationary and integrated of the same order. This can be established analytically by using the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and GLS-ADF tests. The results of the unit root tests using ADF, PP and GLS-ADF tests are shown in Table 2. A perusal of Table 2 shows that the ADF test results applied at the level for all the price series variables did not reject the null hypothesis of non-stationarity as indicated by the tau-statistics which were greater than the t-critical at 5% significance level. But at the succeeding stage (1st difference) the applied ADF test results for all the price series variables rejected the null hypothesis and accepted the alternative hypothesis of the stationarity of the price series as indicated by the tau-statistics which were lower than their respective critical values at 5% significance level. Furthermore, because of the inherent weaknesses of the ADF test: the underlying distribution theories assume that the residual errors are statistically independent and have a constant variance which may not be true for many time series data; it tends to lost its power to test for stationarity if the lag length is too long, it tends to lost its power to test for stationarity if the data have structural break points and also if it contains more than one unit root it tends to lost its power to test for stationarity- its validity and robustness was verified using GLS-ADF test which overcomes this short-coming.

The results of the PP test which is a non-parametric model conform to the results of the ADF test at the level and at first difference.

Also, the results of the GLS-ADF test applied at level and at first difference accepted the null hypothesis of non-stationarity as indicated by tau-statistics in absolute value which were lower than the t-critical at 5% significance level and rejected the null hypothesis in favour of the alternative hypothesis of stationarity of the data as indicated by tau-statistics in absolute value which were higher than the t-critical at 5% significance level, respectively. Since these results were in conformity with the earlier results produced by ADF-test, thus, it can be adjudged that the obtained ADF test results were robust and valid for the subsequent analysis. Because of these inherent weaknesses, great econometric scholars: Maddalla and Kim (1998) as cited by Gujarati *et al.*(2012), Maddalla and Lahiri (2013) suggested that all the traditional unit root test models (DF, ADF and PP tests) should be discarded despite being the most widely used unit root test models. Given that all the price series are now integrated of the same order I(1) as evidenced by ADF, PP and GLS-ADF tests, it became possible to conduct the cointegration tests. It should be noted that since these variables were non-stationary at levels, any attempts to use them will lead to spurious/nonsense regression which is not ideal for policy making and cannot be used for long run prediction.

Table 2: Unit root tests

Tests		**Stage**	**Ivory-Coast**		**Ghana**		**Nigeria**		**Remarks**
			^{2}-stat	**P<0.05**	**^{2}-stat**	**P<0.05**	**^{2}-stat**	**P<0.05**	
ADF		Level	-1.76	0.688	-2.42	0.361	-3.30	0.07	**Non-stationary**
		1st diff.	-5.40*	0.002	-3.98*	0.009	-3.75*	0.04	**Stationary**
			^{2}-stat	**^{2}-critical**	**^{2}-stat**	**^{2}-critical**	**^{2}-stat**	**^{2}-critical**	
PP	**Z(t)**	Level	-0.217	-3.00	-2.267	-3.600	-1.76	3.00	**Non-stationary**
		1st diff.	-5.19*	-3.00	-4.825*	-3.600	-3.67*	3.00	**Stationary**
	Z(rho)	Level	-0.629	-12.50	-7.636	-17.90	-6.48	-12.50	**Non- stationary**
		1st diff.	-22.10*	-12.50	-24.41*	-17.90	-16.67*	-12.50	**Stationary**
ADF-GLS		Level	-1.92	-3.19	-2.42	-3.19	-2.14	-3.19	**Non- stationary**
		1st diff.	-5.66*	-3.19	-4.55*	-3.19	-3.91*	-3.19	**Stationary**

Note: * indicate that unit root at the level or at first difference was rejected at 5 per cent significance.

Multivariate market Cointegration Test Results

The results of cointegration using Johansen's Jusleius maximum likelihood tests are presented in Table 3. To investigate the first null hypothesis that the variables were not cointegrated (r = 0), both the estimated trace and Eigen-value statistics rejected the null hypotheses as their respective test statistic values were higher than their corresponding critical values at 5% significance level and accepted the alternative of one or more cointegrating vectors. Furthermore, the null hypothesis r ≥ 2 from both the trace and maximum Eigen-value tests statistics were accepted and their alternative hypotheses (r = 2) were rejected as their respective test statistic values were less than their corresponding critical values at 5% significance level. Both these tests confirmed that all the three selected tea markets had one cointegrating vectors out of 3 cointegrating equations, indicating that they were weakly integrated and price signals were not fully transmitted from one market to the other to ensure efficiency. On the whole, the results of cointegration tests indicated that the regional tea markets were weakly integrated in the long run, as only one out of the three markets were cointegrated. This also indicates that there are two common stochastic trends; hence two independent markets exist among the three markets. Therefore, it can be deduced that the law of one price between these markets was poor, implying that the price differences between these spatially separated markets were not equal to transaction costs i.e. there exist arbitrage in these markets. Thus, Johnson cointegration test has shown that despite that these selected regional tea markets in West Africa are geographically isolated and spatially segmented; they were fairly connected in terms of tea prices, implying that they have long-run price linkage across them. Also, it can be inferred that the spatial market integration conceptualized as tradability for these markets was consistent with market efficiency as their prices equilibrate across the markets while trade occurs.

Table 3: Multivariate market cointegration test results

H_0	H_1	Eigen value	Trace test	P-value	Lmax test	P-value
r = 0	r ≥1	0.867	46.29**	0.0002	36.272**	0.0001
r ≤ 1	r ≥2	0.368	10.01	0.2848	8.272	0.3598
r ≤ 2	r ≥3	0.092	1.74	0.187	1.742	0.187

Note: **denotes rejection of the null hypothesis at 5 per cent level of significance

Pair-wise market Cointegration Test Results

The results of pair-wise cointegration across the markets are presented in Table 4. A perusal of the Table showed that the market pairs Ivory Coast – Ghana and Ivory Coast - Nigeria, had one cointegrating vectors, indicating that these market pairs were well-cointegrated and there exists long-run price association between them. Furthermore, it implies that the law of one price prevails between these market pairs, meaning that price differences between these market pairs are equal to the transaction cost. Therefore, the spatial market integration conceptualized as tradability for these market pairs are consistent with market efficiency as prices equilibrate across them while trade occurs. On the other hand, the market pair: Ghana- Nigeria market pair had no cointegrating vector, implying non-existent of any cointegration between them and thus, no long-run price association exists between this two market pair. It can be deduced that the law of one price did not prevail between this market pair, and the price difference between them is not equal to transactional costs, thus, market inefficiency between them. Furthermore, the spatial market integration conceptualized as tradability for this market pair is not consistent with market efficiency as prices did not equilibrate across this market pair while trade occurs. However, the market inefficiency between Ghana – Nigeria market pair can be attributed to several factors that undermine the degree of market integration and generate discontinuities in the price responses to exogenous shocks. The first one is the presence of high transaction costs relative to the price differential between this market pair, resulting in an autarkic market. Other factors include the presence of barriers to entry, risk aversion and information failures. Some characteristics of agricultural production, commercialization, and consumption, such as inappropriate transportation infrastructure, entry barriers and information failures, may create more friction in the arbitrage process. Also, it can be deduced that the power of these markets was concentrated in the hand of few traders, low quality and quantity of arrivals in these markets, thereby causing imperfection in these markets. Overall, the results show that the tea markets across the region were integrated as two out of the three relationships were cointegrated, indicating a high level of integration in the tea markets in West Africa.

Table 4: Pair-wise market Cointegration Test Results

Market pair	H_0	H_1	Trace test	P-value	Lmax test	P-value	CE
Ivory Coast- Ghana	r = 0	r ≥1	22.79**	0.02	15.21**	0.06	1CE
	r ≤ 1	r ≥2	7.58	0.10	7.58	0.10	
Ivory Coast- Nigeria	r = 0	r ≥1	16.59**	0.087	15.87**	0.074	1CE
	r ≤ 1	r ≥2	0.722	0.396	0.722	0.395	
Ghana - Nigeria	r = 0	r ≥1	17.298	0.123	11.49	0.225	NONE
	r ≤ 1	r ≥2	5.810	0.213	5.81	0.213	

Note:**denotes rejection of the null hypothesis at 10 per cent level of significance
CE- Cointegration Equation

Multivariate Vector Error Correction Model Results

Price changes in one market will be transmitted on a one-to-one basis to the other market either instantaneously (short-run integration) or over a number of lags (long-run integration), following an adjustment process toward the long-run equilibrium relationship between the price series. The coefficients of ECTs indicate the speed of adjustment of any disequilibrium towards the long-run equilibrium. These coefficients apparently reflect the long-run deviations of the system from the long-run equilibrium level as a result of shock(s) originating from short-run equilibrium. A cursory review of the results shows negative ECTs for all the markets, indicating that the long-run disequilibrium adjustment process would lead to stable long-run prices in all of the selected markets (Table 5). However, the results show that the long-run adjustment coefficients (ECTs) of Ghana and Nigeria markets) were statistically insignificant in explaining the price changes in other markets. The long-run dynamics of tea prices in Ivory-Coast market measured by the ECT display negative and statistically significant attractors. The speed of adjustment (-0.345) is statistically significant at 5% significance level, meaning that, a price shock that induces price deviations from their equilibrium level would induce traders to respond to the shock in a way that prices would converge toward their equilibrium value. In other words, it implies that 34.5% of the previous deviation in the prices of tea in Ivory-Coast market due to short-run shocks is corrected annually in order to establish equilibrium in the long-run. However, the adjustment rate was very slow as it would take approximately 7.9 months to restore back to equilibrium in the long run if eventually, the shocks originate from any of the short-run equilibrium. This coefficient, known as the attractor, helps absorb the effects of shocks and keeps prices in a long-run equilibrium relationship. The higher the attractor in absolute value, the faster would be the speed of adjustment of the prices towards the equilibrium level. However, such an adjustment occurs only if there is a linear and symmetric relationship between the price series of the markets. Furthermore, there were delays in the short-run price transmission except for lagged one price of tea at Ghana market as the coefficients of the lagged price differences were not statistically significant. The prices of tea in Ghana market at lagged one in the short-run was instantly transmitted as indicated by the estimated price coefficient which was significant at 5% significance level. Also, the prices of tea in Ivory- Coast and Ghana markets at lagged one were instantly transmitted to Ghana market as evidenced by the price coefficients which were significant. These negative coefficients indicate that in addition to spatial price differences, some unknown factors have a predominant role in spatial price transmission.

Generally, the long-run price integration of regional tea market in West Africa is noticeable as all the attractor coefficients tend to be negative; indicating that long-run changes in prices in all the markets may lead to a long-run equilibrium in the system. The levels of regional causality appeared to exist to some extent in these spatially separated markets, which shows that the trade barriers are not restricting regional free trade and the price signals transient through these West Africa regional markets. To strength the linkage and interconnectedness between these regional markets for faster transmission of price and management of tea commodity from the surplus area to deficit area, the clarion call is to enhance the development of market infrastructure, use of information and technology in the transaction of goods, processing, transportation and other back-end supply chain. This would definitely help in the development of a single integrated economic market in the West Africa region.

Table 5: Multivariate VECM of the selected tea markets in West Africa

Variable	D(Ivory-Coast)	D(Ghana)	D(Nigeria)
ECT_{t-1}	-0.345 (0.119)**	-0.119 (0.078)^{NS}	-0.078 (0.416)^{NS}
D[Ivory-Coast$_{t-1}$]	0.156 (0.288)^{NS}	0.437 (0.188)**	0.274 (1.01)^{NS}
D[Ivory-Coast$_{t-2}$]	0.44 (0.36)^{NS}	0.396 (0.235)^{NS}	-0.229 (1.26)^{NS}
D[Ivory-Coast$_{t-3}$]	0.32 (0.33)^{NS}	0.278 (0.214)^{NS}	0.525 (1.148)^{NS}
D[Ghana$_{t-1}$]	-1.65 (0.58)**	-0.785 (0.381)*	-1.679 (2.045)^{NS}
D[Ghana$_{t-2}$]	-1.08 (0.68)^{NS}	-0.616 (0.441)^{NS}	-0.119 (2.368)^{NS}
D[Ghana$_{t-3}$]	-0.93 (0.52)^{NS}	-0.184 (0.337)^{NS}	-1.10 (1.81)^{NS}
D[Nigeria$_{t-1}$]	0.002 (0.085)^{NS}	0.070 (0.056)^{NS}	0.134 (0.299)^{NS}
D[Nigeria$_{t-2}$]	0.089 (0.094)^{NS}	0.068 (0.061)^{NS}	0.03 (0.329)^{NS}
D[Nigeria$_{t-3}$]	0.013 (0.102)^{NS}	-0.006 (0.067)^{NS}	0.01 (0.358) ^{NS}

Note: *** ** * implies significance at 1%, 5% and 10% respectively
NS: Non-significant
(): implies Standard error

Granger Causality Test

The Granger causality helps in establishing the direction of causation (if any) between the variables and thus helps in predicting the value of one variable on the basis of other variable. The results of the granger causality tests presented in Table 6 shows that only one F-statistics for each of the causality tests of the prices in Ivory-Coast and Ghana markets on other market were statistically significant, while Nigeria market had none of its F-statistics significant. A perusal of Table 6 shows that there exists bidirectional causality between Ivory Coast-Ghana market pair, meaning that, the former market granger causes the price formation in the latter market which in turn provides the feedback to the former market as well. This implies that this market pair is efficient with no consequence of leverage condition. Further, two market pairs, Ivory Coast- Nigeria and Ghana-Nigeria had no direct causality between them, indicating that neither Ivory Coast nor Ghana market granger causes the price formation in Nigeria market; nay the Nigeria market granger causes the price formation in Ivory Coast and Ghana markets. In other words, there is no long-run price association between these market pairs. From these results, it can be deduced that Ivory Coast-Ghana market pair exhibit strong endogeneity, while prices of tea in Nigeria market exhibited super exogeneity with its counterparts, indicating that the prices of tea in Nigeria market were absolutely exogenous and were determined outside the system perhaps by quality, price intervention, and to some extent by export demand. The exogenity test helps to identify whether the flow of price information is unidirectional or bidirectional. The Wald test for the regional markets signified the dominant role played by the tea prices of Ivory Coast and Ghana markets in the regional tea market in West Africa. Therefore, it can be inferred that Ivory-Coast and Ghana markets are more operational and price efficient when compared to their counterpart, and tea prices in these markets adjust according to demand and supply situation in the international market. The poor market efficiency of Nigeria market is not far from the low quantity of arrivals in the market, poor quality of the commodity, market power concentration in the hand of few traders, poor market infrastructure and market information failure. All these inhibiting factors affecting the efficiency of tea market in Nigeria are due to lack of political will and almost total neglect of agricultural sector by the government since the adoption of structural adjustment programme in the country.

Table 6: Pair-wise Granger causality among selected major palm oil markets

H_0	t-stat	Prob.(P<0.05)	Granger cause	Direction
Ivory Coast → Ghana	9.71	0.014**	Yes	Bidirectional
Ivory Coast ← Ghana	4.86	0.050**	Yes	
Ivory Coast → Nigeria	5.65	0.238	No	None
Ivory Coast ← Nigeria	0.49	0.745	No	
Ghana → Nigeria	2.25	0.199	No	None
Ghana ← Nigeria	1.37	0.363	No	

Note:**denotes rejection of the null hypothesis at 5 per cent level of significance

Impulse Response Functions

The results of impulse response functions presented in Figure 1 shows how and to what extent a standard deviation shock in one of the tea markets affects the current as well as future prices in all the integrated markets over a period of ten years. A perusal of the diagrammatic figure shows that an unexpected shock that is local to the Ivory-Coast market will have a transitory effect on the prices of Ghana and Nigeria markets i.e. the effect of the shock will die out over time. Also, an orthogonalized shock to the price of tea in Ghana market has a transitory effect on the prices of tea in Ivory Coast and Nigeria markets. However, unexpected shocks that are local to the tea prices in Nigeria market will have a transitory effect on the tea prices that will be obtained in Ivory Coast and Ghana market, while it will have a permanent effect on its own market i.e. the price effect will not die out over time. Therefore, it can be deduced that none of the selected markets have a dominant effect over its counterpart in the region i.e. the market impulse response confirm that the price transmission from one market to the other markets and vice versa occur in small proportions. Furthermore, it implies that the prices of tea in these regional markets seemed to be exogenous and will be determined outside the system perhaps by quality, price intervention, and to some extent by export demand. Therefore, all these selected regional tea markets in West Africa are relatively market followers and do not play a significant role in the world internationaltea market.

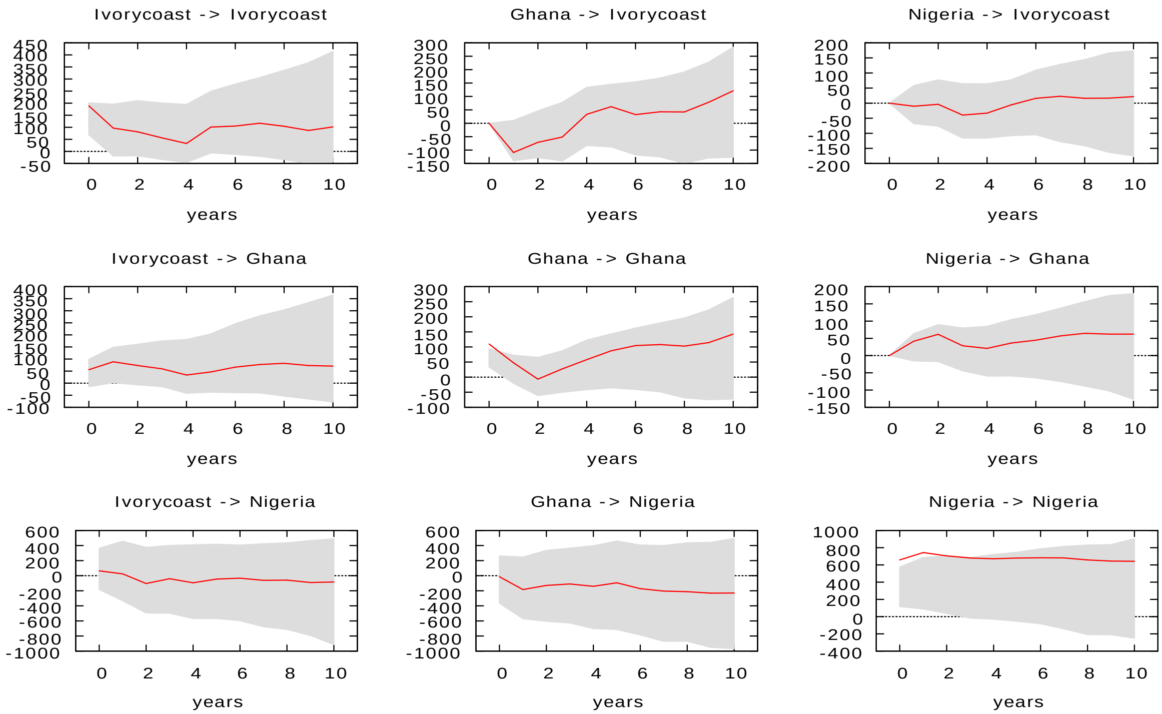

Figure 1: Impulse response of markets to innovation/shocks

Decomposition of Variance for the selected regional Tea Markets in West Africa

The results of variance decomposition for the selected regional tea markets are given in Table 7. The decomposition detailed for the selected markets are as follows: For Ivory-Coast market, in the short-run (first quarter), a shock to the price of tea in Ivory-Coast market will account for 75.15, 24.68 and 0.17% variations of fluctuation in prices at Ivory-Coast (own shock), Ghana and Nigeria markets, respectively; while in the long-run (last quarter), a shock to the price in the same market will account for 73.44, 23.80 and 2.77% variation of fluctuation in prices at Ivory-Coast (own shock), Ghana and Nigeria markets, respectively. Based on this outcome it can be deduced that the effect of the shock on Nigeria market is very marginal when compared to the resultant transmission effect in Ghana market, thus, indicating that Nigeria market is inefficient. In the case of Ghana market, in the short-run, an impulse to the price of tea in Ghana market can cause 45.03, 39.67 and 15.30% of variation in the fluctuation of prices in Ivory-Coast, Ghana (own shock) and Nigeria markets, respectively; while in the long-run (last quarter), an impulse to the price in Ghana market can cause 32.72, 51.92 and 15.36% of variation in the fluctuation of prices in Ivory-Coast, Ghana (own shock) and Nigeria markets, respectively. It is evident that Ghana market will be comparatively competent, and this may be due to its geographical position- the centre-most among the selected tea markets of the region as the price signals in Ghana market would be quickly transmitted to other markets and vice versa. Therefore, the geographical situation and optimal distance between the market places will hold the mutual forces on commodity movements and price formation. In the case of Nigeria market, in the short-run (first quarter), an innovation to the price of tea in Nigeria market can cause 1.00, 3.27 and 95.73% of variation in the fluctuation of the prices in Ivory-Coast, Ghana and Nigeria (own shock), respectively; while in the long-run (last quarter), an innovation to the price in Nigeria market can cause 0.90, 5.27 and 93.83% of variation in the fluctuation of tea prices in Ivory-Coast, Ghana and Nigeria (own shock), respectively. Based on these findings it is obvious that Nigeria market will be inefficient which may be due to poor quality, low quantity of arrival, market information failure, poor infrastructure and oligopolistic tendency. However, it was observed that the shock originating from Ivory-Coast and Nigeria markets at both time periods is more pronounce on the respective market itself when compared to its effect on other markets.

Table 7: Decomposition of variance for the selected tea markets in Nigeria

Ivory-Coast (IVC)				**Ghana**				**Nigeria**			
P	**IVC**	**Ghana**	**Nigeria**	**P**	**IVC**	**Ghana**	**Nigeria**	**P**	**IVC**	**Ghana**	**Nigeria**
1	100.00	0.00	0.00	**1**	20.51	79.49	0.00	**1**	0.94	0.04	99.01
2	78.97	20.85	0.18	**2**	40.56	52.99	6.45	**2**	0.46	3.32	96.22
3	75.15	24.68	0.17	**3**	45.03	39.67	15.29	**3**	1.00	3.27	95.73
4	72.03	25.76	2.21	**4**	48.02	36.59	15.39	**4**	0.85	3.09	96.06
5	70.40	26.10	3.50	**5**	45.36	39.96	14.69	**5**	1.04	3.29	95.67
6	70.72	26.28	3.00	**6**	40.34	45.50	14.16	**6**	0.94	3.06	95.997
7	72.91	24.20	2.89	**7**	36.88	49.58	13.54	**7**	0.84	3.47	95.69
8	74.54	22.53	2.94	**8**	35.06	50.95	13.98	**8**	0.83	4.07	95.10
9	75.46	21.69	2.85	**9**	34.40	50.62	14.98	**9**	0.81	4.64	94.55
10	73.44	23.80	2.77	**10**	32.72	51.92	15.36	**10**	0.90	5.27	93.83

Source: Computed from GRETL computer printout

Diagnostic Testing

The results of diagnostic statistics of VECM model for the selected regional tea markets are shown in Table 8. The autocorrelation tests indicate that the residuals were not serially correlated as evidenced from the Ljung-Box Q-statistics which were not different from zero at 10% probability level ($p>0.10$), thus the acceptance of null hypothesis of no autocorrelation. The Arch test results revealed that the variance of the current residuals and that of the lagged residuals do not correlate as evidenced from the Lagrange multiplier (LM) test statistics which were not different from zero at 10% probability level ($p>0.10$), thus the acceptance of null hypothesis of Arch effects are not present.

The stability tests indicated that none of the models was misspecified as evidence from the Eigen-values which shows that none of the remaining Eigen-values appears close to the unity circle. Furthermore, the result of normality test shows that the residuals are not normally distributed as evidence from Doornik-Hansen test χ^2 which is different from zero at 10% probability level ($p<0.10$). However, when dealing with time series data, non-normality of the residuals is not considered a serious problem, because in most cases these data are not normally distributed. Therefore, based on the outcome of the diagnostic statistics, it can be inferred that all the results were valid and the VECM model used was the best fit.

Table 8a: VECM Diagnostic checking

Test		**Statistic**	**P-value**
Autocorrelation	Ljung-Box Q (Eq1)	6.06	0.195
	Ljung-Box Q (Eq2)	2.47	0.651
	Ljung-Box Q (Eq3)	0.79	0.939
Arch effect	LM-Test (Eq1)	1.43	0.84
	LM-Test (Eq2)	1.20	0.88
	LM-Test (Eq3)	0.80	0.94
Normality	Doornik-Hansen test	23.92	0.0005
Eigen-values	1	0.541	
	2	0.99	
	3	1.47	

Source: Computed from GRETL computer printout

Forecasting Using VECM
Diagnostic Checking

The model verification is concerned with checking the residuals of the model to see if they contained any systematic pattern which still could be removed to improve the VECM. This was done *viz.* investigating the autocorrelations and partial autocorrelations of the residuals at various lags. Using the computed values, it was found that these autocorrelations were not significantly different from zero (Table 8a), thus, proved that the VECM model was an appropriate model for forecasting the data under study.

Validation

One-step ahead forecast of price along with their corresponding standard errors using naïve approach for the period 2004 to 2013 (total 10 data points) in respect of the VECM fitted models was computed.

Table 8b: One step ahead forecast of prices

Date	Ivory-Coast market		Ghana market		Nigeria market	
	Actual	Forecast	Actual	Forecast	Actual	Forecast
2004	392.35	904.81	999.56	998.33	852.09	638.78
2005	624.82	461.81	992.01	799.51	977.74	500.58
2006	656.58	602.34	997.87	959.78	1105.38	1209.60
2007	794.02	936.55	981.00	1045.68	1022.48	762.23
2008	1042.86	1294.91	1140.79	1252.49	1661.62	1283.35
2009	1316.46	1254.10	1165.71	1358.22	707.03	1606.66
2010	1988.43	1665.04	1678.32	1387.38	1032.47	712.31
2011	1703.33	1590.63	1815.23	1791.87	1052.96	353.32
2012	1905.00	1839.57	1700.00	1835.70	437.56	783.08
2013	1991.00	2046.55	1815.00	1884.84	437.56	543.94

The forecasting ability of the VECM model of price series for the regionally selected tea markets was judged on the basis of the mean absolute prediction error (MAPE), root mean square error (RMSE) and relative mean absolute prediction error (RMAPE) values (Table8c).A perusal of Table 8c shows that for all the price series variables, RMAPE is less than 5 percent, indicating the accuracy of the VECM models used.

Table 8c: Validation of models

Market	R^2	MAPE	RMSPE	RMAPE (%)
Ivory-Coast	0.973	18.146	86.97	-11.01
Ghana	0.989	2.83	15.01	0.28
Nigeria	0.793	89.30	245.6	2.04

Source: Authors computation, 2017

Forecasting

One step ahead out of sample forecast of tea price ($/ton) for the selected regional tea markets in West Africa during the period of the year 2014 to 2025 have been computed. The absolute data points are shown in Table 8d and also depicted in Figure 2 (Appendix I) to visualize the performance of the fitted model. A cursory review shows that the prices of tea in all the markets with the exception of Nigeria market will be marked by slight variation i.e will witness slight variation as evidenced by the standard error values. Furthermore, in the situation of bad-news (inflation) the prices in each of the market would not exceed its respective price upper confidence limit, and in the case of good-news (administered prices), the prices in each of the market would not go below its respective price lower confidence limit. For policy implication, Nigerian government should put in place mechanism to checkmate the virulent price instability that will occur in Nigeria tea market in order to protect itself and all market participants, even though this kind of measure will amount to the creation of imperfection in tea market in the region.

Table 8d: Out of sample forecast of tea prices in the selected tea markets ($/ton)

Date	Ivory-Coast market			Ghana market			Nigeria market		
	Forecast	**UCL**	**LCL**	**Forecast**	**UCL**	**LCL**	**Forecast**	**UCL**	**LCL**
2014	22461.61	2616.76	1876.45	1937.05	2178.39	1695.72	127.77	1324.35	126.81
2015	2652.93	3120.89	2184.97	2138.51	2460.63	1816.39	144.12	2128.45	140.21
2016	2730.73	3244.31	2217.15	2333.14	2706.01	1960.26	125.68	2314.67	116.03
2017	2943.34	3483.67	2403.00	2494.28	2892.50	2096.07	451.92	2338.02	241.86
2018	3080.01	3631.93	2528.08	2621.49	3042.85	2200.13	624.17	2478.10	226.45
2019	3286.18	3884.96	2687.41	2748.86	3218.08	2279.64	927.16	2455.58	309.91
2020	3610.53	4247.64	2973.41	2948.70	3484.23	2413.16	1091.65	2562.09	1745.38
2021	3883.60	4567.20	3199.99	3163.15	3768.97	2557.33	1343.12	2569.43	1255.68
2022	4181.71	4900.67	3462.75	3386.89	4057.40	2716.39	1629.60	2512.52	1117.73
2023	4443.48	5198.90	3688.07	3612.04	4343.64	2880.43	1928.02	2430.02	1286.06
2024	4726.18	5543.70	3908.66	3826.30	4631.02	3021.57	2277.88	2283.64	1839.40
2025	5059.15	5953.24	4165.05	4060.91	4951.54	3170.28	2589.18	2169.15	1347.51

Source: Computed from GRETL computer printout

The Indices of Market Concentration

The results of pair-wise indices of market concentration for the selected regional tea market in West Africa are presented in Table 9. The validity of these results was verified *viz.* diagnostic statistics to see whether the models used best fit the specified equation. The diagnostic statistics for all the best models *viz.* Autocorrelation and Arch effect tests show that the residuals have no autocorrelation and no Arch effect as evidenced from the Q-statistics and B-G LM test statistics, respectively, which were not different from zero at 10% significance level ($p>0.10$) (Table 9a). In addition to the autocorrelation test, the Durbin-Watson statistics falls within the recommended range (1.50-2.50) which indicates that the residuals are not serially correlated. However, the results of the normality test for some of the models showed that the residuals were not normally distributed as evidenced by the Jarque-Bera test statistics which were different from zero at 10% significance level ($p<0.10$). As earlier posited, when dealing with time series data, non-normality of the residuals are not considered a serious problem, because in most cases these data are not normality distributed. It should be noted that when dealing with distributed lag model, homoscedasticity and normality are not considered a serious problem. Therefore, based on these diagnostic tests it can be concluded that these results are valid, as all the selected models are the best fit for the regression equations specified. A perusal of the Table 9b shows that the IMC for Ivory Coast-Ghana and Nigeria-Ghana market pairs were less than one in respect of 0.92 and 0.79, respectively, indicating high short-run market integration; the IMC for market pairs *viz.* Ghana-Ivory Coast and Nigeria-Ivory Coast were higher than one, in respect of 1.58 and 1.74, respectively, implying low short-run market integration; while the IMC for Ivory Coast-Nigeria and Ghana-Nigeria market pairs were at infinity indicating no short-run market integration between each pair. For all the two market pairs which have their IMC lower than one, a price change in former cause immediate change in the latter. The short run market integration was faster in the Nigeria-Ghana market pair relative to the Ivory Coast-Ghana market pair. This, however, confirms that Ghana market is comparatively competent, and this might be due to its geographical position-the centre-most among the selected tea markets in the region as the instantaneous price signals in Ivory Coast and Nigeria markets were quickly transmitted to Ghana market. Also, Ghana market is a satellite to the other two selected tea markets in the region.

Table 9a: Diagnostic statistics IMC results

Tests	Ivory Coast – Ghana	Ivory Coast – Nigeria
Autocorrelation LM	0.081 (0.777)	0.243 (0.629)
Durbin-Watson	1.92	2.19
Arch LM	0.217 (0.642)	0.052 (0.822)
Normality	16.90 (0.002)	11.21 (0.004)
	Ghana –Ivory Coast	Ghana – Nigeria
Autocorrelation LM	0.793 (0.386)	0.016 (0.9007)
Durbin-Watson	1.65	1.94
Arch LM	0.576 (0.457)	1.065 (0.315)
Normality	1.831 (0.4004)	1.386 (0.500)
	Nigeria – Ivory Coast	Nigeria – Ghana
Autocorrelation LM	1.825 (0.194)	1.616 (0.221)
Durbin-Watson	1.52	1.53
Arch LM	0.188 (0.670)	0.439 (0.515)
Normality	6.34 (0.042)	7.842 (0.020)

Source: Computed from GRETL computer print-out
Note: Values in parentheses are probability levels

Table 9b: Indices of market connection

Market pair	β_1	β_2	IMC	R^2	Classification
Ivory Coast – Ghana	0.46	0.50	0.92	0.82	High short-run market integration
Ivory Coast – Nigeria	0.92	0.04	∞	0.71	No short-run market integration
Ghana – Ivory Coast	0.63	0.40	1.58	0.91	Low short-run market integration
Ghana – Nigeria	1.04	0.03	∞	0.84	No short-run market integration
Nigeria – Ivory Coast	0.73	0.42	1.74	0.61	Low short-run market integration
Nigeria – Ghana	0.65	0.82	0.79	0.66	High short-run market integration

Source: Authors computation, 2017

Extent of Price Volatility in selected tea markets

The results of GARCH model indicated that GARCH order (1,1) fit the different markets and was found to be the highest order for the entire period (Table 10). A perusal of the GARCH analysis for all the selected markets indicated that volatility in their current year prices depends on the information of price volatility in the preceding year and volatility on the preceding year prices, which were evident from the significant ARCH and GARCH-term termed internal shock. Also, it was evident that volatility in the current year prices of each respective markets did not depends on the price volatility originating from the counterpart markets except for Ghana market where the current price volatility was caused by price volatility in Nigeria market (international shock) as evident from the estimated coefficient which is different from zero at 10% probability level ($p<0.10$). The reason for transmission of price volatility from Nigeria market to Ghana market might be due to proximity and almost uniform nature of their products. Using the ARCH and GARCH-terms, it was observed that the sum of the ($\alpha + \beta$) estimated coefficients for Ghana and Nigeria markets were closer to 'one', indicating the persistence of volatility in tea prices in these markets; while the sum of the ($\alpha + \beta$) estimated coefficients for Ivory-Coast market was greater than 'one', indicating 'explosive' pattern in volatility of tea price in this market. The persistence volatility in Ghana and Nigeria markets implies trade in these markets is at nascent stage (usefulness of trade) while the explosive pattern in the Ivory-Coast market implies that trade is at the advance stage.

Table 10a: Volatility in tea prices from 1991 - 2013

Particulars	**Ivory-Coast market**	**Ghana market**	**Nigeria market**
Constant	3505.23 (4207)^{NS}	12448.41 (1706.93)***	36736.00 (480.08)***
International shock			
Ivory-Coast	-	28.21 (49.50)^{NS}	55.24 (114.63)^{NS}
Ghana	3.77 (111.59)^{NS}	-	-237.77 (211.37)^{NS}
Nigeria	-14.65 (9.72)^{NS}	-13.13 (2.53)***	-
Family shock			
ARCH	-0.47 (0.21)**	-0.306 (0.07)***	-0.165 (0.006)***
GARCH	1.47 (0.002)***	0.935 (0.04)***	1.123 (0.008)***
GARCH fit	1,1	1,1	1,1
$\alpha + \beta$	**1**	**0.634**	**0.96**

Source: Computed from GRETL computer printout
Notes: Figures within the parentheses indicate the calculated standard errors
*** ** and * indicate the significance at 1%, 5% and 10% probability levels respectively
NS: Non-significant

GARCH Diagnostic Testing

The results of the diagnostic statistics to validate the GARCH model for each of the selected market are shown in Table 10b. The test of autocorrelation for each of the selected market shows that the residuals were not correlated as evident from the Q-statistics which were not different from zero at 10 percent probability level (p>0.10). Also, the normality test results show that the residuals for each of the selected markets were normally distributed as evident from the Jarque-Bera test statistics which were not different from zero at 10% probability level (p<0.10). The Arch test results of each selected market revealed that the variance of the current residuals and that of the lagged residuals do not correlate as evidenced by the B-G LM statistics which were not different from zero at 10% significance level. Thus, the null hypotheses of all the aforementioned tests were accepted while the alternative hypotheses were rejected. Therefore, based on these tests, the GARCH (1,1) model is the best fit for the specified equation, thus, all the results obtained were valid for prediction.

Table 10b: Diagnostic checking for GARCH

Market	**Autocorrelation (Q-stat)**	**ARCH test**	**Jarque-Bera test**
Ivory-Coast	2.147 (0.143)	0.195 (0.659)	1.745 (0.418)
Ghana	0.3097 (0.578)	0.13 (0.716)	0.538 (0.764)
Nigeria	0.093 (0.76)	0.007 (0.936)	1.346 (0.510)

Source: Computed from GRETL computer printout
Note: Values in parentheses are probability levels

Leverage effect test

The result of the EGARCH which shows whether there exist leverage effect in the selected markets or not is given in Table 11a. Leverage effect is a negative correlation between the past returns and future volatility of returns i.e. the debt-equity ratio. From the results it was observed that leverage effect only existed in Ivory-Coast market as evidenced by the negativity and 1% significance level of the estimated coefficient of parameter C(4), indicating that a higher leverage effect occurs due to negative returns which translate to a low equity prices (when returns goes down volatility goes up) i.e. a higher debt to equity ratio of tea trade in

Ivory-Coast market. Furthermore, when there is volatility in returns of tea prices in Ivory-Coast market (Bad-news), the risk of the business goes up, and the investors in this market will likely shift their capital to less risky investment. However, a positive shock/news has less effect on present returns when compared to a negative shock/news. However, in the case of Ghana market, there is a risk in tea trade but it is not that pervasive that will make the investors shift to other trade. The reason for high risk in Ivory-Coast market might be due to the partial liberalization of the commodity market. In the case of Nigeria market, it was observed that there was no leverage effect, implying full liberalization of the commodity. Also, the Nigeria tea market is not allocative and technical efficient which is not far from the low quantity of arrival, low grading quality of the commodity, oligopolistic, poor infrastructure and other arbitrage activities which inhibit information transmission.

Table 11a: Estimates of leverage effects

Particulars	Ivory-Coast	Ghana	Nigeria
Constant C(1)	9.43 (1.4E-09)***	12.83 (4.75)***	-2.69 (0.14)***
C(2)	2.697 (0.39)***	-0.018 (1.038)^{NS}	-1.91 (0.57)***
C(3)	-0.036 (0.216)^{NS}	0.69 (1.097)^{NS}	1.32 (0.69)*
EGARCH C(4)	-0.189 (0.047)***	-0.31 (0.49)^{NS}	0.869 (0.003)***
C(5)	0.002 (0.002)^{NS}	0.002 (0.002)^{NS}	-0.004 (0.004)^{NS}
C(6)	-0.001 (0.0004)***	0.001 (0.0006)*	0.0009 (0.003)^{NS}

Source: Computed from EVIEW computer print-out
Notes: Figures within the parentheses indicate the calculated t-statistic
*** ** and * indicate the significance at 1%, 5% and 10% probability levels respectively
NS: Non-significant

EGARCH Diagnostic Testing

The results of the diagnostic statistics to validate the EGARCH model for each of the selected market are given in Table 11b. The test of autocorrelation for each of the selected market shows that the residuals were not correlated as evident from the Q-statistics which were not different from zero at 10% significance level (p>0.10). The Arch test results of each selected market revealed that the variance of the current residuals and that of the lagged residuals do not correlate as evidenced by the B-G LM statistics which were not different from zero at 10% significance level. For the normality test, it was observed that only the price series residuals of Ivory-Coast and Ghana markets were normally distributed as evident from the Jarque-Bera test statistics which were not different from zero at 10% probability level (p<0.10), while the residuals of price series of Nigeria market were not normally distributed as evidenced from the Jarque-Bera test statistic which was different from zero at 10% significance level. However, the non-normality of residuals is not considered a serious problem when dealing with time series data because in most cases data are not normally distributed. Therefore, based on these tests, the EGARCH model is the best fit for the specified equation, thus, all the results obtained were valid for prediction.

Table 11b: Diagnostic checking for EGARCH

Market	Autocorrelation (Q-stat)	ARCH test	Jarque-Bera test
Ivory-Coast	0.003 (0.955)	1.644 (0.1997)	1.649 (0.438)
Ghana	0.193 (0.661)	0.026 (0.873)	0.647 (0.723)
Nigeria	0.235 (0.628)	0.189 (0.664)	44.47 (0.000)

Source: Computed from EVIEW computer print-out
Note: Values in parentheses are probability levels

Conclusions and Recommendation

The study focused on the regional market integration of tea prices among the major tea markets in West Africa. It was observed that the selected regional tea markets were weakly co-integrated and slowly converged to the long-run equilibrium in the sense that the regional tea market is stationary in one direction and non-stationary in two directions, implying that the law of one price (LOP) was poor as the prices of tea were weakly co-integrated. Furthermore, it can be concluded that Ivory-Coast and Ghana markets played a dominant role in price formation of tea in the regional market as the tea prices in these markets adjust according to demand and supply situation in the international market. Also, it can be deduced that the selected regional tea markets in West Africa are relatively market followers and do not play a significant role in the world international tea market because tea prices in these regional markets seemed to be exogenous and will be determined outside the system perhaps by quality, price intervention, and to some extent by export demand. The study proved that price linkages and the interrelationship among the spatial markets are important in economic analysis. The inter-markets price linkages and speed of adjustment to shocks shows that technical costs have a significant impact in determining the degree of market integration. Furthermore, it was observed that tea trade is at the nascent stage in Ghana and Nigeria markets when compared to that of Ivory-Coast market. Also, leverage effect was observed in Ivory-Coast market, indicating that tea trade in Ivory-Coast market is risky and the investors will likely shift their fund to less risky investment. Therefore, it can be concluded that these markets were not quite competitive, thus, justifying the need for regional bloc government intervention designed to improve competitiveness which will in-turn enhance market efficiency. The study recommends that a proper focus on domestic supply management along with international trade coupled with strong market surveillance and intelligence efforts would help control escalating prices and also help in minimizing the distortions widening the gap of the tea prices among the major tea markets in West Africa region.

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Figure 2a: Price forecast of Tea in Ivory-Coast market

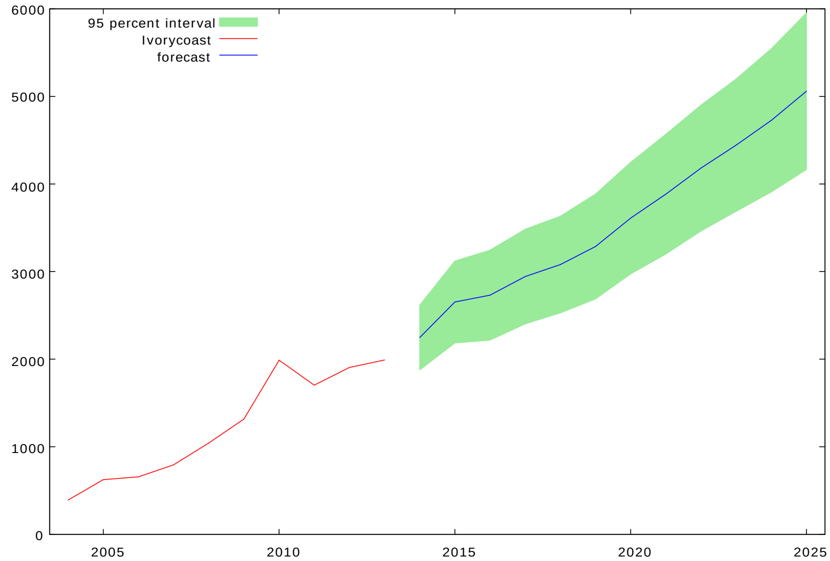
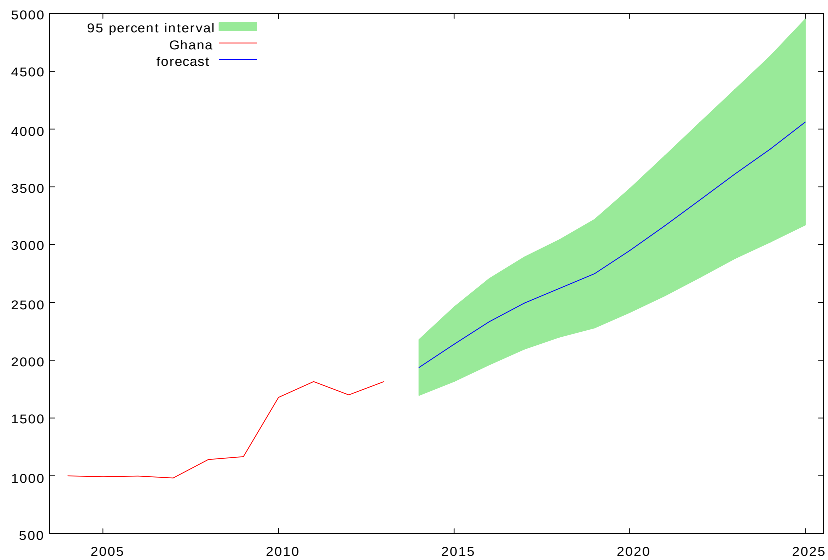


Figure 2b: Price forecast of Tea in Ghana market



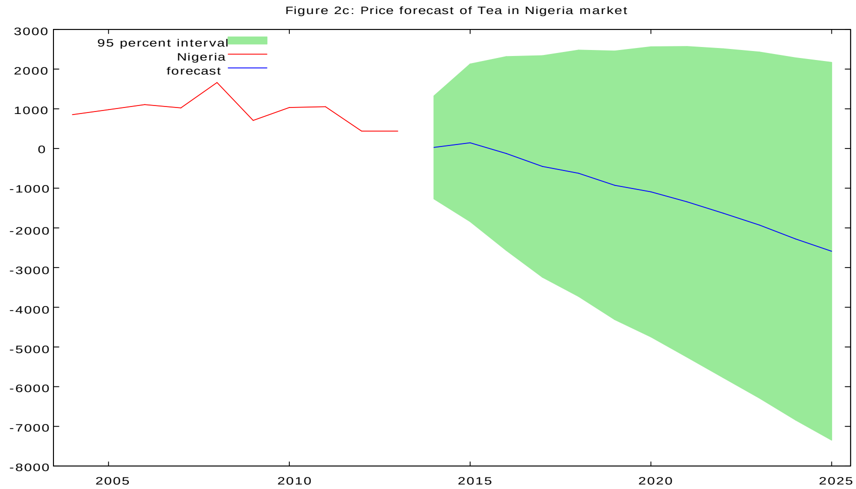


Figure 2: Column 1 Row 1-Price forecast of tea in Ivory-Coast and Ghana markets
Column 2 Row 1-Price forecast of tea in Nigeria market

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IMPACT OF NEEM PLANTATION ON FOUR WEATHER VARIABLES AT AFUNORI, YOBE NORTH, NIGERIA

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Abstract
This paper analyzed the impact of Neem (Azadirachta indica) plantation on four weather variables namely: Rainfall, Relative Humidity (R.H), Temperature and Wind Speed at Afunori, Yobe North, Nigeria. To achieve this, meteorological records of these elements were collected from the protected side of the plantation at three growth stages: the first five years (1999 – 2003), the second five years (2004 – 2008) and the last five years (2009 – 2013). Mean records of the weather variables studied were computed and compared with the records of the same variables collected by the National Meteorological Agency of Nigeria (NIMET) from the unprotected area of the same environment. Results showed that between 1999 and 2003, there were very little differences among weather variables between the protected and unprotected areas. The differences were not significant. In the second five years, marked variations were observed between control values and mean values of the weather variables measured in the protected area of the species. However, differences between average values of rainfall and R.H from both areas were not significant; whereas temperature and wind speed values differed significantly at this stage of growth. In the last five years, meteorological records of the four variables from both protected and unprotected environment varied considerably with same trend of changes as in the second five years. The study concluded that there was direct relationship between the microclimatic potentials of Azadirachta indica plantation at Afunori and its canopy density which varied with stages of growth. It is recommended that there is a need for proper understanding of both botany and adaptation of tree species to be involved in programs and projects of environmental management.

Key words: Impact, microclimate, Azadirachta indica, weather variables

Introduction

Yobe North experiences climatic variations characterized by short rainy season and unpredictable rainfall pattern leading to cyclical draught (YBSES, 2008). Similarly, considerable increases in records of temperature and wind speed have been reported in recent years (NIMET, 2014). The resultant effects of these changes include decline in economic and biological productivity of arable land, development of semi-arid and arid conditions and gradual transformation of Savannah vegetation into Sahel (UNCCD, 1994). Evidently, the continuous decrease in agricultural production and productivity of the area could principally be attributed to such variations in climate (Green Facts, 2015). Apart from climatic variability, the rate of deforestation is startlingly very high and in consequence, desert encroachment is eating up the marginal land at the rate of 0.6 km per annum (FAO, 2009). The severity and the concomitant effects of this problem focused the attention of both the government and concerned stakeholders towards the environment. In effect, various environmental stakeholders indefatigably embarked on afforestation and reforestation projects, sand dune fixation and stabilization programs as well Re-greening urban and rural settlements (NEAZDP, 2003). Prominent tree species commonly involved in these programs include *Azadirachta indica*, *Acacia senegal*, *Faidherbia albida* and *Acacia nilotica* The utilization of these species in programs of environmental management in the state is based on the recommendations of both the Yobe State Afforestation Project (YBSAP) and the Food and Agricultural Organization (FAO) (2008). According to them, these species have been used successfully in various programmes and projects of environmental management. Therefore, they are adapted to the Sudano/Sahel agro ecology. They have comparatively higher microclimatic effects than other species in the same environment.

Generally, all these species have these attributes but the extent at which they achieve these functions varies as does the species. For instance, the microclimatic potentials of each of them may not be the same. Likewise, adaptation to the same environment may differ among the species. Thus, the utilization of any tree species for a certain purpose must consider its potentialities for that purpose as well as its adaptation to that environment. Like other tree species, Neem is highly adapted to the unfavourable agro ecology prevailing in Yobe North and this is supported by its ability to adapt to broad range of climatic and soil conditions (NRC, 1992). Similarly, its microclimatic potentials have been adjudged high (Neem Foundation, 2012). However, the extent particularly in Yobe remains unclear. Therefore, this paper specifically analyses the impact of Neem plantation on weather variables at Afunori, Yobe North, Nigeria.

Aims and Objectives

From the foregoing introduction, it is clear that this work intends to analyse the microclimatic impact of *Azadirachta indicia's* plantation on rainfall, relative humidity, temperature and wind speed at Afunori. Specifically, it is set to:

(i) Study the botany of Neem (*Azadirachta indica*) and its implication on adaptation and microclimate.

(ii) Analyse the impact of the Plantation of the species on four weather variables at Afunori at various stages of growth.

Research Questions

The following questions were raised to find answers to the following—

(i) Does the botany of *Azadirachta indica* have any adaptation and microclimatic implication?

(ii) Does the Neem plantation at Afunori have any impact on the four weather variables at various stages of growth?

Hypotheses

The following hypotheses were tested –

H0: There were no significant differences between mean records of the-four weather variables in

the protected and unprotected areas of *Azadirachta indica* at various stages of growth.

H1: There were significant differences between mean records of the-four weather variables

in the protected and unprotected areas of the species at various stages of growth.

Botany of *Azadirachta indica*

According to Fact Net (2005), *Azadirachta indica* can be *evergreen* or *deciduous* depending on climate. Regardless of the climate, leafless periods are usually brief occurring only during periods of unbearingly extended droughts. At maturity, it can be 15m - 30m long. The tree branches extensively at 2 – 5m forming a broad, dense round or oval crown. Matured trees have stem diameters ranging from 30 – 90cm with well-developed lateral root system that can extend up to 15m deep but with relatively shorter taproot. Bark is moderately thick, fissured and gray on the outer part but reddish brown on the inner. It has alternate leaf arrangement with imparipinnate phyllotaxy. Flowers are either white or cream coloured but are bisexual, sweet,scented, numerous and small. The fruit is a smooth ellipsoidal drupe normally 1.2 – 2.0cm long containing usually one seed. Matured fruits change colour from initial green to yellow as they ripe. It is important to note that *Azadirachta indica* is highly prolific fruit producer commencing at 3 – 5 years and becoming fully productive at 10 – 12 years (Fact Net, 2005).

