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Performance and Apparent Digestibility of Rabbits Fed Oven Dried *Gmelina Arborea* Fruit as Replacement for Maize

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Abstract: *Performance and apparent digestibility of rabbits fed oven-dried gmelina arborea fruit as a replacement for maize as an energy source were investigated for sixteen (16) weeks. A total of thirty-two (32) healthy young New Zealand White rabbits (mixed sexes) were fed with four diets: Diet 1 (0% replacement level of ground Gmelina fruit (GMF), diet 2 (5% replacement level of GMF), diet 3 (10% replacement level of GMF) and diet 4 (15% replacement level of GMF), respectively. Data on performance and apparent digestibility parameters were collected during this period and subjected to analysis using Analysis of Variance (ANOVA). From the results of this study, it is concluded that feeding rabbits with oven dried Gmelina fruits (Gmelina arborea) at varying levels of inclusion (0, 5, 10, and 15%) affected the growth performance parameters. Treatment 1, which has 0% inclusion of Gmelina fruits (Gmelina arborea), had the best final weight, dressed weight, and dressing percentage, although there was no significant difference (p 0.05) from Treatment 4. Furthermore, total digestible nutrients were relatively higher in Treatment 1, which is the control. The study therefore recommended that Gmelina arborea fruits be oven dried before feeding to rabbits to reduce the content of anti-nutritional factors, replace soya bean meal up to 15%, and subsequently increase feed intake, digestibility, and performance of rabbits.*

Keywords: Performance, Apparent Digestibility, Oven Dried *Gmelina Arborea* Fruit

. INTRODUCTION

According to Nworgu (2017), the growth rate of the Nigerian agricultural sector is below the potential of natural and human resources due to the high cost of agricultural inputs, poor funding of agriculture, inadequate functional infrastructural facilities, inconsistencies of government agricultural policies, inadequate private sector participation, poor mechanized farming, and little or no adoption of some simple agricultural technologies developed by scientists. In Nigeria, consumption of animal protein remains low at about 6.0–8.4 g/head/day, which is far below the 13.5g per day prescribed by the World Health Organization (WHO) (Egbunike, 2017). This is also true of the rabbit. Rabbit farming in Nigeria seems to be one aspect of livestock farming that has caught the interest of many Nigerians.

Adoption of rabbit farming as a modern farm practice and a form of mini livestock production is a sure way of attaining high agricultural productivity, an increase in sales and income, and an improvement in the living standards of farmers, as well as providing a basis for more scientific discovery and technological advancement. They are corrective measures for animal protein supplementation and increased meat sources to augment the family feed budget and sustain families in the most extreme economic situations. In the past, a series of works on rabbit farming have been carried out by many authors in line with the prevailing and changing technologies. Also, many researchers have made some attempts to show the reasons for and against the adoption of rabbit farming practices.

Gmelina (*Gmelina arborea*) fruit has been identified as a novel feed ingredient with the potential to reduce the cost of livestock production because the fruits are locally available and regarded as waste, not used as food by man and constituting an environmental hazard (Annongu & Folorunso, 2013). The most important and expensive feed item constituting a large portion of the cost of livestock feed is energy concentrates, especially for grains like maize, (Agunbiade *et al.*, 2001). Maize and its by-products of processing have been playing key roles as sources of energy in concentrated diets for rabbits. However, maize is also a major staple food in most developing countries including Nigeria, a raw material for industries, and an emerging bio-ethanol stock as the world energy crisis deepens (Akinola & Oruwari, 2007; Cotula *et al.* 2008; Spore, 2008). Therefore, the competition among men, industries, and livestock for the use of maize for food, raw materials, and feed, respectively, has heightened the cost of maize, often beyond the reach of livestock farmers. To compound the problem, maize is seasonally available (Omoikhoje *et al.*, 2008). Also, low-income countries, reflecting geographical and climatic zones, are projected to lose 5–10% of overall cereal production to climate change, while 1-3 billion people in poor and food-unsecured countries are facing losses of 10–20% of cereal production under climate change. To put it another way, the use of maize for livestock feed in this uncertain situation when people's direct needs have not been met makes economic and moral sense (Iyayi & Losel, 2001).