Impact of Botanical Structures on Weather Variables

The botanical structures of *Azadirachta. Indica* has considerable microclimatic implication. For instance, its evergreen attributes guarantee continuous protection to the land surface as well as amelioration of the local weather. Again, the height of 15 – 30m at maturity couple with very dense and broad canopy further exerts modification effect on the surrounding environment. Studies have shown that direct relationship exists between canopy density and modification power of trees (FAO & UNEP 2003; Fact Net 2005 and Orwa et.al. 2009). Therefore, It is logical that the greater the height and the denser the canopy, the greater the microclimatic potentials and vice versa.

Impact of Botanical Structures on Adaptation

Azadirachta indica is draught tolerant and is highly adapted to numerous and varied agro-ecological conditions (Parmar and Randhawa, 1993). Certain botanical features of the tree must support these important properties -- “broad adaptation and draught tolerance”. The National Academy of Science (2010) attributed the above properties to the development of long penetrating lateral root system, which can extend up to 15m deep, presence of thick scaly bark and development of swollen water reservoirs along the shoot system. At this point, there is a need to generally review the mechanisms by which forests/tree plantations could influence both local and regional weather and climate to gain more insight.

Influence of Tree Plantations on Weather and Climate

Betts (2006) identified six (6) different mechanisms by which forest and tree plantations could influence both local and regional weather and climate. These mechanisms include albedo of the plantation surface, evapotranspiration, aerodynamic effect, chemical and aerosol effects as well as interaction with carbon dioxide.

The albedo of the plantation surface

The albedo of the plantation surface has been defined as the ratio of the radiation reflected from a surface to the total radiation falling on the surface (Betts and Ball, 2007).Forests and tree plantations have very low albedo compared to other surfaces such as ice and snow that reflect almost all of the incoming solar radiation. The low albedo of tree plantations means that they absorb most of the incoming solar radiation and become warmer; and then warm the air around and above them. The energy transferred from the forest to the surrounding air is called sensible heat and this involves changes in temperature.

Evapotranspiration

Trees absorb water from the soil via their roots and release it into the atmosphere by evapotranspiration, which has several effects on weather and climate (Bosch and Hewlett, 1982). Water is removed from the soil as liquid but is released into the atmosphere as vapor. Energy is required in changing the water from liquid to gaseous state. This cools the plantation surface by evaporating water and producing cooling effect. When water changes phase, energy is either absorbed or released at constant temperature. This energy is referred to as latent heat. The water vapor released could be transported to higher altitudes where temperatures are cooler and can condense to form clouds and rain.

Aerodynamic effect

This is another mechanism by which forest plantations could affect the local weather. Surfaces that are aerodynamically rough increase air turbulence above them and this cause a drag on the air flowing over them leading to reduction in wind speed. Surfaces with low aerodynamic roughness include ice, grasses and crops. However, tree surfaces are aerodynamically rough causing turbulences in the air thereby enhancing exchange of sensible heat and moisture between the trees and air (Yakir and Rotenberg, 2008). When the moisture content of air above the trees becomes larger, convection sets in with consequent formation of cloud and rainfall (Millán, 2008). Trees sway in the wind and this slows down its speed with resultant increase in turbulence (Streiling and Matzarakis, 2003). The momentum gathered by the wind is transferred to the trees and break it.

Chemical and aerosol effects

Forests and tree plantations have a complex but indirect effect on weather and climate. This is due to their physiological impact of changing carbon dioxide levels as well as production and emission of hydrocarbons (Betts & Ball 2007). Fires release the carbon stored in trees into the atmosphere as CO_2. The carbon dioxide produced along with smoke particles has significant impact on climate (Betts, 2006). There are also several chemical effects of forests on local and global climate. Forests absorb CO_2, which acts to cool global climate, but release a range of reactive chemical species that could alter the life time of methane and partly control concentrations of ozone, both of which are important greenhouse gases. These reactive species can also produce aerosols, which have a number of different effects on weather and climate (Bosch and Hewlett, 1982).

Interaction with carbon dioxide

All forests have long-term global climate impacts via interactions with carbon dioxide (CO_2) concentrations in the atmosphere. Carbon dioxide (CO_2) is the most important greenhouse gas, owing to its long life time in the atmosphere and strong absorption of infra-red radiation emitted from the earth's surface (Sanderson et al, 2012). The growth and spread of forests results in an uptake of CO_2, which reduces its levels in the atmosphere resulting in net cooling. However, deforestation raises the surrounding temperature by releasing carbon into the atmosphere as CO_2. Generally, the exchange of sensible and latent heat, moisture, momentum and carbon dioxide between trees and the atmosphere are the key processes by which forests and tree plantations can modify weather and climate.

Impact of Changes in Forest cover on Weather variables

Changes in the vegetation cover of an area occasioned by deforestation of forested land for pasture or arable crop production raises the albedo of the area leading to more reflection of solar energy. Deforested areas have lower surface roughness and leaf area index and this adversely affects their moisture storage capacity. The physical effects of this are increased wind speed and temperatures as well as reduced cloud cover and rainfall (Streiling and Matzarakis, 2003). Ghuman and Lal (1987) in Sanderson et al (2012) examined the impact of deforestation on soils, hydrology and climate in a rain forest in Nigeria. Compared with the forested area, air and surface soil temperatures were higher in the cleared area, and the diurnal cycle in temperature was larger too. Relative humidity in the forested land remained around 90% throughout the day, whereas it fell to 50% during daylight hours in the cleared area.

Impacts of Tree Plantations on Weather Variables in a Semi-Arid Environment: A Review

Yakir and Rotenberg (2008) examined the microclimatic impact of afforestation projects in a semiarid region of Israel. They measured upward and downward fluxes of shortwave and long wave radiation, together with sensible and latent heat fluxes. Although the trees covered less than 60% of the land area, the canopy absorbed 80% of the net solar radiation. Around noon, the air temperature above the trees was warmer than the surface. Similar analysis of the microclimatic impact of various tree plantations on wind speed at many locations in the northern hemisphere by Vautard et al. (2010) indicated a downward trend, and that high wind speeds have declined by a greater proportion on the leeway side. Milan *et al*. (2004) reviewed many studies of rainfall trends in several countries. Rainfall measurements in two adjacent areas in India were compared: one location was undisturbed tree plantation whereas the other had experienced large-scale deforestation. Results indicated decrease in the amount of rainfall and the length of the rainy season in the deforested areas compared to the undisturbed site. Other studies in India and Africa cited by Sanderson *et al*. (2012) provided further empirical evidences of declining rainfall and increasing cases of drought on bare or deforested lands.

Thus, it is glaring that tree plantations modify the conditions of the general environment through the creation of microclimate. However, their microclimatic potentials vary among the individual species. The empirical determination of the microclimatic potential of any species could be an impetus for sustainable environmental management. *Azadirachta indica* like other species in the semi-arid region also exerts microclimatic impact, which is not yet measured in numerical terms. There is an ardent need to determine its microclimatic potentials particularly for the fact that it is the UNs tree of the 21st century (World Neem Conference, 2012).

Methodology

Yobe north (Afunori) is located between latitudes 10^0 27^1 and 13^0 23^1 North and longitudes 9^0 40^1 and 12^0 30^1 East of the equator (YBSES, 2008). The area is bounded on the north by the Niger Republic, on the east by Borno state and Jigawa and Bauchi states on northwest and southwest respectively. The area covers a total land area of 25, 251 KM$^{2.}$ (YBSES, 2008). Drainage is mainly tributary in nature with river Yobe providing seasonal water supply. The climate of the area is characterized by short growing season and unpredictable rainfall pattern as rains often come very late and stops early. Available records have shown that the area receives between 300 and 500mm and the rainy season lasts for only 90 days. Temperature ranges from 39 – 42^0C. Generally, the climate of the area is characterized by frequent cases of drought. The vegetation of the area is mainly Sahel which is under severe and continuous threat of desertification.

The impact of Neem on weather variables in the study area was measured by comparing the mean records of rainfall, relative humidity, temperature and wind speed on the leeway side with records of the same weather variables on the windward side (control).The analysis was accomplished in three stages based on the period covered by this study i.e. from 1999 to 2013 as follows: the first five years (1999 – 2003), the second five years (2004 – 2008) and the last five years (2009 – 2013). The statistical significance of the difference between both values was tested using the student`s t- test. This work adopted Buba (2012) method of student`s t – test computation as shown in the formula below:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\delta_1^2}{n_1} + \frac{\delta_2^2}{n_2}}} \text{.............................. (i)}$$

Where:

t = Student t – test value calculated from meteorological data from both protected and unprotected environment

$\bar{X}_1$ = Mean record of weather variable in the unprotected environment (Control)

$\bar{X}_2$ = Mean record of weather variable in the protected environment (Neem)

δ_1 = Variance of control data from the mean

δ_2 = Variance of Neem data from the mean

n_1 = Number of data from the unprotected area used in the analysis

n_2 = Number of data from the protected area used in the analysis

The degree of freedom (df) for quantifying the acceptable level of error(s) in the analysis is calculated from the following formula:

$$df = n_1 + n_2 - 2 \text{ .... (ii)}$$

Where,

df = degree of freedom

$n_1$and n_2 have already been defined in equation (i) above.

Results

Microclimatic Effects on the Weather Variables in the First Five Years (1999 – 2003)

In the first five years, mean record of rainfall in the protected area of Neem plantation was 36.12 inches which was slightly lower than the control value (36.19 inches). The difference of 0.07 inches between both values was negligible (Table 1). Similarly, relative humidity values showed very little difference. Specifically, the difference was only 1.57% computed between the values of 33.98% and 35.55% for control and the area sheltered by the species respectively. Difference in temperature between both areas also showed similar trend. For instance, the control area recorded an average of 31.14 ^{0}C against 30.37^{0}C within the same period. There was a staggering difference of only 0.77 ^{0}C between both areas. Mean values of wind speed were higher in the control area compared to the protected area of the species. Respective values of 19, 167.06 and 19, 005.53 knots were recorded in both areas giving rise to a difference of 161.53 knots. It was observed that at this stage, differences between control values and values generated from the protected area of the species for the four (4) weather elements studied were not statistically significant (Table 2).

Microclimatic Effect on the Weather Variables in the Second Five Years (2004 – 2008)

Table 1 indicates increase in mean annual rainfall from 35.98 inches (control) to 44.98 inches in the area protected by the species. By comparison, there was a difference of 9.00 inches or 11.12% between the control and protected areas. However, the difference was not significant. Similarly, Relative Humidity (R.H) increased from 35.04% (control) to 48.65% under *A.indica*. Thus, a difference of 13.61% was computed between both areas. This implied that areas protected by *A. indica* were more humid compared to the unprotected site (control). Despite the high difference (16.26%) between mean values of R.H in both areas, it was not significant. Temperature decreased from 33.06 ^{0}C (control) to 24.66 ^{0}C in the protected area of the species giving rise to a difference of 8.4^{0}C between both areas. Thus, mean records of temperatures were lower in the protected areas of A. *indica*. Difference between mean values of temperature in both areas was significant. Wind speed recorded the highest reduction from 15, 735.14 knots (control) to 10, 855.49 knots under the shelters of A. *indica*. The difference of 4, 879.65 knots computed between both areas was not only high but also statistically significant (Table 2).

Microclimatic Effects on the Weather Variables in the last Five Years (2009 – 2013)

Table 1 indicates increase in mean annual rainfall from 31.02 inches in the unprotected area to 42.45 inches under the shelters of *A. indica.* Although the difference of 11.43 inches of rainfall between both areas was high, it was not statistically significant (Table 2). Similarly, Relative Humidity (R.H) recorded similar incremental pattern as rainfall from 28.44% (control) to 45.71% on the leeway side. However, in spite of the difference of 17.27% between both values, it was not significant (Table 2). Temperature reduced from 34.05 ^{0}C (control) to 24.05^{0}C in the protected fields. The difference of 10 ^{0}C between both areas was statistically significant (Table 2). Wind speed reduced considerably from 15, 085.15 knots (control) to 10,554.76 knots in the protected fields. The difference of 4, 530.39 knots between both areas was also significant (Table 2).

Table 1: Impact of Afunori Neem Plantation on the four Weather Variables from 1999 to 2013.

Growth stage	Weather element	Mean NIMET Record**	Mean Record *A. Indica* ***	Difference Between mean values	%
1999 – 2003	Rainfall (inches)	36.19	36.12	0.07	0.097
2004 – 2008	"	35.98	44.98	9.00	11.12
2009 – 2013	"	31.02	42.45	11.43	15.56
1999 – 2003	Relative Humidity (%)	33.98	35.55	1.57	2.26
2004 – 2008	"	35.04	48.65	13.61	16.26
2009 - 2013	"	28.44	45.71	17.27	23.29
1999 - 2003	Temperature (^{0}C)	31.14	30.37	- 0.77	- 1.25
2004 - 2008	"	33.06	24.66	8.40	14.55
2009 - 2013	"	34.05	24.05	10.00	17.21
1999 - 2003	Wind speed (knots)	19, 167.06	19, 005.53	- 161.53	- 0.42
2004 - 2008	"	15, 735.14	10, 855.49	- 4, 879.65	- 18.35
2009 – 2013	"	15, 085.15	10, 554.76	4, 530.39	17.67

Source: ** = Secondary data collected by NIMET (1999 – 2013);
*** = Secondary data from weather stations under the shelters of *Azadirachta indica*at Afunori

Table 2: Statitical significance of the Impact of Afunori Neem Plantation on the four Weather Variables from 1999 to 2013

S/n	Variable of comparison	Stage of growth	Mean NIMET (control) ($\bar{X}$) **	Mean value *Azadirachta indica* ($\bar{X}$) ***	Diff. b/w mean values	Variance of control data from the mean	Variance of *A. indica* data from the *mean*	t – calculated	t - critical	Decision on H0:
1	Rainfall (inches)	1999 – 2003	36.19	36.12	0.07	0.298	0.01464	0.125	2.306004	Accepted
	"	2004 – 2008	35.98	44.98	- 9.00	0.307	0.04024	- 15.25	2.306004	Accepted
	"	2009 – 2013	31.02	42.45	- 11.43	0.423	0.40288	- 12.56	2.306004	Accepted
2	R/H (%)	1999 – 2003	33.30	33.55	- 0.25	0.099	0.40552	- 0.35	2.306004	Accepted
	"	2004 – 2008	35.04	48.65	- 13.61	0.046	0.2594	- 24.75	2.306004	Accepted
	"	2009 – 2013	28.44	45.71	- 17.27	0.211	0.4739	- 20.81	2.306004	Accepted
3	Temperature (^{0}C)	1999 – 2003	31.14	30.37	0.77	0.179	0.221	- 1.22	2.306004	Accepted
	"	2004 – 2008	33.06	24.66	8.40	0.509	0.2794	0 9.44	2.306004	Rejected
	"	2009 – 2013	34.05	24.05	10.00	0.008	1.4376	08.333	2.306004	Rejected
4	WS (Knots)	1999 – 2003	19, 167.06	19005.53	- 161.53	60, 759.51	38.0550	- 0.655	2.306004	Accepted
	"	2004 – 2008	15, 735.14	10855.49	4, 879.65	31, 712.86	203.43	27.31	2.306004	Rejected
	"	2009 – 2013	15, 085.15	10554.76	4, 530.39	24, 129.43	1, 378.28	28.37	2.306004	Rejected

Source: ** = Secondary data collected by NIMET (1999 – 2013); *** = Secondary data from weather stations under the shelters of *Azadirachta indica at* Afunori
Key to abbreviations: diff. = difference, b/w = between, R/H = Relative humidity, WS = Wind Speed

Discussion

It can be observed from Table 1 that in the first five years, there were very little differences between the control records and mean records of rainfall, relative humidity (R.H), temperature and wind speed in the protected areas with *Azadirachta indica.* This little difference has been attributed to low canopy density that could have modified weather variables in the protected areas of the species. It is logical that the greater the canopy density, the greater the microclimatic effect and vice versa. This confirms the direct relationship between canopy density and modification power of trees (FAO and UNEP, 2003). Thus, in the first five years, the impact of plantation of *Azadirachta indica* at Afunori was very low and statistically insignificant (Table 2).

In the second five years, however, mean records of the four weather elements on the leeway side had shown variations from the control record (Windward side). This is due to the development of matured canopies that greatly modified weather variables in the area protected by the species. The greater the canopy, the greater the modification effect (FAO, 2009). Thus, there was considerable increase in the amounts of rainfall and R.H in the second five years; however, differences between mean values of these elements in both areas were not significant (Table 2). This agrees with the early work of Milan *et al*. (2004) where records of rainfall and relative humidity between two adjacent locations in India were compared. Results indicated greater amount of rainfall and R.H in the leeway side of the plantation of *Azadirachta indica* compared to the windward side (control) at maturity. Temperature reduced considerably in the protected fields of *Azadirachta indica* in the second five years. The difference in temperature between the protected and unprotected areas was 8.4 ^{0}C (Table 1) which was lower than 10 ^{0}C reported in India at the same stage of growth (World Neem Conference 2012). These results further confirm the findings of the Neem Foundation (2012) that an average Neem tree can do the job of 10 air conditioners and can lower the outside temperature by 10 ^{0}C. Wind speed recorded higher reduction compared to temperature. Same trend has been reported from many locations in the northern hemisphere at maturity (Vautardetal.2010). Without doubt, high wind speeds have declined by a greater proportion on the leeway side of Neem plantation at Afunori. Unlike rainfall and R.H, differences between mean values of these weather variables in both areas were significant (Table 2). Indeed, this confirms increased modification effect of tree plantation on the surrounding environment with maturity as widely reported in earlier works (Carter, 2005; FAO, 2009; Adekoya, 2007 and Zira, 2014).

In the last five years, mean records of weather variables in the area sheltered by *A. indica* had shown considerable variation from the control record. This is because at this stage, all growth structures responsible for environmental modification were fully matured leading to the development of broader and denser canopies. For instance, tree height increased considerably from 15m to 30m (Fact Net, 2005); while stem diameter changed from 35cm to 90cm (FAO and UNEP, 2003). Researches (Fish wick and Weber, 2012; FAO, 2009 and Zira, 2014) have shown that the denser and broader the canopies, the greatest the modification effect. Thus, the impact of Neem plantation on the four-weather variables in the last five years was greatest than in the first and second five years. However, differences between records of rainfall and R.H for both areas were not significant whereas those of temperature and wind speed were.

Conclusion

Azadirachta indica is the dominant tree species commonly used in program and projects of desertification control both in the Sahel and Sub-Sahara Africa. Its xyrophytic properties make it a reliable species for sand dune fixation and stabilization as well as other projects of environmental management. Like other tree species, its botanical structures influences weather variables through the creation of microclimate. It's wide spread utilization in Yobe north and the state could probably be attributed to its capacity to modify extreme high winds and temperature responsible for cyclical drought in the area. Though the impact of the plantation of *Azadirachta indica* on rainfall and R. H at Afunori was not significant at the three growth stages studied, there were strong indications to belief that large-scale plantations of the species could have significant impact on both weather elements through increased evapotranspiration and aerodynamic roughness. The increased usage of *Azadirachta indica* in desertification control programs of the state is an answer to the three universal questions of plantation forestry: Which tree? Where and Why? This is severally re-iterated by the United Nations in various treaties, agreements, protocols and conventions including the Arusha Agreement, the Kyoto Protocol, the Millennium Development Goals (MDGs) and more recently the Paris Convention on climate change. Critical answers to the above queries could provide useful direction in the selection of desirable species that can tackle ecological problems. As the tree of the 21st century, *A.*

indica proved to be a desert fighter as it significantly counteracted the excesses of extreme high winds and temperature which are the driving engines for both droughts and desertification in the area.

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ANALYSIS OF CROSS-BORDER CATTLE TRADE: A CASE STUDY OF MAIGATARI IN NIGERIA AND DUNGASS IN NIGER REPUBLIC

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Abstract
The study examined the nature of cross-border cattle marketing between Maigatari in Nigeria and Dungass in Niger Republic. Both purposive and random sampling technique were employed for this study. Maigatari and Dungass cattle markets were purposively selected from Nigeria and Niger Republic, respectively. Eighty-five (85) traders and 45 selling agents were randomly selected from Maigatari market, while 50 traders and 35 selling agents were selected from Dungass market. This giving a total sample of 215 respondents. The data were analysed using descriptive statistics. The results revealed that Rahaji breed (sometimes called Red bororo, bodeeji or Wodaabe cattle) is the most popular breed found in both markets. The results show that 89.4% and 82.0% of cattle traders in Maigatari and Dungass, respectively, were wholesalers. The results show that 97.7% and 92.0% of cattle traders confirmed that size of the animals was the basis for cattle differentiation in Maigatari and Dungass markets, respectively. The result further reveals that the highest number of cattle trade was recorded in January, while the lowest was in August for the years examined. Problems affecting of cross-border cattle trade in the study area are illegal fees and taxes, security challenges, inadequate market infrastructures and capital, among others. The study recommended that producers and traders should be encourage to patronize Rahaji breed, since their size and body conformation attract customers, which in turn leads to higher prices. Government should control illegal fees and taxes as well as security challenges in the markets. The traders should strengthen their association in order to source funds from formal financing Institution to overcome problems of inadequate capital. Also, authorities concern should construct/rehabilitate rural–urban roads to improve market efficiency.

Keywords: Cattle breeds, Cross-border trade, Middlemen, Nigeria, Niger Republic

Introduction

Cross-border cattle trade has been long operated between Nigeria and Niger Republic which makes a significant contribution to local livelihood and economic development. The livestock market especially cattle market, is very important for both Nigeria and Niger Republic particularly for populations along the border basin of Kano-Katsina-Maradi (West African Borders and Integration [WABI], 2006). The traditional cattle's marketing remains the major source of livestock and livestock products in developing countries. Cross-border trade (CBT) especially livestock trade in Nigeria and West Africa in general is based on live animals. According to Adesina (2014), the domestic market opportunity for beef is large and growing current estimates of beef consumption was about 360,000 metric tonnes in 2014 and beef consumption per capita was about 2kg. The author added that it has projected an increase in beef consumption in the country from 360,000 tonnes to 1.3 million tonnes by 2050. The deficit necessitates the importation of several thousand heads of cattle from Nigeria's neighbours like Niger, Chad and Cameroon Republics.

Informal cattle trade had been practiced since 1950s across West Africa by small and weak economies of Benin, Togo and the Gambia by adopting the strategy of low-tariff policies (Oculi, 2012). Hence, attracting foreign imports from Africa for transit to richer neighboring economies of Mauritania, Senegal and Mali (for Gambia); Nigeria, Burkina Faso and Niger Republics (by Togo and Benin). Raw materials such as food grain, gold, diamonds, groundnut, livestock and cocoa were imported from those countries. Similarly, products like (petrol and fertilizer) were exported from Nigeria and manufactured goods such as detergent, dairy products and beverages were exported from Ghana, Senegal and Mali across regional borders.

Cross-border trade has been ignored by African state while it remains a vital part of rural economic activity (Oculi, 2012). This may be connected to inadequate support by the government in terms of credit facilities and market infrastructures in the region. According to WABI (2006), traders from Northern Nigeria and Niger Republic understand each other perfectly, belonging to the Hausa area with 50million Hausa speakers. They share 1,500km of common border and are often related by family, religious and lineage links. Hence, those attributes facilitate cattle trade in area. Informal cross-border trade in the short-to-medium term encourages regional trade and contributes to greater food security and enhances income earnings as well as employment opportunities to poor households. In cross-border cattle trade, transaction costs (total cost), high cost of transportation, inadequate market information, activities of marketing agents, insecurity on transport and at market, bargaining processes and payments for multiple/illegal fees or taxes all those factors affect the smooth operation of cattle trade. In addition to this, little research has been done on cross-border cattle trade particularly in the study area. Thus, there is a great need to carry out a research in this field in order to promote economic development and to proffer solutions to the constraints affecting the cattle trade. The specific objectives of the study is to:

1. identify cattle breeds and sources of supply in the study area;
2. examine cattle marketing channel and the functions of marketing agencies in the study area;
3. evaluate the volume of cattle imported from Dungass in Niger Republic into Maigatari cattle market in Nigeria; and
4. Identify constraints affecting cattle trade in the study area.

Methodology

Study Area

The study was conducted in Maigatari cattle market in Jigawa State, Nigeria and Dungass cattle market in Zinder Region, Niger Republic. Jigawa State is located between latitudes 11º N and 13º N and longitudes 8º E and 10º E. The area has a tropical climate and the temperature varies at different times. High temperatures are normally recorded between the months of April and September. The daily minimum and maximum temperatures are 15°C degrees and 35°C, respectively. The rainy season lasts from May to September with average rainfall of between 800 mm. The study area is situated within the Sudan savannah vegetation zone, but there are traces of Guinea savannah in the southern part of the area. It cover about 23,287Km^2 and projected population of about 5,590,272 persons in the State as of 2017 (Maternal, Newborn, Child Health Programme [MNCH2], 2017). The State shares borders with Zinder Region in Niger Republic to the North, to the South with Bauchi State, to the West with Kano State and Yobe State to the East. The study area is dominated mainly by farmers and the area is also a commercial centre of the trans-Sahara trade. The ethnic groups are Hausa – Fulani and Kanuri. The main economic activities in the State are agriculture and trading. The major crops grown include sorghum, millet, maize, wheat, rice, cowpea, sesame, cotton, groundnut and vegetables such as tomato, pepper, onion, cabbage and carrot among other. In addition, fish production and animal husbandry are widely practiced in the study area with major livestock being cattle, sheep, goat and dromedaries, among others.

Zinder State in Niger Republic is located between latitudes 13^0 N and 8^0 N; and longitudes 0^0 E and 8^{0}E and it is situated at elevation of 460 meters above sea level. It shares boundary with Agadez Region in Niger Republic at the North, Jigawa State of Nigeria to the South, Yobe State to the Southeast and Katsina State to the Southwest, The average annual temperature and rainfall in Zinder are 28.0°C and 380mm, respectively. The Region covers 145,430 km² and population was estimated at 291,424 persons as of 2012

(World Population Review, 2017). Zinder Region experiences on average 411 mm of rainfall per year, or 34.3 mm per month. The highest rainfall is in August with an average of 168.1 mm of rainfall. French is an official language. The people are working full time in livestock production and many are in the agro-pastoral sector. The crops grown include cowpea, cotton, peanut, millet, sorghum and cassava among others. Similarly, animal rearing is also an important occupation in the study area, especially among the Fulani, Touareg, Toubout and Arab, where they rear cattle, sheep, goats, dromedaries and donkeys, among others.

Sampling Technique and Sample size

Purposive sampling technique was used to select one cross-border cattle market from Nigeria and another market from Niger Republic. The markets selected were Maigatari cattle market in Jigawa State, Nigeria and Dungass cattle market in Zinder Region State in Niger Republic. These markets were selected because of large volume of cattle trade and their location along the border of Nigeria and Niger Republic. The list of functional cattle marketing middlemen was collected from the traders' and agents' unions from each market, and used as a sampling frame. The model was adapted from Titus *et al*. (2008) because the population was defined. The sample size was estimated according to Yamane (1967) as:

i) $$n_m = \frac{N}{1+N(e)^2} - - - - - - (1)$$

Where;

n_{mgt} = Sample size of the traders in Maigatari market

N = Total number of the functional traders in the association at Maigatari

e^2 = Error term (0.05^2)

ii) $$n_d = \frac{N}{1+N(e)^2} - - - - - - - (2)$$

Where;

n_{dng} = Sample size of the traders in Dungass market

N = Total number of the functional traders in the association at Dungass

e^2 = Error term (0.05^2)

The same formula was used in determining the sample size of the selling agents in the two market locations. In Maigatari market 85 traders and 45 agents were selected randomly with the aid of random number table, while in Dungass market 50 traders and 35 agents were selected. Those sample were selected based on population (N) of the traders and selling agents by using the formula. Thus, 135 traders and 80 agents were used in this research work. The overall total sample was 215 cattle marketing middlemen, which was selected out of 470 middlemen (population) in the study area.

Data Collection

Both primary and secondary data were used for this study. Primary data were collected with the aid of structured questionnaires designed in both open and close ended formats. The data were collected by the researcher and trained enumerators. The information collected from the respondents includes information on cattle trade. Secondary data were from Jigawa State Agricultural Development Authority (JARDA) on volume of cattle traded in Maigatari from Dungass market in 2013 covering 2002 to 2012.

Methods of Data Analysis

Descriptive statistics such as percentage, frequency distribution and charts ware used in analyzing the data. A frequency distribution table has two columns, one showing the range of values 'X' and the other displays the numbers of times each value occurs 'F' columns. In computing the mean from grouped data, we assume some midpoints of each interval classes (Eboh, 2009). Mean of group data is estimated by:

$$\bar{X} = \frac{\sum_{i=1}^{k} f_i m_i}{N} = \frac{\sum_{i=1}^{k} f_i m_i}{\sum f_i} - - - - - - (3)$$

Where,

$\bar{X}$ =mean

f_i = number of cases in the *i*th category, with $\sum f_i = N$

m_i = midpoint of *i*th category
k = number of categories

While mean of ungroup data is estimated by:

$$\bar{X} = \frac{\sum x}{N} \text{ ------------ } (4)$$

Where,
$\bar{X}$= mean
X_i=observations
N= Total number of observations (sample size)
$\sum$ = Summation

Results and Disscussion

General Information on Cross-border Cattle Trade

The two countries are located in West Africa and there is no visa requirements for entry or exit. The document required from cattle market operators is the traders' identity card. The distance between Maigatari and Dungass is about 29 km. The common currencies been used in the past were Nigerian Naira (₦) and Nigerien Franc (CFA) in both markets. Presently Nigerian Naira is the common currency used in these markets. Hausa and Fulfulde are the main languages used for trade in both market locations. Maigatari cattle market is operated on Thursdays while Dungass is operated on Sundays. The markets were organized and well established in terms of cattle transaction and large number of cattle marketing middlemen who patronize the markets.

Breeds of Cattle in the Study area

There are several breeds of cattle found in Nigeria. As depicted in Figure 1, breed found in Maigatari cattle market as confirmed by the respondents (100.0%) was Rahaji (red bororo). This was followed by Bunaji, Sokoto Gudali, and Muturu cattle breeds which constituted about 26.7%, 26.7% and 8.9%, respectively. This implies that Rahaji is the most popular breed in Maigatari. The finding agrees with that of Blench (1999) who reported that Rahaji is one of the largest zebu breeds found along border towns to the north of Jigawa, Yobe and Borno States; and along the southern border towns of Zinder Region in Niger Republic. It is the third most numerous breed of cattle after Bunaji and Bokoloji in Nigeria, and constitutes about 22.0% of the national herd Blench (1999). In addition, Bunaji or White Fulani cattle is the most numerous and widespread of all Nigerian cattle breeds. The estimated population of Bunaji is about 37% of the national herd Blench (1999). They are found in Taraba, Bauchi, Gombe, Adamawa, Katsina and Kano States and spread across the Nigerian Middle Belt. The only areas absent are Borno, where Rahaji and Wadara predominate, and in the south-east, where there are no resident zebu (Blench, 1999). This may be due to climatic conditions of the area that may or may not favour the growth of those breeds.

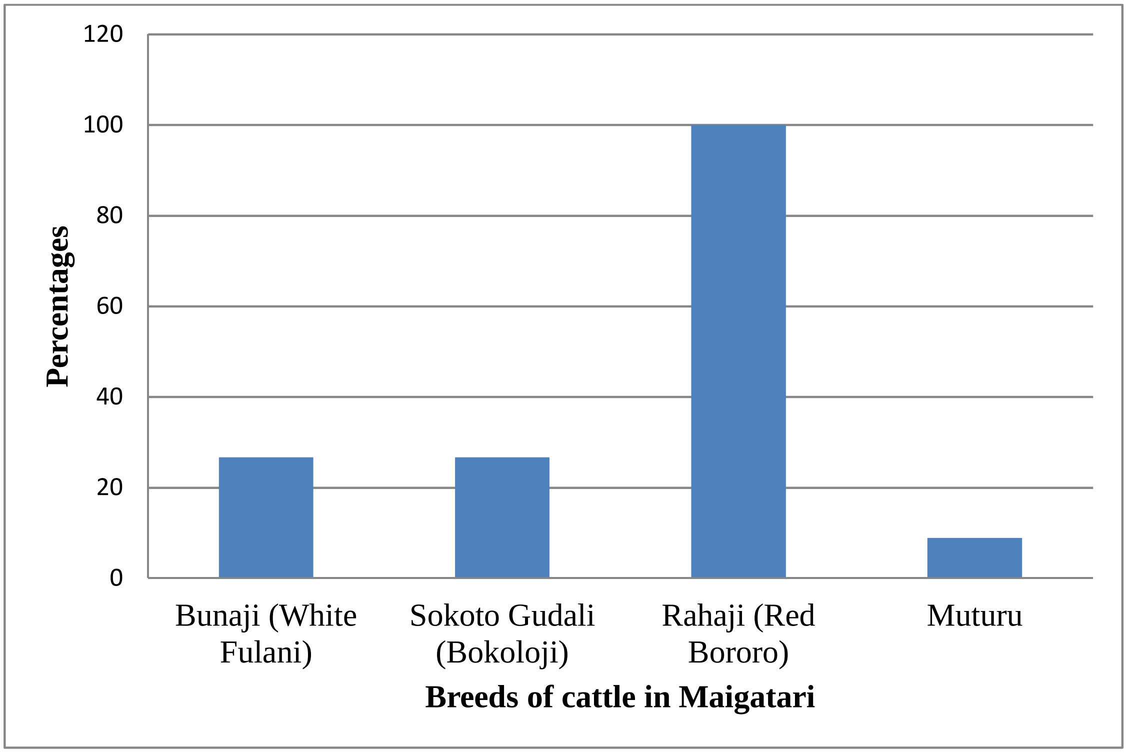

Figure 1: Breed of cattle in Maigatari cattle market, Nigeria.
Source: Field survey, 2013.

The breeds of cattle found in Dungass cattle market are presented in Figure 2. About 97.1% of the respondents observed that Rahaji (red bororo/wodaaBe) was the prominent breed found in Dungass cattle market. The finding is in agreement with that of Blench (1999). Another 22.9%, of the respondents confirmed Azwak as the second popular breed in the market. However, Azwak are commonly found on the border north and west of Tahoua, Tillaberi and Dosso Regions. Azwak in Niger are commonly described as red, light fawn colour, though they can also be white, brown, pied and black. They are lightly built with medium-length horns (ILRI, 2006).

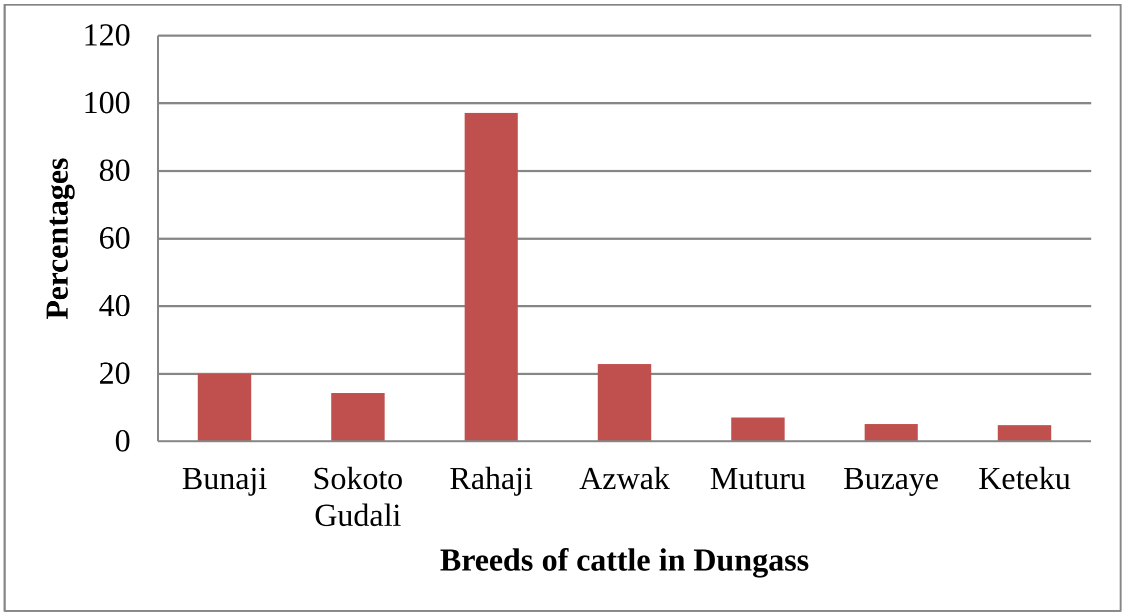

Figure 2: Breeds of cattle in Dungass Cattle Market, Niger Republic.
Source: Field survey, 2013.

Sources of Cattle in the Study Area

Many marketing operators in the study area supply cattle from diverse sources. As indicated in Figure 3, about 43.0% of the respondents confirmed that the main source of cattle in Maigatari cattle market was from other Local Government Areas (LGAs) of Jigawa state as well neighboring States.

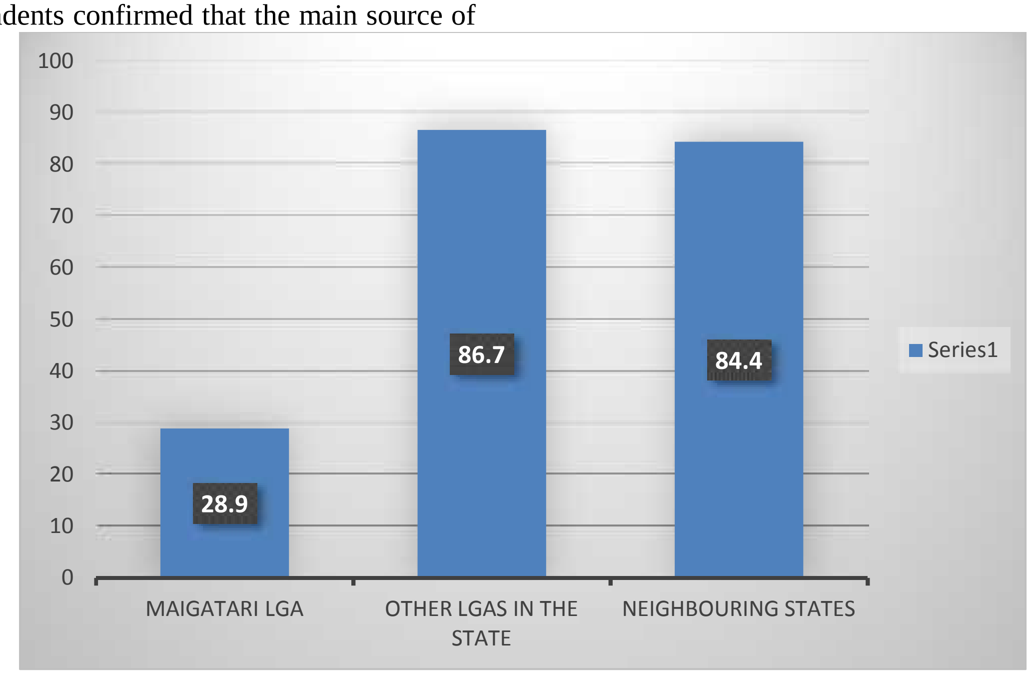

Figure 3: Source of cattle supply to Maigatari cattle market
Source: Field survey, 2013.

Figure 4 shows the major sources of cattle supply to Dungass market. The result shows that 94.3% of the respondents observed that Dungass Commune in Zinder Region as the main sources of cattle into Dungass cattle market. While 57.1% and 54.3% of respondents mentioned Diffa and other Communes in Zinder Region was the main sources of cattle into Dungass cattle market. This implies cattle supply to Dungass market was from Zinder Region. This might be attributed to the large number of cattle producers and regional wholesalers.

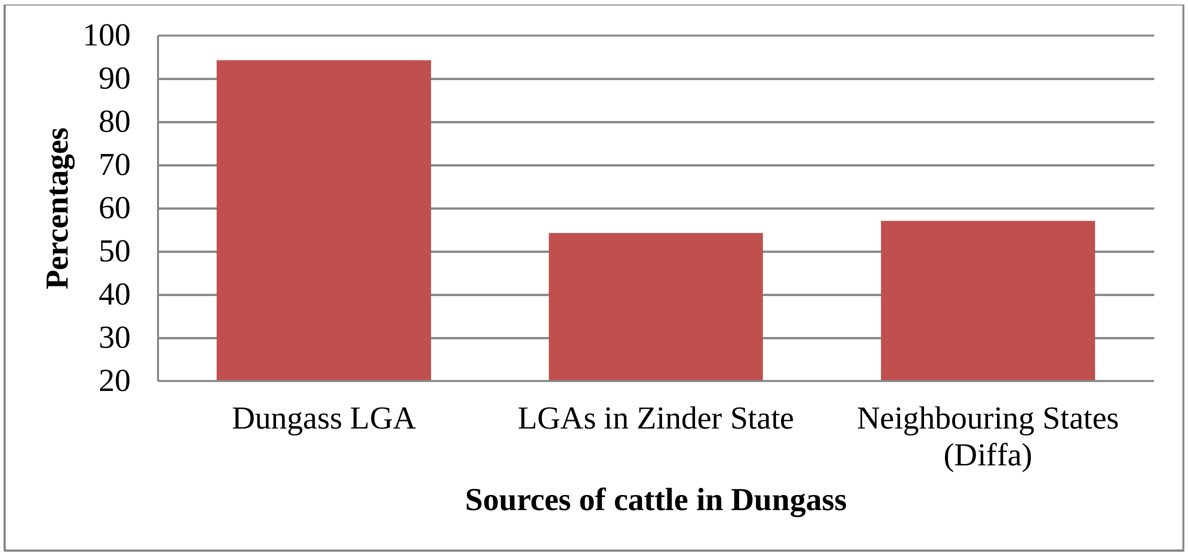

Figure 4: Sources of cattle supply to Dungass cattle market
Source: Field survey, 2013.

Marketing Channels of Cattle in the Study Area

The findings revealed two main different chains in both domestic and cross-border segments of cattle marketing channels. In the domestic segment (Dungass in Niger Republic), the first chain was the producer/pastoralist sells directly to the local butchers who slaughter and sell beef and it products (*Tsire*, *Balangu*, *Kilishi* etc.). The second chain was the main one where the pastoralist takes the cattle to the market directly or through his selling agent (*Dillali*). Also, regional buyers from North (Agadez Region) and East (Diffa Region) shoulder the task of transporting the cattle to the southern part of the country (Dungass border market) in Zinder Region. From the frontier market (Dungass) the cattle were moved to the terminal market (Maigatari in Nigeria) via cattle traders which form the cross-border segment marketing chain. The marketing chain in the cross-border segment was similar to that in the domestic segment. The only difference was that the regional wholesalers in Nigeria take the responsibility of transporting the cattle from North (Maigatari) to the south (places like Port Harcourt, Lagos, Aba, Benin, Enugu, Onitsha etc.). In southern Nigeria, the cattle were then purchased by their local butchers who in turn slaughter and dispose both beef and beef products to the southern consumers.

Marketing Agencies in Cross-Border Cattle Trade

Cattle trade is characterized by the presence of various middlemen in the market. The types of middlemen that participate in cattle trade in the study area are presented in Table 1. The results show that 89.4% of the traders in Maigatari market were local wholesalers in the market. While 49.9% were breeders. In Dungass 82.0% and 50.0% of the traders were local wholesalers and breeders, respectively. The results also show 89.9% and 88.6% of the market operators were wholesalers in Maigatari and Dungass markets, respectively. The findings show that cattle trade is characterized by the presence of various marketing agencies. Both the traders and selling agents in the two market locations confirmed the presence of local wholesalers as the predominant about 89.4% of the market participants. Furthermore, most of the respondents asserted the presence of speculative, regional wholesalers, butchers and breeders in the markets as presented in Table 1. Thus, wholesalers constituted a largest proportion of middlemen in both market locations. This is in conformity with the findings of Murtala *et al.* (2012) and Sulumbe *et al*. (2010) that wholesalers constituted substantial proportion of middlemen in cattle marketing in the study areas.

Table 1: Marketing Agencies in Maigatari and Dungass Markets.

	Maigatari Market		**Dungass Market**		**Total**	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
Traders	**(n=85*)**		**(n=50*)**		**(n=135*)**	
Breeders	39	45.9	25	50.0	64	47.4
Retailers/butchers	63	74.1	29	58.0	92	68.1
Local wholesalers	76	89.4	41	82.0	117	86.7
Regional wholesalers	65	76.5	37	74.0	102	75.6
Speculators	71	83.5	38	76.0	109	80.7
Selling agents	**(n=45*)**		**(n=35***		**(n=80*)**	
Breeders	29	64.4	20	57.4	49	61.3
Retailers/butchers	36	80.0	28	80.0	64	80.0
Local wholesalers	40	88.0	31	88.6	71	88.8
Regional wholesalers	39	86.7	29	82.7	68	85.0
Speculators	38	84.4	30	85.7	68	85.0

*Multiple responses were obtained
Source: Field survey, 2013

Figure 5 shows the categories of agent middlemen in cattle marketing in the study area. In Maigatari market 51.1%, 35.6% and 13.3% of the agents were operating as commission men (*dillalai*), both commission men and brokers; and brokers (*yannakama*), respectively. While in Dungass 62.9%, 31.4% and 5.7% of the agents were commission men, both commission men and brokers; and brokers, respectively. This implies that majority of the agent middlemen were commission men (*Dillalai*) in the two markets. In both markets, majority of the agent middlemen were operating as commission men (*Dillalai*). The commission fee, which is usually called (*La'ada*) serves as binding agreement for the transaction. The factors that determine amount paid to the broker as fee were size of the animal and price paid for the cattle. The fee is usually from ₦500 (1,485.00FCFA) to ₦2,000.00 (5,940.00 FCFA). That is if the price paid by the buyer was moderate or not high, most likely the selling agent may receive favorable fees for the transaction. This is in agreement with the findings of Bose *et al*. (2011) who reported that market agents' fees varies according to the size and price of the cattle paid by the buyers; where commission agents received ₦500.00 – ₦700.00 for small size cattle, ₦800 – ₦1,200.00 for medium size and ₦1,000.00 – ₦1,500.00 for large size cattle. Olukosi *et al*. (2005) categorized agent middlemen as commission men and brokers. Mohammed (2000) observed that marketing system could be impaired in the absence of the market agents because of the large number of both sellers and buyers in agricultural commodity markets.

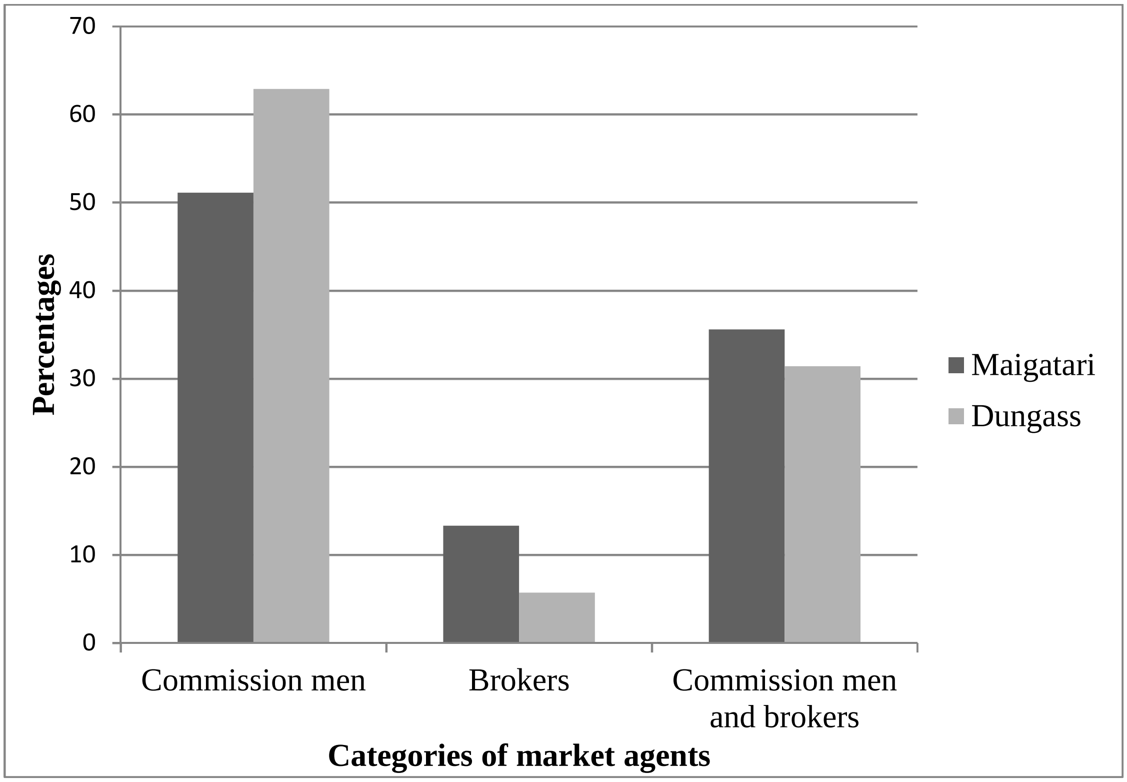

Figure 5: Categories of agent middlemen in the study area
Source: Field survey, 2013

Functions of Marketing Agencies in the Study Area

The result presented in Table 2 shows the functions of traders' and selling agents' associations in the markets. The results show 92.9% and 80.0% of the respondents posits that dispute resolution as a key function of their association in Maigatari and Dungass markets, respectively. About 90.6% and 78.0% of the traders testified that provision of credit to members is one of the roles of their associations in the respective markets. Also, 95.6% and 88.6% of the selling agents gave assistance to producers on transaction, as the main role of their association in Maigatari and Dungass markets, respectively. The results further indicate 86.7% and 24.4% of the respondents identified dispute resolution and provision of credit to members, respectively, as some of the functions of their association in Maigatari market. While in Dungass 85.7% and 20.0% of the brokers testified dispute resolution and provision of credit to members as roles of their association, respectively. The most important function of traders' association is dispute resolution as testified to the traders in Maigatari and Dungass markets. In addition, provision of credits to members; provision of welfare to members and provision of market information as some of the roles of their association in both markets. The implication of these findings is that traders' associations play an important role in facilitating marketing functions in the study area. On the part of the selling agents, giving assistance to sellers and buyers on transaction is the main role of their association in Maigatari and Dungass markets. This finding is in agreement with that of Sulumbe *et al*. (2010) who reported that marketing associations were assisting buyers and sellers as well as providing market information to the traders and producers.

Table 2: Distribution of the Respondents According to Functions of their Associations in the Study Area

	Maigatari Market		Dungass Market		Total	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
Marketers	**(n=85*)**		**(n=50*)**		**(n=135*)**	
Dispute resolution	79	92.9	40	80.0	119	88.1
Provision of market information	67	78.8	37	74.0	104	77.0
Provision of welfare to members	76	89.4	38	76.0	114	84.4
Provision of Credit to members	77	90.6	39	78.0	116	85.9
Commission Men/Brokers	**(n=45*)**		**(n=35*)**3		**(n=80*)**	
Dispute resolution	39	86.7	0	85.7	69	86.3
Provision of market information	31	68.9	24	68.6	55	68.8
Provision of welfare to members	22	46.7	13	37.1	34	42.5
Provision of Credit to members	11	24.4	7	20.0	18	22.5
Assistance on transactions	43	95.6	31	88.6	74	92.5
Provision of security in the market	28	62.2	21	60.0	49	61.3

*Multiple responses were obtained
Source: Field survey, 2013

Volume of Cattle Marketing Activities between Maigatari and Dungass Markets

The number of cattle supplied to Maigatari from Dungass from 2002 to 2012 are presented in Figures 6, 7 and 8. As shown in Figure 6 (2002 – 2005), the highest cattle importations were recorded in January, while the lowest importation was recorded in August. Similarly, Figure 7 which covered the period between 2006 and 2009, shows that the highest importations were recorded in the month of January, while the lowest importations were recorded in August. The results in Figure 8 (2010 – 2012) indicate a similar trend where highest importations were recorded in the month of January, while the lowest importations were recorded in August. It can be noted that cattle importations moved in close range with some kind of interwoven movement in rising and falling pattern within the months of the years studied. It can be seen that the highest importations were observed in the months of January in all the years and this might be attributed to the availability of the animals within this period of the year. This is the period when the pastoralists are present in the region. This conforms to the findings of Mounsour (2008) who reported that cattle importation were highest in the months of December and January to February due to high demand of the animals at that period as well as due to high expectation of remunerative prices by cross-border traders in West African countries. It can be noticed that in all the years studied there was a general decline of importations from January to August. But from September, number of cattle imported increased gradually up to the month of December. The results further indicate that in 2012, a slightly different scenario was observed because cattle importations were high up to months of March, thereafter the supply declined gradually to the month of August. This indicates a great variation exist in monthly importations of cattle in that particular year. It can be concluded that cattle importation showed a trend of increase and decrease pattern in all the years which varies from the base month (August).

It is important to note that no record available for the cattle importation in Niger Republic from Maigatari border market, Nigeria. Effort has been made to collect data on cattle importation from the authorities concerned in Niger Republic, but no importation of livestock from Nigeria, and even if some Nigerien pastoralists purchase cattle from Maigatari (Nigeria) the number of the cattle could be very negligible. The major items that Niger Republic imported from Nigeria are cereals (maize, millet and sorghum), animal feeds, kola nuts, textile materials and the like. Yakouba (2008) and WABI (2006) reported that Maiadu`a market on the border between

Katsina in Nigeria and Niger Republic is among the largest in the region; where beans, millet, maize and groundnut are exported to Niger Republic, while livestock and forest products are imported into Nigeria. It is interesting to note that, this has been observed during data collection whereby most of the pastoralists and traders from Dungass, Niger Republic after selling their cattle, purchase food grains, animal feeds and essential commodities (sugar, flour, cement, textile materials, mattresses, etc.).

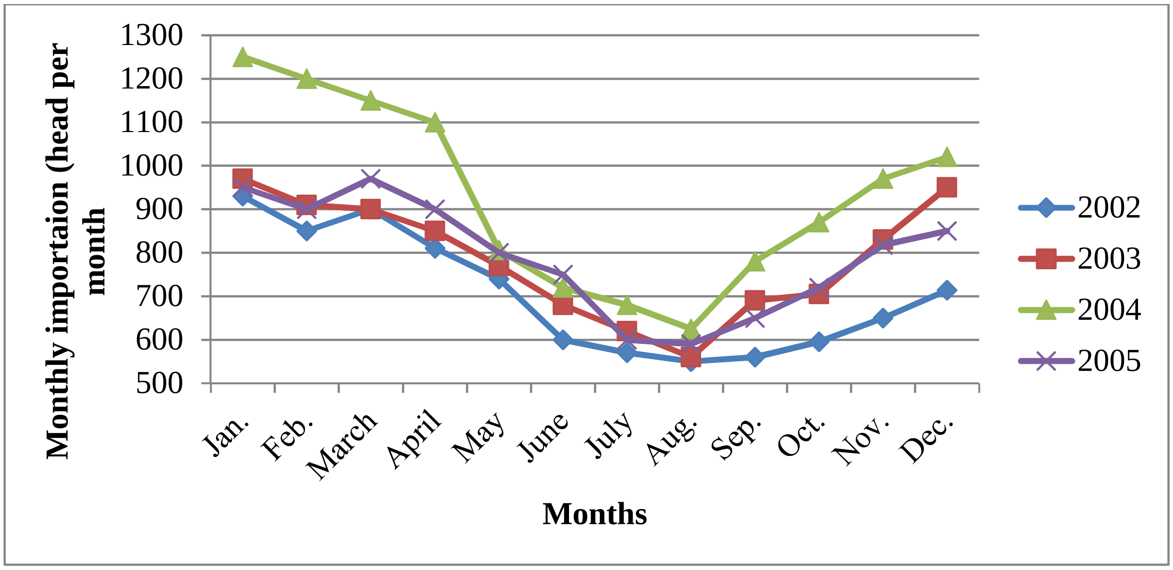

Figure 6: Number of cattle supplied to Maigatari from Dungass (2002 to 2012)
Source: Field survey, 2013.

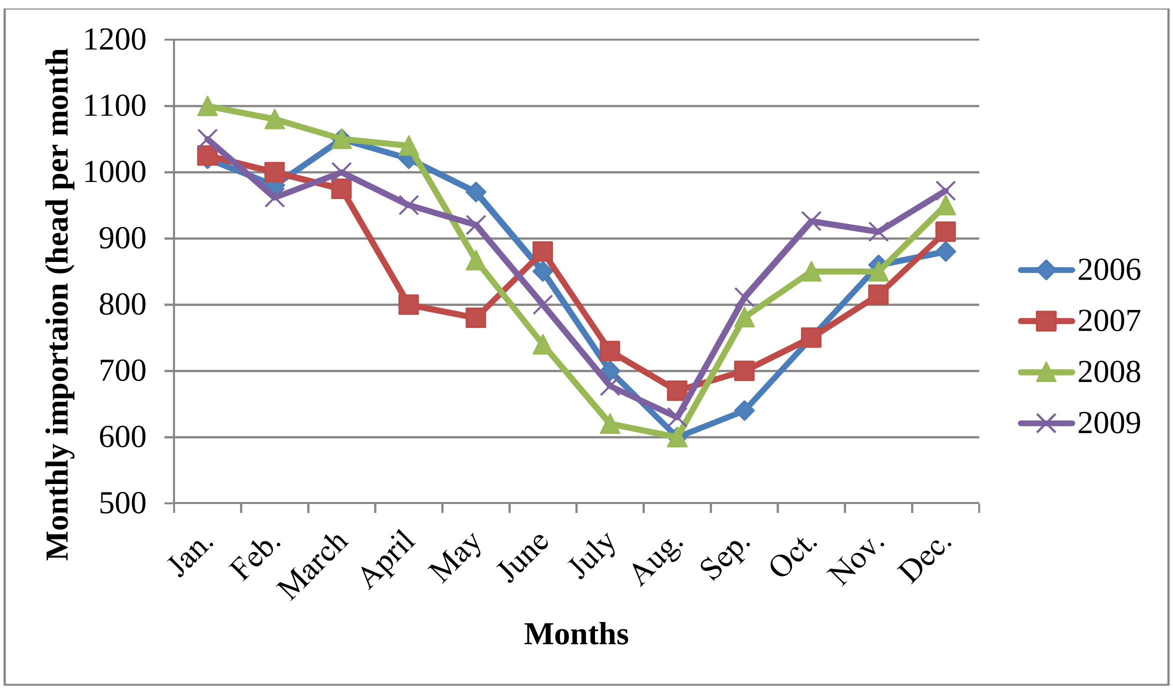

Figure 7: Number of cattle supplied to Maigatari from Dungass (2006 – 2009)
Source: Field survey, 2013.

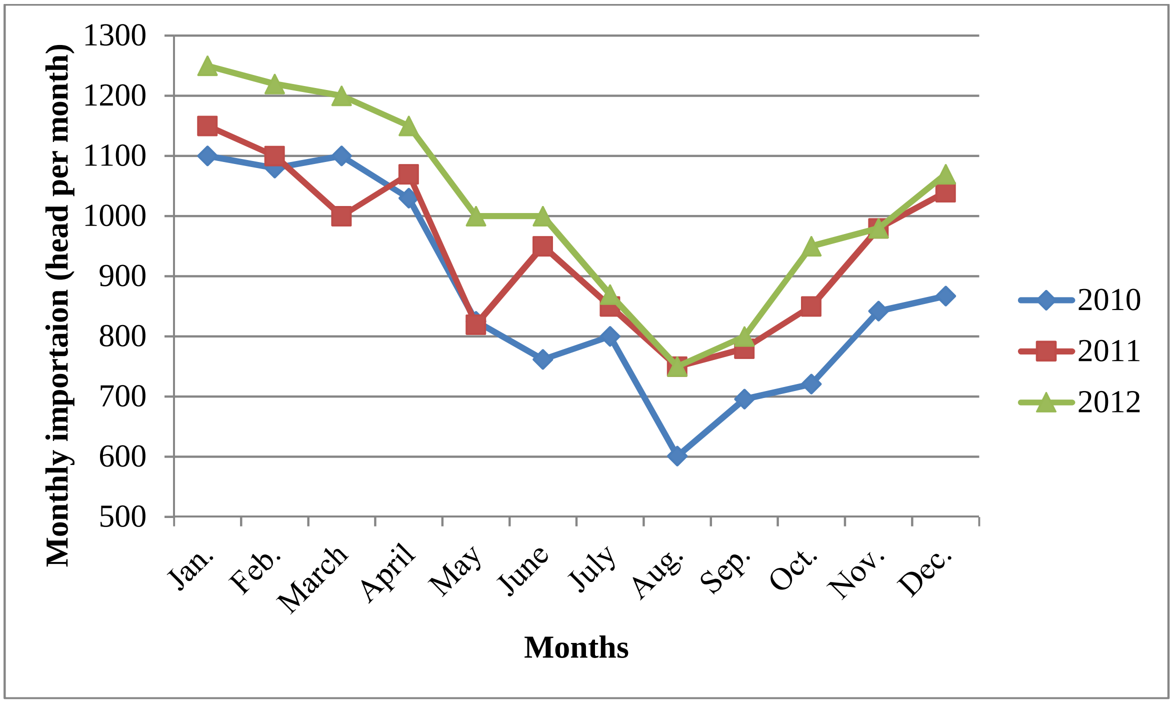

Figure 8: Number of cattle supplied to Maigatari from Dungass (2010 – 2012)
Source: Field survey, 2013.

Problems Affecting Cross-Border Cattle Trade

Figure 9 shows the problems affecting cross-border cattle trade in the study area. The result revealed that constraint to cattle marketing were illegal fees and taxes. This could be probably due to additional amount collected by market officials from the traders as revenue/tax which usually exceeded the official rate of ₦100.0 (297.0 FCFA) per head in Maigatari and ₦500.0 FCFA (₦170.0) per head in Dungass. In addition, inadequate market infrastructures, high cost of transportation, inadequate capital and difficult to access credit were some of the constraints affecting cattle marketing in the study area.

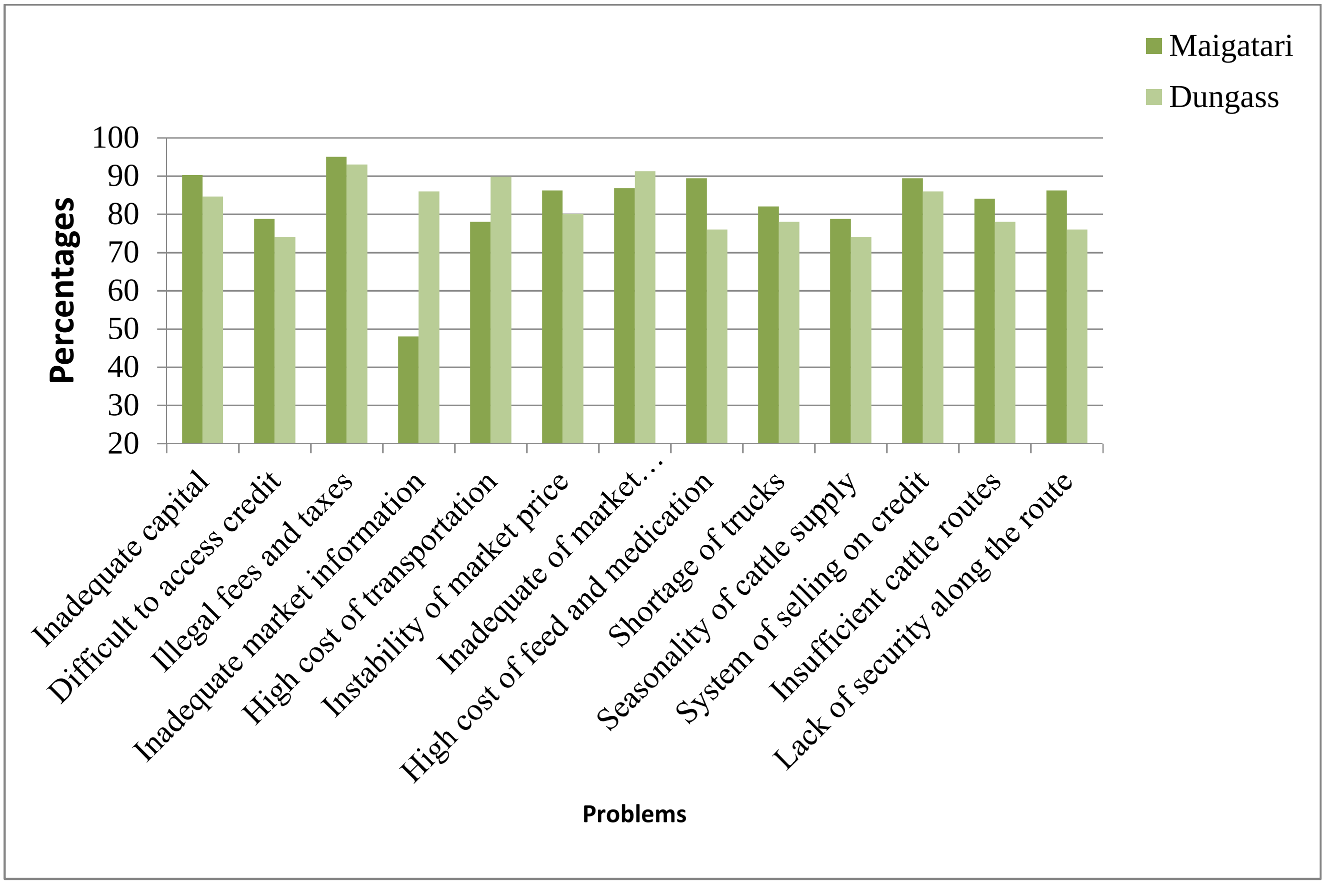

Figure 9: Problems of cross-border cattle trade in the study area.
Source: Field survey, 2013.

Conclusion and Recommendations

Cross-border cattle trade is characterized by the presence of various middlemen in the market who perform one function of marketing or the other. The market operators in the two markets confirmed the presence of local wholesalers as the predominant (89.4% and 82.0%) in the respective markets. Rahaji (red bororo/wodaaBe) was the prominent breed of cattle sold in Maigatari and Dungass markets, respectively. Traders' association was found to play an important role in dispute resolution. The highest cattle sold from Dungass in Niger Republic into Maigatari in Nigeria was recorded in January, while the lowest were recorded in August in all the years studied. Problems affecting cross-border cattle trade in the study area were illegal fees and taxes in both markets, inadequate market infrastructures and capital as well as security challenges, among others. Thus, the study recommended that producers and traders should be encourage to patronize Rahaji breed, since their size and body conformation attract customers, which in turn leads to higher prices. Government should put effort to check out illegal fees and taxes as well as security challenges in the markets, which in turn increases the gross income and safety trade. In addition to this, construction/rehabilitation of rural – urban roads may help greatly to spur growth through efficient market access.

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FIELD PARASITISM OF THE BEET WEBWORM MOTH (*Hymenia recurvalis* F. (LEPIDOPTERA: PYRAUSTINAE)), IN *Amaranthus hybridus* L. IN NORTH EASTERNNIGERIA

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Abstract
The present study was carried out in Maiduguri, north eastern Nigeria, during the cropping seasons of 2014 and 2015 to determine the seasonal infestation rate, larval abundance and parasitism of Hymenia recurvalis Fabricius (Lepidoptera: Pyraustinae) in Amaranthus hybridus L. Collection of feeding larvae was by hand in 15 farmers' fields in 2014 and 17 other farmers' fields in 2015. Random sampling was employed during seven fortnightly visits made during the season to each farmers' field. Collected larvae were reared in the Entomology laboratory (Department of Crop Protection, University of Maiduguri) for recovery of parasitoids or adult moths. Mean percentage of plant infestation by H. recurvalis per farmers' field was 85% in 2014 and 69% in 2015. Mean number of larvae per farmers' field was 145 in 2014 and 98 in 2015. Both mean percentage of plant infestation and number of H. recurvalis larvae were significantly higher in 2014 compared to 2015. Braconid (71% in 2014 and 39% in 2015) and tachinid (22% in 2014 and 45% in 2015) parasitoids seasonally account for moderate to high proportion of host larvae parasitization, whilst that by Ichneumonidae (7% in 2014 and 16% in 2015) is seasonally low. Mean total percentage of larval parasitism per farmers' field significantly varied between years, and was particularly higher (39%) in 2014 than in 2015 (24%). In conclusion, results indicate that H. recurvalis is seasonally responsible for heavy infestation of A. hybridus in parts of north eastern Nigeria. Braconid and tachinid parasitoids seem to be more efficient over ichneumonid ones in parasitizing H. recurvalis larvae. Seasonal larval parasitism rate tends to contribute moderately in regulating the populations of this pest. Further studies may assess field egg and pupal parasitism of H. recurvalis, as well as the antagonistic effects of pathogens and their predation rates, so as to establish the impact of biological control in regulating its populations in A. hybridus.

Keywords: *Amaranthus hybridus*, *Hymenia recurvalis*, Larval parasitoids, Seasonal parasitism, North eastern Nigeria

Introduction

Amaranth (*Amaranthus* spp.) (Caryophyllales: Amaranthaceae) is widely cultivated in the tropics either for its seeds or green leaves. Amaranth species cultivated as green leafy vegetable are often short plants, having wide leaves and small inflorescence (Schippers, 2000; Achigan-Dako *et al*., 2014). They also taste better than the grain types, and may be consumed raw or cooked, singly or in combination with other vegetables, meat, cereals, legumes, and/or tubers. Besides being a good source of dietary fiber, amaranth leaves contain high amounts of vitamin C, iron, beta carotene, calcium, folic acid and protein (Teutonico and Knorr, 1985; Yang and Keding, 2009; Alegbejo, 2013; Achigan-Dako *et al*., 2014). On a dry weight basis, the crude protein content in the leaves range from 20% - 32% (O'Brien and Price, 1983). Amaranth leaves consumption have several health benefits including: 1) Regular intake helps in easing digestion, excessive menstruation and weight management (AVRDC, 2003; Grubben and Denton, 2004; Borah, 2015); 2) The juice extract helps in treating diarrhoea and haemorrhage conditions (AVRDC, 2003; Grubben and Denton, 2004); 3) Its high iron content and dietary fiber makes it good for anaemic patients and for reducing cholesterol and risks of cardiovascular diseases (Grubben and Denton, 2004; Martirosyan *et al*., 2007; Borah, 2015); 4) Lysine contained along with other elements help to fight against free radicals that result in aging or the formation of malignant cells (Borah, 2015; Sahoo *et al*., 2015); and 5) Daily consumption of amaranth leaves, packed with carbohydrates, proteins, minerals and vitamins, at 50 g - 100 g helps reduce the incidence of blindness in children due to poor nutrition (O'Brien and Price, 1983).

Schippers in 2000 and 2004 estimated the yield of amaranth in Africa to fluctuate between 17 t/ha and 40 t/ha. Amaranth cultivated in Nigeria includes *Amaranthus hybridus* L., *Amaranthus dubius* C.Mart. ex Thell., *Amaranthus cruentus* L., *Amaranthus caudatus* L., *Amaranthus viridis* L., *Amaranthus gangenticus* L., *Amaranthus tricolor* L., *Amaranthus hypochondriacus* L., whereas *Amaranthus spinosus* L. and *Amaranthus blitum* L. are weeds (Degri and Randy, 2014; Oke *et al*., 2015; Akin-Idowu *et al*., 2016). Amaranth is cultivated in all the agroecological zones of the country, under rain-fed or irrigated systems. The relative ease of cultivation year round/across seasons, vigorous growth/early maturation with even little moisture, resistance to heat/drought, low labour requirement and high adaptability to a wide range of soils/new environments (Norman, 1992; Maundu *et al*., 2009), makes amaranth a valuable source of diet and income to small-scale farmers. Amaranth leaves are however readily eaten by several lepidopterous pests. The larvae of at least 40 species have been reported to attack amaranth in this country (Akinlosotu, 1983; Richard, 1989; Okunlola *et al*., 2008; Aderolu *et al*., 2013; Oke *et al*., 2015). *Hymenia recurvalis* Fabricius (Lepidoptera: Crambidae: Pyraustinae: Spilomelini) is reported to be the most abundant lepidopterous pest of amaranth during the cropping and/or off-seasons in most parts of Nigeria (Aderolu *et al*., 2013; Ogedegbe and Ezeh, 2015; Ezeh *et al*., 2015; Oke *et al*., 2015; Joseph *et al*., 2016). The richness of parasitoids of lepidopterous pests in various parts of Africa is high (Polaszek, 1998). Effective parasitoids play an important role in regulating their host/insect pest populations. For instance, parasitism of *Busseola fusca* (Fuller) by indigenous parasitoids is high, ≥ 70%, in parts of Kenya (Gitau, 2006) and South Africa (Kfir, 1995). Presently, there is little or no information on the extent of damage caused by *H. recurvalis* in *A. hybridus*, commonly cultivated in north eastern Nigeria and the effect of parasitoids/natural enemies on its populations. This study therefore sought to determine the seasonal infestation rate, larval abundance and parasitism of *H. recurvalis* in *A. hybridus* cultivated in Maiduguri, north eastern Nigeria.

Materials and Methods

This field investigation was carried out during the cropping season in Maiduguri (elevation, 354 meters above sea level; latitude, 11º45' N to 11º51' N; longitude, 13º2' E to 13º9' E), north eastern Nigeria. Accessible farmers' fields planted with *A. hybridus* sole or intercropped with cereals, legumes and/or other leafy vegetables at least 1 km apart were selected. Based on logistics sampling was carried out in 15 farmers' fields in 2014 and 17 other farmers' fields in 2015 (Mailafiya *et al.*, 2010a, b). Seven fortnightly visits were made to each farmers' field during the season. Within each farmers' field,30 *A. hybridus* plants were randomly inspected for the presence of *H. recurvalis* larvae feeding on the leaves (Fig. 1). Each larva was collected by hand and placed in a vial plugged with cotton wool. All larvae were reared as described by Le Ru *et al.* (2006) in the Entomology laboratory (Department of Crop Protection, University of Maiduguri) under ambient conditions (36 ± 8 ºC and 65 ± 7% RH) until larval death or pupation. All pupae and cocoons obtained were kept separately in smaller vials until adult moths/parasitoids emergence. Parasitism was calculated as the percentage of susceptible larvae parasitized (Mailafiya *et al.*, 2010a, b). Data on infestation rate, larval abundance and parasitism were subjected to Kruskal-Wallis test (α = 0.05) in SPSS (version 9.0) to estimate significant differences across years.

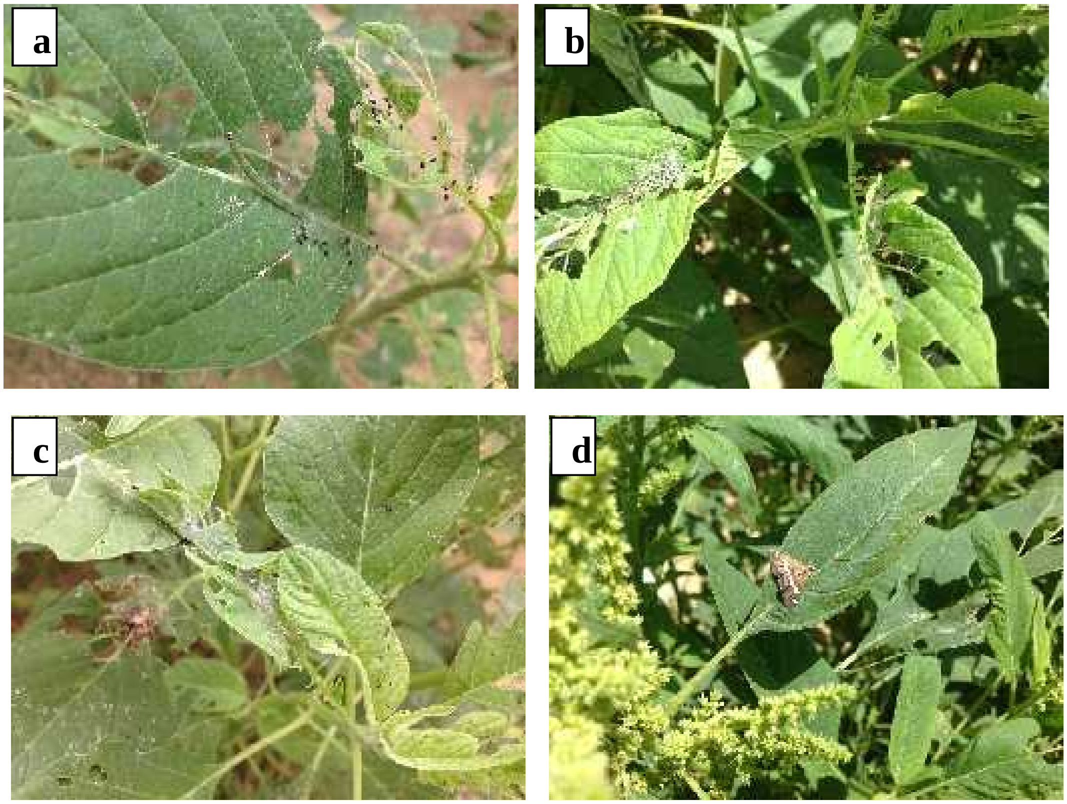

Fig. 1: *Hymenia recurvalis*: (a) Larva/feeding damage, (b and c) larval feeding and webbing damage, and (d) adult moth on *A. hybridus*.

Results

A total of 3,150 and 3,570 *A. hybridus* plants were respectively inspected during 2014 and 2015 cropping seasons. Both mean percentage of plant infestation by *H. recurvalis* and number of larvae per farmers' field varied across years (Table 1). Mean percentage of plant infestation was significantly higher in 2014 (85) than in 2015 (69). Similarly, mean number of *H. recurvalis* larvae was significantly higher in 2014 (146) than in 2015 (98). Larval parasitization of *H. recurvalis* by braconidae was 71% in 2014 and 39% in 2015 (Table 2). Larval parasitization by ichneumonidae was 16% in 2014 and 7% in 2015. Larval parasitization by tachinidae was 22% in 2014 and 45% in 2015. Total larval parasitism of *H. recurvalis* per farmers' field varied with year, and was significantly higher in 2014 (39%) than in 2015 (24%).

Table 1: Mean percent plant infestation by *H. recurvalis* and number of larvae per farmers' field during 2014 and 2015 cropping seasons in Maiduguri

	Mean ± SE		
	2014	**2015**	**Statistics/Total**
N	105	119	224
Percent infestation	85.15±11.02*	69.47±8.31	H = 12.12, P = 0.025
Number of larvae	145.63±23.99*	98.17±16.43	H = 7.25, P = 0.001

N, number of field observations; *, value with asterisk within row is significantly higher than the other;
H, Kruskal-Wallis statistic; *P*, Probability value

Table 2: Mean percent larval parasitism of *H. recurvalis* in *A. hybridus* per farmers' field during 2014 and 2015 cropping seasons in Maiduguri

	Mean percent parasitism ± SE		
	2014	**2015**	**Statistics/Total**
N	105	119	224
Total parasitism	38.52±6.22*	24.33±2.05	*H* = 10.09, *P* = 0.043
Parasitoid family			
Braconidae	71	39	
Ichneumonidae	7	16	
Tachinidae	22	45	

N, number of field observations;
*, value with asterisk within row is significantly higher than the other;
H, Kruskal-Wallis statistic; *P*, Probability value

Discussion

Seasonal high plant infestation rates and number of *H. recurvalis* larvae in farmers' fields indicates that the moth is a major pest of *A. hybridus* in parts of north eastern Nigeria. *Hymenia recurvalis* was hitherto documented to be an abundant lepidopterous pest of amaranth in only 3 subregions of Nigeria including south eastern (Ogedegbe and Ezeh, 2015; Ezeh *et al*., 2015), south western (Aderolu *et al*., 2013) and north southern (Joseph *et al*., 2016) Nigeria. In north western Nigeria, lepidopterous pests were recovered by Imam *et al.* (2010) in irrigated *Amaranthus* spp., but the study documented insect density at family level. Accordingly, the pest status of *H. recurvalis* in amaranth is yet to be confirmed in north western, north central, south southern and central Nigeria. Similar to our results, other researchers in the country observed *H. recurvalis* to be a serious defoliator of particularly *A. hybridus* (Ogedegbe and Ezeh, 2015; Ezeh *et al*., 2015; Joseph *et al*., 2016). The larvae are also abundant in *A. cruentus* (Ezeh *et al*. (2015). Though highly abundant in *Amaranthus* sp. in south western Nigeria (Aderolu *et al*., 2013), *H. recurvalis* was surprisingly recovered from *Celosia argentea* Linn. (Caryophyllales: Amaranthaceae) as the 5^{th} and least ranked pest within the region, but not from *A. hybridus* (Okunlola and Ofuya, 2010; Okunlola and Akinrinnola, 2014). *Hymenia recurvalis* has also been recovered in south southern Nigeria from another cultivated host plant, cowpea (*Vigna unguiculata* L.) Walp, belonging to a different family, Fabaceae (Fabales) (Egho, 2011). Being oligophagous, *H. recurvalis* seems capable of seasonally shifting attack or spreading its population amongst its host plants as found suitable.

This is the first report on biological control of *H. recurvalis* in amaranth cultivated across the country. Although *H. recurvalis* is attacked by parasitoids from three families including Braconidae, Ichneumonidae and Tachinidae, the former and latter parasitoids seasonally account for greater proportion of parasitized larvae, and therefore are the more important parasitoids of this pest in this locality. Moderate seasonal parasitism rate of between 24% and 38%, suggests that fairly good biological control operates against *H. recurvalis* in *A. hybridus*. The impact of biological control against populations of this pest can be much higher if the contributions of parasitoids (across all developmental stages: egg, larval and pupal parasitism), enthomopathogens and predators are considered together.

Conclusion

Our results show that *H. recurvalis* is seasonally responsible for heavy infestation of *A. hybridus* in parts of north eastern Nigeria. The destructive larvae are attacked by parasitoids belonging to three families. Braconidae and Tachinidae, seasonally account for moderate to high proportion of host larvae parasitization over Ichneumonidae. Seasonal/total larval parasitism contributes appreciably in lowering populations of *H. recurvalis* in *A. hybridus* grown in this subregion.

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FORMS AND DISTRIBUTION OF PHOSPHORUS IN FADAMA SOILS OF ABUBAKAR TAFAWA BALEWA UNIVERSITY RESEARCH FARM, YELWA CAMPUS, BAUCHI STATE

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Abstract
Distribution of Phosphorus forms was evaluated in Fadama soils of Abubakar Tafawa Balewa University Research Farm, Yelwa Campus in Bauchi State. A total of 10 composite soil samples comprising 5 each of surface (0-15cm) and sub- surface (15-30cm) were collected in 2010 from each of 5 representative micro-topo position (crest upper, middle, lower and valley) in the studied area. The soil samples were analysed in the laboratory using standard procedure. The result indicated that the soils were mostly sandy clay loam, slightly acidic (pH 4.63 – 5.79). There was significant (p=0.05) difference between location for pH, Exchangeable acidity, Iron content of the soils, and depth of organic carbon. There was also significant (P=0.5) difference between locations for total P, organic P, inorganic P, Al-P, Fe-P, Occluded P and available P, while depth wise, only Al-P and Fe-P showed significant difference. Results revealed that total P and bonded P were higher at the lower and valley as a result of high pH, Fe and Al content in these positions relative to others position. There is need for liming and good management practices in order to improve the microbial activities and chemical properties of the soil to promote mineralization of organic phosphorus.

Keywords: Fadama Soils, Fixation, Distribution and Phosphorus Forms.

Introduction

Phosphorus is the second most used fertilizer element after nitrogen. It is known to be abundant in nature but limited in its elemental form due to its highly reactive nature with other element or compounds (Brady and Weil, 1999). Phosphorus is an essential nutrient which has been observed to limit crop production (Odeite 2004; Attwel and Adams, 1993). Soil phosphorus is classed generally as organic and inorganic (Busman et al., 2002) depending on the nature of the compound in which it occurs. The organic P is found in soils with large population of fauna and thick flora (Busman et al., 2002) while inorganic P in the soil is usually divided into three active and two relatively inactive fractions. The active fraction can be grouped into iron bound phosphorus (Fe-P), Aluminum bound phosphorus (Al-P) and calcium bound phosphorus (Ca-P). The relative inactive fractions are occluded and the reductant soluble forms. The relative proportion of the phosphorus in those two categories varies widely from soil to soil. Total phosphorus in the soil is of no direct practical importance, but depletion of labile P causes some non-labile P to become labile, thus, at slow rate. Availability of phosphorus in Nigeria soils is low, the P compounds commonly found in the soil are mostly unavailable for plant uptake because they are insoluble and when soluble P is added to the soil, it is fixed. The fadama soils are used for production of a variety of crops ranging from rice to vegetable and sugarcane, documented information on the phosphorus forms in fadama soils of Abubakar Tafawa Balewa University Research farm, Yelwa campus is scanty. A proper inventory of soil resources especially now that the cost of inorganic fertilizers is on the increase in Nigeria becomes imperative. The objective of this study was to determine the distribution of phosphorus forms in the fadama soils along a micro- topo sequence of ATBU research farm and to study the effects of depth on forms and distribution of phosphorus in the fadama soils.

Materials and Methods

Study area

Bauchi is located between 10^0 22' and 9^0 47'E with an altitude of about 609.5m above sea level. It is found in the Northern Guinea Savannah (NGS) ecological zone of Nigeria (Bauchi Meteorological Station, 1995). The topography of the state is flat in the northern and central parts of the state with hills in the southern part linking up with plateau state (BSADP diagnostic survey, 1997). The climate is characterised by high temperature and seasonal rainfall. The mean minimum temperature of about 10-12^{0}C occurring in December/January and the mean maximum temperatures ranges from 30-32^{0}C within the month of February/November. The rainfall pattern is unimodal, the mean rainfall ranges from 700mm-1250mm, the dry season is characterised by a pattern of no rainfall which lasts from mid-September to late May. The soils are low in fertility and so high in fertilizer requirement for increased production (Tenebe, 1995).

Soil Sampling and Handling

Composite surface (0-15cm) and sub-surface (15-30) soil samples were collected from five (5) micro-topo positions from Abubakar Tafawa Balewa University Fadama Research Farm, Yelwa Campus in year 2010. Each soil sample was a composite of five sub samples collected about 200m apart. The collected soil samples were stored in a polythene bags and taken to the laboratory. Each sample was separately air dried and then ground using porcelain pestle and mortar. The grounded soil samples were sieved with a 2mm sieve and the five earth fractions collected in separate sample bags which were used for all the laboratory analysis.

Laboratory analyses

The particle size distribution for each sample was determined using hydrometer method as described by Bouyocous (1951), soil pH was determined in 1:1 soil water (H_2O) suspension using electrically calibrated pH meter, while organic carbon was determined by the wet oxidation method as described by Walkley and Black (1934).

The iron (Fe) was determined using GP model of atomic absorption/emission spectrophotometer while exchangeable acidity was determined by KCl extraction method (Maclean, 1965).

Available phosphorus was determined by the Bray 1 method (Bray and Kurtz, 1945). The inorganic phosphorus forms (Aluminium-P, Iron-P, Calcium-P and Occluded-P) were fractionated using the Chang and Jackson (1957) except that the ammonium fluoride reagent was buffered at 8.0 pH (Uriyo and Kassebe, 1972). Organic phosphorus was determined using calorimetric method as described by Pons and Guthuie (1946).

Data Analysis

The data obtained were subjected to analysis of variance (ANOVA) and Student Newman-Keuls was used to separate the means that were significantly different.

Results and Discussion

Soil pH

The pH of the experimental area ranged from 4.63-5.79 indicating slightly acidic as shown in Table1. There was significantly ($P \geq 0.05$) different between the micro-topo positions .The crest and upper position had significantly ($P \geq 0.05$) higher pH values than middle, lower and valley positions. However, the depth showed no significant ($P \geq 0.05$) difference. The low pH in the valley, lower and middle positions may be due to the topography of the studied area, accumulation of iron (Fe) and aluminum (Al) in these micro-topo positions and as a result of the decomposition of organic matter which is known to release H^+ ions in the soils, thus making the soil acidic. The acidity nature of the soil in this area is in agreement with the work of Mustapha et al. (2003) and report from Thompson and Troeh (1978) which state that the soils in tropical savannah zones are found to be within the pH of 4.0 – 7.0.

Organic Carbon

The value for organic carbon as indicated in Table 1 showed that there was no significant (P≥0.05) difference between micro-topo positions but there was significant (P≥0.05) difference depth wise. The 0-15(cm) depth had significantly (P≥0.05) higher O.C than the 15-30 (cm) depth. The vertical distribution of O.C in mineral soils is a general decrease of O.C content with depth. This variation is attributed to the vertical distribution of roots and to a lesser degree to climate and clay content. On a global scale SOC increases with precipitation and decreases with temperature (Post et al 1982).

Exchangeable Acidity

The value of exchangeable acidity ranged from 0.8 to 1.8 (Al^{3+} H^{+}), there was significantly (P≥0.05) different between the micro-topo positions as shown in table 1. The valley position had highest exchangeable acidity than crest, upper, middle and lower positions while the middle position also had significantly (P≥0.05) higher value than crest, upper and lower position which were at bar. There was no significant (P≥0.05) difference in the surface and subsurface of the soils. The higher value of exchangeable acidity in valley position than the other positions indicates high concentration of (Al^{3+} H^{+}) in the area than the other positions. The concentration of the exchangeable acidity could be as a result of the slope and water movement from the crest through the valley position which in turn reduced the pH of the soils. Youdeowei et al. (1999) reported that the amount of rainfall which is low and unimodal as it characterizes in savannah zone of tropics to be the cause of higher concentration of Al^{3+}.

Iron (Fe)

The result for iron in Table 2 showed significant (P≥0.05) difference between the micro-topo positions. Iron content ranged from 5.89- 11.87 (mg kg^{-1}), the valley position had significantly (P≥0.05) higher Fe content than other position which were at bar. There was no significant (P≥0.05) different in Fe content with depth. This could be due to the topography of the studied area which allowed free movement of Fe from crest and accumulated at the valley.

Aluminum Bound Phosphorus (Al-P)

Table 2 showed the value for Al-P ranging from 60.0-140.03 (mg/kg). There was significant (P≥0.05) difference in the Al-P content between the micro-topo positions, where the valley and lower positions had significantly (P≥0.05) higher than other positions. Similarly, crest and upper positions had significantly (P≥0.05) higher value than middle position. The higher in Al-P at the valley and lower positions may be due to the low acidity of the positions which was predominance of Al^{+} and lead to Al and P bound through Al-O-P bond. Mustapha et al. (2007) reported that Al-P is abundant in acid soils with pH range of less than 6 which corroborate with this work.

Table 1: Chemical properties of soil

Location	pH (H_2O)	Organic Carbon(g/kg)	Exchangeable Acidity ($Al^{3+}H^+$)	Iron (mg/kg)
Crest	5.76	7.15	0.80	5.09
Upper	5.53	6.79	0.80	5.89
Middle	5.25	7.73	1.10	6.70
Lower	4.79	6.94	0.70	6.60
Valley	4,63	8.15	1.80	11.87
S.E	0.17	1.42	1.32	1.01
Depth				
Surface	5.20	10.07	1.32	8.18
Subsurface	5.19	4.60	0.76	6.31
S.E	0.11	0.89	0.61	0.64

Iron Bound Phosphorus (Fe-P)

Iron bound phosphorus was the dominant form of phosphorus in the studied soils as indicated in Table 2. The Fe-P content of the soil was significantly ($P \geq 0.05$) different between the micro-topo positions. It ranged from 219.14 – 458.74 (g/kg), the valley and lower positions were significantly ($P \geq 0.05$) higher than the other positions. Similarly, upper and middle positions were higher than the crest position. The highest Fe-P form was recorded at the valley position which had lowest pH value of 4.63 and the crest which had lowest Fe-P form of 219.14 recorded highest pH values of 5.79 respectively. The P^H of the soils is the major factor contributing to the domination of Fe-P in the Fadama soil as reported by Mustapha et al. (2007). Interrelationships among the various P fractions are complex, so the ease at which available phosphorus is released seems to be hard due to Fe-P adsorption. However, understanding the dynamics of P transformations in the soils will provide the basis for sound management of soil and fertilizer P to ensure adequate P availability to plants.

Calcium Bound Phosphorus (Ca-P)

The values for Ca-P as indicated in Table 2 showed that there was no significant ($P \geq 0.05$) difference with both micro-topo position and depth. Ca-P of the studied soils were generally low, this may be due to the low pH of the soils. This corroborate with earlier report of Havlin et al. (1999) that phosphorus minerals are dominated by calicium bound phosphorus in naturel to high pH soils.

Available Phosphorus

The available Phosphorus ranged from 1.75 – 5.98 (mg/kg) indicating low level of available phosphorus on the studied soils. The crest and the upper positions had significantly($P \geq 0.05$) higher available phosphorus compared with middle, lower and valley positions which were at bar. The result obtained in the studied area fell below the finding of Mustapha et al. (2003) who reported 6.12- 11.0 (mg/kg) for Fadama soils in Bauchi state.

Inorganic Phosphorus

The inorganic phosphorus was uniformly distributed with both depth and micro-topo position as shown in Table 2. There was no significant ($P \geq 0.05$) difference with both depth and micro-topo positions. The order of occurrence of inorganic Phosphorus in the studied area were Fe-P > Al-P > Occluded-P > Cal-P.

Organic Phosphorus

The value for organic phosphorus ranged from 660.93 -1602.88 (mg/kg) as shown in Table 2. Valley and lower positions had significantly ($P \geq 0.05$) higher organic phosphorus than the crest, upper and middle positions respectively. This could be as a result of slope of the studied site, cultivated crops, organic matter and low pH which inhabit microbial activity in the soil positions. The result obtained from this studied agreed with the report of Thompson and Troeh (1978) that the availability of organic phosphorus in a soil is affected by organic matter content of the soil, soil pH, and climate.

Total Phosphorus

The total phosphorus level of the soil ranged from 1362 – 2127.31 (mg/kg) as shown in Table2. It followed the same statistical trend with organic phosphorus, the level of total phosphorus in the studied site is high and however, the amount available for plant uptake is low. The decrease in soil solution phosphorus concentration with absorption by plant roots is buffered by both the inorganic and the organic phosphorus fraction in the soils. Hassan and Raji (2006) who worked on part of Bauchi soils obtained most similar value and attributed it partially to high phosphorus levels in the parent materials.

Table 2: Effect of micro-top position and depth on the distribution of forms of phosphorus (mg/ kg).

Location	Al-P	Fe-P	Ca-P	Occluded-P	Available P	Total inorganic P	Total Organic P	Total P
Crest	128.46	219.14	55.55	50.36	3.04	718.49	974.83	1693.32
Upper	105.53	356.40	38.44	72.80	5.98	675.51	691.14	1366.65
Middle	60.00	351.96	77.32	56.97	2.63	701.51	660.93	1362.30
Lower	135.40	420.74	65.09	73.41	2.14	757.51	1369.80	2127.31
Valley	140.03	458.74	58.52	94.34	1.75	500.46	1602.88	2103.34
S.E	12.96	50.28	10.68	7.34	0.89	105.59	189.24	225.24
Depth								
Surface	83.94	495.94	50.68	73.42	3.43	630.68	1064.47	1695.66
Subsurface	143.83	226.85	67.28	65.73	2.79	752.77	1055.36	1808.13
S.E	83.94	31.80	6.76	4.58	0.56	66.85	119.63	186.48

Conclusion

Based on the result obtained from these studied soils of ATBU Fadama research farm, high rate of phosphorus fixation may be expected due to high accumulation of Fe-P and Al-P in the soils. The pH and organic carbon contents of the soil affected the distribution and the availability of phosphorus in these soils. There is need for liming and introduction of biochar or compost or a mixture of biochar and compost to increase the total P, available P, inorganic P fractions and improve the microbial activities and chemical properties of the soil to promote mineralization of organic phosphorus.

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EVAPOTRANSPIRATION, CROP COEFFICIENT AND YIELD RESPONSE FACTOR OF OKRA AS AFFECTED BY DEFICIT IRRIGATION AND MULCH IN SUDAN SAVANNA ECOLOGICAL ZONE OF NIGERIA

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Abstract
A study on crop water requirement and coefficient under different irrigation and mulch levels was conducted during the 2012/2013 dry season at the Institute for Agricultural Research (IAR) irrigation research farm Kadawa, Kano State, Nigeria, using okra as the test crop. The experiment consisted of factorial combinations of four levels of irrigation water application depths (100, 85, 70 and 55% weekly reference evapotranspiration WRETo) and four levels of mulch practice M0 (0 t/ha), M2 (3.2 t/ha), M4 (6.4 t/ha) and M6 (9.6 t/ha) of rice straw. Soil moisture contents before and after irrigation was monitored throughout the seasons with the aid of Theta probe. Seasonal actual evapotranspiration (SETa) ranged from 261.90 to 286.38 mm with the minimum and maximum at 55 and 100% WRETo treatments. The crop coefficient (Kc) value ranged from 0.30 to 1.35 at the initial growth stage (IGS) to final growth stage (FGS) with highest under 100% WRETo and minimum under the deficit treatment. The yield and yield parameters were found to be low in deficit irrigated treatments. Irrigating okra at 55, 70 and 85% WRETo depth reduces the pod yield by 46.9, 38.8 and 14.4% compared with 100% WRETo treatment. Similarly, mulching with 6 kg of rice straw resulted in yield increased compared with other mulch treatments.

Keyword: Crop water requirement, Coefficient, Irrigation, Mulch and Yield

Introduction

The supply of food globally depends on water, at the same time water is becoming scarcer every day. At the beginning of the new century, agriculture faces the challenges to produce more food for inexhaustible population growth, while maintaining almost unchanged land and water input (Hamdy 2003). Okra (Abelmoschus esculentus L. Moench) is one of the important vegetables grown throughout the tropics and warmer parts of the world where water availability is the major constraint to crop production (Tiwari *et al.,* 1998). Water shortage is one of the most important restricting factors in crop production in the world (Umar, 2006). Global trend has seen water becoming scarce not only in arid and drought prone areas but also in regions where rainfall is abundant (Pereira *et al.,* 2002; Traore *et al.,* 2008, 2007). Chronic scarcity of water is experienced in large parts of Africa, the Middle East, the northern part of China, parts of India, Mexico, the western part of the USA, north-east Brazil, in the former Soviet Union and the Central Asian republics (IWMI, 2007). Irrigated agriculture is the primary user of diverted water globally, reaching a proportion that exceeds 70–80% of the total in the arid and semi-arid zones. With increasing municipal and industrial demands for water, its allocation for irrigation agriculture is decreasing steadily. Agriculture currently faces the challenges to produce more food for rapidly growing population, while maintaining almost unchanged land and water input. In the context of coping with scarce water supplies, reducing its use for irrigation and improving its productivity, there is a growing interest in deficit irrigation, defined as the application of water below full crop-water requirements (evapotranspiration) with mild stress and minimal effects on yield.

The effect of water stress on crop growth and yield depends on the crop species and variety on one hand and the magnitude and the time of occurrence of water deficit on the other. Doorenbos and Kassam (1979) stated that the relationship between crop yield and water deficit, that when crop water requirement is fully met, the available water supply and actual evapotranspiration will be equal to the maximum evapotranspiration and, when water supply is insufficient, the actual evapotranspiration would be less than maximum evapotranspiration, which affects yield. Several studies have shown significant effect of water stress on plant yield (Stone, 2003; Klocke *et al.,* 2004; Payero *et al.,* 2006). Similarly, Yadav and Dhankar (2001) observed positive correlation between seed yield and day number to flowering in non-stress conditions, but in stress conditions, this correlation was negative. According to Boland *et al.* (2002) the leaves of plants respond to water stress by the closure of their stomata and this inhibits photosynthesis. In general, crops are more sensitive to water deficit during emergence, flowering and early seed formation than during early (vegetative, after establishment) and late growth stages (ripening). The Kc integrates the crop and soil conditions that make a given crop's evapotranspiration more or less than the reference evapotranspiration.

On the other hand, the yield response factor (Ky) is ratio of relative yield reduction to relative evapotranspiration deficit (Igbadun *et al.,* 2012). It is that factor that integrates the weather, crop and soil conditions that make crop yield less than its potential yield in the face of deficit evapotranspiration. The crop coefficient (Kc) is the ratio of the actual crop evapotranspiration (ETa) to reference crop evapotranspiration (ETo) and it integrates the effects of characteristics that distinguish field crops from grass, like ground cover, canopy properties and aerodynamic resistance. The FAO and World Meteorological Organization (WMO) experts have summarized such evolution in the crop coefficient curve to identify the Kc value corresponding to the different crop development and growth stages (initial, middle and late, hence it has Kc ini, Kc mid, Kc end) (Tarantino and Spano, 2001). Values of Kc for most agricultural crops increase from a minimum value at planting until maximum Kc is reached at about full canopy cover. The Kc tends to decline at a point after a full cover is reached in the crop season.

The declination extent primarily depends on the particular crop growth characteristics (Jensen *et al.,* 1990) and the irrigation management during the late season (Allen *et al.,* 1998). Quantification of crop actual evapotranspiration (ETa) in different growth stages of a crop is a pre-requisite for efficient irrigation scheduling. Crop coefficient ETc of a crop grown in any region depends upon the management practices including irrigation. The soil moisture content and its spatial distribution in root-zone significantly affect the ETc. The ETc can be determined either empirically by adopting various standard methods (Doorenbos and Pruitt, 1977; Allen et al., 1998) with the help of crop-coefficient (Kc) values, or can be measured using lysimeter and/or field water balance. Where, the lysimeter is not available, determination of ETc and Kc values using field water balance method is suggested, as both the methods are based on water balance studies in root zone of plants (Prihar and Sandhu, 1987; Bandyopadhyay and Mallick, 2003).

The information on Kc values of okra is not mentioned either in FAO-24 (Doorenbos and Pruitt, 1977) and/or FAO-56 (Allen et al., 1998), which are considered as the important documents for guiding irrigation water management in crops grown in different agro-climatic regions (Panigrihi and Sahu, 2013). This makes it difficult to estimate ETc and calculate Kc values for okra in any region. Moreover, the estimated Kc value from measured ETc values for okra under deficit irrigation, even under full irrigation is very scanty locally and worldwide.

Water loss through evaporation, though may assist in influencing the microclimate in which a crop grows, is not beneficially used by the crop in yield production. The unproductive losses of water through evaporation could be reduced by mulching. Mulching involves the use of organic or synthetic materials to cover the soil surface. It has the potential of reducing evaporation, conserve soil moisture, modify soil temperature, and improve aeration (Henry *et al.*, 2010). Crop residues and grasses are typical organic materials commonly used for mulching, while synthetic materials (e.g. polyethylene sheet of different thickness and colors) are typical inorganic materials use for mulching. Research evidence has shown that soil surface evaporation contributes largely to the total evapotranspiration in a cropped field (Ahmad *et al.*, 2007). Until the crop attains full vegetative cover, evaporation dominates moisture depletion from the plant root zone. The crop is therefore able to balance its transpiration rate with atmospheric water demand, thus maintaining plant leaf turgidity, which in turn enhances radiation use efficiency and biomass yield production. Mulching with plant residues and/or synthetic materials is a well-established technique for increasing the profitability of many horticultural crops (Duranti and Cuocolo, 1989; Gimenez *et al.*, 2002).

The objectives of this study were: (1) to develop crop coefficients Kc and actual evapotranspiration ETc for field-grown okra under deficit irrigation and mulch practices for Sudan savanna ecological zone of Nigeria; (2) to determine the yield response factors of the okra crop under the mulch levels used. It is anticipated that the information generated in this study will be useful for developing crop water requirements for irrigated okra under deficit irrigation regimes and for the overall improvement of irrigation water management in the study area.

Materials and Methods

Location

The field trials were conducted during the dry seasons of 2013 at the Institute for Agricultural Research (I.A.R.) irrigation fields in Kadawa Kano, Northern Nigeria. Samaru-Zaria. It lies on Longitude 11^0 38' 56" N, Latitude 08^0 25' 56" E and altitude 500 m above the sea level, and is located in the Sudan Savanna Agro-ecological zone of Nigeria with a semi-arid climate. . The rainfall pattern in Kadawa is largely characterized by 6 months wet and dry season. The onset of the rains is in May-June, with monthly totals of 175 mm from May/June through September. August is the wettest month in the area. The mean monthly temperature in Kadawa ranges from 27.8ºC in March up to maximum of 30.4ºC in May.