There is, therefore, a need for the exploitation of other energy sources as alternatives to maize in rabbit diets if the rabbit enterprise in the country is to be sustained. To become a substitute, the feed ingredient, as a matter of necessity, must be cheap, easily accessible and locally available, widely distributed, non-edible by man and, therefore, not competed for as food by man. In this vein, the use of fruit pulps as non-conventional, cheap, and alternative energy sources for maize has been advocated by Annongu and Folorunso, 2003; Oke *et al.*, (2007). According to Aduku and Olukosi (1990), the rabbit occupies a niche mid-way between ruminant and non-ruminant animals because of its simple and non-compartmentalized stomach, enlarged caecum, and colon. As posited by Wariboko, *et al.,* (2019), rhizophora mangle pith (rhizopith) which is a red mangrove plant is a very useful source of animal feed production. The findings of their study justified this by showing that rabbits fed diets with 10 and 15 % rhizopith gained weight faster than those fed the control diet. Further, feed efficiency increased with levels of rhizopith in the diets with rabbits on 15% rhizopith being most efficient. The animal, therefore, has the ability to thrive on forages and crop by-products, and this would certainly help to reduce the cost of rabbit production.

Gmelina fruit has been suggested as a possible energy source in livestock diets by Annongu and Folorunso (2003). Although most fruit pulps and husks are regarded as low-energy, low-protein, and high-fiber feedstuffs, Adejinmi *et al.*, (2007); Oluremi *et al.*, (2007); Ripe Gmelina Fruit Pulp (RGFP) has a better level of crude protein and energy releasing components than most fruit pulps, and is therefore regarded as a carbohydrate source by Annongu and Folorunso, (2003). Consequently, feed formulations exist, for combining ripe gmelina fruit pulp meal (RGFPM) with maize in rabbit feed with the aim of reducing the cost of feeding concentrates to rabbits and maintaining productivity within acceptable limits (Ingweye & Lamidi, 2017).

A review of the literature shows that little has been done on the use of heat-treated gmelina fruit as a feed ingredient for livestock, especially in rabbit diets. It is, therefore, important to generate data to provide another option for farmers in their bid to reduce the cost of rabbit nutrition. Using this fruit to feed livestock will not only benefit livestock owners but will also help to mitigate climate change. Work has been done on the chemical composition of oven dried gmelina fruit as well as the nutritive value. Ingweye and Akpan, (2015); Ingweye and Okon, (2012). However, feeding oven-dried gmelina fruit to rabbits in order to ascertain the digestibility of the nutrients as well as the effect on other performance characteristics is scarce. Therefore, this study was carried out to determine the performance, carcass, organ and apparent digestibility of rabbits fed diets of oven-dried *gmelina arborea* fruit (ODGF) with maize.

Purpose of the Study

The purpose of this study was to investigate the Performance and apparent digestibility of rabbits fed diets of oven dried *gmelina arborea* fruit. Specifically, the study seeks to:

i. Ascertain the extent to which the nutritional composition of oven dried gmelina fruit at replacement levels with maize in diets can enhance the performance of rabbits.
ii. Examine the apparent digestibility coefficient of rabbits fed oven dried gmelina fruit at replacement levels with maize in diets of rabbits.

Research Questions

The following research questions were raised to guide the study.

i. To what extent can the nutritional composition of oven dried gmelina fruit at replacement levels with maize in diets enhance the performance of rabbits?
ii. What is the apparent digestibility coefficient of rabbits fed oven dried gmelina fruit at replacement levels with maize in the diets of rabbits?