Treatments and Experimental Design

For this study, the experiment comprised 16 treatment combinations. The treatments were four levels of irrigation (water application depths) and four levels of mulch practice, making it a 4^2 factorial experiment. The four levels of irrigation were water application depths of 100, 85, 70 and 55% of weekly reference evapotranspiration (ETo), while the four levels of mulch were M0 (0 t/ha), M2 (3.2 t/ha), M4 (6.4 t/ha) and M6 (9.6 t/ha) of rice straw. The irrigation treatments were assigned to the main plots and the mulch treatments were assigned to the sub-plots in a factorial experiment with split plot arrangement and three replications. The main plot was separated by a distance of 1.5 m while the treatments within the main plots were spaced with a distance of 0.5 m.

Agronomic Practices and Measurements

A land area of 40 m by 20 m (0.08 ha) was prepared into level basins of 11.5 m by 2.5 m each after the land had been ploughed and harrowed. Two seeds of okra (Clemson Spineless variety) was sown per hole at inter and intra row spacing of 30 cm x 30 cm and 1.5 cm depth. A compound fertilizer (NPK 15:15:15) was applied at the rate of 22.5 N kg/ha, 22.5 P kg/ha and 22.5 K kg/ha once at two week after sowing (WAS) as side dressing in accordance with (Philip, 1997). Rice straw mulches were weighed and evenly spread in each subplot at the rate of M0 (0 t/ha), M2 (3.2 t/ha), M4 (6.4 t/ha) and M6 (9.6 t/ha).

Irrigation water application

Surface irrigation method was adopted in this study. Water from the main canal was supplied on weekly basis into a lateral ditch which services the basins. A pair of 5 cm diameter polyvinyl chloride (PVC) tube of 50 cm length was installed on one side of the bunds bordering the basin to admit water into the basins. The tubes were installed to give a free orifice flow into the basins. Stage gauges were placed at the water inlet to measure the depth of water over each tube as water enters the basin. PVC cork was placed at the entrance such that when the cork was removed, water would flow into the basins. The time required to apply water to the desired depth was monitored using stop watch. When the desired depth of water was reached, the PVC cork was used to stop the flow of water into the plot. Using the orifice flow equation and the depth of flow recorded from stage gauge, the flow rate into the basin was quickly determined with Equation 1 and related to time of application to give to each plot the desired depth of water application with Equation 2.

$$Q = C_d A\sqrt{2gh} \quad \ldots\ldots\ldots\ldots\ldots 1$$

where Q is discharge (m^3/sec), C_d is coefficient of discharge, A is area of orifice (m^2) and h is height of water above orifice (m).

$$t = \frac{Ad}{Qn} \quad \ldots\ldots\ldots\ldots\ldots \; 2$$

where A is area of basin in m^2, n is application Efficiency 75%, d is depth of water applied to each basin with respect to ETo, t is time (sec).

Determination of Actual Crop Evapotranspiration

The actual evapotranspiration was calculated from measured soil moisture content data using Theta probe (Michael, 1978)

$$ETa = \frac{[M1 - M2]}{100} Di \times Bdi \quad \ldots\ldots\ldots\ldots\ldots 3$$

where ETa is the actual crop evapotranspiration mm/day, M1 is the volumetric moisture content g/g at the first sampling (2 days after irrigation), M2 is the volumetric moisture content at the second sampling (7 days after irrigation), Di is the root zone depth and Bdi is the bulk density of the soil.

Theta probe was used to provide instantaneous soil volumetric moisture content throughout the crop seasons. The probe had metal rod of about 10 cm which was pushed into the soil until the rods were fully covered, power supply was connected and readings were taken from the analogue output (plate 1). The theta probe was calibrated to suit the soil for standardization of the equipment. Soil samples were collected from the various depths for gravimetric moisture determination. Regression analysis was done on volumetric moisture content from gravimetric method on the ordinate axis and their corresponding values indicated by the theta probe on the abscissa axis at various depths and the regression model equation was found to be:

$$Y = 0.871X + 3.821$$

The coefficient of determination obtained was 0.9376. The expression above was used to estimate the soil moisture content (Y) as a function of (X).

Soil moisture content was monitored twice a week throughout the growing season, two days after an irrigation event and on the day before the next irrigation.

Computation of Crop Coefficient

Water application depth per irrigation was estimated with the use of Hargreaves equation (Equation 3) to determine the reference evapotranspiration (ET_o). The weather data were obtained from metrological office of the NIHORT Bagauda close to experimental site.

$$ETo = 0.0023(Tmean + 17.8)(T_{\max} - T_{\min})^{0.5}\,Ra \quad \ldots.4$$

where Tmean is mean of the daily maximum and minimum temperatures and

R_a is extra-terrestrial radiation for daily periods (MJm^{-2} day^{-1}) as detailed by (Allen *et al*., 1998).

Crop coefficient was calculated from measured actual crop evapotranspiration and calculated reference crop evapotranspiration using the Hargreaves equation (Allen et al., 1998).

$$Kc = \frac{ETa}{ETo} \quad \ldots\ldots\ldots\ldots\ldots\ldots\, 5$$

where K*c* is crop coefficient, ETa is actual crop evapotranspiration mm/day and ETo is reference crop evapotranspiration mm/day.

Computation of yield response factor

The yield response factor was computed for each of the mulch practice using the Doorenbos and Kassam (1979) equation re-arranged as

$$\left[1 - \left(\tfrac{Ya}{Ym}\right)\right] = Ky\left[1 - \left(\tfrac{ETa}{ETm}\right)\right] \ldots 6$$

Where: *Ya* is actual crop yield for each treatment (kg/ha), *Ym* is maximum yield of crop at 0% deficit level (kg/ha), *ETa* is actual crop evapotranspiration equivalent to water deficit level (mm/season). *ETm* is maximum water applied (mm/season) and *Ky* is crop yield response factor.

Results and Discussion

Seasonal water use and actual evapotranspiration

Table 1 shows the seasonal water application (SWA) and seasonal actual evapotranspiration (SETa). The means for SWA ranged from 190.6 to 346.2 mm.

There was significant ($P \leq 0.05$) difference in the seasonal actual evapotranspiration (SETa). Fully irrigated treatment 100% ETo had higher SETa than all the other deficit irrigation treatments. Similarly, treatment with 85% ETo had significantly ($P \leq 0.05$) higher SETa than 55% ETo but similar to 70% ETo treatments. However, there was no significant ($P \geq 0.05$) difference among the mulch treatments in SETa. The lower SETa observed with treatments subjected to greater deficit irrigation could be due to greater induction of soil moisture deficit over time which generates interface hydraulic conductivity resistance at the soil-root interface, thus resulting to reduction in SETa. Igbadun *et al.* (2012) found significant differences in SETa among mulch treatments and indicated that moisture conserved may have been used for transpiration process. The lack of significant effect of mulch treatments on SETa observed in the present study could be caused by the short duration of the study and therefore need to be investigated further. SWA, seasonal water applied; SETa and seasonal actual evapotranspiration; I_{55}, water application depth of 55%; I_{70}, water application depth of 70%; I_{85}, water application depth of 85%; I_{100}, water application depth of 100%; M0(0) t/ha; M2(3.2)t/ha; M4(6.4)t/ha, M6(9.6)t/ha and MSD; Minimum significant difference, Means with the same letter in a column are not significantly different at 5% level of probability using Tukey‘s Honesty Significant Difference (HSD) test.

Table 1: Means of seasonal water applied and seasonal actual evapotranspiration of okra in 2012/2013 dry season at Kadawa.

Factor levels/ interaction	SWA (mm)	SETa (mm)
Irrigation Levels(I)		
I_{100}	346.2	286.38[a]
I_{85}	294.1	270.59[b]
I_{70}	241.8	268.62[bc]
I_{50}	190.6	261.90[c]
Mulch Levels(M)		
M0	268.2	270.45
M2	268.2	270.48
M4	268.2	271.11
M6	268.2	275.42
MSD	0.30	0.29
Interaction		
I x M	NS	NS

Actual evapotranspiration at various growth stage of okra

The dynamics of crop water use (ETa) at different growth stages of okra is shown in magnitude of ETa of okra under 100% WRETo was higher than deficit irrigation treatments, indicating higher soil moisture content maintained under fully irrigation treatment. A comparism of ETa as influenced by mulching showed inconsistency in higher and low ETa level irrespective of water application depth. When weekly actual evapotranspiration (ETa) rate was assessed, it was observed more under 100% ETo. Ahmedi *et al.* (2010); Panigrihi and Sahu, (2012) made similar findings and they attributed higher ETa to greater evapotranspiration of crop under increased water supply over deficit treatments. The highest ETa range were observed at the final growth stage FGS (4.8-6.0 mm day^{-1}) followed by mid growth stage MGS (3.9-5.9 mm day^{-1}) and maturity stage MAS (3.4-5.4 mm day^{-1}), whereas, the lowest ETa range was observed at the initial growth stage IGS (1.8-(Table 1.). The peak ETa of treatments supplied with 100, 85, 70 and 55% WRETo, were 42.0, 41.3, 40.6 and 39.9 mm day^{-1} respectively. It can be observed that the 2.9 mm day^{-1}). This findings is in conformity with earlier work of Panigrihi and Sahu (2013) on okra who reported ETa trend in descending order of FGS > MGS > MAS > IGS. They attributed it to the higher atmospheric evaporative demand and the maximum plant growth during FGS. Syeed (2013) observed higher leaf area index and plant height with increasing amount of irrigation water that contributed to total plant biomass. This indicates that vegetative growth was found less affected by excessive irrigation water, resultantly, plants gained higher total plant biomass. Different scientists studied sensitivity of different growth stages of crops to irrigation; they found vegetative stage less sensitive and reproductive stage more sensitive in response to irrigation (Waraich *et al*., 2007; Yenesew and Tilahun, 2009).

Table 2: Weekly actual evapotranspiration at various growth stage of the okra 2012/2013 dry season Kadawa.

Factor	Levels	W3	W4	W5	W6	W7	W8	W9	W10	W11
		IGS		MGS			FGS		MA	
		Weekly Actual Evapotranspiration (mm)								
I_{100}	**M0**	**15.4**	**21.7**	**30.8**	**35.7**	**41.3**	**41.3**	**41.3**	**37.8**	**28.7**
	M2	**14.7**	**20.3**	**29.4**	**31.5**	**39.2**	**41.3**	**41.3**	**34.3**	**25.2**
	M4	**14.7**	**20.3**	**32.9**	**33.6**	**41.3**	**42**	**41.3**	**33.6**	**27.3**
	M6	**16.1**	**20.3**	**30.8**	**32.2**	**40.6**	**40.6**	**42**	**33.6**	**26.6**
I_{85}	**M0**	**14.7**	**20.3**	**30.8**	**31.5**	**38.5**	**37.8**	**41.3**	**32.2**	**25.9**
	M2	**15.4**	**19.6**	**27.3**	**30.1**	**38.5**	**37.1**	**41.3**	**32.9**	**24.5**
	M4	**15.4**	**19.6**	**28.7**	**32.2**	**39.2**	**38.5**	**39.2**	**32.2**	**28.7**
	M6	**14**	**19.6**	**26.6**	**31.5**	**38.5**	**39.2**	**40.6**	**32.9**	**25.9**
I_{70}	**M0**	**13.3**	**20.3**	**29.4**	**32.9**	**37.8**	**38.5**	**39.9**	**33.6**	**27.3**
	M2	**14.7**	**18.9**	**28.7**	**32.9**	**37.8**	**39.2**	**39.9**	**32.9**	**25.2**
	M4	**14**	**19.6**	**29.4**	**32.2**	**38.5**	**35.7**	**38.5**	**30.1**	**23.8**
	M6	**12.6**	**21.7**	**27.3**	**31.5**	**37.1**	**37.8**	**40.6**	**34.3**	**25.2**
I_{50}	**M0**	**14.7**	**16.1**	**29.4**	**31.5**	**37.1**	**37.8**	**39.2**	**28.0**	**26.6**
	M2	**13.3**	**18.2**	**30.1**	**32.2**	**38.5**	**33.6**	**37.1**	**30.1**	**27.3**
	M4	**13.3**	**17.5**	**27.3**	**32.2**	**37.1**	**39.2**	**39.2**	**31.5**	**24.5**
	M6	**13.3**	**19.6**	**30.8**	**32.9**	**34.3**	**37.1**	**39.9**	**29.4**	**26.6**
	ETo	**44.8**	**49**	**47.6**	**46.9**	**45.5**	**41.3**	**39.9**	**44.1**	**42.7**

IGS: initial growth stage, MGS: mid growth stage, FGS: final growth stage, MAS: maturity stage; W: week after sowing; I_{55}, water application depth of 55%; I_{70}, water application depth of 70%; I_{85}, water application depth of 85%; I_{100}, water application depth of 100%; M0 (0 t/ha), M2 (3.2 t/ha); M4 (6.4 t/ha), M6 (9.6 t/ha); ETo, reference evapotranspiration.

Crop coefficient

The values of crop coefficient (Kc) under irrigation treatments at various growth stages for different mulch levels are presented in Alasinrin (2015). Kc graphs were plotted based on different development stage of okra as initial growth stage (IGS), mid growth stage (MGS), final growth stage (FGS) and maturity stage (MAS) following the FAO 56 (Allen *et al.*, 1998) approach. The mean Kc values of irrigation and mulch treatments at various growth stages followed similar trend (Figure 4). Irrespective of the treatments, the highest Kc values were recorded at the FGS followed by MGS and the lowest Kc values were observed at the IGS. It can also be noticed that treatment supplied with 100% ETo resulted to higher Kc values at the FGS, MGS, MAS and IGS compared to the deficit treatments.

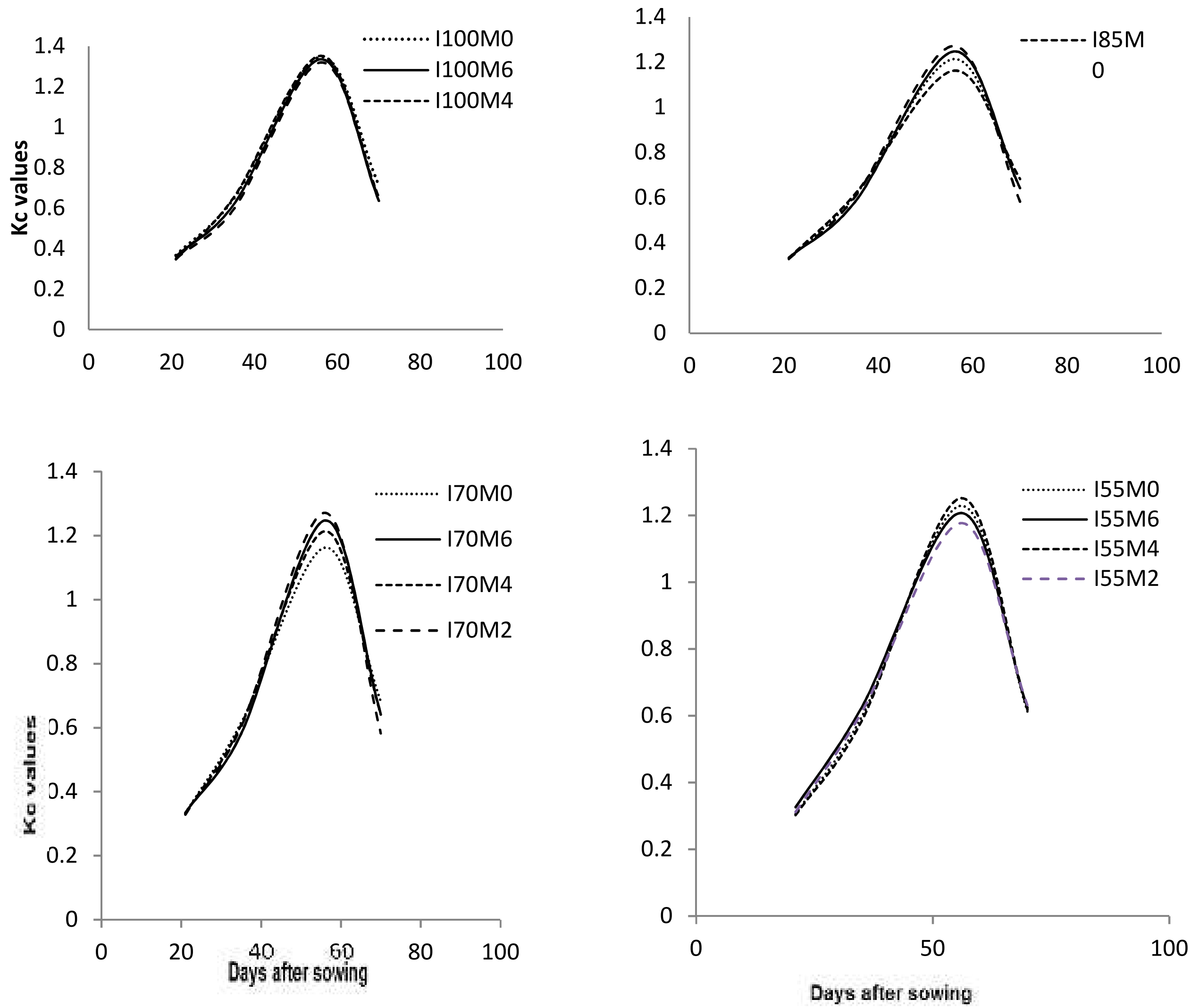


Figure 1: Trends of crop coefficient (Kc) values of irrigation treatments at 100, 85, 70 and 55% WRET under mulch levels M0 (0 t/ha), M2 (3.2 t/ha); M4 (6.4 t/ha), M6 (9.6 t/ha).

The minimum and maximum Kc values for irrigation application depth under M0, M2, M4 and M6 mulch levels were found to be 100 (0.37-1.35, 0.35-1.32, 0.35-1.35 and 0.36-1.34), 85 (0.34-1.26, 0.34-1.27, 0.34-1.26 and 0.33-1.27), 70 (0.33-1.16, 0.33-1.22, 0.33-1.21, and 0.33-1.25) and 55% ETo (0.31-1.21, 0.31-1.18, 0.30-1.25 and 0.33-1.21) Table 1. It can be noticed that Kc values were highly affected by irrigation treatment, the Kc value decreased as deficit irrigation increased. This could be due to higher ETa in the fully irrigated treatment compared with deficit treatment. The findings agree with those of Panigrahi and Sahu, (2013) who reported higher Kc values in fully irrigated crop as compared with deficit treatments. The estimated Kc values for okra at different growth stages IGS (0.37), MGS (0.65), FGS (1.34), and MAS (0.59) under the control treatment 100 (M0 t/ha) are close to that obtained by Panigrihi and Sahu, (2012) as IGS (0.38), MGS (0.72), FGS (1.17), and MAS (0.60), respectively.

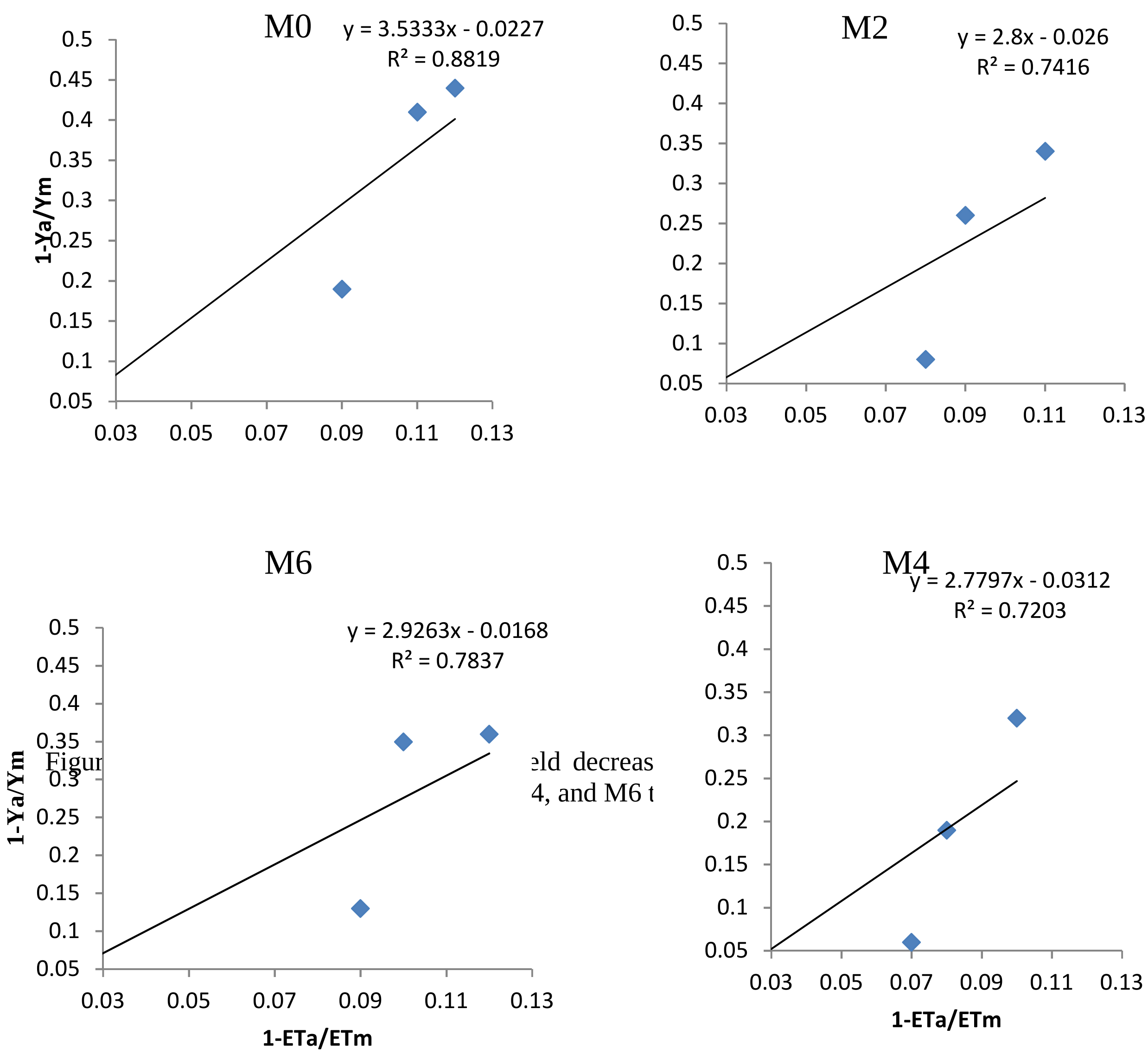
Table 3: Crop coefficient of okra at various growth stages in 2012/2013 dry season at Kadawa.

		Growth stage								
Factor levels/interaction		**IGS**				**MGS**		**FGS**		**MAS**
I_{100}	M0	0.35	0.44	0.64	0.75	0.89	0.98	1.01	0.85	0.67
	M2	0.36	0.42	0.64	0.68	0.87	0.97	1.02	0.75	0.64
	M4	0.33	0.42	0.69	0.72	0.89	1.01	0.99	0.75	0.65
	M6	0.33	0.43	0.62	0.66	0.84	0.98	1.01	0.79	0.63
I_{85}	M0	0.32	0.41	0.64	0.67	0.82	0.89	0.99	0.74	0.62
	M2	0.31	0.39	0.58	0.69	0.82	0.93	0.99	0.72	0.61
	M4	0.33	0.39	0.64	0.68	0.84	0.92	0.95	0.70	0.58
	M6	0.33	0.39	0.58	0.67	0.83	0.89	0.99	0.75	0.63
I_{70}	M0	0.31	0.41	0.61	0.61	0.81	0.84	0.97	0.72	0.61
	M2	0.29	0.40	0.56	0.63	0.79	0.89	0.98	0.71	0.61
	M4	0.31	0.39	0.62	0.65	0.82	0.85	0.93	0.78	0.57
	M6	0.32	0.38	0.60	0.66	0.81	0.84	0.97	0.72	0.59
I_{55}	M0	0.31	0.34	0.61	0.61	0.78	0.85	0.95	0.68	0.60
	M2	0.30	0.39	0.65	0.64	0.74	0.88	0.97	0.70	0.60
	M4	0.28	0.35	0.57	0.63	0.79	0.86	0.91	0.73	0.57
	M6	0.29	0.37	0.64	0.63	0.82	0.84	0.90	0.71	0.56
	ET_O	6.4	7.0	6.8	6.7	6.5	5.9	5.7	6.3	6.1

IGS: initial growth stage, MGS: mid-growth stage, FGS: final growth stage, MAS: maturity stage; I_{55}, water application depth of 55%; I_{70}, water application depth of 70%; I_{85}, water application depth of 85%; I_{100}, water application depth of 100%; M0 (0 t/ha), M2 (3.2 t/ha); M4 (6.4 t/ha), M6 (9.6 t/ha); ETo, reference evapotranspiration

Crop response relative yield and relative seasonal crop water use relationship

Figure 5 showed relationship between relative yield decrease (1-Ya/Ym) and relative evapotranspiration deficit (1-ETa/ETm) for M0, M6, M4 and M2 mulch treatments. Computation of the relative yield decrease was done with reference to the fully irrigated treatment (Alasinrin, 2015). It was observed that the relative yield decrease in deficit treatments compared with fully irrigated treatment were 14.4, 38.8 and 46.9% while the relative SCWU deficit were 28.6, 31.3 and 40.2% for 85, 70 and 55 % ETo respectively. Crop water production function (CWP) expresses the relation between obtained marketable yield (Ya) and the total amount of water evapotranspiration (ETa). The yield response factors (Ky) obtained from mulch levels by plotting the pooled data of the relative yields and relative evapotranspiration were 3.5, 2.9, 2.8 and 2.7 for M6, 4, and 2 kg, respectively. Igbadun (2012) obtained Ky > 1.0 for onion crop. They concluded that with or without mulch, the yield decreases of the onion crop were proportionally greater with increase in evapotranspiration deficit. The coefficient of determination (R^2) for each relationship in this study was good (> 0.72) and Ky > 1.0 indicated that the decrease in yield is proportionally greater with increase in water deficit FAO (1979). Relative decrease in yield might have been due to water stress as affected by deficit SCWU. The decreased in yield as deficit irrigation increased was similarly confirmed from the growth and yield parameters (Table 4). Water stress might have affected growth, development and physiological processes of okra plants, which led to 14.4, 38.8 and 46.9% yield decrease in 85, 70 and 55% ETo.



Figur
eld decreas
4, and M6 t

Table 4: Relative evapotranspiration deficits and relative yield decrease of okra in 2012/2013 seasons.

Factor levels/interaction		1-ETa/ETm	1-Ya/Ym
M0	I_{100}	0.00	0.00
	I_{85}	0.32	0.12
	I_{70}	0.19	0.08
	I_{55}	0.06	0.07
M2	I_{100}	0.00	0.00
	I_{85}	0.34	0.11
	I_{70}	0.26	0.09
	I_{55}	0.08	0.08
M4	I_{100}	0.00	0.00
	I_{85}	0.36	0.12
	I_{70}	0.35	0.10
	I_{55}	0.13	0.90
M6	I_{100}	0.00	0.00
	I_{85}	0.44	0.12
	I_{70}	0.41	0.11
	I_{55}	0.19	0.09

I_{55}, water application depth of 55%; I_{70}, water application depth of 70%; I_{85}, water application depth of 85%; I_{100}, water application depth of 100%; M0 (0 t/ha), M2 (3.2 t/ha); M4 (6.4 t/ha), M6 (9.6 t/ha); (1-Ya/Ym), relative yield decrease and (1-ETa/ETm), relative evapotranspiration deficit

Conclusion

It can be concluded from the results of this study that crop evapotranspiration and Kc were low in deficit treatments compared to fully irrigated treatments. Irrigating okra at 55, 70 and 85% ETo depth reduced the pod yield by 46.9, 38.8 and 14.4% compared to 100% ETo treatment.

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GROWTH PERFORMANCE OF UDA SHEEP FED DIETS CONTAINING GRADED LEVELS OF RHIZOBIUM INOCULATED SOYBEAN GENOTYPE

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Abstract
The study was conducted to determine the growth performance of Uda sheep fed graded levels of residues from Rhizobium inoculated soybean genotype (RISG) (TGx 1951-3F). Thirty-five (35) Uda rams (average body weights 20±3kg) were allotted to diets A, B, C, D, E, F and G having 0%, 10%, 20%, 30%, 40%, 50% and 60% inclusion levels of RISG residues respectively, in a Completely Randomized Design (CRD). The diets were iso-nitrogenous and the trial lasted for twelve (12) weeks. Results obtained showed that animals fed the supplementary diet with 30% inclusion level of residues from RISG had significantly (P<0.05) higher weight gain (10.66kg), average daily weight gain (126.90g/d) and feed intake (1059.56g/d) compared to feeding at other levels. Feed to gain ratio was significantly (P<0.05) lower (8.35) in the 30% inclusion level. The result of cost analysis showed a significant (P<0.05) decline in the cost of feed/kg (N) with an increase in the inclusion level of residues from RISG, however, total feed intake was significantly (P<0.05) higher (89.00kg) in the 30% inclusion level. Result obtained for the cost of feed per kg live weight gain of feeding Uda sheep differed significantly (P<0.05) with lower value (N437.98) obtained in the 30% inclusion level of RISG residues in the diet. It was concluded that for optimum growth performance and economic return, residues from RISG in the diet of growing sheep should not exceed 30%. Finally, it was recommended that residues from RISG could be safely incorporated into the diets of sheep up to 30% inclusion level.

Introduction

The dry season is often characterized by a decline in the supply and quality of herbage available for livestock which makes poor nutrition levels in ruminant animals one of the greatest challenges facing ruminant livestock producers in Nigeria (Tope *et al*., 2012). Feed production and utilization in the dry season to bridge the gap between weight gain and loss at different seasons is the main concern of animal scientists (Sowande *et al*., 2008). Ruminant depends mostly on grasses and legumes which are not available all year round and the forage is of low quality especially during the dry season (Chineke *et al*., 2013). Supplementing low quality feed with the use of conventional feedstuff (such as soybean cake, fishmeal, maize, groundnut cake and many others) may not be cost effective to intensify production in Nigeria due to their high cost and irregular supply (Akinmutimi, 2004) along with competition for these feed resources by humans and animals especially monogastrics (Ajayi *et al.,* 2008). Thus, to reduce the cost of ruminant production without a decline in its productivity and at the same time maintaining an efficient feed utilization, there is the need to seek for alternative feed sources for ruminant feeding other than conventional feedstuff. It is as a result of this that non-conventional feed materials that supply energy and protein originating from farm and agro-industrial wastes are currently being utilized for livestock production (Okonkwo *et al.,* 2008). These non-conventional feed resources should be cheap and readily available, have high nutritive value and should have low demand by humans and livestock (Ndubueze *et al.,* 2006). Many agricultural crop residues with great potentials for ruminant feeding exist and one of such usable crop residues as ruminant feed is soybean residues. Soybean is an important and widely cultivated crop for grain and forage (Muhammad *et al.*, 2001). It is a major source of plant protein and contributes to the improvement of soil fertility by fixing nitrogen in the soil (Rachie, 1985). Soybean is an important fodder crop (Nandanwar and Patil, 1990; Tarawali *et al.*, 1997) and the haulms and husks are extensively used as supplementary feed.

Materials and Methods

Experimental Location

The study was conducted at the Livestock Teaching and Research Farm, Bayero University Kano which lies on latitude 11º58.675' North and longitude 8º25.746' East at an elevation of 468m above sea level. Annual rainfall ranges between 787 and 960mm and it has a mean daily temperature range of 30ºC to 33ºC (KNARDA, 2001).

Experimental Materials

The test material was obtained from the Research Farm of the International Institute of Tropical Agriculture (IITA) Kano Station, Minjibir (12º08'N, 8º31'E and 500m above sea level) in the semi-arid Nigeria with mean annual precipitation of 831.6mm (Okogbenin *et al*., 1999). The experimental animals were purchased from Dan-Awaki Livestock Market, Ungwa-Uku in Kano State while other feed ingredients were purchased from the central market.

Experimental Animals and their Management

Thirty-five (35) male Uda Sheep with average body weight of 20$\pm$3kg were used for this study. The animals were dewormed using Albendazole® (2.5% oral solution), treated with Ivermectin 0.5% Pour-on and administered Oxytetracycline (a broad spectrum antibiotic) at 1ml/50kg body weight.

Feed Formulation and Experimental Design

Seven (7) complete experimental diets were formulated. Treatment A which was the control diet was without residues from Rhizobium inoculated soybean genotype (RISG) (TGx 1951-3F). Treatments B, C, D, E, F and G consisted of 10, 20, 30, 40, 50 and 60% inclusion levels of residues from RISG respectively (Table 1). A Completely Randomized Design (CRD) was used in this trial with a number of animals representing replication and experimental diets serving as treatments. Five (5) animals were allocated to each treatment individually housed in a feeding pen and each group was assigned to one of the experimental diets. The animals were balanced for weight prior to commencement of the trial and fed with experimental diets in the morning and evening for 84 days. The feeding pens were cleaned and disinfected using izal a week before the commencement of the experiment. Each pen was provided with feed and water troughs big enough to allow for adequate feeding and drinking without waste. The feed and water troughs were cleaned every morning before feeding, water was provided *ad libitum*. The animals were weighed bi-weekly between 8:00 am and 9:00 am after overnight fasting throughout the period of the experiment. Daily records of feed intake were kept throughout the 12 weeks of feeding. Feed offered and leftover was weighed in the morning of the following day.

Table 1: Percentage Composition of Experimental Diets (%)

Ingredients	Treatments						
	A	B	C	D	E	F	G
Inclusion levels (%)	0	10	20	30	40	50	60
Maize	20	19	19	17	17	17	9
SBM	18	17	19	20	23	25	30
C/husk	10	10	5	4	0	0	0
W/offal	23	23	18	18	10	7	0
R/bran	28	20	18	10	9	0	0
Salt	1	1	1	1	1	1	1
Total (%)	100	100	100	100	100	100	100
Calculated ME (Kcal)	2244	2202	2188	2147	2138	2140	2019
Calculated CP (%)	16.3	15.7	15.6	15.6	15.6	15.7	16.4

RISG = Rhizobium Inoculated Soybean Genotype residues; SBM = Soybean Meal; C/husk = Cowpea Husk; W/offal = Wheat Offal;
R/bran = Rice Bran; ME = Metabolizable Energy; CP = Crude Protein

Chemical Analysis

Samples of the seven (7) experimental diets and faecal samples were thoroughly mixed, milled using a 2.0mm sieve and analyzed for proximate composition as outlined by AOAC (1999). Acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined according to the method of Van Soest *et al.* (1991).

Statistical Analysis

Data generated were subjected to analysis of variance (ANOVA) using the General Linear Model of SAS (1998). Student Newman Keule (SNK) was used to detect significant differences among means at a probability level of 5%.

Results and Discussion

Table 1 and 2 showed the percentage and proximate composition of the experimental diets. The dry matter and crude protein contents of the experimental diets were similar. The crude fibre content differed significantly ($P<0.05$) with the highest CF value (36.00%) recorded in treatment D and the least (23.35%) in treatment A (control). Similar ($P>0.05$) values were obtained for ether extract though treatment B was numerically higher. The ADF values obtained ranged from 25.35% to 32.70% and differed significantly ($P<0.05$) with higher ADF obtained in treatments C and E whereas lower value was obtained in treatment A (control). Treatments C and E had significantly ($P<0.05$) higher values of NDF compared to other treatments. Ash values obtained differed significantly ($P<0.05$). Higher Ash content was recorded in treatment E while treatments A and B had lower Ash content. The DM (95.35-96.59%) content of the diets in the present study was higher than DM values reported by Bello and Tsado (2013) but were in agreement with values reported by Muhammad *et al* (2013) when they studied the performance of growing Uda sheep fed diets containing similar energy and varying protein levels in semi-arid environment. The CP (15.11-16.89%) values of the experimental diets recorded in the present study were in agreement with reported values by Adu (1985), Muhammad (2005) and Muhammad *et. al.* (2013). The crude protein content of the experimental diets was within the crude protein requirement of 15-18% for growing sheep (ARC, 1990). The values of crude fiber observed in the current study were within the range (16.71 – 36.44%) reported by Chineke *et al.* (2013).

Table 2: Proximate Composition (%) of the Experimental Diets

Treatments	A	B	C	D	E	F	G	
Inclusion levels (%)	0	10	20	30	40	50	60	SEM
Nutrients								
DM	96.45	96.13	96.40	96.17	95.35	96.59	95.96	0.20
CP	15.11	16.52	16.47	16.89	15.14	15.48	15.31	0.20
CF	23.35^{e}	29.10^{c}	32.30^{b}	36.00^{a}	25.78^{d}	24.30^{de}	24.35^{de}	0.18
EE	3.11	5.52	3.97	4.74	4.64	4.48	4.31	0.35
ADF	25.35^{c}	28.31^{b}	32.13^{a}	30.67^{ab}	32.70^{a}	28.49^{b}	33.10^{a}	0.26
NDF	37.93^{c}	34.46^{d}	48.46^{a}	42.90^{b}	47.64^{a}	43.90^{b}	43.44^{b}	0.24
Ash	10.42^{c}	10.51^{c}	12.04^{bc}	12.56^{bc}	15.61^{a}	11.96^{bc}	14.56^{ab}	0.25

$^{a, b, c, d, e}$ Means in the same row with different superscripts are significantly different (P<0.05). RISG – Rhizobium Inoculated Soybean Genotype

Results on feed intake and live weight change are presented on Table 3. Weight gain was significantly (P<0.05) higher in treatment D and lower in treatments E, A, F and G. Treatment D recorded highest value (126.90g/d) on average daily weight gain and was significantly different (P<0.05) from the other treatments except treatments C, B and E. For feed intake, treatment D was significantly (P<0.05) higher whereas treatment G was lower. Treatments F (12.28) and G (11.82) recorded the highest value on feed to gain ratio and differed significantly (P<0.05) from other treatments except treatments B (9.29) and D (8.35). Feed intake values (624.84 – 1059.56g/d) recorded in the present study for varying levels of RISG residue inclusion in diets of Uda sheep were within the range (808.08 – 1470.00g/d) reported by Bello and Tsado (2013).

The differences observed in intake for the various treatment groups could be attributed to the different inclusion levels of RISG residues offered. Results of this experiment indicated an increase in feed intake with increasing levels of residues from RISG up to 30% inclusion level, after which the feed intake of the animals declined. The decline in feed intake as the inclusion level of RISG residues increased from 40% could be attributed to the high lignin content of soybean stalk (Gupta *et al.*, 1978), thus as the quantity of RISG residue inclusion in the diets increased from 40%, digestibility of feed declined as a result of increasing lignin levels which impedes fibre digestion and limits feed digestibility (Ayres *et al.*, 1986).

Results of the current study indicated that the average daily weight gain (ADG) of the experimental animals is higher in treatment D with 30% inclusion level of RISG residues in the diet. The ADG values obtained in this study were within the range reported by Muhammad *et al*. (2013) in their study of the performance of growing Uda sheep fed diets containing similar and varying protein levels in a semi-arid environment. The ADG value obtained in treatment D (126.98g/day) was better than ADG of 83.33g/day and 53g/day reported by Sirajo *et al.* (2010) and Abil *et al.* (1992) respectively.

The high and significant weight gain recorded by the animals in treatment D was probably due to better utilization of nutrients by the animals. ADG values of 78 - 183g was reported by Adu and Brinckman (1981) when they fed fattened sheep with varying levels of guinea corn and groundnut cake with *Digitaria smutsii* hay as source of roughage. Average daily gain (ADG) recorded for this experiment (52.86 – 126.90g/day) is comparable to what had been reported for conventional feed ingredients.

Inclusion of RISG residues up to 30% produced positive effects on live weight gains. The trend in live weight change obtained from animals in treatments B to D showed an increasing tendency, which was proportionate to the quantity of RISG residue inclusion in the diets. The Values (8.34 – 12.28) obtained for feed to gain ratio were within and slightly below the range of values reported by Ochepo *et al.* (2012) when goats were fed complete diets containing sugar cane peels. Feed to gain ratio value recorded was lower in treatment D indicating that the animals in this treatment were more efficient in utilization of feed and that the animals had better ability to convert feed to flesh.

The lower the feed to gain ratio, the better for the animals as less feed will be converted to flesh. The results of feed to gain ratio were in line with what Maigandi and Nasiru (2006) obtained. Table 4 presents the cost of production of incorporating residues from RISG on the performance of animals. Treatments D and C had high total cost of feed consumed because they had higher feed intake. The result of this study indicated that cost of feed per kg live weight gain was lower (N437.98) in treatment D with 30% inclusion level followed by treatment B (N521.40) and treatment C (N531.63). This indicated that the inclusion of residues from RISG in the diets of sheep even at 10% would significantly reduce the cost of feed per kg live weight gain. The cost of feed per kg live weight gain was lower for treatments D and C because animals in the treatments had a higher live weight gain (LWG) and average daily weight gain (ADG). It is, therefore, obvious that the use of crop residues can reduce the cost of livestock production. Maigandi *et al.* (2002) made similar observations when they used fore-stomach digesta in the diet of growing sheep.

Conclusion

Feed intake, live weight gain and feed cost of production were better for animals fed diet containing 30% inclusion level of residues from RISG, confirming the benefits of incorporating RISG residues in increasing intake and live weight gain, and in reducing the cost of production. Feed to gain ratio was lower in treatment D indicating that animals in this treatment were more efficient in feed utilization. It is therefore recommended that residues from RISG could be safely incorporated into the diets of growing sheep up to an inclusion level of 30% without compromising growth and economic performance.

Table 3: Feed Intake and Live Weight Gain of Uda Sheep fed residues from Rhizobium Inoculated Soybean Genotype

Parameters	A	B	C	D	E	F	G	SEM
Initial weight (kg)	21.50	20.33	20.67	20.67	20.75	21.00	20.83	0.83
Final weight (kg)	27.10	28.30	29.13	31.33	27.25	25.85	25.27	0.72
Weight gain (kg)	5.60^{b}	7.97^{ab}	8.46^{ab}	10.66^{a}	6.50^{b}	4.85^{b}	4.44^{b}	0.36
Average daily weight gain (g/d)	66.67^{b}	94.88^{ab}	100.71^{ab}	126.90^{a}	77.38^{ab}	57.74^{b}	52.86^{b}	4.29
Feed intake (g/d)	710.36^{cd}	881.11^{bc}	1015.28^{ab}	1059.56^{a}	852.26^{bc}	708.93^{cd}	624.84^{d}	16.42
Feed to gain ratio	10.65^{ab}	9.29^{bc}	10.08^{abc}	8.35^{c}	11.01^{ab}	12.28^{a}	11.82^{a}	0.17

$^{a, b, c, d}$ Means in the same row with different superscripts are significantly different (P<0.05). SEM = Standard Error of Mean

Table 4: Costs of Feeding Rhizobium Inoculated Soybean Genotype Residues to Uda Sheep

Parameters | Treatments	A	B	C	D	E	F	G	SEM
Cost of feed (N/kg)	60.72^{a}	56.15^{b}	52.73^{c}	52.46^{c}	49.69^{c}	50.87^{c}	49.89^{c}	0.26
Total feed intake (kg)	59.67^{ab}	74.01^{ab}	85.28^{ab}	89.00^{a}	71.59^{ab}	59.55^{ab}	52.49^{b}	4.49
Total cost of feed consumed (N)	3623.16	4155.66	4496.81	4668.94	3557.31	3029.31	2618.73	20.12
Cost of feed/kg live weight gain (N)	646.92^{a}	521.40^{f}	531.63^{e}	437.98^{g}	547.30^{d}	624.52^{b}	589.67^{c}	0.25

$^{a, b, c, d, e, f, g}$ Means in the same row with different superscripts are significantly different (P<0.05). SEM = Standard Error of Mean

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HAEMATOLOGICAL AND SERUM BIOCHEMICAL PARAMETERS OF UDA SHEEP FED DIETS CONTAINING GRADED LEVELS OF RHIZOBIUM INOCULATED SOYBEAN GENOTYPE

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Abstract
The study was conducted to evaluate the effect of feeding graded levels of residues from Rhizobium inoculated soybean genotype (RISG) (TGx 1951-3F) diets on haematological and serum biochemical parameters of Uda sheep. Thirty-five (35) Uda rams (average body weights 20±3kg) were allotted to diets A, B, C, D, E, F and G having 0%, 10%, 20%, 30%, 40%, 50% and 60% inclusion levels of RISG respectively, in a Completely Randomized Design (CRD). The diets were iso-nitrogenous, and the trial lasted for twelve (12) weeks. Treatment effect on all reported parameters except white blood cell, globulin and cholesterol was not significant (P>0.05). The mean value of white blood cell observed in treatment G (12.60 x $10^3/\mu L$) was similar (P>0.05) to the values obtained in treatments F (10.00 x $10^3/\mu L$), D (9.50 x $10^3/\mu L$), E (9.00 x $10^3/\mu L$), B (8.90 x $10^3/\mu L$) and C (8.60 x $10^3/\mu L$) but differed from the value observed in treatment A (7.70 x $10^3/\mu L$) which was the control. Higher values of globulin were observed in treatments D (3.85g/dL) and C (3.50g/dL) and were significantly (P<0.05) different from values observed in other treatments, however, significant (P<0.05) increase was observed in the cholesterol (1.01, 1.30, 1.43, 1.52. 2.04, 2.18 and 2.24mmol/L) levels with increase in residues from RISG inclusion in the diets. It was concluded that inclusion of Rhizobium inoculated soybean genotype (TGx 1951-3F) in the diet of Uda sheep had no adverse effect on the haematological and serum biochemical parameters evaluated. It was recommended in the study that residues from RISG (TGx 1951-3F) can be safely incorporated in diets of Uda sheep up to 30% inclusion level.

Introduction

Ruminant animals constitute a very important part in the livestock subsector of the Nigerian agricultural economy (Fajemisin *et al*., 2010). They fulfill a most useful task in supplying human populace with meat, milk, skin, hair and other products (Adeloye, 1998). A major challenge facing ruminant livestock farmers in Nigeria is the poor nutrition levels in animals during the dry season when there is a decline in the supply and quality of herbage for livestock (Tope *et al*., 2012). The scarcity of energy and protein feedstuffs during this period is a major setback to ruminant livestock production in the tropics (Adegbola, 1982) as ruminants depend mostly on grasses and legumes which are not available all year round (Chineke *et al*., 2013). Consequently, the available forages are dry, protein content is very low and there is marked decrease in voluntary intake and digestibility by the animal (Oyenuga, 1968; Steinbach, 1997). Groundnut cake (GNC) and cotton seed cake (CSC) are the common protein supplements for livestock feed in Nigeria in periods of low yield and availability of poor quality herbage (Maigandi, 2001). The prices of these protein supplements have been rising, thereby increasing the cost of production (Maigandi, 2001). This prompted researchers to consider the use of alternative sources of feed ingredients in order to reduce the cost of production; one most promising material being considered is residues from soybean. Earlier reports stated soybean as the most nutritious, easily digested food of the bean family and is one of the richest and cheapest sources of protein (Badole *et al.*, 2015). Rhizobial inoculation of soybean seeds with *Bradyrhizobium japonicum* is beneficial to nodulation, plant growth and nitrogen fixation and thus, provides a more consistent nodulation and higher yields (Upfold and Olechowski, 1994). The objective of this study is to determine the haematology and serum biochemistry of Uda Sheep fed residues from Rhizobium inoculated soybean genotype (RISG) (TGx 1951-3F).

Materials and Methods

Experimental Location

The study was conducted at the Livestock Teaching and Research Farm, Bayero University Kano which lies on latitude 11°58.675' North and longitude 8°25.746' East on an elevation of 468m above sea level. Annual rainfall ranges between 787 and 960mm and it has a mean daily temperature range of 30°C to 33°C (KNARDA, 2001).

Experimental Treatments

The test material was obtained from the Research Farm of the International Institute of Tropical Agriculture (IITA) Kano Station, Minjibir (12°08'N, 8°31'E and 500m above sea level) in the semi-arid Nigeria with mean annual precipitation of 831.6mm (Okogbenin *et al*., 1999).

Experimental Animals and their Management

Thirty-five (35) male Uda Sheep with an average body weight of 20±3kg were used for this study. The animals were dewormed using Albendazole® (2.5% oral solution), treated with Ivermectin 0.5% Pour-on and administered Oxytetracycline (a broad spectrum antibiotic) at 1ml/50kg body weight.

Feed Formulation and Experimental Design

Seven (7) complete experimental diets were formulated. Treatment A which was the control diet was without residues from rhizobium inoculated soybean genotype (RISG) (TGx 1951-3F). Treatments B, C, D, E, F and G consisted of 10, 20, 30, 40, 50 and 60% inclusion levels of residues from RISG respectively (Table 1). A Completely Randomized Design (CRD) was used in this trial in which five (5) animals were allocated to each treatment individually housed in a feeding pen and each group was assigned to one of the experimental diets. The animals were balanced for weight prior to commencement of the trial and fed with experimental diets in the morning and evening for 84 days. The feeding pens were cleaned and disinfected using izal a week before the commencement of the experiment. Each pen was provided with feed and water troughs big enough to allow for sufficient feeding and drinking without waste. The feed and water troughs were cleaned every morning before feeding, water was provided *ad libitum*. The animals were weighed after being subjected to overnight fasting bi-weekly between 8:00 am and 9:00 am throughout the period of the experiment. Daily records of feed intake were kept throughout the 12 weeks of feeding. Feed offered and leftover were weighed in the morning of the following day.

Table 1: Composition of Experimental Diets (%)

Ingredients	Treatments						
	A	B	C	D	E	F	G
RISG	0	10	20	30	40	50	60
Maize	20	19	19	17	17	17	9
SBM	18	17	19	20	23	25	30
C/husk	10	10	5	4	0	0	0
W/offal	23	23	18	18	10	7	0
R/bran	28	20	18	10	9	0	0
Salt	1	1	1	1	1	1	1
Total (%)	100	100	100	100	100	100	100
Calculated ME (Kcal)	2244	2202	2188	2147	2138	2140	2019
Calculated CP (%)	16.3	15.7	15.6	15.6	15.6	15.7	16.4

RISG = Rhizobium Inoculated Soybean Genotype residues;
SBM = Soybean Meal;
C/husk = Cowpea Husk;
W/offal = Wheat Offal;
R/bran = Rice Bran;
ME = Metabolizable Energy;
CP = Crude Protein

Blood Sample Collection
At the end of the trial, blood samples were randomly collected from twenty-one animals (three from each group). Bleeding was done early in the morning before feeding and an average of 10mls of blood was collected from each animal via jugular vein puncture for haematology and serum chemistry. Five (5) mls of the blood sample was placed in EDTA (anti coagulant) bottle for haematological analysis while the remaining 5ml was placed in a plain container for blood chemistry analysis. Serum was obtained by centrifugation and serum sample was stored in a deep freezer at -10^{o}C until analyzed.

Chemical Analysis
Samples of the seven (7) experimental diets were thoroughly mixed, milled using a 2.0 mm sieve and analyzed for proximate composition as outlined by AOAC (2000). Acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined according to the method of Van Soest *et al.* (1991).

Blood Analysis
Packed cell volume was determined by microhaematocrit method (Igene and Iboh, 2004), heamoglobin concentration was determined as described by Jain (1993) while red blood cell and white blood cell count were determined using Neubaur counter as described by Oni *et al*. (2010). Mean corpuscular haemoglobin (MCH), mean corpuscular volume (MCV) and mean corpuscular haemoglobin concentration (MCHC) were calculated from red blood cell (RBC), haemoglobin (Hb) and packed cell volume (PCV) values respectively, according to methods described by Dachie and Lewis (2001). Blood urea nitrogen and glucose were determined by an enzymatic colorimetric method (Helmut and Yvette, 1959), creatinine was determined by the method of Bonsnes and Taussky (1945) while cholesterol was determined by the method of Allain *et al*. (1974). Serum total protein and albumin were determined by the method of Peters *et al.* (1984) and globulin determined according to Coles (1986).

Statistical Analysis
Data generated were subjected to analysis of variance (ANOVA) using the General Linear Model of SAS (1998). Student Newman Keule (SNK) was used to detect significant differences among means at a probability level of 5%.