II. MATERIALS AND METHODS

Measurement of Performance Parameters in Rabbits

The measurements of the performance parameters of the rabbits lasted for sixteen (16) weeks. The animals were individually weighed at the start of the trial to obtain their initial body weights and thereafter every seven days (weekly) to obtain weight gains. Feed intake, body weight gain, feed conversion ratio (FCR), water intake, and water-to-feed ratio were measured and or calculated. The animals were fed daily. Water and experimental diets were provided twice, with one half provided in the morning (at 07:30 hours) and the other half in the evening (at 16.00 hours). The leftover feed at the end of each day was subtracted from the feed supplied the previous day to obtain the daily feed intake. The feed conversion ratio was calculated by dividing the mean feed intake per treatment by the mean body weight gain at a point in time. Daily feed intake and weekly body weight gains were taken before serving fresh feed and water in the morning. On the last day of the experiment (the end of the growth trial – 16 weeks) the final weight was taken. Weekly weight gain in grams was calculated by subtracting the current week's weight from the preceding week's weight. The daily water intake for each rabbit was calculated by subtracting the amount of water that was left over from the amount that was given the day before and taking into account the amount that evaporated. Shoremi *et al.* (2001) explained how to do this.

Apparent Nutrient Digestibility Trials of Rabbits.

At the end of the growth phase (16 weeks), three (3) rabbits placed in individual pens of similar weight per treatment were selected for the determination of apparent digestibility. This trial lasted for fifteen days (5 days for adjustment and 10 days for data collection). During this period, the experimental rabbits were fed a ration allowance of 60g of the growing diets per day without forage supplementation. Faecal collections of individual rabbits were done on a 24-hour basis before fresh feed was served in the morning throughout the ten-day trial period. The fresh faeces from each animal were weighed and then reweighed after oven drying at 80^{o}C for 24 hours. Similarly, the daily feed intake per replicate was also recorded during the period. The feces were bulked, mixed, and milled before being analyzed for their proximate constituents. In addition, proximate analyses of the diets were carried out. All proximate analyses were carried out as recommended by the methods of AOAC (1995). The analyzed proximate components include crude protein (CP), crude fiber (CF), ether extract (EE), ash, nitrogen free extract (NFE), and calorific value. The apparent digestibility coefficients were calculated using the formula prescribed by Obun and Ayanwale (2006):

$$\text{Apparent digestibility coefficient} = \frac{\text{Nutrient in feed} - \text{Nutrient in faeces}}{\text{Nutrient in feed}} \times \frac{100}{1}$$

III. RESULTS

Performance of Rabbits Fed Diets of Maize and Oven Dried Gmelina Fruit

The performance characteristics of rabbits fed oven dried gmelina fruit is shown in Table 1. The feed intake, weight gain, final body weights, feed conversion ratio and the feed to water intake of rabbits fed the experimental diets were significantly ($p < 0.05$) different. However, the initial body weights and the water intakes of the experimental animals were not significantly ($p > 0.05$) different.

Table 4.1: Performance of Rabbits Fed Diets of Maize and Oven Dried Gmelina Fruit at Various Replacement Levels

Parameters	Treatment 1 (Control- 0%)	Treatment 2 (5%)	Treatment 3 (10%)	Treatment 4 (15%)
Initial weight (g)	1130.00±0.06 ^{ns}	1230.00±0.07 ^{ns}	1140.00±0.06 ^{ns}	1150.00±0.09 ^{ns}
Feed Intake (g)	1430±0.31^{c}	1830±0.24^{a}	1580±0.28^{b}	1380±0.32^{d}
Weight gain (g)	379.00±0.02^{a}	262.00±0.23^{c}	224.00±0.26^{d}	323.00±0.24 ^{b}
Final weight (g)	1509.67±0.16^{ns}	1492.33±0.17^{ns}	1364.00±0.20^{ns}	1473.00±0.17^{ns}
FCR (Feed Intake/Gain)	3.77±1.33^{b}	6.98± 1.78^{a}	7.05± 6.09^{a}	4.27±4.67^{b}
Water Intake (ml/day)	310.55±0.16 ^{ns}	300.56±0.17 ^{ns}	330.05±0.15 ^{ns}	325.08±0.17 ^{ns}
FWR	1: 4.60±0.31^{c}	1: 6.10±0.24^{a}	1: 4.78±0.28^{b}	1: 4.25±0.32^{d}
Mortality	0.0	0.0	0.0	0.0