Results and Discussion
Proximate Composition (%) of Experimental Diets
The proximate composition of the experimental diets used in the trial is presented in Table 2. From the table, it was observed that the dry matter content ranged from 95.35% to 96.59%. The dry matter values obtained were similar (P>0.05) in all the treatments. The crude protein varied from 15.11% in treatment A to 16.89% in treatment D. There was no significant (P>0.05) difference in the crude protein values obtained for all the treatments. The crude fiber values obtained differed significantly (P<0.05) with the highest crude fiber value obtained in treatment D and the least in treatment A (control). The ether extract values obtained for the treatments were similar (P>0.05) though treatment B had slightly higher value. The ADF values obtained ranged from 25.35% to 32.70%. Values of ADF obtained for the treatments differ significantly (P<0.05) with higher ADF values obtained in treatments C and E whereas lower value was obtained in

treatment A (control). Significant ($P<0.05$) difference was observed in the values of NDF obtained for all the treatments with treatments C and E having higher values whereas the least value was obtained in the control. The Ash values obtained ranged from 10.42% to 15.61% and differed significantly ($P<0.05$%) across the treatments. The crude protein content observed in the present study falls within the crude protein requirement of 15-18% for growing sheep (ARC, 1990; Adu, 1985). The values of crude fiber observed in this study were within the range (16.71 – 36.44%) reported by Chineke *et al.* (2013).

Table 2: Proximate Composition (%) of the Experimental Diets

Treatments	A	B	C	D	E	F	G	
Inclusion levels (%)	0	10	20	30	40	50	60	SEM
Nutrients								
DM	96.45	96.13	96.40	96.17	95.35	96.59	95.96	0.20
CP	15.11	16.52	16.47	16.89	15.14	15.48	15.31	0.20
CF	23.35^{e}	29.10^{c}	32.30^{b}	36.00^{a}	25.78^{d}	24.30^{de}	24.35^{de}	0.18
EE	3.11	5.52	3.97	4.74	4.64	4.48	4.31	0.35
ADF	25.35^{c}	28.31^{b}	32.13^{a}	30.67^{ab}	32.70^{a}	28.49^{b}	33.10^{a}	0.26
NDF	37.93^{c}	34.46^{d}	48.46^{a}	42.90^{b}	47.64^{a}	43.90^{b}	43.44^{b}	0.24
Ash	10.42^{c}	10.51^{c}	12.04^{bc}	12.56^{bc}	15.61^{a}	11.96^{bc}	14.56^{ab}	0.25

Means in the same row with different superscripts are significantly different ($P<0.05$). RISG – Rhizobium Inoculated Soybean Genotype

Table 3 shows the haematological response of the experimental animals fed the treatment diets. The values for packed cell volume, haemoglobin and red blood cell did not show any significant ($P>0.05$) difference among the treatment means. White blood cell count was significantly ($P<0.05$) higher in treatment G, differences between other treatments were similar except for treatment A (control) which had the least value of white blood cell count. There was no significant ($P>0.05$) variation in the values observed for mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration between the control diet and the test diets. The PCV values observed in the present study (25.00-33.00%) were within the normal range (27.0-45.0%) as reported by Banerjee (2007). The PCV values were also in agreement with those cited by Daramola *et al*. (2005) and Ikhimioya and Imasuen (2007). Haemoglobin values observed were within the reported range (9.00-15.00g/dL) for sheep and were in agreement with the reports of Garba and Abubakar (2012) and Orheruata *et al.* (2004). The PCV and Hb values obtained showed that the experimental diets were adequate for the nutritional requirements of the experimental animals and the test diets did not cause any danger to the animals. The RBC for this study did not show any significant differences between the test diets and the control and are in line with RBC values (9-10) x 10^{6}µl reported by Campbell *et al.* (2003). The white blood cell counts (WBC) were similar for all the animals fed the test diets, consequently, the immunity of the animals fed such diets may probably be similar (Murray *et al*., 1993; Frandson, 1981). The result also indicated that the animals might have produced more WBC in response to the nutritional adequacy of the diets; this implies that the diets supported haemopoietic tissues (i.e. red blood cell forming tissues) with resultant production of adequate WBC (Frandson, 1981) as toxic substances in feed tend to suppress haemopoietic tissues with consequent production of lower WBC (Eroschenko, 2000). The MCV, MCH and MCHC values observed in the present study were within the mean ranges (32.10 ± 0.42) fl, (10.65 ± 0.17) pg and (33.10 ± 0.29) g/dL respectively, for clinically healthy Iraqi Awassi sheep as cited by Badawi and Al-Hadithy (2014).

Table 3: Haematological Parameters of Uda Sheep fed Graded Levels of residues from RISG

Parameters	Treatments							
	A	B	C	D	E	F	G	SEM
RISG Inclusion level (%)	0	10	20	30	40	50	60	
Packed Cell Volume (%)	25.00	29.67	29.67	33.00	28.00	29.50	32.00	1.70
Haemoglobin concentration (g/dL)	9.10	9.63	9.67	10.80	9.30	9.65	10.50	0.61
Red Blood Cell (x 10^6µL)	8.46	9.70	9.73	9.95	9.11	9.30	9.82	0.53
White Blood Cell (x 10^9L)	7.70^{b}	8.90^{ab}	8.60^{ab}	9.50^{ab}	9.00^{ab}	10.00^{ab}	12.60^{a}	0.40
Mean Corpuscular Volume (fl)	29.55	30.59	30.49	33.17	30.74	31.72	32.59	1.12
Mean Corpuscular Haemoglobin (Pg)	10.75	9.93	9.94	10.85	10.21	10.38	10.69	0.22
Mean Corpuscular Haemoglobin Concentration (g/dL)	36.40	32.46	32.59	32.73	33.21	32.71	32.81	0.75

Means in the same row with different superscripts are significantly different (P<0.05). RISG – Rhizobium Inoculated Soybean Genotype

The effect of the diets on blood chemistry is shown in Table 4. There was no significant difference (P>0.05) in the mean values obtained for blood urea nitrogen, total protein and albumin across all treatments. Globulin level varied significantly (P<0.05) with the highest mean values observed in the blood of animals fed 30% and 20% inclusion levels and the least in animals fed 50% inclusion level of RISG.

The result showed no significant difference (P>0.05) across the treatment means in the level of glucose and creatinine, however, the mean blood cholesterol was highest in animals on 60% and 50% inclusion levels and differed significantly (P<0.05) across the treatment means. The mean blood urea nitrogen values in the control and test diets were within and slightly above the normal range 3.70mmol/L – 9.30mmol/L reported for sheep (The Merck, 1998; Duncan and Prassee, 1986). The mean values were also slightly above reported values by Garba and Abubakar (2012) and Aruwayo *et al.* (2009). The slight increase in the blood urea nitrogen values could be attributed to the increased nitrogen content of the soybean residues.

This implies that treatment of soybean with rhizobium inoculants must have resulted in an increase in the nitrogen content of the residues as inoculation with *Bradyrhizobuim japonicum* is beneficial to nodulation and nitrogen fixation (Upfold and Olechowski, 1994). Blood urea nitrogen accurately reflects the intake of effective rumen degradable protein and its balance with fermentable metabolizable energy (Whitaker, 1998). The normal and non-significant blood urea nitrogen values in this study are indications that the amino acids of the diets were balanced and the animals were in a positive energy balance throughout the present study and that the test diets provided adequate protein for the experimental animals.

This agrees with Coles (1986) that low dietary protein may result in a decrease in urea nitrogen. This also showed that residues from RISG up to 60% inclusion level did not interfere with the renal function. The total protein had the highest mean value in the 30% inclusion level of residues from RISG while albumin had the highest mean value in the 50% inclusion level. The value obtained for serum globulin was lower and slightly within values reported by Aruwayo *et al.* (2011) but lower than the range (17.15 –23.51g/dL) as reported by Khan *et al.* (2013).

The glucose concentrations of the Uda sheep were not significantly different and values obtained were within the normal range (2.4-4.5mmol/L) as reported by The Merck (1998). The mean value for creatinine is highest in the 0% inclusion level. High creatinine is an indicator of poor protein and amino acid metabolism that can lead to impaired renal function and cardiac infarction (Gray and Howorth, 1980). Uda Sheep fed diet containing 0% inclusion level of RISG had the lowest cholesterol content. The cholesterol level increased with increasing level of RISG residues and was in agreement with the reports of Devendra *et al.* (2008) in Coimbatore sheep

(2.12±5.17mmol/L) and Jawasreh *et al.* (2010) in Awassi sheep (2.25±3.40mmol/L) but lower than the range reported by Garba and Abubakar (2012).The value was also within reported range of 1.18 – 2.91mmol/L (Khan *et al.*, 2013) in Karadi sheep, however, Njidda *et al.* (2013) reported higher cholesterol concentrations for different breeds of goats in Northern Nigeria. Cholesterol concentrations have been reported to be influenced by the degree of stress (Shaffer *et al.,* 1981).

Table 4: Serum Biochemical Parameters of Uda Sheep fed Graded Levels of residues from RISG

Parameters	Treatments							
	A	B	C	D	E	F	G	SEM
RISG Inclusion level (%)	0	10	20	30	40	50	60	
Blood Urea Nitrogen (mmol/L)	10.35	13.43	11.53	14.00	10.15	12.10	13.50	2.02
Total Protein (g/dL)	5.43	5.93	6.82	7.05	5.67	5.75	6.20	0.55
Albumin (g/dL)	2.90	3.20	3.32	3.20	3.10	3.70	3.20	0.09
Globulin (g/dL)	2.53^{b}	2.73^{b}	3.50^{a}	3.85^{a}	2.57^{b}	2.05^{c}	3.00^{b}	0.29
Glucose (mmol/L)	3.60	3.97	3.87	3.93	4.45	4.55	3.70	0.51
Creatinine (mg/dL)	1.06	0.92	0.85	0.85	0.90	0.97	0.99	0.03
Cholesterol (mmol/L)	1.01^{d}	1.30^{c}	1.43^{c}	1.52^{c}	2.04^{b}	2.18^{a}	2.24^{a}	0.18

Means in the same row with different superscripts are significantly different ($P<0.05$). RISG – Rhizobium Inoculated Soybean Genotype

Conclusion

The results of haematology and serum biochemistry of Uda sheep fed residues from rhizobium inoculated soybean genotype (RISG) revealed that the test diets supplied the required nutrients needed by the animals and the test diets were not detrimental to the health of the animals. Thus, residues from rhizobium inoculated soybean genotypes can be safely incorporated into sheep feeds.

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EFFECTS OF SUBSTITUTING GROUNDNUT HAULMS WITH *Piliostigma reticulatum* HAY ON LIVEWEIGHT CHANGES OF RED SOKOTO BUCKS IN SEMI-ARID ZONE, NIGERIA

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Abstract
Twenty (20) growing Red Sokoto bucks weighing 14.5± 0.5 kg were used to evaluate the effect of graded levels of Piliostigma reticulatum hay in the diet on liveweight changes. The study was conducted at Teaching and Research Farm, Federal University Dutse. The treatments were Piliostigma reticulatum hay (PRH) replacing Groundnut haulms (GH) at 0% (T1), 25% (T2), 50% (T3), 75% (T4), and 100% (T5) in a Completely Randomized Design (CRD) experiment with four replications. The results of proximate and fibre constituents' analysis of diets shows 100% GH (T1) having DM (88.67%); ASH (8.10%); OM (80.57%) and CP (23.07%). Their content decreases as the inclusion levels of PRH increases. However, treatment with 100% PRH was higher in CF (28.23%); EE (4.63%); NDF (56.90%); ADF (44.20%); HEMCEL (12.70%) and LIG (20.07%). There were significant differences (P<0.05) in dry matter intake of experimental diets. The intake varies from 741.83g/day in T5 to 794.31g/day in T2 and decreases with increase in PRH inclusion levels. There was a significant increase in liveweight gain from 3.13kg in T5 to 6.85kg in T2. highest level of liveweight was gained at T2 (25% PRH), in conclusion Piliostigma reticulatum hay can be use to substitute up to 50% Groundnut haulms in a basal diet of ruminant animals without adverse effect on liveweight changes.

Keywords: weight gain, *Piliostigma reticulatum* hay, Groundnut haulms, Red Sokoto Bucks, Liveweight

Introduction

The most challenging constraint in small ruminant production in the tropics is the shortfall and poor quality of the available energy and protein feedstuffs particularly during the dry season (Osuji *et al*. 1993). During critical periods, available forages do usually contain low energy and protein and this affects voluntary intake and digestibility leading to loss of weight amongst the animals (Mbahi *et al*. 2006).

In addition to the above, extortionate cost of conventional feed stuffs because of competition with man and monogastrics also stand as a militating factor to the realization of the full potential of small ruminant production (Njoya *et al*. 2005). The above prevailing condition justifies efforts towards sourcing for alternative and locally available means of feeding ruminants to increase their productivity while contending with the problem of insufficient conventional feed resources. According to Topps (1992), attention of ruminant scientists all over the world in recent years has shifted to cheaper and locally available alternative feedstuffs which should be nutritionally viable, non-toxic and of little or no dietary value in human diets. This perhaps, makes Small scale farmers to rely on browse and crop residues during the dry season (Smith *et al*. 1991).

Browse plants have many advantages as far as livestock production is concerned. They are less subject to seasonal variation. They can serve as the only feeding stuff to keep livestock in healthy and fair condition (Bamikole *et al*. 2004). However, they are not adequate as a sole feeding stuff for high producing species (Uguru, 2014). Browse plants are also very palatable and can offer considerable potentials as feeds to livestock (Yahaya *et al*. 2000). They are also useful in enhancing the sustainability of farming systems because they usually live long and require low maintenance cost than other species. One of the common browse plant found in the semi-arid zone is *Piliostigma reticulatum*.

Kargo (*Piliostigma reticulatum)* is a leguminous medium-sized tree which grows wild in the tropics and is one of the commonest species of Piliostigma (Hochst) in the northern part of Nigeria, where it is locally known as Kargo or Kalgo (Akin-Osanaiye *et al*. 2009). According to Diack *et al*, (2000), *Piliostigma reticulatum* is an endophitic legume, with no nodules, non-fixing N, from the *Cesalpiniaceae* family, is usually a shrub but can occasionally be a tree. It grows on sandy, clayey and lateritic soils, During the dry season, it can regrow up to 90cm with a canopy diameter of 100 to 175cm. Annually, 402kgDM/ha biomass are produced, for an average density of 317 shrubs per ha. According to Heuze and Tran (2013) fresh leaves of *Piliostigma spp* contain 6.4-15.3 %CP, 20.0-32.1%CF, 19.7-39.8 %DM, 47.6-64.2 %NDF, 31.5-56.0 %ADF, 13.0-31.2 % Lignin, 0.2-46.0% CT and 18.7 MJKgDM GE. The objective of the study was to assess the effect of substituting groundnut haulms with *Piliostigma reticulatum* hay on liveweight changes of Red Sokoto Bucks in the study area and the nutritive values of the diets.

Materials and Method

Description of the Study Area

The study was conducted at the Teaching and Research Farm, Federal University Dutse, Jigawa State on longitudes $11^0 42'$ to 12^0 27' and latitudes $07^0 29'$ to $11^0 04'$ at an altitude of 434m above sea level in the semiarid zone of Nigeria. Dutse has an average rainfall of 743 mm/annum, with a mean annual temperature of 26.5^0C (KWM, 2011).

Experimental Animals and their Management

Twenty (20) growing male Red Sokoto Bucks weighing 14.5$\pm$ 0.5 kg were procured from Gujungu weekly market in Taura Local Government Area, Jigawa State. The animals were quarantined for 3 weeks and ear tagged for identification and were dewormed with anthelmintics (Albendazole®) at 3ml/10kg body weight one week before commencement of experiment; and dosage repeated after 3 days. The goats were housed in individual pens (1.25 m^2), well-lighted and adequately ventilated building with concrete floor. The pens were disinfected with Izal solutions before the animal arrival and cleaned daily.

Treatments and Experimental Design

The treatments evaluated were diets containing *Piliostigma reticulatum* hay (PRH) at 0%, 25%, 50%, 75%, and 100% inclusion levels replacing Groundnut haulms (GH) as basal diet in a Completely Randomized Design (CRD) experiment with four replications. PRH used in this trial was source from Jigawar Tsada Village in Dutse Local Government Area; it was bagged in a 50kg jute bags and transported to Federal University Dutse, while GH was purchased from a local market in Dutse. Concentrate supplement (Table 1) was offered at 100g per animal per day at 08:00h daily for the duration of the trial and clean drinking water was given *ad-libitum*. Feed intake was determined daily from measurements of quantity of feed offered and the residue of the feed leftovers. Liveweight of the goats were taken at weekly interval to determine weight gain.

Table 1: Composition of Supplement Used

Ingredients	Percentages
Groundnut cake	8.0
Maize	8.0
Cowpea husk	20.0
Wheat offal	18.0
Rice milling waste	45.5
Salt	0.5
Total	**100**
Calculated analysis	
Energy (Kcal/kg)	2029
Crude Protein (%)	12.1
Crude Fibre (%)	21.4
Ether Extract (%)	4.3
Cost/Kg (₦)	26.62

Chemical Analysis

The samples of PRH, GH and supplement were oven dried at 65ºC for 48 hours, thereafter sub-samples were ground in a hammer mill to pass through a 1mm mesh sieve for determination of: dry matter (DM), crude protein (CP), crude fibre (CF), nitrogen free extract (NFE), ether extract (EE) and ash (ASH) according to procedures described by A. O. A. C, (1999). Fibre fractions: neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin were determined according to procedures described by (Van Soest *et al*., 1991). Metabolizable energy (ME) was calculated using the equation described by (Pauzenga, 1985) MEkcal/kg = 37(%CP) + 81.1(%EE) + 35.5(%NDF).

Statistical Analysis

The data collected from chemical analysis and growth trial were subjected to analysis of variance (ANOVA) using General Linear Model of SAS 2003. where differences in means were detected by Fisher's least significant difference (FLSD) at 5% level of probability.

Results and Discussion

Proximate and fibre constituents' analysis of basal diets is presented in Table 2. Treatment with 100% GH (T1) was higher in DM (88.67%); ASH (8.10%) OM (80.57%) and CP (23.07%). Their content decreases as the inclusion levels of PRH increases. However, treatment with 100% PRH was higher in CF (28.23%); EE (4.63%); NDF (56.90%); ADF (44.20) HEMCEL (12.70%) and LIG (20.07%).

The %ASH and %OM values obtained in this study were in agreement with the values (19.80 - 4.20 ash; 86.55 – 72.64 OM) reported by Njidda, (2010) and Garba (2014) on semi-arid browse plants, while the DM content was lower than that reported by same authors. This could be due to variation in locations and season in which the trial was conducted. The %CP values obtained in the current study was in agreement with values (12-13%) reported by Norton (1994) for most tropical legumes and the range of 10-15% for most browse plants. Also Rittner and Reed (1992) reported a range of crude protein concentration of 137.5-212.5g/kg DM for West African browse. Leng (1990) and Meissner (1997) reported that the minimum CP content for rumen function and for maintenance is between 70-80g CP/kg DM for ruminants. However, all the fibre fractions were within the values reported by Garba (2014).

Table 2: Proximate and Fibre Constituents of the Experimental Feeds

Variables	**Graded levels of PRH substituting GH**					**SE**	**LOS**
	T1:0%PRH + 100 GH	**T2:25%PRH + 75 GH**	**T3:50%PRH + 50 GH**	**T4:75%PRH + 25 GH**	**T5:100%PRH + 0 GH**		
DM	88.67^{a}	84.50^{b}	83.65^{b}	80.36^{c}	78.50^{d}	0.96	*
ASH	8.10^{a}	7.62^{b}	7.13^{c}	6.70^{cd}	6.53^{d}	0.16	*
OM	80.57^{a}	76.88^{b}	76.52^{b}	73.66^{c}	71.97^{c}	0.83	*
CP	23.07^{a}	20.30^{b}	16.85^{c}	13.79^{d}	10.57^{e}	1.20	*
CF	27.17^{ab}	26.37^{b}	26.95^{b}	26.76^{b}	28.23^{a}	0.22	*
EE	2.37^{e}	2.78^{d}	3.40^{c}	3.95^{b}	4.63^{a}	0.22	*
NDF	44.50^{e}	46.83^{d}	50.43^{c}	53.33^{b}	56.90^{a}	1.19	*
ADF	36.73^{e}	38.67^{d}	40.80^{c}	42.77^{b}	44.20^{a}	0.73	*
HEMCEL	7.77^{d}	8.17^{cd}	9.63^{bc}	10.57^{b}	12.70^{a}	0.52	*
LIGNIN	6.97^{e}	10.28^{d}	13.85^{c}	17.47^{b}	20.07^{a}	1.27	*

a, b, c means in the same row bearing different superscripts are significantly different (P<0.05) level, * = significant at P<0.05.

The performance of Red Sokoto Bucks fed graded levels of PRH is shown in Table 3. The result shows that there were significant differences (P<0.05) in dry matter intake of treatment diets. The intakes ranged from 741.83g/day in T5 to 794.31g/day in T2 and decreases with increase in PRH inclusion levels. There was a similar trend in liveweight gain as compared to dry matter intake, liveweight gain vary from 3.13kg in T5 to 6.85kg in T2. A different trend was obtained in terms of feed conversion ratio; it decreases as inclusion levels of PRH increases and vary from 11.00g in T2 to 23.94g in T5.

Dry matter intake differed between treatments with highest daily feed intake of 794.31g recorded in T2, which is slightly higher than the values reported by Aganga and Mesho (2008). They reported an average daily DM intake of 768.40g and 790g for goats fed *A. fleckii* and *A. tortilis* respectively as supplements. However, intake of experimental diets decreased as the level of PRH inclusion increases from 25% to 100%. This is in agreement with the finding of Makaranga, (2002); who reported reduction in intake of dry matter and crude protein when sheep were fed with browse diets containing tannins.

Weight gain by Red Sokoto Bucks differed significantly among treatment diets, with the highest value of 6.85kg recorded in 25% inclusion level of PRH (T2). This was slightly higher than the value of 6.23kg reported by Yahaya *et al*, (2000); when varied levels of *A. seyal Del.* was used as replacement for cotton seed cake in sheep. Increasing levels of PRH affected performance of experimental animals negatively. These may be because of higher levels of tannin in PRH. Study by Tanner *et al*, (1990), reported that polyphenolic compounds can complex with protein to cause substantial reduction in feed digestion rate and consequently affect feed utilization.

Table3: Liveweight Changes of Red Sokoto Bucks Fed Graded Levels of *Piliostigma reticulatum* Hay and Groundnut haulms in the Semi-Arid Zone of Nigeria

Parameters	Graded levels of PRF substituting GH					SE±	LOS
	T1:0%PRH + 100 GH	T2:25%PR H + 75 GH	T3:50%PR H + 50 GH	T4:75%PR H + 25 GH	T5:100%P RH + 0 GH		
Initial body weight (Kg)	14.50	14.10	14.45	14.28	14.78	0.20	NS
Final body weight (Kg)	20.95[a]	20.95[a]	20.98[a]	19.40[b]	17.90[c]	0.32	*
Daily Intake of Basal Diet (g)	793.44[a]	794.31[a]	786.08[a]	768.32[b]	741.83[c]	4.61	*
Daily Intake of supplement (g)	100.00	100.00	100.00	100.00	100.00	0.00	NS
Total Intake (g)	893.44[a]	894.31[a]	886.08[b]	868.32[c]	841.83[d]	4.61	*
Liveweight Gain (Kg)	6.45[a]	6.85[a]	6.35[a]	5.13[b]	3.13[c]	0.33	*
Daily Weight Gain (g)	76.79[a]	81.55[a]	77.68[a]	61.01[b]	37.20[c]	3.96	*
Feed Conversion Ratio (g)	11.66[b]	11.00[b]	11.42[b]	14.35[b]	23.94[a]	1.27	*

a, b, c means in the same row bearing different superscripts are significantly different (P<0.05) level, * = significant at P<0.05; and NS = not significant at P>0.05.

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EFFECT OF PHOSPHORUS FERTILIZER AND ARBUSCULAR MYCORRHIZAL FUNGAL INOCULANT ON LEAF NUTRIENT CONCENTRATION AND YIELD OF CASSAVA (*Manihot esculentum* Crantz) IN SUDAN SAVANNA AGRO-ECOLOGY OF NIGERIA

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Abstract
Cassava production is facilitated by its agronomic and nutritional advantages over other crops because of its ability to grow on marginal soils. Nonetheless, low soil fertility is a principal constraint to its production necessitating application of soil amendments. A field trial was conducted in a Sudan savanna of Nigeria to examine the response of cassava to P fertilizer and arbuscular mycorrhiza fungal (AMF) inoculants. Treatments included three levels of P fertilizer (0, 17.5 and 35 P_2O_5 ha^{-1}) and three levels of AMF inoculants (control, Glomygel and Symbiom) laid in a split plot design with P fertilizers as main plot and AMF inoculants as subplots. The result showed that application of P fertilizer did not influence N and P leaf concentration but significantly ($P<0.05$) decreased leaf concentration of K, Zn and Cu. Significant ($P<0.05$) difference in Zn and Cu leaf concentration was also observed as a result of AMF inoculation. While variable responses in nutrient were observed as a result of P and AMF application, these did not translate into yield differences as a result of background soil P. Although yield is ultimate in many crop productions, some plant part may be equally important. It was concluded that AMF employed to increase nutrient content of cassava but this requires further investigation at scale and in time before recommendations are made.

Keywords: P fertilizers, AMF inoculants, nutrient concentrations, cassava

Introduction

Cassava production in Nigeria has gained prominence and been consistently ranked the highest in the world harvesting over 37.5 million tones (FAOSTAT, 2012). This is because cassava is considered very important crop that produces more calories per unit. The crop is usually grown on marginal soils because of its ability to tolerate drought and give a reasonable yield in soils with low fertility. The agronomic and nutritional advantages of cassava over other staples are some of the factors that facilitate its production.

Many reports have shown that cassava responds to fertilizer use (Asare *et al*., 2009; Adjei-Nsiah and Issaka, 2013). In fact, cassava's need for fertilizer is increasing since the traditional means of maintaining soil fertility such as intercropping and mulching of plant residues are abandoned under more intensive production systems. Although fertilizer use may be the easiest way to improve cassava productivity and sustainability, high prices limit the adoption of fertilizers. There are however, other options to improve cassava productivity and increase nutrient availability, within the farming system. One of these options includes the use of soil microbes. In particular, the rhizosphere symbionts named arbuscular mycorrhizal fungi (AMF) have received considerable attention as a potential low-input solution. Given the potential benefits to agricultural productivity, manipulation of AMF communities by inoculation has been attempted at the field scale (Verbruggen *et al*., 2012). Reports from field experiments revealed a high colonization due to AMF inoculation was positively correlated with crop yields and P uptake, which were increased by more than 30% (Lekberg and Koide, 2005). Others reported that AMF have their most significant effect on improving plant growth as they enhance uptake of nutrients such as Zn, Cu, Fe, and Co (Killham and Firestone, 1983). The aim of this research therefore is to examine the effect of P fertilizer and AMF inoculants on the leaf nutrient concentration and yield of cassava in Sudan savanna agro-ecology of Nigeria.

Materials and Methods

Experimental Site Description

The experiment was conducted at the Institute for Agricultural Research Station Minjibir, Kano. The station is located in the Sudan savanna of Nigeria at N12^0 08´31. 5´´, E008^0 40´15.5´´and 436m above sea level. The field was under continuous cultivation and the previous crop harvested was cowpea (*Vigna unguiculata*).

Soil Sampling and Analysis

Soil samples for pre-planting analyses were taken at three depths: 0-15cm, 15-30cm and 30-45cm. Soil from the field was sampled by randomly selecting points in the field from which soil cores were taken. About 15 to 20 points were considered and soil cores were taken and bulked to make composite sample for laboratory analysis. The physical and chemical analyses were determined using standard methods as outlined by Anderson and Ingram (1993).

Field Establishment, Layout and Treatment Application

The field was cleared, ploughed, harrowed and ridged at 75cm a part using tractor to create a fine tilth. The field was then divided according to experimental treatments using pegs. There were total number of 27 plots and each plot size was 72m^2. Planting was done when the rain was fully established. The cassava variety planted was TME 419. The cassava stem cuttings, approximately 25 cm long, were planted at 1m x 0.75 m spacing giving a planting density of 13,333 plants per ha. The experiment was laid in split plot design with phosphorus rates as main plot and the AMF inoculants as subplot. Treatments included three (3) phosphorus levels as main plots (0, 17.5, 35 kg P_2O_5 ha^{-1}) and three (3) AMF inoculants types as subplots (Glomygel, Symbiom, and Control).

The application of fertilizer was done based on the recommendation made by National Root Crop Research Institute (NCRI) of Nigeria (90 kg N ha^{-1}, 35 kg P_2O_5 ha^{-1} and 75 kg K_2O ha^{-1}). While N and K were applied uniformly as recommended, P was applied according to the treatments. The side dressing method for fertilizer application was adopted to ensure adequate fertilization.

Two inoculants (Glomygel and Symbiom) were obtained in concentrated form and diluted before application as recommended by producers (Glomygel diluted in water in ratio = 1:3 and 2ml/cassava applied. Symbiom diluted with sand in the ratio= 1:9 and 2g/cassava applied). Inoculation was done at 20 days after planting after the stem cuttings had developed fine roots. This was done by carefully lifting the cassava stem cuttings and applying the inoculants beneath the stem cuttings.

Harvesting

Harvesting was done at exactly 12 months after planting when the plants had attained maturity. This was done by hand pulling. A net plot of 12 m^2 consisting of 12 plants was marked in each plot and the plant samples were taken therein. Both fresh weights of the roots, stem and leaves were taken in situ using a field scale. Dried leaf samples were ground, sieved and analyzed for nutrient concentrations.

Statistical Analysis

All data collected were subjected to analysis of variance using SAS software 9.4. Where significant F rates are observed, Standard error was used to separate treatment means.

Results

The physical and chemical properties of the experimental soil are presented in Table 1. The soil was moderately acidic, which was in agreement with the general characteristics of an Alfisol soil order of the tropics but within the suitable range for cassava production (Howeler, 2002). The total N and organic carbon of both sites were very low. The soil was loamy sand and had good proportion of soil particles. The soil was deep, friable and well aerated which encouraged drainage. These attributes were favorable to good cassava root formation.

Effect of P fertilizers and AMF inoculants on the leaf nutrient concentrations

Analysis of the leaf nutrient concentrations has shown that application of different levels of fertilizers did not have influence on the N and P leaf concentration but there was significant ($P<0.05$) leaf K concentration (Table 2). It showed that where 0 kg P_2O_5 ha^{-1} was applied recorded higher leaf K concentration.

Analysis of micronutrient leaf concentration showed that there was significant ($P<0.05$) Zn and Cu leaf concentrations as a result of P applications. Significantly higher Cu leaf concentration was recorded where 0 kg P_2O_5 ha^{-1} was applied. The effect of AMF inoculants also showed significantly ($P<0.01$) higher Cu concentration where Glomygel recorded the highest concentration. Symbiom on the other hand recorded significantly ($P<0.01$) higher Zn and Mn leaf concentration than Glomygel and control. There was also significant ($P>0.05$) Phosphorus (P) x Inoculant (I) interaction in leaf Cu concentration. Neither the P nor AMF application showed significant Fe leaf concentration. However the P x I interaction was highly significant (Table 3).

The interaction between P fertilizers and AMF inoculants in terms of leaf Cu concentration is given below (Fig 1). It showed that 0 kg P_2O_5 ha^{-1} + Glomygel inoculants significantly ($P<0.05$) increased the Cu leaf concentration over other combinations. Highly significant ($P<0.01$) interaction between P fertilizers and AMF inoculants in leaf Fe concentration was also recorded. It also follows similar trend with the leaf Cu concentration where the combination 0 kg P_2O_5 ha^{-1} + Glomygel inoculant was at par with the remaining combinations (Fig 2).

Effect of P fertilizers and AMF inoculants on the yield of cassava

Analysis of the yield of cassava showed that the treatment applications (both phosphorus and inoculants) have not had impact on the cassava fresh yields nor was there significant difference in the P x I interaction (Table 4).

Discussion

The soil of the experimental site was loamy sand and had good proportion of soil particles. It was deep, friable and well aerated which encouraged drainage. These attributes were favorable to good cassava root formation. Also, the soil was moderately suitable due to its medium level of soil chemical characteristics in comparison with the nutrient requirement for cassava production as reported by Howeler (2002). It was reported that cassava grows on wide range of soils provided the soil texture is friable enough to allow the development of tubers. However, it does better on light sandy loams or on loamy sands, which are fertile and deep (Ande *et al*., 2008; Seesahai *et al*., 2008) as was the case in the experimental site for this study.

The study also showed that application of P fertilizers did not influence macronutrients concentration of cassava leaf. On the other hand, concentrations of some micronutrient in leaf, notably Zn, Cu and Mn, were decreased with P application. This may be attributed to the antagonistic effect of P on micronutrient concentration. It has been reported that P interaction with micronutrients leads to decrease concentration of micronutrients (Barben *et al*., 2007). Conversely, inoculation with AMF inoculants improved the leaf concentrations of Zn Cu and Mn. Inoculating plant with AMF has been reported to improve uptake of micronutrient such as Zn, Cu, Mn and Fe and hence their tissue concentrations (Krishnakumar *et al*., 2013).

Application of fertilizer in this study did not lead to significant difference in cassava yield. This non-responsiveness to P fertilizer application could be as a result of high residual P in the site since the field was in continuous cultivation with consistent P application. According to Karamanos *et al*. (2007), residual P is expected to build in the soil when the removal of P by crops is lower than the fertilizer P applied. This can be explained by the much high soil test P in the study site (Table 1). Soil test P levels can be raised if rates of P applied exceed the rates of P removal by the crop (Synder, 2000). Besides, as reported by Howeler (2002), when cassava yield is high, the N and P removal per ton dry matter in root is actually lower than most crops.

Conclusion

Our study has shown that application of P fertilizers and AMF inoculants in Sudan savanna agro-ecology did not lead to cassava yield increases. This was attributed to high background P in the study site, which affected the nutrient uptake and led to non-responsiveness of cassava to P application. However, inoculation of cassava with AMF has led to significant increases in the leaf micronutrient concentration implying higher uptake from soil, which is important for the crop production. It would therefore be important to further investigate these findings in space and time in order to make recommendations.

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Table 1: Physical and Chemical analyses of the experimental soil

Treatment	N (g/kg)	P (g/kg)	K (g/kg)
P Level (P)			
0	35.82	3.42	18.53a
17.5	34.82	3.44	16.87b
35	35.97	3.46	17.67b
SE	0.94	0.03	0.46
Inoculant (I)			
Glomygel	33.89	3.44	17.83
Symbiom	36.11	3.43	17.63
Control	36.93	3.47	17.21
SE	1.06	0.04	0.52
Interaction P x I			
Significance	NS	NS	NS

Table 2: Effect P and AMF inoculants on leaf macronutrient concentrations

Property	Depth (cm)		
	0-15	15-30	30-45
Sand (%)	81	81	79
Silt (%)	10	12	10
Clay (%)	9	7	11
Texture	Loamy sand	Loamy sand	Sandy Loam
pH ($CaCl_2$)	5.44	5.99	5.63
Total N (gkg^{-1})	0.14	0.07	0.07
Organic C (gkg^{-1})	2.39	2.19	2.59
Available P (gkg^{-1})	10.92	9.62	4.50
Ca ($Cmol^{(+)} kg^{-1}$)	2.81	4.49	4.28
Mg ($Cmol^{(+)} kg^{-1}$)	0.21	0.2	0.22
K ($Cmol^{(+)} kg^{-1}$)	0.22	0.27	0.14
Na ($Cmol^{(+)} kg^{-1}$)	0.29	0.29	0.21
ECEC ($Cmol^{(+)} kg^{-1}$)	3.53	5.25	4.86

NS = not significant; * = P<0.05; ** = P<0.01

Table 4: Effect of phosphorus and AMF inoculants on root, shoot and total plant biomass

Treatment	Root Fresh Yield (t/ha)	Shoot Fresh Yield (t/ha)	Total Plant Fresh Biomass (t/ha)
P Level (P)			
0	34.99	48.22	83.22
17.5	36.00	43.51	79.51
35	31.01	36.44	67.46
SE	3.10	3.11	6.07
Inoculant (I)			
Glomygel	33.19	41.04	74.22
Symbiom	34.52	42.91	77.43
Control	34.30	44.22	78.53
SE	3.10	3.11	6.07
Interaction P x I			
Significance	NS	NS	NS

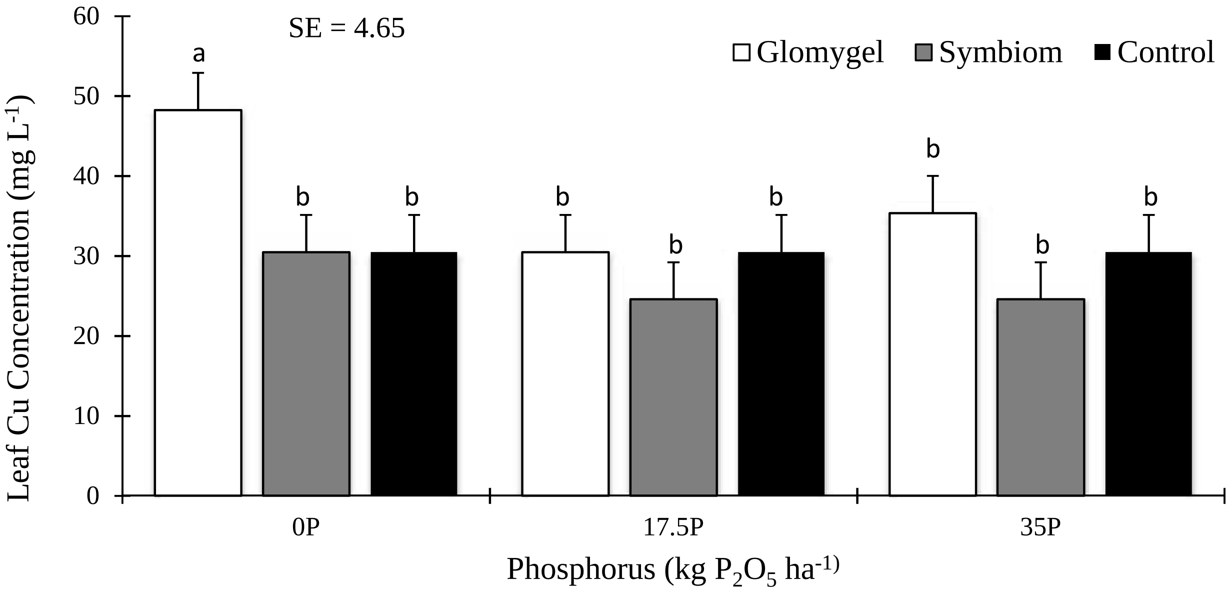

Figure 1: Interaction between P fertilizer and AMF inoculants on the leaf Cu concentration

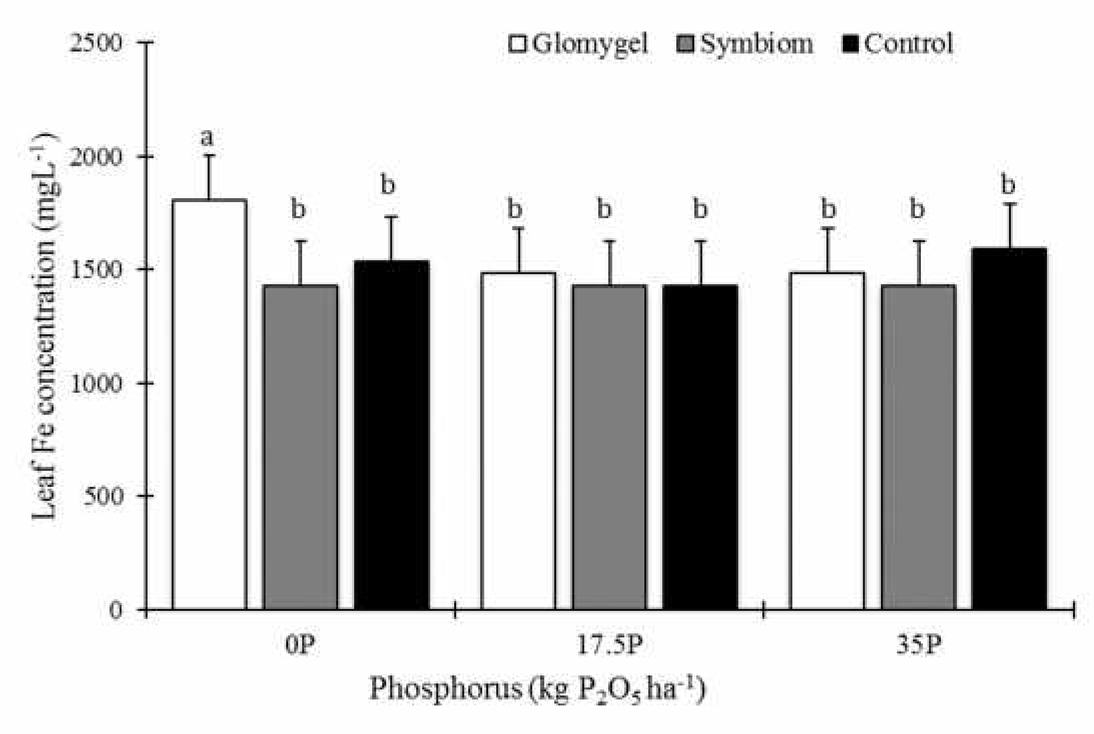

Figure 2: Interaction between P fertilizer and AMF inoculants on the leaf Fe concentration

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CATTLE (*Bos indicus*) MARKETING IN MAJOR LIVESTOCK MARKETS OF KANO AND JIGAWA STATES, NIGERIA

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Abstract
The interaction effects of weeks of the month, seasons (Early Dry-EDS, Late Dry-LDS, Early Rainy-ERS and Late Rainy-LRS), years (2008 and 2009) and market (Wudil, Dambatta, Maigatari and Gujungu) on live weight and price of cattle were investigated at the major livestock markets of Kano (Wudil and Dambatta) and Jigawa (Gujungu and Maigatari) States. A total of 10,400 cattle (50 cattle per week per market) were randomly sampled. Prices and live weights of cattle were recorded using 50 structured questionnaires administered weekly through visits to the markets from May 2008 to May 2009. Data collected were fitted in a nested set of a completely randomized design and step-wise regression was used to compare variables. Results showed that the lowest cattle price /KgLW was obtained at Wudil and Gujungu (second week), Maigatari and Dambatta (fifth week) were N206.17/Kg, N 202.67/Kg, N 195.65/Kg and N 191.52/Kg, respectively. The mean price/KgLW of (N 219.60/Kg) of cattle in Wudil market was the highest during the ERS compared to Gujungu (N 199.94/Kg), Maigatari (N 209.85/Kg) and Dambatta (N 198.05/Kg). In both years, highest mean weight of cattle was recorded at Wudil (317.81 vs 357.82 Kg) and Dambatta (331.53 vs 326.38 Kg) compared to Gujungu (310.21 vs 313.28 Kg) and Maigatari (310.78 vs 321.31 Kg). In 2008, the lowest values of N 186.60/KgLW and N 188.90/KgLW were obtained during LRS and ERS at Maigatari and Dambatta, respectively. In 2009 the lowest value of N 198.24/KgLW was recorded at Gujungu market during LRS. The weight (β =0.906; p>0.001), sex (β =0.033; p>0.001), age (β =0.006; p>0.001) and breed (β =0.003; p>0.001) of cattle significantly (p<0.001) contributed to cattle price. The week (β = 1614.0; p<0.001), month (β = 273.7; p<0.005), season (β=238.735; p<0.001) and year (β=965.895; p<0.001) of sale significantly affected prices of cattle in the study area. It was concluded that cattle parameters and period of sales determines cattle price in the study area.

Key words: Cattle, Market, Price, Season, Week and Year

Introduction

West Africa is recognized as a reservoir of great genetic diversity with multifunctional livestock rearing systems. According to Missohou and Adakal (2004), short horn cattle of West Africa has a live adult weight ranging from a minimum of 115 to 750 Kg for Samba breeds in Benin and Togo, and Kuri breeds in Niger and Nigeria. However, the live adult weight of Zebu cattle ranges from an estimated 240Kg for females to 660Kg for males of the Sokoto Gudali breed in Nigeria (FAO, 2005). These animals contribute significantly to an estimated 25% of household income (Willson, 1990).

Sanni et al. (2004) observed that majority of poor rural households depend essentially on livestock for their income. Animal products play a direct and indirect role of reducing food insecurity in Nigeria and other West African Countries. The intake rate of animal protein in daily diet is an important indicator of a country's developmental level. Sassons (1986) classified nutritional indicators and described as under nourished, a country that consumed 2000 Kcal and 10 to 30g of animal protein per capita per day. The minimum calorie required by a 65Kg person in a situation of food security is 2400 Kcal and at least 55g animal protein daily. According Honfoga and Vander Boom (2003), in most developing nations, livestock producers are far away from reaching the minimum requirements for calorie and animal protein.

In traditional pastoral and agro-pastoral systems, productivity by weight is 7 to 14 Kg/year/cow and is labour intensive. Though there is availability of cheap labour in the African pastoral system, productivity is low and this is compounded by poor marketing system (Williams et al., 2004). Cattle in Nigeria are supplied through domestic production from pastoral and agro-pastoral systems. Other sources of cattle supply are imports from the Niger, Chad and Cameroon (MARD, 2005).

The importation of cattle by Nigeria fell from 187, 600 heads in 1999 to 54, 000 heads in 2001 (Kamuanga et al., 2008) Theoretically, the Nigerian Market is expected to grow mainly due to demographic changes, growing urbanization, the creation of new international cattle market in Kano and the development of all border markets, ideal management of cattle markets, a political decision to develop local supply and the construction of new abattoirs in Kano and Kaduna (SWACOCED/ECOWAS, 2008). The condition required to increase the rate of sustainable exploitation of livestock resources in Nigeria must be combined with measures to ensured good understanding of livestock marketing systems and to improve their efficiency. Hence, the current study was designed to assess the effect of weeks of the month, season, year and market on live weight and price of cattle at the major livestock markets of Kano and Jigawa States.

Materials and Methods

Study Area

The study was conducted at Jigawa (Gujungu and Maigatari) and Kano (Dambatta and Wudil) States. Kano and Jigawa states cover a combined area of 43,000 km2 in the Sudan Savannah Vegetation Zone of Northern Nigeria. The area is characterized by a long (October April) hot dry season and a short (May-September) rainy season with an average annual rainfall ranging from 787 to 960 mm and mean annual temperature that ranged from 21 to 39^0C (Olofin, 1987). Jigawa State lies between latitudes 110 35' and 130 00' East and longitude 80 00' and 100 35' North (Olofin, 1987). The state is bordered to the West by Kano State, to the East by Bauchi and Yobe States and to the North by the Republic of Niger (Anonymous, 2003). Kano State lies between longitude 90 30' and 12° 30' North and Latitude 9° 30' and 8° 42' East. Kano State borders Jigawa State by North and South, Northwest by Katsina State, Kaduna State by Southwest and Bauchi State by Southeast.

The breeds of cattle predominantly found in these areas are White Fulani (Bunaji), Sokoto Gudali (Bokoloji), Red Bororo (Rahaji), Adamawa Gudali and Kuri (Blench, 1999).

Sampling Technique

Data on market location, cattle LW (weight band), and weeks of the month, season, year and price were collected using structured questionnaires between May 16, 2008 to May 10, 2009 by trained enumerators with the aid of traditional middle men ("*Sarkin Turke*"). Price of cattle was recorded as the accepted price negotiated between the buyers and middle men, which were verified by *"Sarkin Turke"* (Barnerjee, 2005).

Method of data Analysis

The experiment was laid in a 2x4x4 nested design. The factors were 2008 and 2009, 4 Markets (Wudil, Dambatta, Maigatari and Gujungu) and 4 seasons (EDS, LDS, ERS and LRS). Significantly difference means were separated using Duncan Multiple Range Test (DMRT) and Least Significant Difference

(Gomez and Gomez, 1989). The degree of association of cattle parameters (live weight, sex and age), period (week, season and year) and market of sales were arranged factorially and analyzed using Step-wise Multiple Regression Models (Greene, 1993) as shown in equations 1 and 2.

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta4x4 + U \ldots (1)$$

Where:
$\beta0 – \beta4$= regression coefficients
X_1 = Live weight
X_2 = Sex
X_3 = Age
X_4 = Breed
U = error term

$$Y= \beta0+ \beta1x1 + \beta2x2 + \beta3x3 + \beta4x4 + U \ldots (2)$$

Where
β_0 = Intercept
X_1 = Week
X_2 = Season
X_3= Year
X_4 =Market

Results and Discussion

The interaction of week and market on live weight and price of cattle is shown in Table 1. The lowest price/KgLW was obtained at Wudil (₦206.17/Kg) and Gujungu (₦ 202.67/Kg) during the second week of the month while the lowest values were obtained at Maigatari (₦ 195.65/Kg) and Dambatta (₦ 191.52/Kg) during the fifth week of the month. The highest price/KgLW was obtained during the fifth week of the month for Wudil (₦ 215.43/Kg), during the first week for Gujungu (₦ 211.06/Kg), second week for Maigatari (₦ 208.13/Kg) and Dambatta (₦ 213.18/Kg). Wudil and Gujungu markets recorded the lowest price/KgLW during the second week of the month. This may be attributed to the fact that key market participants are salary and wage earners which manifest in decrease demand of cattle in both urban and rural markets, which reduces price. Adamu and Ndako-Ganna (2003) established that celebrations, fuel price and transportation cost contribute significantly to livestock price in Lapai and Lambatta markets of Niger State, during the fifth week of the month, cattle supply at Dambatta and Maigatari markets tend to be high in anticipation of patronage by salary and wage earners, which tend to glut the markets and reduce price. According to Adamu (1982) livestock marketing is a complex activity involving several categories of players such as sellers, buyers, transporters and commission agents.

Table 1: Interaction Effect of Week and Market on Live Weight and Price of Cattle

Week of the month	Markets (Mean ±SE)			
First Week of the month	Wudil	Gujungu	Maigatari	Dambatta
Weight (Kg)	340.90±4.46	289.80±4.09	294.89±4.28	321.93±4.87
Price (₦)	70,824.7±1136.45	61,165.7±885.03	60,287.3±11010.96	67,844.3±1159.25
Price (Kg/LW)	207.75	211.06	204.43	210.74
Second (8th – 14th day)				
Weight (Kg)	311.92±4.87	276.30±4.36	315.16±4.13	317.0±4.30
Price (₦)	64,310.4±1077.11	56,000.2±920.16	65,595.8±996.78	67,578.4±1045.39
Price (Kg/LW)	206.17	202.67	208.13	213.18
Third (15th – 21st day)				
Weight (Kg)	332.69±4.22	313.03±4.34	339.88±4.46	330.36±4.54
Price (₦)	69,042±1053.35	64,677.5±969.52	70,444.8±1150.24	66,968.7±948.71
Price (Kg/LW)	207.52	206.62	207.26	202.71
Fourth (22nd – 28th day)				
Weight (Kg)	343.63±4.62	334.36±4.78	295.98±4.74	351.10±4.07
Price (₦)	72,207.6±1094.47	70,707.5±1064.60	60,458.5±1025.90	72,511.5±930.89
Price (Kg/LW)	210.13	211.47	204.26	206.52
Fifth (29th -31st day)				
Weight (Kg)	317.33±8.62	404.91±8.36	363.17±9.59	325.89±8.39
Price (₦)	-68,361.0±25 85.44	027.6±1908.02 -71	056.70±2149.33 -	62,413.5±1902.21
Price (Kg/LW)	-215.43	-209.99	-195.65	-191.52

Source: computed from survey data, 2009

Table 2 shows the interaction of market and season on live weight and price of cattle. The mean price/KgLW of cattle in Wudil (₦ 219.60/Kg) market was the highest during the ERS compared to Gujungu (₦ 199.94/Kg), Maigatari (₦ 209.85/Kg) and Dambatta (₦ 198.05/Kg). The mean price of cattle during the LRS in Gujungu (₦ 203.07/Kg) and Dambatta (₦ 203.32/Kg) were similar and higher than the price obtained at Wudil (₦ 189.92/Kg) and Maigatari (₦ 186.59/Kg). Highest price of cattle were recorded during EDS and LDS for the four markets studied. Cattle live weight recorded were highest during LRS, which could be due to the fact that forage were at peak of nutrient profile, likewise diseases prevalence is generally low. This result is similar to the reports of Yakubu *et* al. (2006) on small ruminants, which shows that cattle tends to gain weight during LRS in southeastern Bauchi State.

The low cattle price during EDS was attributed to farmers' behavior of selling some of their stock to augment short fall in grains before next harvest. This practice by farmers increase cattle supply which could reduce price, contrary to the report of Jabo and Muhammed (2009) Wudil market recorded its highest mean price/KgLW during ERS while Gujungu had its highest price value during both EDS and LDS. Jabo and Muhammed (2009) reported that mean price offered for cattle during the late rainy and early dry seasons were highest and the least price was recorded during the ERS. This is also in accordance with the study of Mohammed (2000) in which the highest price of cattle and dromedaries were recorded during the dry season in Northern Nigeria

Table 2: Interaction Effect of Market and Season on Live Weight and Price

Season	**Market (Mean ± SE)**			
	Wudil	**Gujungu**	**Maigatari**	**Dambatta**
Early rainy (Apr-Jun)				
Weight (Kg)	316.30 ± 4.72	329.58 ± 3.02	329.58 ± 4.29	232.09 ± 4.08
Price (₦)	74,055.00 ± 1433.50	61,784.00 ± 917.89	69,163.94 ± 1184.09	65,768.47 ± 1085.73
Price (₦/KgLW)	211.96	199.94	209.85	198.05
Late rainy (Jul-Sep)				
Weight (Kg)	316.30 ± 3.62	351.12 ± 4.19	321.76 ± 4.11	360.70 ± 3.94
Price (₦)	60,073.00 ± 841.09	71,303.00 ± 912.01	60,038.00 ± 967.69	73,336.02 ± 883.93
Price (₦/KgLW)	189.92	203.07	186.59	203.32
Early dry (Oct-Dec)				
Weight (Kg)	309.00 ± 4.92	284.21 ± 5.37	298.19 ± 4.72	301.42 ± 4.66
Price (₦)	67,004.00 ± 1072.57	60,909.00 ± 1164.27	62,541.54 ± 1003.80	64,151.57 ± 1019.76
Price (₦ /KgLW)	216.84	214.30	209.74	212.83
Late dry (Jan-Mar)				
Weight (Kg)	354.73 ± 3.76	303.58 ± 3.88	309.00 ± 4.41	327.51 ± 4.15
Price (₦)	76,026.00 ± 864.48	66,569.17 ± 832.62	66,708.00 ± 948.14	70,279.29 ± 926.24
Price (₦ /KgLW)	214.32	219.28	215.88	214.58

Source: computed from survey data, 2009

Table 3 shows the interaction of market and year on live weight and price of cattle. In both years (2008 and 2009) highest mean weight of cattle were recorded at Wudil (317.81 vs 357.82 Kg) and Dambatta (331.53 vs 326.38 Kg) as compared to Gujungu (310.21 vs 313.28 Kg) and Maigatari (310.78 vs 321.31 Kg). The price/KgLW in Maigatari was the lowest in 2008 (₦ 200.99/Kg) while Wudil market had the lowest price/KgLW (₦ 211.41/Kg) in 2009.

No difference was recorded in live weight of cattle in the markets studied between 2008 and 2009. It is recorded that changes in cattle parameters due to years manifest over a long period of time (Adamu, 1982; Bailey *et al.*1999). In both years studied, Wudil and Dambatta markets had cattle with highest mean weights. This confirmed the results of Egbewande *et al*. (2010) that larger cattle brought to the markets with proximity to urban centers usually command higher prices. Slight variation was recorded in prices of cattle in both urban and rural markets, probably as a result of changes in infrastructure and services such as veterinary services and rural roads associated with cattle marketing.

Table 3: Interaction Effect of Market and Year on Live Weight and Price of Cattle

Market	**2008 (Mean ± SE)**			**2009 (Mean ± SE)**		
	Weight (Kg)	Price (₦)	Price (₦/KgLW)	Weight (Kg)	Price (₦)	Price (₦/KgLW)
Wudil	317.81±2.81	65,736.08 ±719.25	206.84	357.82±3.25	75,464.59±734.22	211.41
Gujungu	310.21±3.09	63,803.75 ±688.00	205.67	313.28±3.09	66,665.50 ±659.28	212.80
Maigatari	310.78±2.79	62,464.95 ±680.85	200.99	321.31±3.64	68,337.47 ±774.73	212.68
Dambatta	331.53±2.76	67,464.11 ±642.68	203.49			213.45

Source: computed from survey data, 2009

The interaction of season, year and market on mean live weight and price of cattle is shown in Table 4. The highest price/KgLW was obtained at Wudil (₦ 218.03/Kg) market during ERS of 2008, while Gujungu market had its highest value of ₦ 219.28/KgLW during LDS of 2009. The lowest values of ₦ 186.60/KgLW and ₦ 188.90/KgLW were obtained during LRS and ERS at Maigatari and Dambatta in 2008, respectively. In 2009 the lowest value of ₦ 198.24/KgLW was recorded at Gujungu market during LRS. There is no consistency in prices and weight of cattle due to market, season and year which could be related to high variability in reasons for selling cattle. Bailey *et al*. (1999) reported that pastoralists sell livestock for cash and as necessitated by climatic and other socio-economic conditions. Dalgado *et al*. (1999) stressed the fact that urban consumers diversify their diets as a result of the wider choice offered and exposure to more varied cultural influences. Urban dwellers consumed more animal products than their rural counterparts. According to Thuillier Cedan and Bricas (1998) the proportion of food expenditure allocated to animal products reaches 30.8% in urban Cotonou, Benin Republic.

Table 4: Interaction effect of season, Year and Market on Mean Live Weight and Price of Cattle

Market	**2008 (Mean±SE)**			**2009 (Mean ±SE)**		
Wudil	**Weight (Kg)**	**Price (₦)**	**Price (₦/KgLW)**	**Weight (Kg)**	**Weight (Kg)**	**Price (₦/KgLW)**
ERS	338.10±6.53	73,716.14±2,195.18	218.03	366.56±6.41	74,571.74±1,387.28	203.41
LRS	316.31±3.62	60,073.37±841.09	189.92	-	-	-
EDS	309.05±4.92	67,004.29±1,072.57	216.81	-	-	-
LDS	-	-	-	354.73±3.76	76,026.92±864.48	214.32
Gujungu						
ERS	288.82±4.74	56,242.19±1,208.71	194.73	336.78±5.95	69,191.67±1,294.46	205.45
LRS	361.15±4.61	73,631.00±1,010.46	203.88	300.97±8.50	59,665.00±1,679.78	198.24
EDS	284.21±5.37	60,909.23±1,164.27	214.31	-	-	-
LDS	-	-	-	303.58±3.88	66,569.17±832.62	219.28
Maigatari						
ERS	313.77±5.83	66,840.69±1,879.75	213.02	347.98±6.20	71,866.67±1,320.56	206.53
LRS	321.76±4.11	60,038.92±967.69	186.60	-	-	-
EDS	298.19±4.72	62,541.54±1,003.80	209.74	-	-	-
LDS	-	-	-	308.10±4.41	66,708.62±948.14	216.52
Dambatta						
ERS	338.36±5.51	63,917.25±1,549.72	188.90	323.74±6.04	66,236.77±1,456.51	204.60
LRS	360.02±3.97	73,267.73±891.35	203.51	-	-	-
EDS	301.42±4.66	64,151.57±1,019.76	212.83	-	-	-
LDS	-	-	-	327.51±4.15	70,279.29±926.24	214.59

ERS=Early Rainy Season, LRS=Late Rainy Season, EDS=Early Dry Season and LDS=Late Dry Season
Source: computed from survey data, 2009

Table 5 shows the stepwise regression analysis of factors of cattle price. The weight (β =0.906; p>0.001), sex (β =0.033; p>0.001), age (β =0.006; p>0.001) and breed (β =0.003; p>0.001) of cattle significantly (p<0.001) contributed to cattle price. The weight of cattle determined 90.6% of price of cattle (0.906). The sex of cattle negatively affected price in the markets studied. This findings were similar to the reports of Jabo and Muhammed (2009) who indicated significant influence of age, sex, breed and season of the year on price of cattle in Sokoto State, Nigeria. In a study of analyses of market concentration among beef marketers, Oladeebo and Dare (2008) reported that cost of beef and transport contributed positively and significantly to yearly sales earnings.

Table 5: Step-wise Regression Analysis for Factors Affecting Cattle

Step	Factor	Coefficient (β)	T
1	Constant	3.357E3***	6.179E4***
2	Constant	0.919	-353.183***
	Weight (Kg)	0.909	5.855E4***
	Sex of Animal	-0.034	-2.163E3***
3	Constant		411.195***
	Weight (Kg)	0.906	4.771E4***
	Sex of Animal	-0.033	-2.148E3***
	Age (Years)	0.006	-448.221***
4	Constant		-448.221***
	Weight (Kg)	0.906	4.766E4***
	Sex of Animal	-0.033	-2.150E3***
	Age (Years)	0.006	317.609***
	Breed of Cattle	0.003	180.798***

Source: computed from survey data, 2009
R = 0.919; R^2=0.846; ns = not significant; ***P<0.001 **P<0.05; * P<0.1;
R= Product moment coefficient
P = Probability level

Table 6 shows regression summary of the relationship between price of cattle as affected by period of sales, the weeks (β = 1614.0; p<0.001), months (β = 273.7; p<0.005), and year (β=965.895; p<0.001) of sales. No significant effect was recorded on cattle price and season of the year. Season affected price of cattle negatively (β= - 724.1; p<0.01).This implies that unit change in season could increase or decrease price of cattle in the study area by ±724.1.

Prices of cattle increase with increase in weeks of the month. Changes of the season from LDS to EDS increase price of cattle. The result was similar to the report of Akinleye and Sekunmade (2005) on hedonic analyses of livestock prices in Lagos State. Ojiako and Olayode (2008) reported the trend of livestock production and reported that time trend is positive and significant for periods as obtained in the current study.

Table 6: Regression Summary for Dependent Variable Price of Cattle

Independent Variable (Fixed)	**Coefficient (β)**	**SE± β**	**T (n=10,465)**
Intercept	82595.0	2288.325	36.0941***
Week	1641.0	192.251	8.5355***
Month	273.7	124.755	2.194*
Season	-724.1	238.735	-0.329**
Year	7093.2	956.895	7.4127***
Market	450.7	236.063	1.9094ns

ns = not significant; ***P<0.001 **P<0.05; * P<0.1;SE ± = standard error T = t value
Source : computed from survey data, 2009

Conclusion and Recommendations

Livestock production is considered as a vital source of employment and livelihood to many farming households in Nigerians and cattle are the most predominant and highly valued livestock in Nigeria. Highest price of cattle was recorded during Early Dry Season (EDS) and Late Dry Season (LDS) for the four markets studied and the most important determinant of price were weight, age and breed of the cattle. Therefore, the study recommends that producers and marketers should pay particularly attention to these variables in cattle marketing decision.

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RESPONSE OF OKRA (*Abelmoschus esculentus* (L) *Moench*) VARIETIES TO NPK FERTILIZER AND POULTRY MANURE IN NORTHERN GUINEA SAVANNAH OF NIGERIA

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Abstract
Field and pot trials were conducted during the 2012 rainy season at the Research Farm of the Institute for Agricultural Research Samaru and in the Orchard of the Department of Agronomy, Ahmadu Bello University Zaria respectively, to evaluate the effects of NPK fertilizer rates (0, 50, 100 kg ha^{-1}) at 50 % N, 30 % P, 30 % K and poultry manure levels (0, 2, 4 t ha^{-1}) on the performance of two okra varieties (Clemson spineless and Ex-Samaru-4). The designs used were Randomized Complete Block Design (RCBD) and Complete Randomized Design for field and pot trials respectively, replicated three times in all possible factorial combinations. Results showed no significant difference in 100- seeds weight, fruit length, and fruit diameter when NPK fertilizer was varied from 0 to 100 kg ha-^{1}, except at 7 WAS (weeks after sowing), higher number of fruits per plant (5.0), number of seeds per pod (80) and fruit weight (17 g) were recorded from 0 to 50 kg NPK ha^{-1} in both trials. Other yield parameters were significantly at par. Varying poultry manure from 0 to 4 t ha^{-1} increased fruit yield in both trials. Significant interactions were observed on variety and poultry manure on number of fruits per plant. Okra variety Clemson spineless gave longer fruits than variety Ex-Samaru-4, however both varieties were statistically at par on fruit yield kg ha^{-1} in both trials. Based on the result obtained in this study the best variety of okra is Clemson spineless and application of 100 and 50 kg ha^{-1} NPK fertilizer is recommended in order to attain optimum yield in field and pot trials. Furthermore, application of poultry manure at 4 t ha^{-1} is recommended for good yield of okra in the northern guinea savannah of Nigeria.

Keywords: NPK Fertilizer, Poultry Manure and Okra Varieties (Clemson spineless and Ex-Samaru-4)

Introduction

Okra (*Abelmoschus esculentus* (L) *Moench*) belongs to the family Malvacea, a flowering plant, originated from tropical and sub-tropical Africa, and it is natural to West Africa (Tindall, 1983). It is one of the important crops cultivated in Nigeria (Alimi, 2005). It is a leading fruit in the Nigerian market on the basis of land area, production and value (Akin- Taylor, 1996). Okra is mainly cultivated for its 'pods' which are cooked and eaten in Nigeria. Okra is a good source of vitamins, minerals, calories and amino acid found in seeds and compares favourably with those in poultry eggs and soya bean (Schippers, 2000).

Fertilizer use has been a long-time event in Nigeria. In spite of its use, crop yield is not increasing correspondingly, which reflect low fertilizer use efficiency (Ogunniyi, 2012). Plants need NPK for optimum growth and yield, the quantity required may differ from variety to variety and environmental factors. For optimum growth and yield, okra required 40-60 N, 20-40 P and 20-40 K (kg ha^{-1}) (Anonymous, 2004). Farmers commonly used inorganic fertilizer for the supply of these nutrients, the extent to which farmers can depend on this, is constrained by unavailability of the right type of inorganic fertilizer at the right time, high cost, lack of technical know-how and lack of access to credit facilities to support farming (Chude, 1999). Other problems related to the use of chemical fertilizers include inadequate supply, adulteration and high cost (Ahmed, 2006), while the continuous use may have pollution effect to the environment (Ojeniyi, 2007 Manure, most especially from animal waste serve a better alternative and a necessary option for improved okra production especially in the Guinea savannah of Northern Nigeria where the soils are highly depleted of some vital essential nutrients, poultry manure is relatively cheap, readily available and tend to be higher than inorganic fertilizer in terms of yield and improvement of soil physical properties. The use of manure, especially poultry droppings and other agricultural by-product for crop production has helped to improve agricultural practice in West African countries. The increasing demand for organic farm produce for its attendant health benefits and risk- free characteristic is another dimension to the use of organic manure in Agriculture especially in vegetables and fruits production (Anonymous, 2012). Nigerian Savannah soils are largely deficient in major essential nutrients like N, P and K, this makes it necessary to be replenished with the nutrients from sources like poultry, cow and goat manure, poultry manure has been found to have higher nutrient concentration (Iken and Amusa, 2004). Other benefits of manure application are improvement of physico-chemical properties of the soil which will result in improve okra productivity.

Other ways of improving soil fertility without resorting to mineral fertilizer is to use agricultural and agro-industrial residues as soil organic amendment. Most of the organic fertilizer materials are waste or bi-products of other agricultural crops and animals which are used to augment the soil nutrient status, the biological and physical conditions of the soil. The use of poultry manure as a means of maintaining and increasing soil fertility has been reported (Ojeniyi *et al*., 2003; Ojeniyi, 2007). Manure when efficiently and effectively used, ensures sustainable crop productivity by immobilizing nutrients that are susceptible to leaching. Nutrients contained in poultry manures are released more slowly ensuring longer residual effects, improved root development and higher crop yields (Abou El-Magd, 2005). Akinfasoye (1997) reported that Varietal difference also plays a role in yield determination in yield of okra. Information on adequate use of both NPK fertilizer and poultry manure on different varieties of okra are limited in the study, therefore this research was designed with the following objectives

(i) To determine the effect of NPK fertilizer and poultry manure on yield and yield components of okra.
(ii) To assess the performance of two okra varieties under the climatic conditions of Samaru.

Materials and Method

Field and pot trials to test the performance of Okra under different level of NPK fertilizer and poultry manure during 2012 rainy season were conducted at the Research Farm of the Institute for Agricultural Research, Zaria (11^0 $11^{'}$ N, 07^0 $38^{'}$ E, 684 meters above sea level) and in the Orchard of the Department of Agronomy, Ahmadu Bello University Zaria respectively. Poultry manure sample of broiler chicken was collected from Haf-sabil farm (Samaru Zaria) and analysed using routine analysis to determine the chemical properties of the manure. The treatments consist of two okra varieties (Clemson spineless and Ex-Samaru-4), obtained from Institute for Agricultural Research Samaru Zaria (I.A.R), three levels each of NPK (20:10:10) at the rates of 0, 50 and 100kg ha^{-1} and poultry manure at 0, 2 and 4 t ha^{-1}.

The field experiment was laid out in Randomized Complete Block Design (RCBD) with treatments arranged in all possible factorial combinations giving a total of 18 treatments and replicated three times, each gross plot was 4.5 m x 4 m long (18 m^2) and comprises of 6 ridges. While the net plot area was 3 m x 4 m (12 m^2) comprising of 4 ridges, at 75 and 40 cm inter and intra row spacing. For the pot trial, it was laid out in Complete Randomized Design (CRD) replicated three times.

Each plastic pot of 490 cm^2 cubic area was filled with 10 kg of soil (from area BZ of A.B.U) after gravels was separated. The seeds were treated with seed dressing chemical Apron star (20% w/w thimethoxan, 20% w/w metalaxyl-m and 2% w/w difenoconazole) at the rate of 10 g per 5 kg of seed against fungus and insect pests. Three seeds were sown per hole at intra row spacing of 40 cm on ridges. The seedlings were thinned to two plants per stand at two weeks after sowing (WAS) in the field trial, and to three stands per pot in the pot trial. Poultry manure was applied 3 days before planting in both trials, by incorporating it into the soil along the ridges in shallow groves of about 5cm in field trial for NPK fertilizer was applied by side dressing at 2 WAS as per treatments (0, 50 and 100 kg ha-^{1}) in both trials. Glyphosate herbicide was applied at the rate of 1.4 kg a.i ha-^{1} prior to land preparation to kill the emerged weeds before planting. Hoe weeding was carried out at 3 and 5 WAS in the field trial while for the pot trial, weeds were hand pulled on a regular basis. Artificial watering was done for two (2 weeks) at the end of the pot trial when rainfall had seized in order to supplement the crop water requirement.

The okra plants were sprayed against beetles and caterpillars, with Cyper force pesticide that has both systemic and contact action, at the rate of 0.5 litres per hectare (30 ml per 15 litres of water) four times during plant growth, at four days intervals. Spraying starts from 3 weeks after seedling emergence, and stopped before the plant starts fruiting. The rainfall, temperature and relative humidity data were obtained from the IAR meteorological station Samaru, Zaria throughout the period of the trials. Five plants were randomly sampled and tagged from each plot in the field, and all the three plants in the pot trial for observation on yield parameters at 3, 5 and 7 WAS, These Comprise of number of fruits per plant, fruit length, fruit diameter, fresh fruit weight per plot, fruit yield (kg ha^{-1}), number of seeds per pod and100-seed weight. The data collected was subjected to statistical analysis of variance to test the significance of treatments effect using the F-test (Snedecor and Cochran 1967). The means were separated using Duncan Multiple Range Test (Duncan, 1955).

Results

The result in table 1 shows the effect of treatment on some yield components. Both results in the field and pot trial showed no significant difference in number of fruits between the varieties evaluated. In the field experiment, application of NPK fertilizer at 100 kg ha^{-1} produced higher number of fruits (5.0) per plant than the control (3.0). The application of 50 kg NPK ha^{-1} and the control had statically similar number of fruits per plant. There was a significant interaction between variety and poultry manure in the field trial, while in the pot trial the result shows that the treatments had no significant effect on number of fruits per plant.

The Interaction between varieties and poultry manure on number of fruits per plant of okra varieties during 2012 rainy season in field trial at Samaru is presented in Table 2. It shows that varying poultry manure rates had no significant influence on number of fruits in Clemson spineless. However, Ex-Samaru-4 shows a corresponding increase in the number of fruits as the levels of applied poultry manure was increased.

When varieties were considered at 0 t ha^{-1} poultry manure, variety Clemson spineless produced higher number of (4.0) fruits than Ex-Samaru-4, however, when poultry manure was increased from 0 to 2 t ha^{-1}there was no significant difference in number of fruits between the varieties, but at 4 t ha^{-1} poultry manure, Ex–Samaru-4 significantly gave higher number of fruits per plant than Clemson spineless.

The results in both trials showed that varying poultry manure had no significant influence on fruits weight. Increase in NPK fertilizer from the control to 50 kg NPK ha^{-1} significantly increased fruit weight per plant, further increase to 100 kg NPK ha^{-1} gave fruit weight that were statistically similar to that at 50kg ha^{-1} in both trials. The interactions between the various treatments were not significant.

Similarly, in field and pot trials, Clemson spineless significantly produced longer fruits than Ex-Samaru-4. Neither NPK fertilizer nor poultry manure significantly influenced fruit length. None of the treatment interactions were significant on fruit length in both trials. Furthermore, the results show that the treatments had no significant influence on fruit diameter in both trials.

Table 1: Effects of NPK fertilizer and poultry manure on number of fruits, fresh fruit weight, fruit length and fruit diameter of okra varieties during 2012 rainy season field and pot trials at Samaru.

	Number of Fruits/plant		**Fresh Fruit Weight/plant**		**Fruit Length (cm)**		**Fruit Diameter (cm)**	
Treatment	Field	Pot	Field	Pot	Field	Pot	Field	Pot
Variety(V)								
Clemson spineless	4	5	14.82	15	12.03a	10.72a	2.08	1.85
Ex-samaru4	4	5	13.87	14.86	9.48b	7.14b	2.12	2.06
SE±	0.71	0.31	0.828	0.837	0.512	0.385	0.051	0.073
NPK (kg ha^{-1}) (F)								
0	3.0b	4	11.08b	11.56b	10.54	7.6	2.06	1.84
50	4.0ab	5	15.01a	15.45a	10.21	7.56	2.04	1.97
100	5.0a	5	16.94a	17.01a	11.52	8.62	2.17	2.05
SE±	0.27	0.38	1.004	1.025	0.051	0.471	0.062	0.089
Poultry manure t ha^{-1} (P)								
0	4	4	13.63	13.98	10.8	8.01	2.05	1.96
2	4	5	13.37	14.08.	10.8	7.67	2.15	1.97
4	4	5	16.02	16.07	10.67	8.11	2.08	1.93
SE±	0.27	0.38	1.004	1.025	0.051	0.471	0.062	0.089
Interaction								
V*F	NS	NS	NS	NS	NS	NS	NS	NS
V*P	*	NS	NS	NS	NS	NS	NS	NS
F*P	NS	NS	NS	NS	NS	NS	NS	NS
V*F*P	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant

Table 2: Interaction between varieties and poultry manure on number of fruits of Okra varieties during 2012 rainy season field trial at Samaru.

Poultry manure (tha^{-1})			
Treatment	0	2	4
Clemson spineless	4.0b	4.0b	4.0b
Ex-Samaru-4	3.0c	4.0b	5.0a
SE±	0.375		

Means followed by unlike letter are significantly different at 5% level of probability using DMRT were significant with respect to this character.

The effect of NPK fertilizer and poultry manure on some yield components is presented in **Table 3**. The result shows that in the field experiment, none of the treatments significantly affected number of seed per pod. In the pot trial, there was also no significant difference in number of seeds per pod between the varieties and varying poultry manure rates. However, when NPK fertilizer rates were varied, the control had the least number of seeds than 50 and 100 kg NPK ha^{-1} which were statistically comparable. The treatment interactions were not significant in both field and pot trials.

The result in the field shows no significant difference in 100-seeds weight between the varieties evaluated. However, in the pot trial Clemson spineless gave lower weight of 100-seeds than Ex-Samaru-4. Neither NPK fertilizer nor poultry manure significantly influenced 100-seed weight in both trials. No significant treatment interactions on 100-seed weight observed in both trials.

Table 3: Effects of NPK fertilizer and poultry manure on number of seeds per pod, 100-seeds weight (g) and fruit yield (kg ha^{-1}) of okra varieties during 2012 rainy season field and pot trials at Samaru.

	Number of Seeds per Pod		**100-seed weight (g)**		**Fruit Yield (kg ha^{-1})**	
Treatment	Field	Pot	Field	Pot	Field	Pot
Variety(V)						
Clemson spineless	78	80	4.83	4.18b	4110.6	4292.8
Ex-Samaru-4	79	78	5.08	5.00a	3937.2	3983.7
SE±	1.64	2.07	0.209	0.153	342.222	387.226
NPK rates (kg ha^{-1}) (F)						
0	76	65.0b	5.04	4.5	2728.0c	2892.3b
50	81	81.0a	4.93	4.64	4060.1b	4337.8a
100	78	80.0a	4.89	4.63	5283.6a	5184.6a
SE±	2.03	3.06	0.256	0.187	419.186	473.311
Poultry manure (t ha^{-1}) (P)						
0	78	78	5.08	4.46	3677.8	3480.9b
2	79	81	5.07	4.66	3699.1	3792.0ab
4	79	80	4.76	4.66	4694.8	5141.8a
SE±	2.03	3.06	0.256	0.187	419.186	473.311
Interaction						
V*F	NS	NS	NS	NS	NS	NS
V*P	NS	NS	NS	NS	NS	NS
F*P	NS	NS	NS	NS	NS	NS
V*F*P	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant

The result showed non-significant difference in fruit yield between the varieties in both trials. Increase in NPK fertilizer from 0 to 100 kg NPK ha^{-1} led to a corresponding increase in total yield of okra varieties in the field trial, highest fresh yield (5283.6 kg ha^{-1}) was obtained at 100 kg NPK ha^{-1}. Varying poultry manure rates did not significantly affect the fresh fruit yield (kg ha^{-1}) in field trial, while in pot trials 4 tha^{-1} poultry manure significantly gave the highest fruit yield (5141.8 kg ha^{-1}). There were no significant treatments interactions on fresh fruit yield (kg ha^{-1}).

Discussion

The significant difference recorded between the two okra varieties on fruit length and 100-seeds weight could be explained that these characteristics are genetical factors of the varieties which cannot be influenced by environmental and treatments given seriously. Variety Clemson spineless was observed to have longer pods than Ex-Samaru-4. Differences in yield of crops have been attributed mainly to the cultivars grown and their genetic makeup (Akinfasoye, 1997). Despite the aforementioned differences, the varieties were statistically comparable with respect to most of the yield characters. The improved (Clemson spineless) had no significant advantage over the local variety (Ex-Samaru 4) in respect to the treatments. The application of NPK however enhanced fruit weight and fruit yield per hectare. This agrees with the findings of Adediran and Banjoko (2003) which showed that application of NPK fertilizer is important in enhancing fruit number and yield of okra. Application of NPK fertilizer was also reported to cause a significant effect on fruit weight, fruit number and yield of okra (Jan *et al*., 2002). This is however contrary to the findings of Obi (2005) who reported no significant increase in fruit yield and fruit weight of okra plants with NPK fertilization.

Yield components such as number of fruits per plant, fruit diameter, number of seeds per pod, fruit weight per plant and 100-seeds weight were not significantly influenced by the application of poultry manure. This could be attributed to the fact that vegetative growth had been favoured more if poultry manure was applied at higher dosage. Application of high rate of manure with higher N content has been reported to cause reduction in fruits yield (Adekiya and Agbede, 2009). A significant response in fruit yield (kg ha^{-1}) to poultry manure was observed only in the pot trial, and this could be attributed to the Homogenous nature of the soil environment in the pot which facilitated evenly distribution of water and nutrients for proper uptake.

The result is in agreement with the findings of Nehra *et al*. (2001) and Sanwal (2007) that higher yield response due to organic manure is ascribed to the physical and biological properties of soil which results in better supply of nutrients that led to good crop yield.

The non-significant response in fruit yield (kg ha^{-1}) to poultry manure experienced in the field experiment could be as a result of water logging experienced in some of the plots made it difficult for the plants to respire and utilise the nutrient available in the soil for its growth and development, thus causing reduction in yield. Rajashree (2009) also reported that higher yield response of crops due to organic manure application could be attributed to improved physical and biological properties of soil resulting in better supply of nutrients to the plant.

The interactions between varieties and poultry manure on number of fruits per plant which Ex-Samaru-4 gave higher number of fruits per plant than Clemson spineless could be due to the genetic composition of the individual variety and their ability to adapt to the environmental conditions.

Conclusion and Recommendations

Application of 4 t ha^{-1} poultry manure using either of the varieties should be recommended for okra production for the pot trial in the northern guinea savanna of Nigeria. However, application of 100 kg ha-^{1} NPK fertilizer is recommended for okra production in the field, while 50 kg ha-^{1} in the pot trial for optimum yield.

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WATER QUALITY EVALUATION FOR IRRIGATION IN TOMAS IRRIGATION SCHEME, KANO, NIGERIA

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Abstract
The study evaluates the quality of underground and surface/ drainage water for irrigation purposes in Tomas irrigation Kano Nigeria. Water samples were collected from three (3) mapping units identified as Ballauda (Ba), Tomas (To) and Ladi (La), and analysed for parameters related to salinity, sodicity and toxicity. The results of salinity hazards using Electrical Conductivity (EC) and Total Dissolved Solids (TDS) of the irrigation water (IW) and drainage water (DW) were found to be low ranging from 0.09 to 0.85dsm^{-1} and 30 to 420 mgl^{-1} respectively. The pH of the irrigation and drainage water were strongly acidic to neutral 5.8 to 7.2. The underground and drainage water were found to be low in carbonates and bicarbonates with respective values ranging from 0.2 to 0.4mgl^{-1} and 0.7 to 3.5 mgl^{-1}. However, the Residual Sodium Carbonate (RSC) in all the mapping units ranged -2.6 to -7.9 mgl^{-1} indicating negligible amount of carbonate and bicarbonate. Furthermore, the Sodium Adsorption Ratio (SAR) was low 0.01 to 0.09 likewise the Adjusted SAR 0.02 to 0.24. Moderate levels of Ca were recorded in all the water samples 2.65 to 7.12 cmol (+) kg^{-1}, while values for Mg, Na and K were all found to be low. No nitrate was detected in the water, but sulphate and chloride levels were 0.5 to 2.4 mgl^{-1} and 0.09 to 0.95 mgl^{-1} respectively. Other quality parameters such as boron levels (1.8- 2.0 mgl^{-1}) were indicating threat to phyto-toxicity in future. In conclusion, the water from underground and surface/drainage was found to be safe and suitable for irrigation, with a threat to boron phyto-toxicity.

Key words: Water Quality, Sodicity, Salinity and Phyto- toxicity.

Introduction

The practice of irrigation consists of applying water to the part of the soil profile that serves as the root zone, for immediate and subsequent use of the crop. The water used for irrigation came from ocean drifts, reservoirs, high level underground water table, mineral weathering of rocks and minerals (Harney *et al.*, 2005; Asiamah, 1995). This can cause a buildup of salts in the root zone, particularly if the internal drainage of the soils is restricted and leaching either due to rainfall or applied irrigation is in adequate. (Sanchez and Silvertooth, 1996) High level of salts in the irrigation water reduces water availability to the crop (because of osmotic pressure) and causes yield reduction (Ezlit et al.,2010)

Several studies were carried out to assess the impact of irrigation water quality on soil properties and crop growth (Richards, 1954; Wilcox and Durum, 1967; Asiamah, 1995; Malgwi, 2001; Omar, 2012). The most important irrigation water parameters for estimating salinity and sodicity hazards include electrical conductivity (EC), Total Dissolved salts (TDS), Sodium adsorption ratio (SAR), Adjusted SAR, Residual Sodium Carbonate (RSC) and amount of toxic substances. Irrigation water with EC of 7.5dsm^{-1} is considered safe. However, irrigation water with EC of > 4dsm^{-1} may result in soil salinization. The higher the EC, the less water is available to plant, even though the soil may appear wet (Bauder *et al.*, 2011). High saline irrigation water reduces seed germination, rooting, growth, establishment and fruiting of plants (Hillel, 2000). The threshold limit of RSC in irrigation water was > 2.5cmolkg^{-1}, and anything <1.25

cmolkg^{-1}is considered safe, while ESP of > 10% was considered toxic.

Besides being toxic to the plants, the use of salty underground water for irrigation has led to deleterious effect on the morphology and chemistry of soils, showing high levels of Na and Ca throughout the profile (Asiamah, 1995). Suarez *et al.* (2006) found that a SAR increase caused by irrigation water had an adverse impact on water infiltration for clay and loam. High SAR levels also might result in a breakdown of soil structure and water infiltration problems and as such the soil tends to seal and become hard and compact when dry (Duncan, Carrow and Huck,2009). Bauder *et al*. (2011) has affirmed that, the reductions in infiltration can occur when irrigation water contains high sodium relative to the calcium and magnesium contents. High level of bicarbonates in irrigation water can form complexes with Mg and Ca, thereby reducing Ca and Mg for plant uptake and colloidal dispersion (Lienauer and Devitt, 2013). In arid regions, boron is considered the most harmful elements in irrigation water. The Food and Agricukture (2007) have confirmed the toxicity of Boron even at relatively very low concentrations of 0.6 mgl^{-1}, while a chloride content exceeding 10mgl^{-1} may cause severe problems to crops (FAO, 2007). The application of poor quality irrigation water and its detrimental effects on soil properties can reduce quality and yield of crops. This paper discusses the quality of water used for irrigation in Tomas irrigation scheme.

Materials and Methods

Description of the study area

The study area is located within old Dambatta and new Makoda Local Government Areas, in the western part of Kano State, east of Kano - Daura road. It is situated approximately between latitudes 12º 18` and 12º 25`N, longitude 8º 32` and 8º 38`E. (Figure 1). The area has a seasonal climate which is largely determined by inter tropical discontinuity zone (IDZ). The rainy season normally begins in May and ends in September. The seasonal variation in temperatures show increase from January (29.5^{O}C) to May (38.22^{O}C). The weathered basement complex rocks are overlain by thick deposits of colluvial, alluvial and aeolian materials or a combination of these, just like that of Jakara River (Malgwi 2001). In general, the soils are weakly developed with little horizon differentiation (MANRK 1978). The natural vegetation was of Sudan sub humid (FDLAR, 2013). The vegetation was modified by cultivation, bush burning, and animal grazing.

Water sampling

Underground and surface water were sampled from three (3) soil mapping units Ballauda(Ba), Ladi (La), Sansan (Sn) and Tomas (To), produced by Ministry of Agriculture and Natural Resources, Kano (MANRK, 1978). The samples were collected in plastic bottles for laboratory analysis. Parameters determined were pH, Electrical Conductivity (EC), Dissolved cations (Ca, Mg, K, Na), Carbonate and Bicarbonate, Boron, Sulphate, Chloride and Nitrate were determined using standard laboratory procedures as described by Barua and Brthakur (1997). Sodium Adsorption Ratio (SAR), Adjusted SAR (Adj. SAR), Residual Sodium Carbonate (RSC), and Total Dissolved Solids (TDS) were all calculated using standard formulae.

Data analysis

The sampling procedure was completely randomized, and the data generated were statistically analyzed by descriptive statistic using ranges and means (Agbenin, 1995).

Results and Discussion

The parameters analyzed were that of Salinity hazards, Sodicity hazards (permeability), Anionic composition, pH, Basic cations, and heavy/toxic metals. The Electrical Conductivity (EC) and Total Dissolved Solids(TDS) of all the water samples were low (table 1), and therefore indicated no potential threat of salinity, as their EC and TDS values fell below the critical level of 0 to 3dSm^{-1} and 0 to 2000 mgl^{-1} for irrigation water (Shahinasi and Kashuta, 2008). Therefore, the irrigation water does not pose any danger to the soils and crops and it is considered suitable for irrigation. The pH of the irrigation and drainage waters ranged from 5.8 to 7.2. This indicates an acidic to neutral condition. Safe pH range for irrigation water was between 6.0 and 8.5 (Omar, 2012).

The Residual Sodium Carbonate (RSC) was found to be negative in all the water samples studied, indicating negligible number of carbonates and bicarbonates in the water (Lakotoro and Singh, 2000). Residual Sodium Carbonate value of > 2.5 may lead to salt build up, which may hinder the air and water movement by clogging the soil pores and lead to degradation of the physical condition of soil (Surthasiny, *et al*., 2012). The values in (Table 1) confirms the suitability of the water for irrigation, as the carbonates and the bicarbonates levels in the irrigation water did not reach the limit proposed by Landon (1991).

Lower values of Mg, Na and K and moderate levels of Ca were observed in all the water samples (Table 1). The low Na concentration in the water was an indication that, the water is free from problems associated with high Na concentration (Omar, 2012). When the sodium ion is high in irrigation water, it tends to be absorbed by clay particles, displacing Ca and Mg ions, there by leading to reduced soil permeability and poor internal drainage (Belkhiri, *et al.*, 2010). The Sodium Adsorption Ratio (SAR) and Adjusted SAR were also low making the irrigation water non sodic and therefore suitable for irrigation.

Although nitrate, sulphate, chloride and boron are essential to plants in very low amount, they can be toxic to sensitive crops at high concentrations (Bauder *et al.*, 2011). No nitrate was detected in the Tomas irrigation water. The values for sulphate and chloride were not up to the critical limits of 960 mgl^{-1}, proposed by Landon (1991). However, chloride content of as low as >10 mgl^{-1} may cause severe problems to crops (FAO, 2007). So the water samples were good, suitable and safe for irrigation purposes with regards to their nitrate, chloride and sulphate contents. For Boron, values which ranged from 1.8 to 2.0 mgl^{-1} were considered adequate when compared to the critical value of 0 to 2.0 mgl^{-1} proposed by Landon (1991). The Food and Agricultural Organization (2007), identified Boron to be extremely toxic even at relatively very low concentration of 0.6 mgl^{-1}.

Conclusion

The underground and surface water used for irrigation in Tomas irrigation scheme was found to be safe and suitable in relation to salinity, sodicity, and miscelleneous hazards. But for toxicity, there was a threat to Boron phyto-toxicity in future. Therefore, at present there are no hazards associated with the use of both surface water and groundwater for irrigation in watari irrigation scheme.

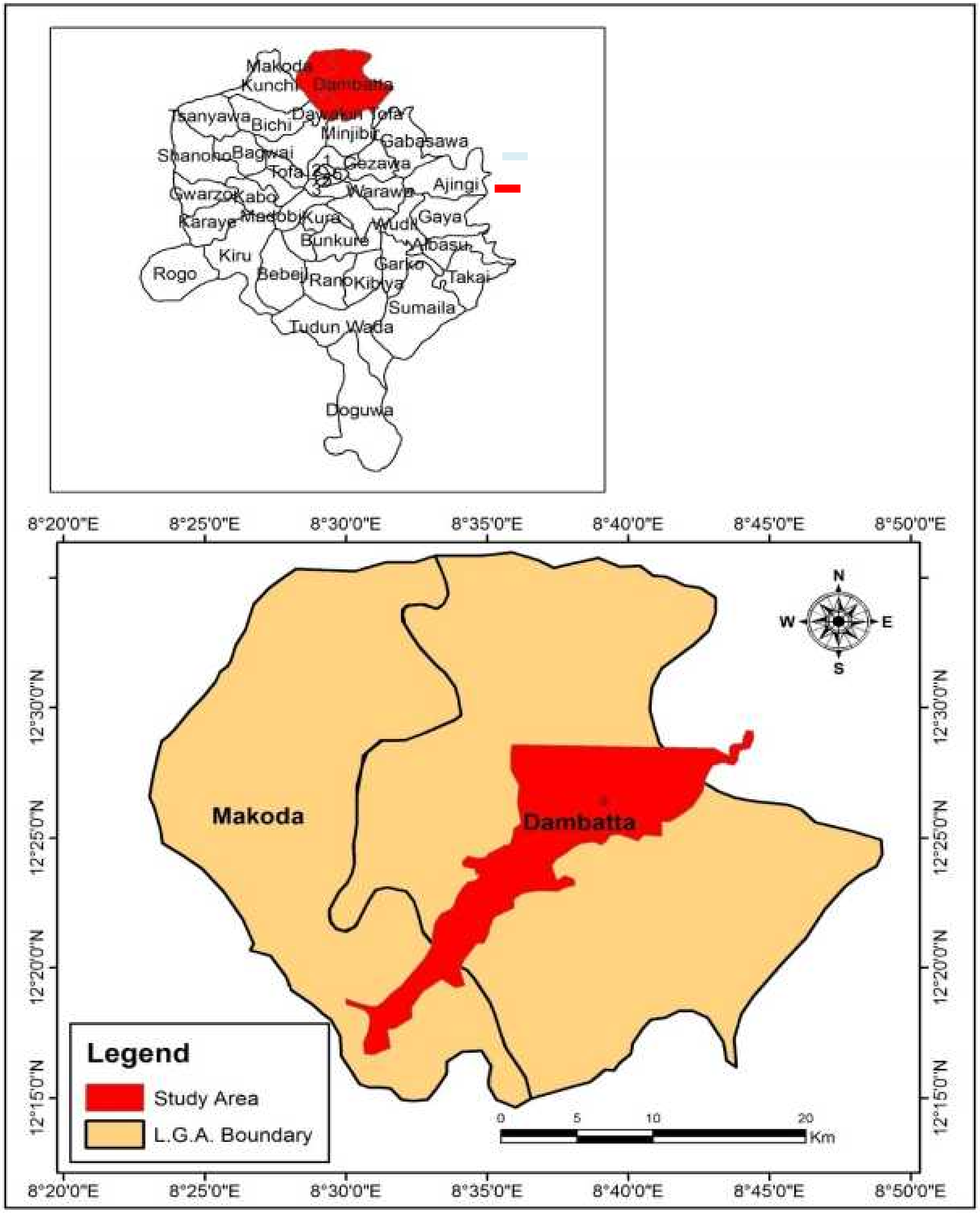

Figure 1: Map of Kano State showing the location of Tomas irrigation scheme

Table 1: Irrigation water quality indicators in Tomas irrigation scheme, showing mean values.

Mapping Units	PH	EC dS m^{-1}	Cl^{-1} mg l^{-1}	Co_3^{-2}	RSC	Hco_3^{-1}	SO_4^{-2}	BORON	TDS	K	Na	Ca	Mg	NO_3^{-1}	SAR	Adj. SAR
Ba(IW)	5.8	0.09	2.6	0.4	-6.4	2.0	420.000	1.9	420.00	0.02	0.08	6.23	2.56	0	0.04	0.09
Ba(DW)	6.9	0.5	2.7	0.4	-5.7	3.5	0.7	1.9	200.00	0.02	0.08	7.12	2.41	0	0.04	0.04
TO(IW)	7.2	0.09	1.7	0.3	-7.9	1.8	0.7	1.9	50.00	0.05	0.02	5.81	4.2	0	0.09	0.24
TO(DW)	7.2	0.85	2	0.4	-7.0	1.0	2.4	2.0	30.00	0.01	0.01	4.65	3.76	0	0.05	0.12
La(IW)	6.5	0.1	1.8	0.2	-7.0	1.2	0.5	1.9	50.00	0.07	0.02	5.43	2.8	0	0.09	0.22
La(DW)	6.6	0.95	1.7	0.2	-2.6	0.7	0.6	1.8	30.00	0.05	0.02	2.65	1.87	0	0.01	0.02

Key: Ba (IW) and Ba (DW):
Ballauda (IW) irrigation water and(DW) drainage water. To (IW) and To (DW):
Tomas (IW) irrigation water and (DW) drainage water. La (IW) and La (DW):
Ladi (IW) irrigation water and (DW) drainage water.

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EFFECT BAOBAB LEAF MEAL BASED DIETS ON THE PERFORMANCE AND CARCASS CHARACTERISTICS OF GROWER RABBITS

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Abstract
The experiment was conducted at Teaching and Research Farm of Department of Animal Science, Kano University of Science and Technology, Wudil to determine the performance and carcass characteristics of grower rabbits fed diets containing Baobab (Adansonia digitata) Leaf Meal (BLM). A total of thirty (30) mongrel grower rabbits (8 – 10weeks) were allotted to five diets containing baobab leaf meal at 0, 5 10, 15 and 20 % dietary levels designated as Treatments 1, 2, 3, 4 and 5 respectively. Each treatment was replicated three times and the experiment lasted for 12 weeks. The results showed that there were significant differences (P<0.05) in the final body weight (1491.33 - 1937.0g), daily weight gain (23.59 - 39.33g), feed intake (88.67-118.67g) and feed conversion ratio (2.75 - 3.79). Similarly, the carcass weights (814.03-1342.04g) and dressing percentage (55.95 - 73.21%) were significantly (P<0.05) affected by the dietary treatments. Most of the organs weight (heart, lung, liver, kidney and pancreas) were significantly (P<0.05) influenced by the dietary treatments. The feed cost per kilogram gain was significantly (P<0.05) better for grower rabbits fed Treatment 4 diet (₦222.99) compared to others. Therefore, baobab leaf meal can be incorporated in the diet of rabbits up to 15% dietary level with no adverse effect on productive indices/parameters and reasonable reduction in production cost.

Key words: Grower rabbits, Baobab leaf meal, Growth performance and carcass characteristics.

Introduction

Rabbit production is one of the attractive options for rapid animal protein production due to its advantages over other species of livestock. These include prolificacy, short generation interval, low feed consumption compared to cattle sheep and goat, its small maintenance cost and its ability to utilize appreciable quantity of forage compared to other non-ruminant animals. Feed is the largest single cost item for livestock and poultry production accounting for 60 – 80% of the total cost (Adegbola, 2004; Lawrence *et al.*, 2008). There is stiff competition that exists between man and animal for available feed resources with growing in livestock production (Robinson and Singh, 2001). This has greatly reduced profit margin and placed a great limitation on the rate of expansion of livestock industry in most of the industries. One of the pragmatic approaches of solving the problem of high feed cost is the use of readily available ingredients but less utilized such as plants resources like baobab leaves.

Baobab (*Adansonia digitata*) tree is a deciduous, drought and fire tolerant tree that is widely distributed in most African countries. The tree is massive and may be up to 20–30-meter-high with a lifespan of several hundred years (Heuze *et al*., 2013). This tree produces fruits all year round in the savannah zone of Nigeria, though the leaves are used for soup in the drier part of Nigeria particularly in the semi arid zone. It has been reported that Baobab leaves are rich in vitamin C, sugars, potassium and calcium (Coattes and Palgrave, 1985). The anti-nutritional factors that have been found in Baobab leaf meal include oxalate (8%) phytate (1%) and saponin (2.5%) trysin inhibitors (Osaman, 2004, Belewu 2008), Amylase inhibitors and tannin (Igboeli *et al*, 1997). The objective of the study was to determine the effect of dietary utilization of baobab leaf meal on productive parameters and cost benefit analysis of grower rabbits.

Materials and Methods

Experimental Site

This study was conducted at Teaching and Research farm of Kano University of Science and technology Wudil. The area lies between latitude $12^{0}58'$ N and longitude $8^{0}25'$ E. The mean annual rainfall is 890 mm with relative humidity of 75% during the rainy season. The location is situated at about 430m above sea level with a mean temperature of 26^{0}C. (Olofin *et al*., 2008).

Experimental Materials

Baobab leaves used for this study were bought from Wudil weekly market which is located within Wudil local Government area, Kano State, Nigeria. The baobab leaves were dried and milled using hammer mill to obtain baobab leaves meal. The sample was subjected to proximate analysis to evaluate the chemical composition and nutrient in the Biochemical laboratory of Animal Science, A. B.U., Zaria, as shown in Table 1.

Experimental Diets

Five experimental diets were formulated to contain 0%, 5%, 10%, 15% and 20% dietary level of baobab leaf meal for T_1, T_2, T_3, T_4 and T_5 respectively (Table 2). The diets were balanced as much as possible for crude protein and energy to meet the requirement of rabbits in accordance with the standard of NRC, (1990).

Experimental Animals, Design and Management

Thirty (30) Grower mongrel rabbits (Mixed breed) were used for the study. The rabbits were purchased from commercial rabbit keepers at Wudil market Kano State, Nigeria. They were quarantined upon arrival and treated against internal and external parasite using ivermectin at a dose rate of 200mg/Kg body weight subcutaneously. The grower rabbits were housed individually in rabbit's hutches. Rabbits were randomly assigned to treatments in a completely randomized design (CRD). Each treatment was replicated 3 times with equal number of animals. Feed were offered daily and water was supplied *ad libitum.*

Data collection

The rabbits were weighed individually at the beginning of the experiment using 10Kg weighing scale and thereafter, weekly weight gains were monitored on weekly basis. Feed intake was determined by measuring known quantity of feed supplied in the morning and left-over were weighed the following morning. Feed intakes were evaluated by subtracting the left-over from the amount offered. Rabbits were weighed on weekly basis to determine the weekly weight gains of each rabbit fed different treatments. The feed conversion ratio was calculated as the ratio of daily feed intake to unit weight gain of grower rabbits. At the end of the experiment four rabbits were randomly chosen from each treatment, slaughtered and eviscerated for carcass analysis. The carcass and organs weights were weighed using an electric weighing digital scale.

Statistical analysis

Data collected was subjected analysis of variance using SAS (2002) software package and where significance were existing, Duncan's multiple range test option (Duncan, 1955) was used to separate the means.

Results and Discussion

The results of the performance of rabbits are presented in Table 3. The results showed there were significant differences ($P< 0.05$) in the final body weight, total weight gain and daily feed intake, weight gain and feed conversion ratio. The final body weight was found to be higher for rabbits fed 15% baobab leaf meal diet (1937.00g) and significantly ($P<0.05$) similar with treatments 1(1842.33g) and 3(1857.0g). The lowest value final body weight was obtained for rabbits fed 20% dietary level of BLM (1491.33g). Daily weight gain was significantly ($P<0.05$) better and higher for those fed Treatment 4 (39.33g) and was statistically similar with values of Treatment 1, 2 and 3. The lowest value of daily weight gain was obtained for rabbits fed treatment 5 (23.59g). This agreed with report of Igboeli, *et al.* (1997) who said boabab leaf and seeds contain some essential nutrients that can influence growth rate. The work of Saulawa (2011) reveals that the leaves are eaten by wild and domestic animals as a source of fodder during dry season. The feed cost per kilogram gain was found better for grower

rabbits fed Treatment 4 (₦222.99) compared to others. This agreed with findings of Osman (2004) who stated that inclusion of baobab leaf meal in the rabbit diets may therefore be a way of reducing a cost of formulating rabbit diet. The feed conversion ratio was found to be better with the rabbits fed treatment 4 (2.75) whereas treatment 5 recorded least (3.79). This may be due to feed utilization by grower rabbits at 15% dietary level. This also agreed with report of Doma (1998) who said that the lower the feed conversion ratio the better the diet. No significant differences (P>0.05) observed for mortality among the treatments fed to rabbits containing baobab leaf meal.
The result of carcass analysis is presented in Table 4. There were significant differences (P<0.05) in the values observed for final live weight, carcass weight and dressing percentages across the treatments. The final live weight was recorded highest for rabbits fed Treatment 4 (1930.67g) and lowest for those fed 20% baobab leaf meal diet. Similarly, the carcass yield and dressing percentages were significantly (P<0.05) better for grower rabbits fed 15% BLM diets. The value of the carcass weight was highest at 15% BLM diets compared to others. Aduku and Olukosi (1990) also reported that changes in dressing percentages may be attributed to the differences in weight at slaughter stage.
The result of organs weights was also presented in Table 4. There were significant differences (P<0.05) in the values of organs weights (Heart, lung, liver, kidney and pancreas). The heart was found to be highest in Treatment 3 and 5, while the lung was significantly (P<0.05) higher in treatment 1 and 3. The liver weight was similar in all the treatments except for treatment 5 which is lower. It was concluded that grower rabbits can be finished on the diets whose baobab leave meal is 15% with no adverse effects. The study therefore recommend that BLM can be used as informed by the reasonably better production performance relative to other inclusion levels as far as the North-western Nigeria is concerned. Similar experiment should be carried out using different species of animals.