$^{a, b, c, d}$: Mean on the same row different superscripts are significantly differently ($p< 0.05$); ^{ns} - Not significant, FCR (Feed Conversion Ratio), FWR (Feed Water Ratio)

The feed intake (FI) of rabbits in the study was significantly ($p < 0.05$) different. Treatment 2 had the highest feed intake of 1830±0.24g. This was followed by Treatment 3 (1580±0.28g), Treatment 1 (1430±0.31g) and the least value was observed in Treatment 4 (1380±0.32g). However, Pius *et al*. (2019) in their work on the effect of rations with fresh leaves of *Gmelina arborea* on the growth performance and organ weights of rabbit bucks reported significant but lower values of feed intake than those reported in this study. Similar values of feed intake, though not significant, were reported by Fanimo *et al*. (2003) when they worked on growth performance, nutrient digestibility, and carcass characteristics of growing rabbits fed cashew apple waste. Other authors and the feed intake they reported include Ikyume *et al*. (2019), who recorded feed intake between 36.11 and 50.54, Ozung *et al*. (2017), who recorded feed intake between 52.98 and 66.94, and Hadiza (2019), who recorded feed intake values between 83.99 and 84.48. There was a decrease in feed intake with increasing fibre content in the diets as revealed by the rabbits in Treatment 4 with an intake of 1380±0.32g and fibre content of 28.34±16.19 in this study. This trend was also applicable to Treatment 3 with an intake of 1580±0.28g and fibre content of 15.84±2.67. This is in agreement with the findings of Etchu, Ngu, Yongabi, and Woogeng (2014), who explained that feed consumption in rabbits tends to decrease with increasing fibre levels in feed. Furthermore, other factors that would have affected feed intake as observed in this study could also be feed availability, the quality of the feed in terms of its nutrient content, and palatability.

The final body weights of rabbits were significantly ($p < 0.05$) different. Results revealed that rabbits in Treatment 1 (control group) exhibited the highest body weight gains and final body weights (1509.67±0.16g) as opposed to the Gmelina fruit incorporated feeds in decreasing order of Treatments 4 (1473.00±0.17g), Treatment 2 (1492.33±0.17g) and Treatment 3 (1364.00±0.20g) respectively. Treatment 1 had the highest final body weight. This implied that the final body weights of the rabbits decreased with *Gmelina arborea* addition, though not significantly ($p<0.05$). Pius *et al*. (2019) reported a similar final weight of rabbit that ranged between 1178 and 1672g. Higher values were reported by Hadiza (2019), who reported a final weight of rabbit between 1819 and 1979g. Using bitter cola, Ebenebe et al. (2016) measured final body weights ranging from 1407 to 1614.Ozung *et al*. (2017) also gave values between 1266 and 1650.Ingweye and Okon (2015) reported final body weights of between 1605 and 1900. Furthermore, the variation in final body weights of rabbits across the treatments recorded in this study could be attributed to variations in the crude protein (CP) contents and the metabolizable energy (ME) of the different feeds. This follows the findings reported by the Scientific Committee on Animal Health and Animal Welfare (2000) that diets of high energy and protein content promote fast growth.

The weight gains and final body weights of rabbits were significantly ($p < 0.05$) different. Results revealed that rabbits in Treatment 1 (control group) exhibited the highest weight gains and final body weights (379.00±0.02g; 1509.67±0.16g) as opposed to the Gmelina fruit incorporated feeds in decreasing order of Treatments 4 (323.00±0.24g ; 1473.00±0.17g) Treatment 2 (262.00±0.23; 1492.33±0.17g) and Treatments 3 (224.00±0.26 ; 1364.00±0.20g) respectively. The trend in the values of the weight gains and the final body weights among the rabbits is in agreement with the findings of Etchu *et al*. (2014), who stated that rabbits performed better on a low-fiber diet than on a high-fiber diet.

The feed conversion ratios (FCR) of rabbits were significantly ($p < 0.05$) different. Results revealed that rabbits in Treatment 3 exhibited the highest FCR (7.05± 6.09), followed by Treatment 2 (6.98± 1.78), Treatment 4 (4.27±4.67) and Treatment 1 (3.77±1.33) respectively. The varying fibre content of the diets used in this study contributed to the variation in the feed conversion ratios. The values in this study were lower than those reported by other authors. For instance, Pius *et al*. (2019) reported significant feed conversion ratio values that were between 7.88 and 17.01. Ramchurn *et al*. (2000) recorded feed conversion ratios between 4.8 and 7.8 when they worked on the digestibility and growth of domestic rabbits using multi-nutrient blocks as a feed supplement. Furthermore, Fanimo *et al*. (2003), Ikyume *et al*. (2019), Ozung *et al*. (2017), and Hadiza (2019) reported similar feed conversion ratios. According to Maertens and Gidenne (2016), feed accounts for the largest part of the production costs in animal production. Therefore, the efficient use of feed by farm animals, mostly expressed as feed conversion ratio (FCR), is a key indicator to judge the performance and profitability of a farming system. Similarly, it is an index of the efficiency of converting unit feed into unit weight gain (feed/gain) (Etchu *et al*., 2014). As a result, the Gmelina fruit was incorporated into the experimental diets: Treatments 3, 2, and 4 with higher fibre contents revealed higher FCR values. This increase is in agreement with the findings of Pote*et al*. (1980). Similarly, Alawa and Amadi (1991) observed that rabbits consume more high-fiber diets to compensate for the low energy content of such diets.

The water intake of rabbits was not significantly ($p > 0.05$) different. However, numerical results revealed that rabbits in Treatment 3 exhibited the highest water consumption (330.05±0.15ml/day), followed by Treatment 4 (325.08±0.17ml/day), Treatment 1

(310.55±0.16ml/day) and Treatment 2 (300.56±0.17ml/day) respectively. The results revealed that water intake was higher for the drier feeds (i.e., feeds with lower moisture and higher dry matter content). Therefore, from the study, the Gmelina fruit incorporated diets Treatment 3 and Treatment 4 with lower moisture contents of 4.73±0.37% and 5.36±0.11% respectively, were presumed to be drier, so the rabbits in that group tended to consume more water. The results of this study are in agreement with the findings of Etchu *et al*. (2014), who explained that water intake (WI) is a function of the nature of the diet, the age of the animal and ambient temperature, and that the drier the diet, the greater the quantity of water consumed. Consequently, the quantity of water consumed by the rabbits in this study was within the normal range (100 – 600ml/day) of water intake recommended for healthy rabbits.

The feed to water intake ratios of rabbits by the experimental groups were significantly ($p < 0.05$) different. The results revealed that rabbits in Treatment 2 portrayed the highest feed to water consumption (1: 6.10±0.24), followed by Treatment 3 (1: 4.78±0.28), Treatment 1 (1: 4.60±0.31), and Treatment 4 (1: 4.25±0.32) respectively. The result revealed that rabbits with the highest feed intake exhibited a higher feed-to-water intake ratio.

No mortality (death) was recorded in all the experimental groups: (zero Gmelina fruit inclusion) and Gmelina incorporated diets: Treatment 2 (5% Gmelina fruit inclusion), Treatment 3 (10% Gmelina fruit inclusion) and Treatment (15% Gmelina fruit inclusion). This result is in agreement with the findings of Ahemen, Shaahu, and Kwaghve (2016), who concluded that growing rabbits could be fed a diet containing up to 15% *Gmelina arborea* leaf meal without any harmful effects on growth performance, genital tract dimensions, visceral organ weights, or haematological parameters of rabbits.