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Table 1: Proximate composition of Boabab leaf meal

Proximate component	Percentage (%)
Dry matter	94.86
Crude protein	13.25
Crude fibre	10.97
Ether extract	2.44
Ash	11.21
Nitrogen free extract	62.13

Table 2: Composition of grower rabbit diets containing Boabab leaf meal (%).

	Treatments				
Ingredients	**T1 (0)**	**T2 (5)**	**T3 (10)**	**T4 (15)**	**T5 (20)**
Maize	50.03	47.53	45.03	42.53	40.02
Baobab leaf meal	0.00	2.50	5.00	7.50	10.01
Soya beans meal	9.99	9.99	9.99	9.99	9.99
Groundnut cake	9.98	9.98	9.98	9.98	9.98
Wheat offal	25.40	25.40	25.40	25.40	25.40
Bone meal	3.50	3.50	3.50	3.50	3.50
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.30	0.30	0.30	0.30	0.30
Methionine	0.25	0.25	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**	**100**
Calculated Analysis					
Crude protein (%)	18.00	18.01	18.02	18.03	18.04
M. Energy (Kcal/kg)	2562	2557	2558	2567	2559
Crude fibre (%)	11.24	12.39	12.41	13.56	13.80
Ether extract (%)	4.57	4.81	5.01	4.66	4.72
Ash (%)	9.14	10.01	9.14	8.92	8.82

Table 3: Performance of grower rabbits fed diet containing Boabab leaf meal (%).

	Treatments					
Parameters	**T1 (0)**	**T2 (5)**	**T3 (10)**	**T4 (15)**	**T5 (20)**	**SEM**
Initial body weight (g)	826.33	834.33	843.33	835.67	830.67	25.22^{ns}
Final body weight (g)	1842.33^{ab}	1763.33^{b}	1857.00^{ab}	1937.00^{a}	1491.33^{c}	42.97*
Daily weight gain (g)	36.29^{a}	33.18^{a}	36.20^{a}	39.33^{a}	23.59^{b}	1.98*
Total weight gain (g)	1016.00^{a}	929.00^{a}	1013.6^{a}	1101.33^{a}	660.67^{b}	55.45*
Daily feed intake (g)	118.67^{a}	110.00^{a}	117.67^{a}	108.00^{ab}	88.67^{b}	6.28
Feed cost ₦/ kg gain	267.91^{ab}	270.22^{ab}	220.68^{b}	222.99^{b}	314.06^{a}	19.59*
Feed conversion ratio	3.28^{ab}	3.31^{ab}	3.34^{ab}	2.75^{b}	3.79^{a}	0.27*
Mortality rate (%)	0.33	0.00	0.33	0.00	0.33	0.26*

abc= means with different superscript on the same raw are significantly different ($P<0.05$) SEM=standard error of means

Table 4: Carcass and organs characteristics of grower rabbits fed diet containing Boabab leaf meal (%).

	Treatments					
Parameters	**T1 (0)**	**T2 (5)**	**T3 (10)**	**T4 (15)**	**T5 (20)**	**SEM**
Final live weight (g)	1846.34^{a}	1735.00^{b}	1863.67^{a}	1930.67^{a}	1454.67^{c}	39.16*
Carcass weight (g)	1187.3^{ab}	1071.3^{b}	1127.7^{ab}	1342.04^{a}	814.03^{c}	74.16*
Dressing percentage (%)	66.487^{ab}	65.505^{ab}	64.042^{ab}	73.21^{a}	55.95^{b}	3.84*
Head(g)	153.67^{a}	185.00^{b}	189.00^{a}	192.00^{a}	119.67^{c}	21.62*
Feet (g)	26.853^{b}	23.00^{c}	25.33^{b}	31.71^{a}	21.6667^{c}	0.61*
Felt (g)	164.000^{a}	158.667^{a}	159.000^{a}	136.000^{b}	127.000^{b}	4.54*
Heart (g)	2.82^{ac}	3.36^{bc}	4.40^{a}	2.59^{c}	3.57^{ab}	0.27*
Lung (g)	9.14^{a}	5.98^{bc}	4.45^{a}	6.68^{b}	4.43^{c}	0.54*
Liver (g)	47.33^{a}	44.40^{ab}	40.00^{ab}	42.33^{bc}	38.33^{c}	1.35*
Kidney (g)	8.25^{b}	7.23^{c}	8.61^{ab}	9.28^{a}	6.26^{c}	0.24*
Pancreas (g)	2.04^{bc}	2.50^{ab}	4.00^{a}	3.42^{ab}	1.77^{c}	0.47*

abc= means with different superscript on the row statistically different ($P> 0.05$) SEM= standard error of mean

THE EFFECTS OF TIME AND MARKET ON CATTLE (*Bos indicus*) MARKETING IN KANO AND JIGAWA STATES-NIGERIA

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Abstract
The interaction effects of weeks of the month, season (Early Dry-EDS, Late Dry-LDS, Early Rainy-ERS and Late Rainy-LRS), year (2008 and 2009) and market (Wudil, Dambatta, Maigatari and Gujungu) on live weight and price of cattle were investigated at the major livestock markets of Kano (Wudil and Dambatta) and Jigawa (Gujungu and Maigatari) States. A total of 10,400 cattle (50 cattle per week per market) were randomly sampled. Prices and live weights of cattle were recorded using 50 copies of structured questionnaires which were administered weekly through visits to the markets from May 2008 to May 2009. Data collected were fitted in a nested set of a completely randomized design and step-wise regression was used to compare variables. Results showed that the lowest cattle price/KgLW as obtained at Wudil (second week), Gujungu (second week), Maigatari (fifth week) and Dambatta (fifth week) were ₦206.17/Kg, ₦ 202.67/Kg, ₦ 195.65/Kg and ₦ 191.52/Kg, respectively. The mean price/KgLW of cattle in Wudil (₦ 219.60/Kg) market was the highest during the ERS compared to Gujungu (₦ 199.94/Kg), Maigatari (₦ 209.85/Kg) and Dambatta (₦ 198.05/Kg). In both years, highest mean weight of cattle was recorded at Wudil (317.81 vs 357.82 Kg) and Dambatta (331.53 vs 326.38 Kg) compared to Gujungu (310.21 vs 313.28 Kg) and Maigatari (310.78 vs 321.31 Kg). In 2008, the lowest values of ₦ 186.60/KgLW and ₦ 188.90/KgLW were obtained during LRS and ERS at Maigatari and Dambatta, respectively. In 2009 the lowest value of ₦ 198.24/KgLW was recorded at Gujungu market during LRS. The weight (β =0906; $p>0.001$), sex (β =0.033; $p>0.001$), age (β =0.006; $p>0.001$) and breed (β =0.003; $p>0.001$) of cattle significantly ($p<0.001$) contributed to cattle price. The week (β = 1614.0; $p<0.001$), month (β = 273.7; $p<0.005$), season (β=238.735; $p<0.001$) and year (β=965.895; $p<0.001$) of sale significantly affected prices of cattle in the study area. Based on the findings it can be concluded that the week of the month determines price /KgLW. The highest mean weights of cattle were recorded in urban markets. The weight of cattle determined over 90% of its price. Prices of cattle increase with increase in weeks of the month. Changes of the season from LDS to EDS increase price of cattle. It is recommended that these parameters should guide both producers and marketers on cattle marketing decisions.

Key words: Cattle, Market, Price, Season, Week and Year

Introduction

West Africa is recognized as a reservoir of great genetic diversity with multifunctional livestock rearing systems. According to Missohou and Adakal (2004), short horn cattle of West Africa has a live adult weight ranging from a minimum of 115 to 750 Kg for Samba breeds in Benin and Togo, and Kuri breeds in Niger and Nigeria. However, the live adult weight of Zebu cattle ranges from an estimated 240Kg for females to 660Kg for males of the Sokoto Gudali breed in Nigeria (FAO, 2005). These animals contribute significantly to an estimated 25% of household income (Willson, 1990).

According to Sanni *et al*. (2004) majority of poor rural households depend essentially on livestock for their income. The same authors further stated that Animal products play a direct and indirect role of reducing food insecurity in Nigeria and other West African Countries. The intake rate of animal protein in daily diet is an important indicator of a country's developmental level. Sassons (1986) classified nutritional indicators and described as under nourished, a country that consumed 2000 Kcal and 10 to 30g of animal protein *per capita* per day. The minimum calorie required by a 65Kg person in a situation of food security is 2400 Kcal and at least 55g animal protein daily. In most developing nations, herders and communities involved in livestock production are far away from reaching the minimum requirements for calorie and animal protein (Honfoga and Vander Boom, 2003).

In traditional pastoral and agropastoral systems, productivity by weight is 7 to 14 Kg/year/cow and is labour intensive. Labour is plentiful in most African pastoral systems, but is poorly paid for, this result in an overall poor productivity which is compounded by poor marketing system (Williams *et al*., 2004). Cattle in Nigeria are supplied through domestic production from pastoral and agropastoral systems. Other sources of supply are the Niger, Chad and Cameroon Republics (MARD, 2005).

Kamuanga *et al.* (2008) reported that the importation of cattle by Nigeria fell from 187, 600 heads in 1999 to 54, 000 heads in 2001. Theoretically, the Nigerian Market is expected to grow mainly due to demographic changes and growing urbanization; the creation of new international cattle market in Kano and the development of all border markets; ideal management of cattle markets; a political decision to develop local supply; and the construction of new abattoirs in Kano and Kaduna (SWACOCED/ECOWAS, 2008). The condition required to increase the rate of sustainable exploitation of livestock resources in Nigeria must be combined with measures to ensured good understanding of livestock marketing systems and to improve their efficiency. Hence, the study was designed to assess the effect of weeks of the month, season, year and market on live weight and price of cattle at the major livestock markets of Kano and Jigawa States.

Methodology

The study was conducted at Jigawa (Gujungu and Maigatari livestock markets which operate on Sundays and Thursdays, respectively) and Kano (Dambatta that operates every Sunday and Wudil that operates on Fridays) States. Kano and Jigawa states cover a combined area of 43,000 km^2 in the Sudan Savannah Vegetation Zone of Northern Nigeria. The area is characterized by a long (October - April) hot dry season and a short (May-September) rainy season with an average annual rainfall ranging from 787 to 960 mm and mean annual temperature that ranged from 21 to 39 ºC Jigawa State lies between latitudes 11^0 35' and 13^0 00' East and longitude 8^0 00' and 10^0 35' North (Olofin, 1987). The state is bordered to the West by Kano State, to the East by Bauchi and Yobe States and to the North by the Republic of Niger (Anonymous, 2003). Kano State lies between longitude 9^0 30' and 12° 30' North and Latitude 9° 30' and 8° 42' East. Kano State borders Jigawa State by North and South, North-West by Katsina State, Kaduna State by South-West and Bauchi State by South East.

The breeds of cattle that are predominantly found in this area are White Fulani (Bunaji), Sokoto Gudali (Bokoloji), Red Bororo (Rahaji), Adamawa Gudali and Kuri (Blench, 1999). Data on market location, cattle LW (weight band), and weeks of the month, season, year and price were collected on personal visit to the four (4) selected markets, weekly for a period lasting from May 16, 2008 to May 10, 2009 using trained enumerators with the aid structured questionnaires with the assistance of traditional middle men (*Sarkin Turke*). Price of cattle was recorded as the accepted price negotiated between the buyers and middle men, which were verified by *Sarkin Turke* (Barnerjee, 2005*).*

The experiment was laid in a 2x4x4 nested design. The factors were 2 years (2008 and 2009), 4 Markets (Wudil, Dambatta, Maigatari and Gujungu) and 4 seasons

(EDS, LDS, ERS and LRS). Significantly difference means were separated using Duncan Multiple Range Test (DMRT) and Least Significant Difference where appropriate (Gomez and Gomez, 1989). The degree of association of cattle parameters (live weight, sex and age), period (week, season and year) and market of sales were arranged factorially and analyzed using Step-wise Multiple Regression Models (Greene, 1993) as shown in equations 1 and 2.

$$Y = \beta_0 + \beta_1 X_1 + \cdots \beta_4 X_4 \ldots\ldots\ldots(1)$$

Where:
$\beta_0 - \beta_4$= regression coefficients
X_1= Live weight
X_2= Sex
X_3= Age
X_4 = Breed

$$Y = \beta_0 + \beta_1 X_1 + \cdots \beta_4 X_4 \ldots\ldots\ldots(2)$$

Where
β_0 = regression coefficient
X_1 = Week
X_2 = Season
X_3= Year
X_4 =Market

Results and Discussion

The interaction of week and market on live weight and price of cattle is shown in Table 1. The lowest price/KgLW was obtained at Wudil (₦206.17/Kg) and Gujungu (₦ 202.67/Kg) during the second week of the month while the lowest values were obtained at Maigatari (₦ 195.65/Kg) and Dambatta (₦ 191.52/Kg) during the fifth week of the month. The highest price/KgLW was obtained during the fifth week of the month for Wudil (₦ 215.43/Kg), during the first week for Gujungu (₦ 211.06/Kg), second week for Maigatari (₦ 208.13/Kg) and Dambatta (₦ 213.18/Kg). Wudil and Gujungu markets recorded the lowest price/KgLW during the second week of the month. This may be attributed to low demand due the fact that most of the market participants were salary and wage earners and could have exhausted their cyclical income which manifested in decrease demand of cattle in both urban and rural markets, which reduces price. During the fifth week of the month, cattle supply at Dambatta and Maigatari markets tend to be high in anticipation of patronage by salary and wage earners, which may glut the markets and tend to reduce price.

Table 1: Interaction Effect of Week and Market on Live Weight and Price of Cattle

Weeks of the month	Markets (Mean ±SE)			
	Wudil	Gujungu	Maigatari	Dambatta
Weight (Kg)	340.90±4.46	289.80±4.09	294.89±4.28	321.93±4.87
Price (₦)	70,824.7±1136.45	61,165.7±885.03	60,287.3±11010.96	67,844.3±1159.25
Price (Kg/LW)	207.75	211.06	204.43	210.74
Second (8^{th} – 14^{th} day)				
Weight (Kg)	311.92±4.87	276.30±4.36	315.16±4.13	317.0±4.30
Price (₦)	64,310.4±1077.11	56,000.2±920.16	65,595.8±996.78	67,578.4±1045.39
Price (Kg/LW)	206.17	202.67	208.13	213.18
Third (15^{th} – 21^{st} day)				
Weight (Kg)	332.69±4.22	313.03±4.34	339.88±4.46	330.36±4.54
Price (₦)	69,042±1053.35	64,677.5±969.52	70,444.8±1150.24	66,968.7±948.71
Price (Kg/LW)	207.52	206.62	207.26	202.71
Fourth (22^{nd} – 28^{th} day)				
Weight (Kg)	343.63±4.62	334.36±4.78	295.98±4.74	351.10±4.07
Price (₦)	72,207.6±1094.47	70,707.5±1064.60	60,458.5±1025.90	72,511.5±930.89
Price (Kg/LW)	210.13	211.47	204.26	206.52
Fifth (29^{th} -31^{st} day)				
Weight (Kg)	317.33±8.62	404.91±8.36	363.17±9.59	325.89±8.39
Price (₦)	68,361.0±2585.44	85,027.6±1908.02	71,056.70±2149.33	62,413.5±1902.21
Price (Kg/LW)	215.43	209.99	195.65	191.52

Source: Computed from survey data, 2009

Table 2 shows the interaction of market and season on live weight and price of cattle. The mean price/KgLW of cattle in Wudil (₦ 219.60/Kg) market was the highest during the ERS compared to Gujungu (₦ 199.94/Kg), Maigatari (₦ 209.85/Kg) and Dambatta (₦ 198.05/Kg). The mean price of cattle during the LRS in Gujungu (₦ 203.07/Kg) and Dambatta (₦ 203.32/Kg) were similar and higher than the price obtained at Wudil (₦ 189.92/Kg) and Maigatari (₦ 186.59/Kg). Highest price of cattle were recorded during EDS and LDS for the four markets studied. Cattle live weight recorded were highest during LRS, which could be due to the fact that during that period, the animal might have adjusted to the type of feed available and most forage were at peak of nutrient profile, likewise low diseases prevalence . Stress due to constant rains and poorly housed cattle that are characteristics of extensive management has significantly reduced. This result is similar to the reports of Yakubu *et al*. (2006) on small ruminants, which tends to gain weight during LRS in southeastern Bauchi State. The low cattle price during EDS was attributed to farmers' behavior of disposing their stock to augment short fall in grains before next harvest. The rush to market by farmers increase cattle supply which could reduce price, contrary to the report of Jabo and Muhammed (2009) who averred that mean price offered for cattle during the late rainy and early dry seasons were highest and the least price was recorded during the ERS. This is also in accordance with the report of Mohammed (2000) in which the highest price of cattle and dromedaries were recorded during the dry season in Northern Nigeria. Wudil market recorded its highest mean price/KgLW during ERS while Gujungu had its highest price value during both EDS and LDS.

Table 2: Interaction Effect of Market and Season on Live Weight and Price

Season	Markets (Mean ± SE)			
	Wudil	**Gujungu**	**Maigatari**	**Dambatta**
Early rainy (Apr-Jun)	Weight (Kg)	329.58 ± 3.02	329.58 ± 4.29	232.09 ± 4.08
	Price (₦)	61,784.00 ± 917.89	69,163.94 ± 1184.09	65,768.47 ± 1085.73
Late rainy (Jul-Sep)	Price (₦/KgLW)	199.94	209.85	198.05
	Weight (Kg)	351.12 ± 4.19	321.76 ± 4.11	360.70 ± 3.94
	Price (₦)	71,303.00 ± 912.01	60,038.00 ± 967.69	73,336.02 ± 883.93
Early dry (Oct-Dec)	Price (₦/KgLW)	203.07	186.59	203.32
	Weight (Kg)	284.21 ± 5.37	298.19 ± 4.72	301.42 ± 4.66
	Price (₦)	60,909.00 ± 1164.27	62,541.54 ± 1003.80	64,151.57 ± 1019.76
Late dry (Jan-Mar)	Price (₦ /KgLW)	214.30	209.74	212.83
	Weight (Kg)	303.58 ± 3.88	309.00 ± 4.41	327.51 ± 4.15
	Price (₦)	66,569.17 ± 832.62	66,708.00 ± 948.14	70,279.29 ± 926.24
	Price (₦ /KgLW)	219.28	215.88	214.58

Source: Computed from survey data, 2009

Table 3 shows the interaction of market and year on live weight and price of cattle. In both years (2008 and 2009) highest mean weight of cattle were recorded at Wudil (317.81 vs 357.82 Kg) and Dambatta (331.53 vs 326.38 Kg) as compared to Gujungu (310.21 vs 313.28 Kg) and Maigatari (310.78 vs 321.31 Kg). The price/KgLW in Maigatari was the lowest in 2008 (₦ 200.99/Kg) while Wudil market had the lowest price/KgLW (₦ 211.41/Kg) in 2009. In both years studied, Wudil and Dambatta markets had cattle with highest mean weights. This confirmed the results of Egbewande *et al*. (2010), that larger cattle were brought to the markets with proximity to urban centers and usually command higher prices. Slight variation was recorded in prices of cattle in both urban and rural markets, probably as a result of changes in infrastructure and services associated with cattle marketing.

Table 3: Interaction Effect of Market and Year on Live Weight and Price of Cattle

Market	2008 (Mean ± SE)			2009 (Mean ± SE)		
	Weight (Kg)	**Price (₦)**	**Price (₦/KgLW)**	**Weight (Kg)**	**Price (₦)**	**Price (₦/KgLW)**
Wudil	317.81±2.81	65,736.08 ±719.25	206.84	357.82±3.25	75,464.59 ±734.22	211.41
Gujungu	310.21±3.09	63,803.75 ±688.00	205.67	313.28±3.09	66,665.50 ±659.28	212.80
Maigatari	310.78±2.79	62,464.95 ±680.85	200.99	321.31±3.64	68,337.47 ±774.73	212.68
Dambatta	331.53±2.76	67,464.11 ±642.68	203.49	326.38±3.42	69,666.53 ±782.02	213.45

Source: Computed from survey data, 2009

Table 4 shows the interaction effect of season, Year and Market on Mean Live Weight and Price of Cattle The highest price/KgLW was obtained at Wudil (₦ 218.03/Kg) market during ERS of 2008, while Gujungu market had its highest value of ₦ 219.28/KgLW during LDS of 2009. The lowest values of ₦ 186.60/KgLW and ₦ 188.90/KgLW were obtained during LRS and ERS at Maigatari and Dambatta in 2008, respectively. In 2009 the lowest value of ₦ 198.24/KgLW was recorded at Gujungu market during LRS. There is no consistency in prices and weight of cattle due to market, season and year which could be related to high variability in reasons for selling livestock. Bailey *et al*. (1999) reported that pastoralists sell livestock for cash and as necessitated by climatic and other socio-economic conditions. Dalgado *et al*. (1999) stressed the fact that urban consumers diversify their diets as a result of the wider choice offered and exposure to more varied cultural influences. Urban dwellers consumed more animal products than their rural counterparts. According to Thuillier-Cedan and Bricas (1998) the proportion of food expenditure allocated to animal products reaches 30.8% in urban Cotonou, Benin Republic.

Table 4: Interaction effect of season, Year and Market on Mean Live Weight and Price of Cattle

Market	**2008 (Mean±SE)**			**2009 (Mean ±SE)**		
Wudil	**Weight (Kg)**	**Price (₦)**	**Price (₦/KgLW)**	**Weight (Kg)**	**Price (₦)**	**Price (₦/KgLW)**
ERS	338.10±6.53	73,716.14±2,195.18	218.03	366.56±6.41	74,571.74±1,387.28	203.41
LRS	316.31±3.62	60,073.37±841.09	189.92	-	-	-
EDS	309.05±4.92	67,004.29±1,072.57	216.81	-	-	-
LDS	-	-	-	354.73±3.76	76,026.92±864.48	214.32
Gujungu						
ERS	288.82±4.74	56,242.19±1,208.71	194.73	336.78±5.95	69,191.67±1,294.46	205.45
LRS	361.15±4.61	73,631.00±1,010.46	203.88	300.97±8.50	59,665.00±1,679.78	198.24
EDS	284.21±5.37	60,909.23±1,164.27	214.31	-	-	-
LDS	-	-	-	303.58±3.88	66,569.17±832.62	219.28
Maigatari						
ERS	313.77±5.83	66,840.69±1,879.75	213.02	347.98±6.20	71,866.67±1,320.56	206.53
LRS	321.76±4.11	60,038.92±967.69	186.60	-	-	-
EDS	298.19±4.72	62,541.54±1,003.80	209.74	-	-	-
LDS	-	-	-	308.10±4.41	66,708.62±948.14	216.52
Dambatta						
ERS	338.36±5.51	63,917.25±1,549.72	188.90	323.74±6.04	66,236.77±1,456.51	204.60
LRS	360.02±3.97	73,267.73±891.35	203.51	-	-	-
EDS	301.42±4.66	64,151.57±1,019.76	212.83	-	-	-
LDS	-	-	-	327.51±4.15	70,279.29±926.24	214.59

Source: Computed from survey data, 2009

Table 5 shows the stepwise regression analysis of factors of cattle price. The weight (β =0.906; p>0.001), sex (β =0.033; p>0.001), age (β =0.006; p>0.001) and breed (β =0.003; p>0.001) of cattle significantly (p<0.001) contributed to cattle price. The weight of cattle determined over 90.6% of price of cattle. The sex of cattle negatively affected price in the markets studied. The contribution of age (β = 0.006) and breed (β =0.003) of cattle to price were also significant at 1% level of probability (p<0.001). This finding were similar to the reports of Jabo and Muhammed (2009) who indicated significant influence of age, sex, breed and season of the year on price of cattle in Sokoto State, Nigeria.

Table 5: Step-wise Regression Analysis for Factors Affecting Cattle

Step	Factor	Coefficient (β)	T
1	Constant -	-3.357E3***	6.179E4***
2	Constant	0.919	-353.183***
	Weight (Kg)	0.909	5.855E4***
	Sex of Animal	-0.034	-2.163E3***
3	Constant	-	411.195***
	Weight (Kg)	0.906	4.771E4***
	Sex of Animal	-0.033	-2.148E3***
	Age (Years)	0.006	317.408***
4	Constant	-	448.221***
	Weight (Kg)	0.906	4.766E4***
	Sex	-0.033	-2.150E3***
	Age (Years)	0.006	317.609***
	Breed of Cattle	0.003	180.798***

R = 0.919;
R^2=0.846; (***p<0.001)
T = t value
Source: Computed from survey data, 2009

Table 6 shows regression summary for dependent variable, price of cattle as affected by period of sales. The weeks (β = 1614.0; p<0.001), months (β = 273.7; p<0.005), season (β=238.735; p<0.001) and year (β=965.895; p<0.001) of sale significantly affected prices of cattle in the study area. No significant effect of market was recorded on cattle price and season of the year affected price of cattle negatively (β= - 724.1; p<0.01). Prices of cattle increase with increase in weeks of the month. Changes of the season from LDS to EDS increase price of cattle. The result was similar to the report of Akinleye and Sekunmade (2005) on hedonic analyses of livestock prices in Lagos State. Ojiako and Olayode (2008) reported the trend of livestock production and reported that time trend is positive and significant for periods as obtained in the current study.

Table 6: Regression Summary for Dependent Variable Price of Cattle

Independent Variable (Fixed)	Coefficient (β)	SE± β	t(n=10,465)
Intercept	82595.0	2288.325	36.0941***
Week	1641.0	192.251	8.5355***
Month	273.7	124.755	2.194*
Season	-724.1	238.735	-0.329**
Year	7093.2	956.895	7.4127***
Market	450.7	236.063	1.9094ns

ns = not significant; *-P<0.05; **-P<0.01; ***P<0.001
SE ± = standard error
t = t value

Conclusion and Recommendations

Based on the findings it can be concluded that the week of the month determines price /KgLW**.**. The highest mean weights of cattle were recorded in urban markets. The weight of cattle determined over 90% of its price . Prices of cattle increase with increase in weeks of the month. Changes of the season from LDS to EDS increase price of cattle. It is recommended that these parameters should guide both producers and marketers on cattle marketing decisions.

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INFLUENCE OF TILLAGE AND NITROGEN FERTILISER ON SOIL MICROBIAL BIOMASS CARBON AND SOME SOIL PROPERTIES IN NORTHERN GUINEA SAVANNAH, NIGERIA

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Abstract
Excessive cultivation of soil can result in a severe decrease in microbial biomass and their activities. In spite of lots of information available depicting relationships between soil management practices and available soil microbes, same is still vaguely understood by soil scientists under tropical and subtropical conditions, especially in continuously cropped soils. A field experiment was conducted in 2013 rainy season on a Typic Haplustalf at the research farm of the Institute for Agricultural Research (IAR) Samaru, Zaria, Nigeria to assess the effects of two tillage practices (Conventional and Reduced) and nitrogen (N) rates (0 and 90 kg N ha^{-1}) on soil bacterial population of a continuously cropped Alfisol. Statistically higher clay (5.22 %) and silt (19.67 %) fractions were observed under Conventional (CT) than Reduced Tillage (RT), which contained 4.44 % and 18.11 %, clay and silt fractions respectively. A 619.44 mg kg^{-1} soil microbial biomass carbon (SMBC) was observed in CT and was statistically higher ($P<0.05$) than the 483.89 mg kg^{-1} observed in RT. Neither N nor its interaction with tillage had significant ($P>0.05$) contribution to any of the parameters. Further research effort is, therefore, recommended on the topic so as to allow for a better understanding on the subject.

Keywords: Alfisol, bacterial population, particle size distribution, Tillage

Introduction

The soil microbial biomass (SMB), about half of which is located in the surface of soil profile where most of the nutrient release also occurs, consists mostly of bacteria and fungi, which decompose crop soil organic matter (SOM) and other residues in soil (Griffin *et al.*, 2013). The decomposition process releases such nutrients as nitrogen (N) into the soil environment. These are, as such, made available for crop utilisation. Generally, up to 5 % of the total organic carbon and N in soil is in the microbial biomass (Smith and Paul, 1990). When microorganisms die, these nutrients are released in plant-available forms. Soil microbial biomass is also an early indicator of changes in total soil organic carbon (OC), which is an important component of SOM that regulates the transformation and storage of nutrients (Weaver *et al.*, 1994). The SMB is affected by such factors that change the water and/or carbon content of soil, including climate, soil type and management practices (Hoyle *et al.*, 2013).

Clay, soil reaction (pH) and OC are among the most important properties of soil that affect SMB. Therefore, soils with high clay separates for example, generally have a higher SMB as such soils retain more water and often contain more OC. Also, soil pH near 7.0 is generally labelled most suitable for the SMB (Griffin *et al.*, 2013). Management of crop residues influences SMB being one of the primary forms of OC and nutrients used by the microbial biomass. Retaining crop residues, therefore, provides a practical means of increasing the SMB via increase in the quantity of OC available to them (Franzluebbers *et al.*, 1999). Less disruptive tillage operations can also increase the SMB. This is due to increase in the microbial biomass through the increase in labile carbon into the soil. Such management practices also ensure soil aggregate and fungal networks protection. The crop types being utilised in a rotation can also affect the SMB. Residues of legumes, for example, can increase SMB due to their greater N contents. Also rotations including longer phases of pasture increase SMB due to consequent reduced soil disturbance.

Soil microorganisms are important for the enzymatic degradation of complex organic substances for the release of nutrients from the mineral soil fraction (Samuel *et al*., 2008), but usually occupying less than 1 % of the soil volume, while their number and efficiency are very high. The number and activity of soil microorganisms are dependent on crop, soil type and soil cultivation as well as on the macro- and micro-climate of a given location (Dalal and Mayer, 1986). The activities of soil microbes provide a unique integrated biological assessment of soil due to their relationship to soil biology. Therefore, soil microbial activities such as biological and biochemical processes give an indication of approximate soil microbial population, for example bacteria. The activities of bacteria, for example, include water dynamics, nutrient cycling, and disease suppression. Some bacteria produce substances that bind soil particles into small aggregates which enhance soil performance (Samuel *et al.*, 2008).

Bacteria, typically a few micrometres in length, constitute a large domain of prokaryotic microorganisms with a wide range of shapes, ranging from spheres to rods and spirals. Bacteria were among the first life forms to appear on earth, and are present in most habitats, including soil, water, acidic hot springs, radioactive waste and in plants and animals (Fredrickson *et al.*, 2004) and almost everywhere (Choi, 2013; Oskin, 2013). There are about 40 million bacterial cells in a gram of soil, a million bacterial cells in a millilitre of fresh water and an approximately 5×10^{30} bacteria on Earth (Whitman *et al.*, 1998), forming a biomass that exceeds that of all plants and animals (Hogan, 2010). Bacteria are vital in nutrients recycling. Many steps in such nutrient cycles as biological nitrogen fixation and putrefaction depend on them. In the biological communities surrounding hydrothermal vents and cold seeps, bacteria provide the nutrients needed to sustain life by converting dissolved compounds such as hydrogen sulphide (H_2S) and methane (CH_4) to energy (Choi, 2013).

Most upland soils of continuously cropped lands found in the Northern Guinea Savannah (NGS) of Nigeria are characterised by low inherent fertility status. They are also low in water holding capacity, organic matter, cation exchange capacity (CEC), total nitrogen (N) and phosphorus (P). The soils also have low water infiltration capacity that causes a concomitant poor internal drainage due to poor structure (Odunze, 2003). These features indicate soils of low productivity potential.

The Nigerian NGS is composed of a land area of about 5.6 million km^2, and about 42 % of the resident human population of the area are said to contribute towards the region's improved agricultural production. The most common soils in this region are Alfisols of low organic matter, CEC, total N, P, sulphur (S), and exchangeable potassium (K) (Jabbar, 1995; Odunze, 2003), indicating low productivity. They are also reported to be acidic (4.0–5.8 pH) in reaction but have moderate P fixation properties (Carsky *et al*., 1998). They vary from one location to another due to differences in climate, parent materials, relief, organisms and time (Jenny, 1980).

Excessive cultivation of a soil can result in a detrimental decrease in its microbial biomass and general microbial activities (Samuel *et al.*, 2008). It is often important to know not only the types of bacteria present but also their population in the soil. This is often obtained from the relationship between their various activities as well as their population. There are lots of information depicting the relationships between soil management practice and available soil microbes, but this is still vaguely understood by soil scientists under tropical and subtropical conditions, especially for bacteria; and in continuously cropped lands (Samuel *et al.*, 2008). This paper sought to evaluate the roles of tillage and nitrogen fertiliser on soil microbial biomass carbon of a continuously cropped soil in Northern Guinea Savannah zone of Nigeria.

Materials and Methods

The trial was conducted on a Typic Haplustalf at the research farm of the Institute for Agricultural Research (IAR)

Samaru, Zaria. Samaru is located in the northern guinea savannah (NGS) of Nigeria (11^0 11' N and 7^0 38' E) and is characterised by a tropical continental type of climate. Long-term annual rainfall in the zone averages about 1050 mm mostly with a peak at August. The rainfall period starts in May, but often stops in the month of September or early October. Dry season sets in by October and lasts into the month of May. Soil moisture and temperature regimes in the area are inferred to be ustic and isohyperthermic respectively. Mea6n air temperature in the zone ranges between 25 ^{0}C and 28 ^{0}C during the rainy season (June to September) and decreases to less than 20 ^{0}C in the months between December and February (Odunze *et al.,* 2004; Oluwasemire *et al.,* 2004). The site had been under crop rotation and N rates trial for seven years before it was modified to accommodate tillage as an additional experimental factor in the past three years. The soil of the study area was loamy in texture (Yusuf *et al.,* 2012).

Treatment and Experimental Design

Treatments consisted of a factorial combination of four levels of nitrogen fertiliser rates (0, 30, 60 and 90 kg N ha^{-1}) and two tillage (RT and CT) practices. These were arranged in all the possible combinations. The treatments were laid out in a randomized complete block design (RCBD) replicated thrice. Each plot contained six ridges of 6 m each.

Sample Collection

Soil samples were collected with micro-auger at 3 points from plots that received 0 and 90 kg N ha^{-1} levels at a depth of 0-5 cm. The samples were bulked, and some portion air-dried and sieved through a 2 mm mesh for some physical and chemical analyses. Subsamples were further sieved through 1 mm mesh and taken to laboratory for the biochemical analyses.

Laboratory Soil Analyses

The soil samples collected were analysed for pH, particle size distribution (PSD) and soil microbial biomass carbon (SMBC). The pH was determined in the ratio of 1 to 2.5 soil to water and 0.01 M $CaCl_2$ suspensions, using glass electrode pH meter as elaborated by Agbenin (1995). Following the PSD determination using the hydrometer method (Gee and Bauder, 1986), the textural classes were consequently also determined. The SMBC was by the fumigation-extraction method (Nelson and Sommers, 1982; Okalebo *et al.,* 2002). The effects of tillage and N rate on soil bacterial population were estimated on the bases of soil pH and particle size distribution (Giller and Wilson, 1991; Baath *et al*., 1995).

Statistical analysis

The data generated were subjected to analysis of variance (ANOVA) using the Generalised Linear Model (GLM) procedure of Statistical Analysis System (SAS) (SAS, 2014). Where the F-ratios were observed to be significant at 5 % level of probability, the treatment means were separated using Least Significant Difference (LSD).

Results and Discussion

Effects of tillage and N rate on soil microbial biomass carbon

Reports have shown that SMB was greater in the macro- than in micro-aggregates size class while SMBN and SMBP are higher in the micro- than in macro-aggregates (Singh and Singh, 1995). The soil microbial biomass was found to increase under RT than under CT in a study by Berner *et al.* (2008). However, effects of tillage and N rate on the SMBC content of the soil under study were as presented in Figures1 and 2 respectively.

Effect of tillage on SMBC was as shown in Figure 1. The result showed a significant ($P<0.05$) difference between CT (619.44 mg kg^{-1}) and RT (483.89 mg kg^{-1}). There was no significant ($P>0.05$) difference between 0 and 90 kg N ha^{-1} rates on SMBC (Figure 2). Significant ($P<0.05$) difference was, however, observed in SMBC with the application of different rates of N fertiliser in a study by Ethan (2014). This may be due to some biotic and abiotic differences between soils of the locations.

The SMBC was, however, not affected by tillage in a work by Caldero'n *et al.* (2001). The significant ($P<0.05$) effect of tillage type on SMBC observed in this work may be attributable to differences in management practice and also to factors such as soil type, climate (rainfall is usually the limiting factor for microbial biomass) because these factors can change the water or carbon content of soil (Hoyle and Murphy, 2006; Hoyle *et al*; 2013).

Effects of tillage and N rate on soil bacterial population

Effects of tillage and N rate on bacterial population due to pH

Soil pH is among the factors that influence soil microbial distribution and structure. Highly acidic or alkaline soil affects many common microbes such as *Azotobacter vinelandii* and *Rhizobia spp.* as the optimum pH for most soils is near neutral.

The result for the effect of tillage on soil pH, as shown on Table 1, indicated that there was no significant difference (P>0.05) between the pH of RT and CT for both pH (in water and $CaCl_2$). However, the pH in water (5.03) and that in $CaCl_2$ (4.61) for RT were higher relative to that of CT, which were 4.83 and 4.60 respectively, although statistically similar.

On the other hand, effect of N rate on the soil pH, as also shown by Table 1, indicated that there was no significant (P>0.05) difference between the N rates (0 kg N ha^{-1} and 90 kg N ha^{-1}) in both pH (in water and in $CaCl_2$). It is noteworthy that the pH, in water, for 90 kg N ha^{-1} was higher relative to that of 0 kg N ha^{-1}, but conversely, that in $CaCl_2$ was higher in 0 kg N ha^{-1} compared to 90 kg N ha^{-1}. The effect of interaction between tillage type and N rate was also not significant (P>0.05) for both pH (in water and in $CaCl_2$). Bacterial population and activity decline at low pH levels. This means that although statistically similar, more bacterial population is expected in RT than in CT, as bacteria are known to grow and thrive in a pH range of between 5-9 with an optimum of (pH) 7 (Baath *et al*., 1995; Smith and Doran, 1996). However, this very acidic pH, like very alkaline pH levels, tends to drastically slow down or even halt organic matter mineralisation due to consequent poor microbial activity linked to bacteria (Smith and Doran, 1996). Rhizobia species of bacteria also do not nodulate and fix N effectively under pH values less than 5.5 (Jensen and Thomas, 2010). McLean (1982) also observed that acidity, neutrality, or alkalinity of a soil influences the solubility of various compounds, the relative binding of ions to exchange sites, and the activities of various microorganisms.

Effects of tillage and N rate on bacterial population due to particle size distribution

It was reported that the soil particle size distribution influences soil microbial distribution in various ways. The effects of tillage and N rate on particle size distribution are as shown in Table 1. There was a significant difference (P<0.05) between the tillage practices in terms of the sand, silt and clay distributions in the soil. Conventional tillage recorded significantly (P<0.05) more clay (5.22 %) and silt (19.67 %) separates than the RT, which recorded only 4.44 % and 18.11 % clay and silt, respectively. There was, however, no significant difference (P>0.05) between the tillage types in terms of sand fraction, yet less sand was observed in CT than RT soil. This further strengthens the possibility of higher bacterial population in the CT practice than in RT. This is because the fine textured separates preponderant in the CT observed will provide an insulating advantage against vulnerability of bacteria to the piercing heat from high sun temperatures reaching the bacteria than coarse textured sandy soils, which are relatively the worst (Giller and Wilson, 1991; England *et al*., 1993). This gives bacteria higher chances for survival in the Conventionally than Reduced tilled soil.

The result also showed no significant (P>0.05) difference between the 0 kg N ha^{-1} and 90 kg N ha^{-1} in terms of the soil separates. There was equally no significant (P>0.05) interaction between tillage type and N rate in terms of particle size distribution. This indicated that N rate had no significant contribution towards the type of soil texture and, consequently to bacterial population in this perspective.

Correlation of soil microbial biomass C and soil particle size distributions

There was only one significant (P<0.01) but negative correlation between silt and sand separates and a negative but non-significant correlation between sand and clay particles (Table 2). There was however, neither a significant (P>0.05) correlation between SMBC and any of the particle sizes nor between the other sizes. This reaffirmed, although not to a significant level in the study, that the more the sand separates soil the less the SMBC, and vice-versa. The positive correlation between SMBC and clay, though not statistically significant, at least indicated more support to the finding of this study.

Conclusion

The results of this study showed that the soil microbial biomass carbon content of the soil was significantly affected by tillage and not by N rate of application or pH. Based on pH, a more befitting bacterial population condition was observed in Reduced than Conventional Tillage, and vice-versa based on particle size distribution. More research efforts on the topic would allow for a better understanding about the subject.

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Table 1: Effects of tillage and N rate on soil pH and soil particle size

Treatment	pH		Particle Size Distribution (%)		
	(in H_2O)	(in $CaCl_2$)	Clay	Silt	Sand
Tillage					
Reduced	5.03	4.61	4.44[b]	18.11[b]	77.11
Conventional	4.83	4.60	5.22[a]	19.67[a]	75.11
SE±	0.076	0.056	0.190	0.376	0.340
N rate					
0	4.92	4.66	4.67	19.00	76.11
90	4.94	4.53	5.00	18.78	76.11
SE±	0.076	0.056	0.190	0.376	0.340
Interaction					
T×N	NS	NS	NS	NS	NS

NS= Not significant at 5 % level of probability

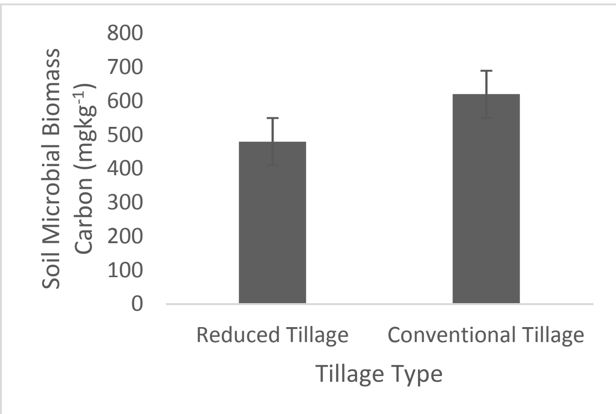

Figure 1: Effect of Tillage on SMBC

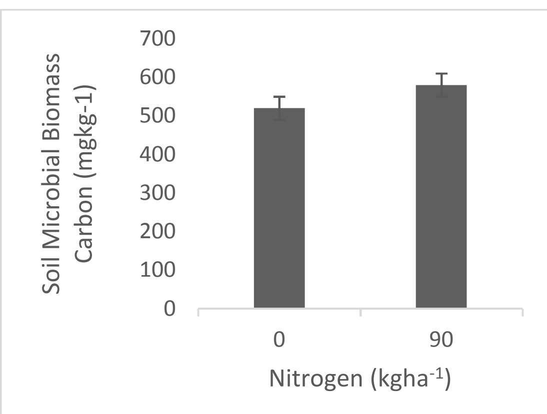

Figure 2: Effect of N Rate on SMBC

Table 2 Pearson correlation matrix of SMBC and soil texture

	SMBC	Clay	Silt	Sand
SMBC	1.000	0.228^{NS}	0.130^{NS}	-0.250^{NS}
Clay		1.000	0.011^{NS}	-0.331^{NS}
Silt			1.000	-0.876**
Sand				1.000

SMBC=Soil microbial biomass carbon

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SEASONAL DENSITY AND RELATIVE IMPORTANCE OF INSECT PESTS ASSOCIATED WITH CUCUMBER (*Cucumis sativus* L.) IN MAIDUGURI, NORTH EASTERN NIGERIA

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Abstract
This study was conducted during the cropping seasons of 2014 and 2015 in Maiduguri, north eastern Nigeria, to determine the density of insect pests associated with cucumber. Data collection was from 21 farmers' fields having cucumber plants. Data on insect density was analyzed using Kruskal-Wallis test. Seven insect pests were found, viz.: the Cotton-Melon Aphid, Aphis gossypii Glover (Homoptera: Aphididae); Crucifer Flea Beetle, Phyllotreta cruciferae Goeze (Coleoptera: Chrysomelidae); Cucumber Moth, Diaphania indica (Saunders) (Lepidoptera: Crambidae); Leaf Miner, Liriomyza sp. (Diptera: Agromyzidae); Melon Fly, Bactrocera (= Dacus) cucurbitae Coquillett (Diptera: Tephritidae); Red Melon Beetle, Aulacophora africana Weise (Coleoptera: Chrysomelidae); and Whitefly, Bemisia tabaci (Gennadius) (Hemiptera: Aleyrodidae). Aphis gossypii (95-100), followed by B. tabaci (3-5) had significantly higher seasonal pest densities per cucumber leave than those of A. africana, D. indica, Liriomyza sp. and P. cruciferae (0.09-0.47). Cucumber fruit infestation of between 23% and 40% tends to support high seasonal abundance (523-672) of B. cucurbitae per farmers' fields. Relative importance of the three major insect pests, A. gossypii, B. tabaci and B. cucurbitae, found and the need for sustainable management of cucumber insect pest problems are discussed.

Keywords: Cucumber/*Cucumis sativus*, *Aphis gossypii*, *Bemisia tabaci*, *Bactrocera cucurbitae*, seasonal pest density, relative importance.

Introduction

Cucumber (*Cucumis sativus* L. (Cucurbitaceae)) is an important annual warm weather creeping plant, cultivated worldwide for its edible fruits (Badgery-Parker *et al*., 2015). It thrives in well drained/sandy loam soil and at high elevations (≥ 2000 meters) in tropical Africa (Agriculture Nigeria, 2017). Although largely cultivated in the northern and central regions of Nigeria, cucumber is grown all over the country (Oladele, 2002). Cucumber has several nutritive, medicinal and cosmetic values. The fresh fruits are eaten raw or cooked, singly or in salads. The fruit is rich in vitamin (A, B1, B6, B9, C and D) and minerals (Calcium, Magnesium, and Potassium) (van Luijk, 2004; Alex du Toit, 2012; Agriculture Nigeria, 2017). Cucumber has most of the daily vitamin needs of the human body. The skin alone contains about 10% of the daily vitamin C requirement. Cucumbers consumption further keeps the body hydrated, aids digestion, rids the body of toxins, and helps to remedy chronic constipation or care for skin irritations, sunburns, heat rash and sores (Alex du Toit, 2012). It is also used as a cleansing cosmetic to soften and whiten the skin, while the juice is used in many beauty products (Nature on the Shelf, 2017). Use of cucumber has also been linked with stimulation of hair growth, insulin production, reduction of cholesterol levels and blood pressure regulation (Alex du Toit, 2012).

World production of cucumber in 2002 was estimated to be 36 million tons harvested from about 2 million ha (FAO, 2003). Africa only contributes less than 1.5% of the world production, with approximately 507,000 tons from 25,000 ha. Cucumber is frequently attacked by a myriad of insect pest and diseases (over 40 different diseases) at all stages of development, especially when growing conditions are less favourable (Bernhardt *et al*., 1988; Zitter *et al*., 1996 van Luijk, 2004). Aphids, whiteflies and thrips are common pests of cucumber that readily serve as vectors for viruses or diseases that cause serious pest problems. Crop attack by beetles, melon flies, leaf miners, leaf hoppers, spider mites, caterpillars, slugs, etc can also result in severe damage. Presently, information on cucumber infestation in north eastern Nigeria is very scanty and almost non-existent. This study was therefore initiated to determine the density of insect pests associated with cucumber cultivated in Maiduguri, north eastern Nigeria.

Materials and Methods

Investigations were carried out in farmers' fields during the cropping season over two years in Maiduguri (elevation, 354 meters above sea level; latitude, 11º45' N to 11º51' N; longitude, 13º2' E to 13º9' E), north eastern Nigeria. Fifty cucumber leaves were randomly inspected during each of seven fortnightly visits made to the same 12 farmers' fields in 2014 and nine other farmers' fields in 2015. Visual sampling of pests was carried out at morning hours, 8:00 to 10:30 am, when the insects were relatively inactive. The insects were counted visually, and data recorded according to species. Very small insects were counted with the aid of magnifying glass. Each lepidopterous larva was collected by hand and placed in a vial plugged with cotton wool. All larvae were reared as described by Le Ru *et al.* (2006) in the Entomology laboratory (Department of Crop Protection, University of Maiduguri) under ambient conditions (36 ± 8 ºC and 65 ± 7% RH) until larval/pupal death or emergence of adult moths. The numbers of infested and infected fruits were recorded following harvest at weekly intervals. Dipterous larvae in all infested fruits were reared in the laboratory until death of larvae/pupae or emergence of adult flies. Kruskal-Wallis test ($\alpha = 0.05$) or one-way analyses of variance was performed in SPSS (version 9.0) to estimate significant differences in insect densities per year. Pairwise comparisons were done using Mann-Whitney test.

Results

Sampling covered both vegetative and reproductive crop phases. In all, 4,200 and 3,150 cucumber leaves were inspected during the cropping season in 2014 and 2015, respectively. Six insect pests, viz.: the Cotton-Melon Aphid, *Aphis gossypii* Glover (Homoptera: Aphididae); Crucifer Flea Beetle, *Phyllotreta cruciferae* Goeze (Coleoptera: Chrysomelidae); Cucumber Moth, *Diaphania indica* (Saunders) (Lepidoptera: Crambidae); Leaf Miner, *Liriomyza* sp. (Diptera: Agromyzidae); Red Melon Beetle, *Aulacophora africana* Weise (Coleoptera: Chrysomelidae); and Whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) were found attacking the leaves or tender climbing stems of cucumber, while one other insect pest, the Melon Fly, *Bactrocera* (= *Dacus*) *cucurbitae* Coquillett (Diptera: Tephritidae), attacked the fruits (Fig. 1).

In 2014, the density of *A. gossypii* was higher than those of *A. africana* (U = 4.0230; P = 0.001), *B. tabaci* (U = 3.147; P = 0.001), *D. indica* (U = 2.055; P = 0.001), *Liriomyza* sp. (U = 4.317; P = 0.001) and *P. cruciferae* (U = 2.861; P = 0.001) (Table 1). Similarly, the density of *B. tabaci* was higher than those of *A. africana* (U = 2.988; P = 0.012), *D. indica* (U = 4.215; P = 0.014), *Liriomyza* sp. (U = 2.554; P = 0.021) and *P. cruciferae* (U = 3.015; P = 0.017). The density of *A. africana* was not significantly different to those of *D. indica* (U = 2.555; P = 0.436), *Liriomyza* sp. (U = 3.579; P = 0.891) and *P. cruciferae* (U = 1.725; P = 0.923). Similarly, the density of *D. indica* was not significantly different to those of *Liriomyza* sp. (U = 3.459; P = 0.573) and *P. cruciferae* (U = 3.225; P = 0.337). Also, the density of *Liriomyza* sp. was not significantly different to that of *P. cruciferae* (U = 1.315; P = 0.472). In 2015, the density of *A. gossypii* was higher than those of *A. africana* (U = 3.1177; P = 0.001), *B. tabaci* (U = 1.005; P = 0.001), *D. indica* (U = 1.995; P = 0.001), *Liriomyza* sp. (U = 2.335; P = 0.001) and *P. cruciferae* (U = 3.445; P = 0.001). Similarly, the density of *B. tabaci* was higher than those of *A. africana* (U = 4.249; P = 0.001), *D. indica* (U = 1.113; P = 0.007), *Liriomyza* sp. (U = 5.251; P = 0.015) and *P. cruciferae* (U = 2.332; P = 0.008). The density of *A. africana* was not significantly different to those of *D. indica* (U = 4.137; P = 0.216), *Liriomyza* sp. (U = 2.354; P = 0.249) and *P. cruciferae* (U = 3.461; P = 0.144). Similarly, the density of *D. indica* was not significantly different to those of *Liriomyza* sp. (U = 1.005; P = 0.117) and *P. cruciferae* (U = 2.557; P = 0.114). Also, the density of *Liriomyza* sp. was not significantly different to that of *P. cruciferae* (U = 3.300; P = 0.225).