Apparent Digestibility Coefficient of Rabbits Fed Oven Dried Gmelina Fruit

Table 4.6: Apparent Digestibility Coefficient of Rabbits Fed Varying Inclusion Rates of Oven Dried Gmelina Fruit

Parameters (g)	Treatment 1 (Control - 0%)	Treatment 2 (5%)	Treatment 3 (10%)	Treatment 4 (15%)
Crude protein	94.65^{ns}	90.86^{ns}	93.65^{ns}	93.5^{ns}
Ash	45.45^{ns}	47.09^{ns}	35.27^{ns}	47.66^{ns}
Gross energy	78.95^{ns}	59.47^{ns}	59.27^{ns}	61.05^{ns}
NFE	15.84^{c}	17.29^{b}	3.52^{d}	17.42^{a}
Ether Extract	95.04^{ns}	94.01^{ns}	94.76^{ns}	93.77^{ns}
Crude fibre	91.10^{ns}	89.40^{ns}	86.95^{ns}	85.09^{ns}

$^{a, b, c, d,}$ means within same row with different superscripts are significantly different ($p<0.05$).

Table 4.6 reveals the apparent digestibility coefficient of rabbits fed oven-dried Gmelina fruit. The highest apparent digestibility coefficient for protein was observed in Treatment 1

(94.65%) and the least was observed in Treatment 2 (90.86%). For ash, the highest value was recorded at Treatment 4 (47.66%) and the least at Treatment 3 (35.27%). Furthermore, the highest apparent digestibility coefficient for gross energy was observed in Treatment 1 (78.95%) and the least in Treatment 3 (59.27%). Treatment 1 (95.04%) had the highest apparent digestibility coefficient for ether extract, while the least was in Treatment 4 (93.77%). Furthermore, the highest apparent digestibility coefficient for fibre was observed in Treatment 1 (91.10%) and the least in Treatment 4 (85.09%).

The results of the apparent digestibility in the study indicated good utilization of the test ingredients by the rabbits, which is expressed by the high values observed in most of the parameters assessed in the study. Values for protein digestibility in comparison with those of other authors are relative. Meineri and Peiretti (2007) reported a range of 71–73%), whereas Ronke *et al*. (2014), Ingweye and Lamidi (2017), and Ikyume *et al*. (2019) in the latter research had 79, 85, and 76%, respectively. However, all compared reports are lower than the findings of this work, which recorded an average of 93.17%. Ozung *et al*. (2017) reported a range of 75-78% although the animals were fed with cocoa pods. It was, however, reported by Pier *et al.* (2014), that most of the nutrients, including protein, were more in the rabbit faeces than was observed in the test feed material. The values for ash are similar to those reported by Ingweye and Lamidi (2017) and Ozung *et al.* (2017). Non-significant values of lipid/ether extract have been reported by Rumchurn *et al.* (2020). The values reported in this study fell within the range of values reported by Ebenebe *et al*. (2016) and Ozung *et al*. (2017).

Variation in the digestibility of fibre has been reported by other authors. While Fanimo *et al.* (2003) reported significant variations in fibre digestibility in rabbits, Ingweye and Lamidi (2017) and Ikyume *et al*. (2019) reported non-significant variations. The values reported by these authors are, however, within those reported in this study. In their work on the performance and nutrient digestibility of young pigs fed dietary raw and processed *Gmelina arborea fruits,* Annongu *et al.* (2006) observed significant differences in digestibility of dry matter, protein, and fibre. They also observed that dietary *Gmelina arborea fruits* also influenced metabolizable energy as well as daily energy absorbed and retained. Values for these parameters decreased with an increasing level of raw *Gmelina arborea fruit* meal in diets. Conversely, there was improvement in the digestibility of these nutrients following *Gmelina arborea fruit* treatments or when a low level of raw *Gmelina arborea fruits* was fed for incorporation at a low level. They also revealed that treatment of high-fibre feedstuffs with alkali could assist in breaking ligno-cellulose complex walls, releasing nutrients and enhancing digestibility. Their results on nitrogen balance followed a trend similar to the other nutrients discussed. High nitrogen utilization on the 30% treated and 10% raw *Gmelina arborea fruit* meals suggested improved or better nutritional value of the test feedstuff treated or included at low levels.