Mean percent fruit infestation by *B. cucurbitae* ranged from 23% in 2015 to 40% in 2014, but was not significantly different between years (Table 2). Mean number of *B. cucurbitae* adults from infested fruits per farmers' field was significantly higher in 2014 (672) compared to 2015 (530). Fruits infected with disease pathogen(s) ranged from 22% in 2015 to 28% in 2014, but was not significantly different between years.

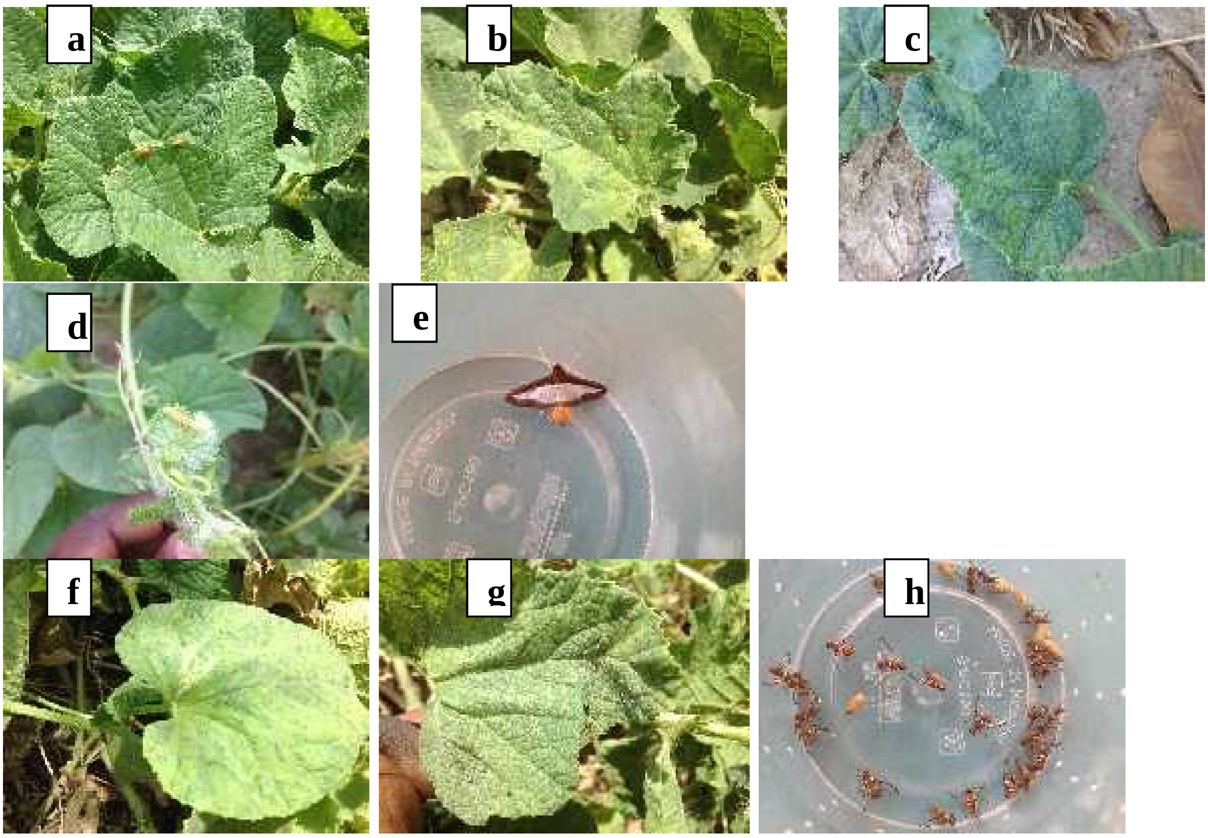

Fig. 1: Insect pests of cucumber: (a) *A. africana*, (b) *A. gossypii*, (c) *B. tabaci*, (d and e) *D. indica* larva/ adult, (g) *Liriomyza* sp., (h) *P. cruciferae* and (i) *B. cucurbitae* pupae and adults

Table 1: Mean density of insect pests per cucumber leave in farmers' fields during 2014 and 2015 cropping seasons in Maiduguri

Insect pest	**Mean density ± SE**	
	2014	**2015**
A. africana	0.47±0.09	0.35±0.07
A. gossypii	95.11±9.89	100.69±15.44
B. tabaci	5.32±1.06	2.87±0.96
D. indica	0.09±0.02	0.15±0.05
Liriomyza sp.	0.33±0.04	0.28±0.04
P. cruciferae	0.41±0.08	0.46±0.10
N (Total, 147)	84	63
Statistics	H = 6.05, P = 0.018	H = 2.41, P = 0.005

N, number of field observations; *H*, Kruskal-Wallis statistic; *P*, Probability value

Table 2: Mean percent fruits infestation by *B. cucurbitae* and the total number of flies collected per farmers' field during 2014 and 2015 cropping seasons in Maiduguri

Year	Mean ± SE		
	B. cucurbitae		Infected fruits (%)
	Infestation (%)	Total no.	
2014	39.77±2.54	671.54±14.12*	28.32±3.21
2015	23.23±1.73	529.95±10.94	22.11±3.91
N (Total, 129)	129	129	129
Statistics	Ns	*H* = 3.03, P = 0.008	Ns

*, value with asterisk within column is significantly higher than the other;
N, number of field observations; ns, no significant differences between means;
H, Kruskal-Wallis statistic; *P*, Probability value

Discussion

Exceedingly higher density of *A. gossypii,* followed by *B. tabaci* over other insect pests found indicates that they are more important pests of cucumber in parts of north eastern Nigeria. Moderate fruit infestation coupled with high abundance of *B. cucurbitae* per farmers' field also indicates that the melon fly is an important pest of cucumber in this locality. *Liriomyza* sp., which is capable of inflicting serious injury to cucumber (van Luijk, 2004), seasonally occurs in low density. In Hawaii, *Liriomyza* sp. are normally a secondary pest kept in check by natural enemies, i.e., tiny wasp-like parasitoids (Valenzuela *et al*., 1994).

Low density of *D. indica* was also expected, as lepidopterous pests are generally of minor importance in cucumber, except for cutworms which can devastate young cucumber plants by chewing through the stems at the soil line (Valenzuela *et al*., 1994). By contrast, none recovery of thrips and mites in this semi-arid locality was somewhat surprising and unexplained, as the population pressures or outbreaks of these pests can readily be high during hot and dry conditions (Hamasaki, 1987; Rosenheim *et al*., 1990; Welter *et al*., 1990; Boll *et al*., 2007). Field studies by Esan (2011) and Pitan and Filani (2014a, b) in south western Nigeria recorded lower (75% and 50%) crop damage and populations of beetles (*Podagrica uniforma*, *Epilachna chrysomelina*, *Diabrotica undecimpunclala*, *Acalymma villella* and *Epilachna borealis*) and fruit flies (*Bactrocera invadens*, *B. cucurbitae* and *Dacus ciliatus*,) in cucumber (irrespective of variety) intercropped with amaranth or maize compared with the monocrop. Their results partly align with ours, in that, though different sets of insects were recovered in two different regions of Nigeria, the density of insect pests attacking cucumber in this region is low in intercropped cucumber. Here, cucumber is often intercropped with two to five other crops including cereals mainly sorghum, millet and maize, legumes mainly cowpea, groundnut and bambara groundnut, and vegetables mainly sorrel and amaranth.

Pest density in cucumber monocrop fields could not be provided, as none of such fields was encountered in this study. In spite of this, relatively high density of *A. gossypii* and *B. tabaci* in this locality is a reason for concern. Since, even at low density, aphids damage cucumber by feeding on plant sap, and by spreading important viral diseases (from infected plants or weeds via winged forms that fly) such as cucumber mosaic virus (CMV), zucchini yellow mosaic virus (ZYMV), and papaya ringspot virus (PRSV) that can devastate cucumber crops in the tropics (van Luijk, 2004).

Aphid feeding damage can reduce plant vigor and may cause leaf deformation, while intense feeding encourages sooty mold growth (Valenzuela *et al*., 1994). More still, aphids can quickly reproduce in one week and have several generations in a single growing cycle. *Bemisia tabaci* feed on plant sap, and can reduce plant vigor and yield when populations are very high (van Luijk, 2004). Also, excessive feeding by *B. tabaci* can directly kill susceptible crops, as both nymphs and adults excrete large amounts of honeydew (a sweet sticky liquid/secretion deposited on the leave surfaces), on which black sooty mold can grow and interfere (screening out sunlight) with leaf photosynthesis and transpiration (Valenzuela *et al*., 1994). *Bemisia tabaci* is also capable of causing great indirect damage by transmitting a range of viruses that cause yellowing, such as cucumber vein yellowing virus (CVYV) and cucumber yellows virus (CYV).

In some cucurbits, *B. tabaci* inject a toxin in susceptible crops causing the leave surface to turn silvery. Adults of *B. cucurbitae* feed on honeydew from aphids, whiteflies, leafhoppers, etc., and therefore, are highly attracted to their excretions in and around cultivated fields. Attack by this fly might be severe on young developing fruits, particularly under high humidity conditions following cessation of rains (Valenzuela *et al*., 1994).

Although cucumber is susceptible to serious losses from several pests including *A. gossypii*, *B. tabaci*, *B. cucurbitae*, leafminers, mosaic viruses, and soil-borne and foliar diseases, the crop is reported to tolerate substantial foliar damage before economic damage occurs (Valenzuela *et al*., 1994). This makes it crucial to always prevent outbreaks of these major pests or minimize insect pest problems. It is crucial to detect insect pest presence early, and then, select and apply appropriate control measures. Farmers must be wary of using insecticides to control *A. gossypii* and *B. tabaci*, as their exploding population growth rates make them prone to developing pesticide resistance when exposed to frequent applications of the same insecticide. Rather, emphasis should be given to conserving the natural enemies of cucumber pests, as well as augmenting their abundance or enhancing their effectiveness through habitat management.

Aphids, whiteflies and melon flies infest a very wide range of host plants including vegetables, ornamentals, field crops and/or weeds (Uchida *et al*., 1990). Furthermore, *B. cucurbitae* develops within: i) fruits of cucumber and other vegetables, i.e., melons, squashes, peppers, tomatoes, etc, that constitute major in-field reservoirs, and ii) alternate weedy hosts which amongst others include wild bittermelon, castor bean and wild amaranth that constitute out-field reservoirs of *B. cucurbitae* and cucurbit virus diseases (Valenzuela *et al*., 1994). To lower crop infestation by *B. cucurbitae*, it is imperative to apply specific non-chemical pest management practices, which include: i) use of resistant varieties; ii) prompt destruction of old crops (so as: (a) not to serve as in-field reservoirs, and (b) also to reduce aphid movement and the diseases they carry to healthy crops), iii) non disposal of culled infested fruits in close proximity to cultivated fields, which otherwise supports *B. cucurbitae* to complete its life cycle and further cause damage, and iv) use of maize borders as trap crop to attract melon flies in fields where alternate weedy hosts are less prevalent around the field margins (Koistra, 1971; Valenzuela *et al*., 1994). In all, sustainable management of cucumber insect pests should be based on an integrated approach that suitably incorporates use of appropriate and effective non-chemical control measures including natural enemies, cultural and physical/mechanical practices, resistant varieties, and efficient insecticides as the last defense line.

Conclusion

Present results indicate that *A. gossypii, B. tabaci* and *B. cucurbitae* are major pests of cucumber in parts of north eastern Nigeria. Besides being capable of injuring the crop directly via feeding, the former two pests are vectors of important cucumber diseases, even if present in very low densities. Exploding population growth rates further makes both pests prone to developing insecticides resistance. Prevention of outbreaks of these major pests is crucial, and requires thorough understanding of insects' bioecology. In all, sustainable management of cucumber insect pests requires suitable integration of both non-chemical control measures and efficient/responsible use of insecticides as the last resort.

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IDENTIFICATION OF SUPERIOR PARENTS AND POTENTIAL HYBRIDS IN PEARL MILLET (*Pennisetum glaucum* L. R. Br.) IN A DIALLEL CROSS

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Abstract

High yielding pearl millet adaptable to marginal rainfall areas are important particularly in north eastern Nigeria where it is an important staple. Traditional cultivars do not provide the expected yield and returns to farmers. Thus, the need to develop and provide improved varieties with superior grain yield. Nursery experiment was conducted at University of Maiduguri Teaching and Research Farm with seven pearl millet parents (SOSAT-C88, Geron tsuntsu, Ex-Borno, Zango, LCIC9702, Dan digali and PEO5948) crossed using diallel (Griffins Method II Model I) to generate 21 hybrids. The hybrids with their parents (28 entries) were evaluated in 2012 cropping season at Dukke, Akko Local Government Area of Gombe State and University of Maiduguri Teaching and Research Farm in a randomized complete block design with three replications. Gene action, General Combining Ability (GCA) and Specific Combining Ability (SCA) effects and best parent heterosis were determined to identify superior parents and hybrids. Data were collected on: days to 50% flowering, leaves/plant, tillers/plant, plant height, panicle length, panicle girth, panicles/plot, seeds/panicle, 1000 grain weight, downy mildew incidence and grain yield. Analysis of variance revealed significant difference among the entries for most traits, implying the presence of genetic variability. GCA effects of the parents showed that LCIC9702 was the best general combiner followed by Zango, Dan digali and PEO5948, while estimates of SCA revealed, hybrids SOSAT-C88 × PEO5948 and LCIC9702 × PEO5948 were good cross combination for downy mildew tolerance. Similarly, SOSAT-C88 × Dan digali and Geron tsuntsu × Dan digali were the best hybrids for panicle length, while, SOSAT-C88 × PEO5948 was best for panicle girth and number of panicles. Heterosis revealed that Zango × LCIC9702, Geron tsuntsu × PEO5948, Zango × PEO-5948, SOSAT-C88 × Geron tsuntsu, SOSAT-C88 × PEO5948 and SOSAT-C88 × LCIC9702 had the best better parent heterosis for total grain yield. These hybrids have been identified as best for improving grain yield and could further be evaluated for stability and superior performance.

Key Words: Pearl Millet, General Combining Ability, Specific Combining Ability, Diallel, High Parent Heterosis

Introduction

Pearl millet [*Pennisetum glaucum* (L) R. Br.] is the most widely grown type of millet in Africa and the Indian sub-continent. It is well adapted to growing areas characterized by drought, low fertility and high temperature (FAO, 2007). Africa produces over 51% of the world's total pearl millet and it is second in importance after sorghum as staple crop in Nigeria. The crop is grown worldwide purposely for food and forage (Girgi *et al*., 2006). In marginal rainfall areas, farmers grow low yielding cultivars characterized by yield stability rather than high grain yield per se, minimizing risk of crop failure rather than high grain yield as priority (Kelley *et al*., 1996).

Breeding of pearl millet for higher grain yield rather than stability is therefore important since it is a staple food for the poorest of the poor and relatively performs where other crops would fail. Izge *et al*. (2005) reported that high grain yield potentials exist among pearl millets because of the high genotypic variability among land races. However, most cultivars grown today are poor yielding and this could be the reason why interest in hybrid varieties is growing steadily in Nigeria.

High yielding varieties adapted to harsh environments and marginal rainfall areas like north-eastern Nigeria have been developed in other climes but are not available particularly, in Gombe and Borno States of Nigeria and indeed most parts of Nigeria. Low yielding cultivars do not give the commensurate expected return to our farmers, hence the need to develop and provide pearl millet varieties with high grain yield. However, to develop high yielding varieties, knowledge of the genetic factors responsible for the inheritance of important traits is essential. This can be achieved through the identification of the predominant genetic components and establishing the magnitude of their effects on trait expression. The genetic analysis would help in elucidating the combining ability which would subsequently lead to the identification of best parent combinations that translate to superior performing hybrids. The objectives of the study were to determine the nature of the gene action, estimate the combining ability effects and the levels of better parent heterosis (BPH) for grain yield and other yield traits.

Materials and Methods

Four improved and three local pearl millet cultivars were used as parents in a diallel cross excluding the reciprocals (Griffins Method II Model I). The pearl millet lines were selected based on their geographical diversity, variability in yield and agronomic traits. The materials were obtained from Kembu, in Akko Local Government Area of Gombe State and Lake Chad Research Institutes (LCRI) Maiduguri in Borno State as described in Table 1.

The initial breeding for the base population was conducted in 2011/2012 off-season at University of Maiduguri Teaching and Research Farm (11^0 $6^'$ N; $13^0 17^'$ S) under irrigation. In 2012, the twenty-one (21) hybrids and seven parental lines obtained were evaluated in Maiduguri, Sudan Savannah and Dukke, northern Guinea Savannah (10^o $8^'$ N and 11^o $20^'$ S).

Table 1: Description of parental lines used in the study

Cultivars	Source	Days to 50% Flowering	Description
Geron tsuntu	Kembu	65	Long hairy panicle, dark grey seeds, medium sized seeds and adapted to the Sudan and Sahel regions of Nigeria.
Zango	Kembu	75	Very long, semi compact panicles and late maturing.
Dan digali	Kembu	70	Small panicles (candle in shape) with a semi-compact medium sized seed.
SOSAT-C88	LCRI	53	Long, cylindrical and compact panicle, large seeds, early maturing.
Ex-Borno	LCRI	60	Medium maturing, medium sized seed and adapted to the Sahel region of Nigeria.
LCIC 9702	LCRI	57	Long compacted panicles early maturing, candle-like in shape with large seeds.
PEO 5984	LCRI	60	Panicles are average in length with thick girth, large seeds and medium maturing.

The 28 entries were laid out in a Randomized Complete Block Design (RCBD) with three replications at two locations. Plot size was 3 m × 5 m and consisted of four rows. Seeds were treated with Apron Star WS at recommended rate and sown by hand at 75 cm inter row and 50 cm intra row spacing. After germination, seedlings were thinned to two plants per hill 2 - 3 weeks after sowing. Compound fertilizer (NPK 15:15:15) at the rate of 60 kg/ha was applied in two split doses one at planting and at 5 weeks after sowing. Weed control was done manually by using hoe at 3 weeks and 7 weeks respectively after sowing according to Onwueme and Sinha (1991) and as required afterwards. Harvesting was done manually using hoe to cut the stalks and the panicles were cut with hand knife.

Data collection was done on the following parameters according to the work of Izge *et al*.

(2007): days to 50% flowering, numbers of tillers/plant, number of leaves/plant, downy mildew incidence and plant height. Other parameters on which data were collected were: panicle length, panicle width, 1000 grain weight, number of seeds/panicle and grain yields.
The data collected were subjected to analysis of variance (ANOVA). The GCA variance, the SCA variance and their respective effects were estimated according to Singh and Chaudhary (1985). The better parent heterosis was also estimated and the levels of significance among them were compared based on the work of Liang *et al*. (1972).

Results and Discussion
Pooled Analysis of Variance
The mean squares for combining ability are presented in Table 2. All the traits had highly significant difference ($P\leq0.01$) for location. Similarly, there was highly significant difference for replication/location for the measured traits except for number of tillers/plant, number of panicles/plot, 1000 grain weight and grain yield/plot, which did not show any significant difference. All the traits exhibited highly significant difference ($P\leq0.01$) among the entries, except for days to 50% flowering which was significant at 5% level of probability. However, there was no significant difference among the entries for number of tillers/plant. Significant difference ($P\leq0.05$) was observed among the parents for number of tillers/plant and 1000 grain weight. The other traits exhibited highly significant difference ($P\leq0.01$) among each other and between parents.
The result in Table 2 also revealed that, highly significant difference ($P\leq0.01$) existed for days to 50 % flowering, number of leaves/plant, plant height, panicle length, panicle diameter, 1000 grain weight and number of seeds/panicle among the hybrids. Also, location × parent interaction had highly significant difference for number of leaves/plant and significant difference for grain yield/plot and grain yield/ha (Table 2). On the other hand, location × hybrid interactions had highly significant difference for number of leaves/plot and significant difference for number of tillers/plant. Location × entries interaction had highly significant difference ($P\leq0.01$) for leaves/plant, seeds/panicle, grain yield/plot and grain yield/ha, while significant difference ($P\leq0.05$) was observed for tillers/plant and panicles/plot.

Performance of parental lines and hybrids
The results for mean performances of parental lines and their hybrids are presented in Table 3. The result revealed highly significant (($P\leq0.01$) and significant ($P\leq0.05$) differences in performance among the parents and hybrids in all the traits. The high level of significant difference implies the presence of considerable variability among the parents and the hybrids. The significant difference in mean performance particularly among pearl millet has been reported by Mainasara (2012).
The results show that *Zango* had the highest days to 50% flowering (75.83 days) and equally highest level of downy mildew incidence (54.17%), while LCIC9702 had the least days to 50% flowering with 68.58 days. The pearl millet line LCIC9702 had earlier been described as early maturing and this result confirms it.
Ex-Borno produced the highest yield compared to the other parents both in terms of grain yield/plot (1.19 kg) and grain yield/hectare (795.60 kg/ha). Incidentally, Ex-Borno which gave the highest grain yield had the lowest downy mildew incidence of 15 % considering both the parents and the hybrids. LCIC9702 (2624) on the other hand, had the highest number of seeds. This cultivar has very long panicles; therefore, higher number of seeds/panicle is expected.
Among the hybrids, SOSAT-C88 × Ex-Borno and Ex-Borno × LCIC9702 had had the highest yield/plot and yield/ha (1.38 g/plot and 922.27 kg/ha; 1.39 g/plot and 927.82 kg/ha, respectively). However, *Geron tsuntsu* × *Zango* had the highest number of leaves/plant (9) and panicle length (41.32 cm). SOSAT-C88 × LCIC9702 recorded the highest 1000 grain weight of 8.45 g, while Ex-Borno × *Zango* had the longest panicle length of 185.56 cm. The hybrid LCIC9702 × *Dan digali* recorded the highest number of tillers.
The pooled analysis of variance results indicated a variable environment in which the entries were evaluated. The significant differences observed for entries and location

interaction indicated a high level of environmental variation for expression of heterosis. Accordingly, stability analysis would be important in order to identify which location was suitable for a particular hybrid. Izge (2006), reported similar results of strong environmental influence when testing pearl millets for heterosis.

Estimates of GCA and SCA effects

The estimates of general combining ability effects of parents and specific combining ability effects of hybrids are presented in Table 4. Variation was observed among the parents for most of the traits. The GCA effect revealed that, LCIC9702 was the best general combiner because it had significant and positive GCA effects in more traits than the other parents. The results indicated that the parents used for the genetic analysis were diverse as reported by Naik *et al*. (1999), where the combining ability of pearl millet yield and it's were studied. The SCA effect was higher than the GCA effect for most traits. This indicates that these traits would be very difficult to improve through simple selection schemes such as pedigree recurrent selection, because it would be difficult to predict the short-term response to selection. The second best general combiner among the parents was *Zango* followed by Ex-Borno, *Dan digali* and PEO5948, which had high or highly significant positive GCA effects for some traits as indicated in Table 4.

The results show that LCIC9702 had the least negative GCA effect value (-1.61) for days to 50% flowering as well as downy mildew incidence, indicating that it can be used in breeding for early maturity and resistance to downy mildew. This result confirms the findings of Mainasara (2012). It was also observed that hybrids with higher SCA effects were mostly from parents with good GCA effects for a particular trait. Gama *et al*., (1995) and Lakshamana (2008) reported that, one of the important criteria in heterosis breeding is the choice of appropriate parents to be used in the hybridization programme. It is therefore necessary to select parents with good general combining ability for yield and its component traits in order to get good performance. The hybrid SOSAT-C88 × PEO5948 had positive and significant SCA effect for number of panicles/plot.

The analysis also revealed that only SOSAT-C88 × PEO5948 showed positive and significant SCA effect for downy mildew incidence. This implies that the hybrid could be susceptible to downy mildew disease. The hybrids; *Zango* × *Dan digali* and LCIC9702 × PEO5948 had negative SCA effect for downy mildew incidence indicating that they could be tolerant to the disease.

The exceptional performance of the hybrids could be attributed to the good genetic potential of the parents in terms of days to 50% flowering, plant height, panicle diameter, downy mildew incidence, grain yield/plot and grain yield kg/ha. The SCA effect values in all the traits among the hybrids were variable, this finding concur with that of Mainasara (2012). It was found that hybrid SOSAT-C88 × PEO5948 was the best in terms of SCA effect for days to 50% flowering, plant height, panicle diameter, number of panicle/plot, 1000 grain weight, grain yield/plot and grain yield kg/ha. This was followed by *Geron tsuntsu* × PEO 5948 which also had good SCA effect for days to 50% flowering, number of panicles/plot, downy mildew incidence, 1000 grain weight, grain yield/plot and grain yield kg/ha.

The result shows that high SCA effect comes into play due to the fact that, either one or both parents could combine to produce hybrid with high SCA effect. Similar results had been reported by Mathur and Mathur (1983) where parents showing high GCA effects for yield were found to show high GCA effects for one or more yield components and even in their subsequent hybrids. Other results obtained from hybrids having desirable SCA effects for different characters has also been reported using different genotypes (Majid *et al*. 2010; Aminu and Izge 2013; Aminu *et al*. 2014). Umar *et al*. (2014) further stated that, better specific combining hybrids might involve two good generals combining parents but this is not a rule for all cases. Sometimes two poor combiners may ensue to produce good specific combinations. Some of the superior hybrids could be from both parents with high × high general combiners or either one of the parents with high GCA effect (high × low or low × high) or parents that are low × low general combiners. It therefore means that the parents with either high GCA or low GCA would have a higher chance of having excellent complimentarity with other parents (Umar *et al*. 2014; Aminu and Izge, 2013 and Majid *et al*. 2010).

The superior cross combinations involving low × low GCA parents could result from over dominance or epistasis (Hallauer and Miranda 1988; Majid *et al*. 2010). Such type of gene action may be exploited in cross pollinated crops like maize (Umar *et al*. 2014) and pearl millet.

Heterosis of hybrids over best parent in traits of pearl millet

The result for best parent heterosis (BPH) of hybrids in pearl millet traits are presented in Table 5. The results revealed that SOSAT-C88 × *Dan digali* had the least heterosis level -5.58% in days to 50% flowering, followed by SOSAT-C88 × *Zango* with -5.39% and *Geron tsuntsu* × PEO5948 with -4.80%. On the other hand, *Dan digali* × PEO 5948 had the highest and positive BPH value of 8.51%, followed by SOSAT-C88 × Ex-Borno (1.44 %) and *Geron tsuntsu* × *Zango* (1.20 %). The result also revealed that SOSAT-C88 × *Zango* had the highest level of BPH (13.27%) for number of tillers/plant, followed by LCIC9702 × PEO5948 (12.20%) and *Ex-Borno* × PEO5948 (10.79%).

The result for plant height revealed that, *Zango* × LCIC9702 had 24.61% BPH, followed by *Zango* × PEO5948 (21.93%) and SOSAT-C88 × *Zango* (21.70%). Similarly, SOSAT-C88 × PEO5948 had the highest BPH of 10.83% for panicle length followed by LCIC9702 × PEO5948 (9.47%) and SOSAT-C88 × LCIC9702 (8.29%). On the other hand, *Ex-Borno* × LCIC9702 had a BPH of 9.86% for panicle diameter, followed by *Zango* × *Dan digali* (8.99%) and *Dan digali* × PEO5948 (8.80%).

Hybrid *Geron tsuntsu* × *Zango* had 23.63% BPH for number of seeds/panicle, while Ex-Borno × PEO5948 had 21.33%. The hybrid *Geron tsuntsu* × PEO5948 had 103.35% BPH for number of panicles/plot and this was followed by SOSAT-C88 × PEO5948 (93.70%) and SOSAT-C88 × *Geron tsuntsu* (76.43%). The hybrids with least good parent heterosis values for percent downy mildew incidence included SOSAT-C88 × PEO 5948 (-64.28%) *Zango* × PEO5948 (-60.30%) and LCIC9702 × PEO5948 (-55.35%). The negative BPH values for downy mildew incidence entails degrees of resistance of the hybrids to downy mildew infection. On the other hand, high positive BPH for downy mildew incidence indicates the level of susceptibility of the hybrids. Ati (2015) reported that, negative heterosis observed in downy mildew incidence and days to 50% flowering are desirable in breeding for earliness and downy mildew resistance. It reaffirmed that; negative heterosis for earliness indicated the scope of developing high yielding and early maturing hybrids. Heterosis for earliness has also been reported by Kushwah and Singh (1992), Chavan and Nerker (1994). The result for 1000 grain weight reveals that hybrid SOSAT-C88 × LCIC9702 had the highest BPH of 20.20%.

For grain yield, *Zango* × LCIC9702 had the highest BPH of 113.21% BPH for grain/plot and 115.21% for grain/ha. The least BPH in yield was observed in *Ex-Borno* × *Zango* which had a negative BPH in both yield/plot (-36.67%) and yield/ha (-36.45%). It can be inferred that there is a clear disparity among the levels of heterosis associated with different traits in these hybrids particularly for grain yield. The heterosis for yield revealed that grain yield was more influenced by panicle components rather than by vegetative components, this could be clearly seen from the degree of heterosis exhibited by number of panicles which outweighed that of plant height. This finding conforms to that of Ati (2015), Ugale *et al*. (1989) and Baviskar (1990). However, the same result contradicts that of Mainasara (2012) who reported that improvement in grain yield could be achieved through improving vegetative components. The negative BPH observed in traits such as, panicle length, number of tillers, panicle diameter and grain yield could be due to sample variation, linkage, inadequate statistical and genetic models (Ati, 2015).

Conclusion

In conclusion, the study revealed that most of the traits were predominantly controlled by non-additive rather than by additive genetic effects. *Ex-Borno* was the best performing parent in terms of grain yield. Similarly, SOSAT × *Ex-Borno* and Ex-Borno × LCIC9702 were the best performing hybrids for grain yield. *Ex-Borno* and PEO5948 had the best GCA effects for grain yield, while SOSAT-C88 × PEO5948 and *Geron tsuntsu* × PEO5948 had the best SCA effects for grain yield. Zango × LCIC9702 and SOSAT-C88 × *Geron tsuntsu* had the best in BPH for grain yield. This study also concludes that highest specific combining ability for grain yield was manifested in number of panicles/plot and panicle diameter indicating that, improvement in grain yield could be achieved through the improvements of panicle components.

Cross combinations with high SCA effect for grain yield also exhibited significant BPH and had at least one parent with significant GCA effect. More than 70% of the hybrids showed positive SCA effect for number of panicles/plot and grain yield kg/ha signifying the potential for exploiting hybrid vigour through recurrent selection in pearl millet improvement programme.

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Table 2: Mean squares and analysis of variance for combining ability in a diallel cross of pearl millet combined across locations

Source of Variation	DF	Days to 50% flowering	Leaves/ Plant	No. Tillers/ Plant	Downy Mildew Incidence (%)	Plant Height (m)	Panicle Length (m)	Panicles /Plot	Panicle diameter (m)	1000 Grain Wt. (g)	No. Seeds /Panicle	Grain Yield/ Plot (kg)	Grain Yield/ha (kg)
Location	1	2747.99**	214.85**	3.77**	2750.05**	67614**	28.85**	104935.24**	7.16**	109.56**	77675968.05**	61.11**	27162168.59**
Rep/Location	4	31.99**	0.79**	0.18	2842.35**	562.41*	23.82**	250.16	2.31**	0.96	4589566.55**	0.14	60468.43**
Entries	27	39.19*	1.27**	0.57	791.69**	890.99**	201.57**	1276.06**	1.53**	2.45**	992149.02*	0.49**	217896.22**
Parents	6	39.52	1.82**	0.79*	1031.75	1621.68**	218.83**	158.22**	1.68**	1.71*	1364389.53	0.39**	171863.39**
Hybrids	20	34.25**	1.05**	0.54	413.57	642.38**	154.31**	604.71*	1.50**	2.93**	1849637.59**	0.28	124005.23
Location × Parents	6	10.27	0.98**	0.26	253.97	113.50	6.53	399.08	0.22	0.80	1001564.87	0.18*	81977.86*
Location × Hybrids	20	11.31	0.51**	0.78*	363.12	211.97	3.15	393.15	0.30	0.75	366575.75	0.22	97160.37
Location × Entries	27	10.85	0.58**	0.68*	333.58	200.80	3.77	578.23*	0.29	0.91	784521.55**	0.29**	128566.81**
GCA	6	75.05**	2.82**	1.14**	383.67	2524.34**	774.60**	1317.35**	5.34**	6.29**	1539825.90*	0.58**	259456.34**
SCA	21	301.55*	0.68**	0.36	864.97**	344.12*	21.90**	1227.93**	0.50*	1.64	591198.78**	0.45**	200110.51**
GCA × Location	6	10.16	0.39	1.03*	573.53	253.11	5.38	751.10*	0.63*	0.86	586339.35	0.44**	197089.76**
SCA × Location	21	10.66	0.67**	0.59	320.19	194.90	2.70	556.30*	0.22	0.99	661678.23	0.25*	111424.66
Pooled Error	108	16.07	0.22	0.39	359.03	180.41	6.74	327.67	0.26	0.84	625989.00	0.15	68697.84
GCA:SCA		0.249	4.15	3.17	0.44	7.34	35.37	1.07	10.68	3.84	2.60	1.29	1.30

**P≤0.01 * P≤0.05

Table 3: Mean performance of parental lines and their hybrids for traits of pearl millet combined across locations

Parental lines	Days to 50% flowering	leaves/ plant	Tillers/ plant	Plant height (cm)	Panicle length (cm)	Panicle diameter (cm)	No. of seeds/ panicle	No. of panicle/ plot	Downy mildew incidence (%)	1000 grain weight (g)	Grain yield/plot (kg)	Grain yield (kg/ha)
SOSAT-C88	74.17^{abc}	7.87^{d-g}	2.98^{de}	149.93^{jkl}	20.87^{mn}	7.44^{d-j}	1814.27^{a-d}	37.50^{gh}	46.67^{ab}	5.95^{hi}	0.59^{e-i}	390.02^{e-i}
Geron tsuntsu	70.83^{b-h}	8.42^{a-d}	3.43^{a-e}	165.27^{d-j}	36.32^{c-f}	6.56^{kl}	1479.16^{a-d}	33.00^{h}	44.17^{abc}	6.67^{d-l}	0.45^{i}	300.02^{i}
Ex-Borno	70.33^{c-h}	8.27^{a-f}	3.80^{abc}	183.83^{ab}	25.77^{i-l}	7.30^{e-j}	1032.80^{cd}	76.67^{ab}	15.00^{f}	7.68^{a-e}	1.19^{a-d}	795.60^{a-d}
Zango	75.83^{a}	8.55^{ab}	3.23^{cde}	182.12^{abc}	39.27^{a}	7.12^{g-l}	1612.07^{a-d}	33.00^{h}	54.17^{a}	6.78^{c-h}	0.53^{hi}	351.13^{hi}
LCIC-9702	68.58^{fgh}	6.85^{l}	3.80^{a-d}	144.42^{l}	21.10^{n}	7.16^{e-j}	2623.89^{ab}	54.79^{b-f}	46.63^{ab}	6.69^{c-g}	0.52^{ghi}	346.98^{ghi}
Dan digali	71.67^{b-g}	7.63^{c-h}	3.42^{a-e}	167.83^{c-h}	30.48^{c-g}	7.03^{i-l}	2365.47^{a}	46.50^{e-h}	40.83^{a-d}	6.55^{f-l}	0.56^{f-i}	374.46^{f-i}
PEO-5948	72.17^{a-f}	7.88^{kl}	2.78^{e}	146.18^{kl}	20.80^{mn}	8.30^{ab}	1223.24^{cd}	39.67^{fgh}	52.50^{a}	7.07^{b-f}	0.75^{d-i}	498.91^{d-i}
Mean	71.94	7.92	3.35	162.80	27.81	7.27	1742.27	45.88	42.85	6.77	0.66	436.74
SE ±	0.26	0.19	0.19	1.21	1.35	0.18	12.99	2.17	1.85	0.00	0.29	7.52
Hybrids												
SOSAT-C88 × *Geron tsuntsu*	67.17^{h}	7.70^{f-k}	3.28^{cde}	160.86^{g-k}	29.40^{a-e}	7.20^{f-k}	1192.63^{cd}	66.17^{a-e}	26.67^{b-f}	7.27^{c-f}	1.11^{a-d}	742.26^{a-d}
SOSAT-C88 × *Ex-Borno*	69.00^{e-h}	8.47^{bc}	3.80^{abc}	163.25^{f-j}	21.83^{mn}	7.79^{b-f}	1584.89^{a-d}	71.50^{a-d}	30.83^{a-f}	7.97^{ab}	1.38^{a}	922.27^{a}
SOSAT-C88 × *Zango*	70.33^{c-h}	8.13^{c-g}	3.67^{a-d}	182.46^{abc}	33.33^{b-d}	7.52^{d-j}	1122.78^{c-d}	65.83^{a-e}	28.33^{b-f}	7.13^{c-f}	1.00^{a-f}	663.37^{a-f}
SOSAT-C88 × LCIC 9702	66.83^{h}	7.33^{j-l}	3.72^{abc}	157.02^{g-l}	22.60^{k-n}	7.76^{b-g}	1149.13^{c-d}	75.17^{abc}	20.83^{c-f}	8.45a	1.03^{a-e}	688.92^{a-e}
SOSAT-C88 × *Dan digali*	67.67^{gh}	7.63^{g-k}	3.38^{c-e}	157.47^{g-l}	29.32^{e-i}	6.88^{jkl}	1697.98^{a-d}	70.17^{a-d}	39.33^{a-e}	6.75^{d-i}	0.90^{b-i}	596.70^{b-i}
SOSAT-C88 × PEO 5948	69.17^{d-h}	7.80^{e-g}	3.17^{c-e}	163.98^{e-j}	23.13^{k-n}	8.55^{a}	1178.66^{bcd}	76.83^{ab}	16.67^{ef}	6.88^{d-i}	1.27^{abc}	844.49^{abc}
Geron tsuntsu* × *Ex-Borno	69.83^{c-h}	7.83^{c-g}	4.03^{a-b}	171.10^{a-g}	26.03^{h-k}	7.41^{d-j}	1205.82^{cd}	82.83^{a}	15.83^{ef}	6.97^{b-h}	1.27^{abc}	848.93^{abc}
Geron tsuntsu* × *Zango	72.67^{a-e}	8.88^{a}	3.43^{a-e}	178.75^{a-e}	41.32^{a}	6.93^{i-l}	1993.08^{abc}	52.17^{d-h}	40.50^{a-d}	5.97^{ghi}	0.80^{d-i}	531.14^{d-i}
***Geron tsuntsu* × LCIC 9702**	68.00^{fgh}	7.50^{i-l}	3.63^{a-d}	150.08^{jkl}	27.90^{f-j}	7.75^{b-g}	1322.23^{bcd}	73.50^{abc}	39.17^{a-e}	7.28^{c-f}	0.98^{a-g}	652.25^{a-g}
Geron tsuntsu* × *Dan digali	69.33^{d-h}	7.85^{d-g}	3.48^{a-e}	153.75^{h-l}	32.35^{b-d}	6.91^{i-l}	1658.59^{a-d}	59.33^{a-e}	21.67^{c-f}	6.47^{f-i}	0.80^{d-i}	530.03^{d-i}
***Geron tsuntsu* × PEO 5948**	66.67^{h}	8.23^{a-g}	3.30^{cde}	169.42^{b-g}	30.50^{c-g}	7.70^{b-h}	1083.00^{cd}	80.67^{a}	27.50^{b-f}	7.40^{a-f}	1.32^{ab}	881.16^{ab}
Ex-Borno* × *Zango	75.17^{ab}	8.57^{ab}	3.21^{cde}	185.56^{a}	34.12^{bc}	7.18^{f-k}	1163.81^{cd}	46.33^{e-h}	36.67^{a-f}	7.28^{c-f}	0.76^{d-i}	505.58^{d-i}
***Ex-Borno* × LCIC 9702**	70.17^{c-h}	8.35^{a-e}	3.83^{abc}	170.31^{a-g}	23.27^{lmn}	8.02^{bcd}	1107.24^{cd}	74.00^{abc}	28.33^{b-f}	7.98^{ab}	1.39^{a}	927.82^{a}
Ex-Borno* × *Dan digali	72.67^{a-e}	8.42^{a-d}	3.80^{abc}	177.35^{a-f}	24.37^{j-m}	7.17^{f-k}	1422.26^{a-d}	57.67^{b-g}	40.83^{a-d}	7.08^{c-f}	0.96^{a-h}	641.14^{a-b}
***Ex-Borno* × PEO 5948**	72.00^{a-d}	8.20^{c-g}	3.38^{c-e}	167.58^{c-h}	22.37^{k-n}	7.66^{b-f}	1484.27^{a-d}	55.83^{c-g}	28.33^{b-f}	7.83^{abc}	0.87^{c-i}	578.92^{c-i}
***Zango* × LCIC 9702**	69.50^{d-h}	8.50^{a}	3.58^{a-d}	180.12^{a-d}	29.80^{d-g}	7.07^{h-l}	1159.77^{cd}	72.17^{a-d}	19.19^{def}	7.38^{b-f}	1.13^{a-d}	750.04^{a-d}
Zango* × *Dan digali	69.17^{d-h}	7.68^{g-k}	3.67^{a-d}	167.08^{c-i}	35.17^{b}	6.48^{l}	1458.25^{a-d}	52.17^{d-h}	40.83^{a-d}	6.68^{f-i}	0.62^{e-i}	414.47^{e-i}
***Zango* × PEO 5948**	70.67^{c-h}	8.20^{a-h}	3.35^{c-e}	181.90^{abc}	33.20^{bcd}	7.95^{b-e}	917.49^{d}	63.83^{a-e}	20.83^{c-f}	6.97^{b-h}	1.31^{abc}	874.49^{abc}
LCIC 9702 × *Dan digali*	68.75^{d-h}	7.23^{l-k}	3.47^{abc}	151.60^{i-l}	27.33^{g-j}	7.11^{i-l}	1326.77^{a}	69.50^{a-d}	23.83^{b-f}	7.18^{e-i}	1.02^{a-f}	680.57^{a-f}
LCIC 9702×PEO 5948	68.00^{f-h}	7.75^{e-j}	4.13^{a}	163.53^{e-j}	22.77^{k-n}	8.16^{bc}	1238.93^{cd}	71.83^{a-d}	20.83^{c-f}	7.75^{a-d}	1.18^{a-d}	786.71^{a-d}
***Dan digali* × PEO 5948**	75.17^{ab}	8.67^{ab}	3.23^{cde}	171.42^{a-g}	29.55^{d-h}	7.57^{c-i}	1606.15^{a-d}	53.00^{d-h}	30.83^{a-f}	5.70^{i}	0.97^{a-h}	645.59^{a-h}
Mean	69.90	8.02	3.55	167.84	28.36	7.47	1336.86	66.19	28.47	7.16	1.05	700.54
SE ±	0.28	0.15	0.14	0.79	0.95	0.18	6.94	2.13	1.40	0.24	0.20	5.42

Table 4: Estimate of GCA effects of parents and SCA effects of hybrids in pearl millet across locations

Parental lines and Hybrids	Days to 50% flowering	Leaves/ plant	Tillers/ plant	Plant height (cm)	Panicle length (cm)	Panicle diameter (cm)	No. of seeds/ panicle	No. of panicles/ plot	Downy mildew incidence (%)	1000 grain weight (g)	Grain yield/plot (kg)	Grain yield/ha (kg)
SOSAT-C88	-1.02	-0.16	-0.10	-4.99*	-2.63**	0.15	-26.66	2.83	-0.78	0.11	0.05	30.41
Geron tsuntsu	-1.00	-0.2	-0.12	-2.95	3.66**	-0.23**	-2.49	0.62	0.38	-0.23	-0.03	-21.34
Ex-Borno	1.10	0.29	0.16	7.01**	-3.02**	0.07	-135.84	3.07	-2.71	0.45**	0.13	83.59
Zango	1.69*	0.28	-0.83	12.58**	6.76**	-9.26**	-74.96	-8.27	3.96	-0.20	-0.12	-77.85
LCIC 9702	-1.64*	-0.35*	0.24**	-7.50**	-3.62**	0.14	52.93	7.04	-2.00	0.41*	0.04	26.92
Dan digali	0.53	-0.14	0.01	-3.32	1.33**	-0.43**	361.35*	-5.05	3.62	-0.54**	-0.16	-109.60
PEO 5948	0.34	0.10	-0.20*	-0.84	-2.37**	0.55**	-174.32	-0.26	-2.47	0.00	0.10	67.87
SE ±	**1.12**	**0.28**	**0.14**	**3.20**	**0.60**	**0.12**	**241.13**	**6.88**	**4.24**	**0.26**	**0.16**	**107.83**
SOSAT-C88 × *Geron tsuntsu*	-1.03	-0.13	-0.13	1.68	0.06	-0.16	-199.92	-0.62	-3.62	0.30	0.11	71.02
SOSAT-C88 × *Ex-Borno*	-1.29	0.33	0.21	-5.90	-0.93	0.13	352.69	2.27	3.64	0.31	0.22	146.11
SOSAT-C88 × *Zango*	-0.55	0.00	0.32	7.74	0.79	0.18	-197.31	7.93	-5.53	0.14	0.07	48.64
SOSAT-C88 × LCIC 9702	-0.72	-0.16	0.05	2.37	0.44	0.02	-298.85	1.96	-7.07	0.84	-0.05	-30.57
SOSAT-C88 × *Dandigali*	-2.05	-0.08	-0.05	-1.36	2.21*	-0.28	-58.41	9.05	5.81	0.09	0.02	13.72
SOSAT-C88 × PEO 5984	-6.36	-0.32	0.28	9.90	2.00	0.72*	-512.95	42.40*	28.31*	1.05	0.63	417.00
Geron tsuntsu* × *Ex-Borno	-0.48	-0.45	0.36	-0.09	-2.92**	0.13	-77.55	15.81	-12.53	-0.35	0.19	124.52
Geron tsuntsu* × *Zango	1.76	0.11	0.00	1.99	2.59**	-0.02	648.82	-3.52	7.47	-0.69	-0.05	-31.84
***Geron tsuntsu* × LCIC 9702**	0.43	-0.13	-0.12	-6.59	-0.45	0.39	-149.92	2.50	10.09	0.01	-0.02	-15.49
Geron tsuntsu* × *Dan digali	-0.41	0.00	-0.04	-7.11	-0.95	0.13	-121.97	0.43	-13.03	0.14	0.00	-1.20
***Geron tsuntsu* × PEO 5948**	-5.50	-0.30	0.05	2.04	0.11	0.37	-224.33	48.52	-13.81	0.51	0.74	491.93
Ex-Borno* × *Zango	2.16	-0.01	-0.04	-1.16	1.97	-0.07	-47.10	-11.81	4.73	-0.05	-0.24	-162.32
***Ex-Borno* × LCIC 9702**	0.50	0.40	-0.10	3.67	1.49	0.37	-231.56	0.55	2.35	0.03	0.23	155.16
Ex-Borno* × *Dan digali	0.83	0.25	0.10	6.52	-2.35*	0.09	-224.95	-3.69	9.23	0.08	0.01	4.99
***Ex-Borno* × PEO 5948**	2.43	0.13	-0.06	-8.40	-4.05*	-0.12	489.99	-17.52	13.10	0.61	-0.30	-200.96
***Zango* × LCIC 9702**	-0.77	0.57	-0.10	7.90	-1.75	-0.26	-239.91	10.05	-13.47	0.08	0.21	138.81
Zango* × *Dan digali	-3.27	-0.47	0.21	-9.32	-1.33	-0.26	-249.85	2.15	2.57	0.33	-0.09	-60.25
***Zango* × PEO 5948**	-3.81	-0.17	0.23	13.31	3.06	0.02	-595.22	22.81	-26.90*	-0.02	0.57	377.64
LCIC 9702 × *Dan digali*	0.40	-0.31	0.02	-4.52	0.83	-0.14	416.70	3.84	-6.48	-0.32	0.13	86.10
LCIC 9702 × PEO 5948	-1.98	0.36	0.88	12.33	1.23	0.45	-626.30	22.29	-25.36*	1.14	0.59	393.51
***Dan digali* × PEO 5948**	3.69	0.80	0.02	1.11	2.76	-0.44	-243.66	1.69	-3.90	-1.38	0.14	93.66
SE ±	**1.21**	**0.28**	**0.14**	**3.20**	**0.60**	**0.12**	**241.13**	**6.88**	**4.24**	**0.26**	**0.16**	**107.83**

**P<0.01*P<0.0

Table 5: Heterosis of hybrids over high parents in traits of pearl millet combined across locations

Hybrids	Days to 50% flowering	Leaves/ plant	Tillers/ plant	Plant height (cm)	Panicle length (cm)	Panicle diameter (cm)	No. of seeds/ panicle	No. of panicles/ plot	Downy mildew incidence (%)	1000 grain weight (g)	Grain yield/plot (kg)	Grain yield/ha (kg)
SOSAT-C88 × *Geron tsuntsu*	-4.11	-8.55	-4.33	7.29	-19.05	-3.23	-35.16	76.45	-39.62	11.87	88.14	90.32
SOSAT-C88 × *Ex-Borno*	-1.91	1.44	0.00	8.88	-15.25	4.84	-13.83	-6.74	102.20	3.78	15.83	15.92
SOSAT-C88 × *Zango*	-5.39	-4.80	13.27	21.70	-15.10	1.08	-38.99	75.55	-39.30	5.01	69.49	70.09
SOSAT-C88 × LCIC 9702	-1.72	-3.05	0.81	8.63	8.29	4.30	-41.59	32.27	-55.35	20.20	76.44	76.64
SOSAT-C88 × *Dan digali*	-5.58	-2.92	-1.17	5.02	-7.12	-7.53	-28.83	50.90	-3.65	3.37	52.54	52.99
SOSAT-C88 × PEO 5984	-4.16	-2.38	6.02	9.92	10.83	3.01	-35.92	93.70	-64.28	-2.55	69.33	69.26
Geron tsuntsu* × *Ex-Borno	-0.30	-2.97	6.05	3.54	-28.33	1.51	-184.79	8.05	5.60	-9.24	5.83	6.70
Geron tsuntsu* × *Zango	3.61	1.20	0.00	8.16	5.22	-2.67	23.63	58.09	-3.78	-12.08	50.94	51.27
***Gerontsuntsu* × LCIC 9702**	0.00	-10.93	-1.36	3.83	-23.18	6.16	-38.81	29.33	-11.32	2.98	84.91	85.38
Geron tsuntsu* × *Dan digali	-1.01	-6.77	1.45	-6.97	-10.93	-1.71	-30.47	38.32	-46.93	-4.01	42.86	42.58
***Geron tsuntsu* × PEO 5948**	-4.80	-2.14	-4.07	13.56	-16.02	-7.23	-26.78	103.35	-37.74	4.67	76.00	76.61
Ex-Borno × *Zango*	6.87	0.23	-15.26	1.89	-13.11	-1.64	-27.81	-39.57	144.47	-5.08	-36.67	-36.45
Ex-Borno × LCIC 9702	3.19	0.00	1.05	17.83	-14.24	9.86	-47.09	-3.48	88.93	3.91	15.83	16.62
Ex-Borno × *Dan digali*	3.74	0.84	0.00	5.67	-20.07	-1.78	-41.08	-24.78	172.20	-7.68	-20.00	-19.41
Ex-Borno × PEO 5948	4.49	-1.80	10.79	12.67	-13.19	-5.66	21.33	-27.17	88.93	2.08	-27.50	-27.23
***Zango* × LCIC 9702**	2.21	0.58	-2.71	24.61	-24.12	-3.15	-44.57	26.99	-58.92	5.12	113.21	115.21
Zango* × Dan *digali	-3.49	-10.18	7.31	-0.44	-10.44	8.99	-38.87	12.19	-0.02	-1.62	12.50	11.42
***Zango* × PEO 5948**	-2.08	-4.09	3.40	21.93	-15.46	-4.22	-43.09	60.90	-60.30	-3.96	74.67	75.28
LCIC 9702 × *Dan digali*	2.21	-5.76	2.98	5.04	-11.61	-3.97	-5.57	21.71	-36.74	-5.41	78.57	77.79
LCIC 9702 × PEO 5948	0.00	-3.00	12.20	13.82	9.47	-1.69	-40.79	26.39	-55.35	9.62	57.33	57.68
***Dan digali* × PEO 5948**	4.48	8.51	-4.79	15.01	-3.08	8.80	-32.53	13.98	-24.49	-19.38	29.33	29.40