Ingweye and Lamidi (2017) evaluated the nutrient digestibility and reproductive performance of rabbits fed ripe gmelina fruit pulp (RGFP)-based diets. Ripe gmelina fruit pulp replaced maize at 0, 25, 50, 75, and 100% for diets I, II, III, IV, and V, respectively. Grower/gestation diets had 17% crude protein and 2500 kcal (ME)/kg, while lactation diets had 18% crude protein and 2600 kcal (ME)/kg. At age 16 weeks, one buck and two does per group were selected for a seven-day digestibility trial. Rabbits were fed 60 g of the grower diets per day without forage. Daily feed intake and feces collections were recorded. Three healthy does and a buck with well-developed testicles per group with similar body weights were selected for mating at 20 weeks old, at one buck to three does. They observed that the digestibility of NFE, ash, EE, CP, and CF values ranged from 53.21-53.19, 92.21-92.19, 91.34-91.20, 85.61–85.29, and 94.04–94.02, respectively. Replacement of maize with ripe gmelina fruit pulp did not affect ($p > 0.05$) the nutrient digestibility of the diets. Replacing maize with ripe gmelina fruit pulp reduced litter size at weaning, mean survival rate, litter weight at 21 days, litter weight at weaning, milk yield, and weight gain, but had no effect on litter weight at birth, number of matings per conception ($p > 0.05$), or abortion/still birth. For good reproduction, they recommended that ripe gmelina fruit pulp not replace maize in rabbit diets at more than 25%.

IV. CONCLUSION

From the results of this study, it is concluded that feeding rabbits with oven dried Gmelina fruits (*Gmelina arborea*) at varying levels of inclusion (0, 5, 10, and 15 %) affected the growth performance parameters. Treatment 1 which is 0% inclusion of Gmelina fruits (*Gmelina arborea*) had the best final weight, dressed weight and dressing percentage. Furthermore, total digestible nutrient was relatively higher in Treatment 1 which is the control. The response of the rabbits fed oven dry Gmelina fruits (*Gmelina arborea*) could be as a result of the treatment which likely may have had reduced phytochemical components and the fibre content of the Gmelina fruits. The duration of the research could be a reason as well. However, results for the apparent digestibility were positive which suggest that the drying released more nutrients inside the rabbits that could be assimilated that made the concentration of the nutrients in the feces higher.

V. RECOMMENDATIONS

The following recommendations are therefore made from the results of this study:

1. *Gmelina arborea* fruits should be oven dried before they are fed to rabbits to reduce the content of anti-nutritional factors and subsequently increase feed intake, digestibility and performance of rabbits
2. Treatment 2 (5%) oven dry Gmelina fruits (*Gmelina arborea*) gave the mean best performance in terms of live weight, weight gain, dressed weight and dressing percentage and haematological parameters of rabbits and it is therefore recommended for feeding rabbits.
3. A general sensitization of the use of oven dry Gmelina fruits (*Gmelina arborea*) should be carried out to promote its use among rabbit farmers.

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Evaluation of Some Botanical Insecticides against irrigated Onion Thrip (*Thrip tabaci*) on Onion in Maiduguri Borno State, Nigeria

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Abstract: *The experiment was conducted under irrigation during the 2021 dry season to investigate the effects of some botanical insecticides against irrigated onion thrip (Thrip tabaci) on onion in Maiduguri Borno State, Nigeria. The experiment was carried out in the Teaching andResearch Farm of the Department, Agricultural Technology Ramat Polytechnic Maiduguri BornoState, Nigeria. The experiment was laid out in a Randomized Complete Block Design (RCBD) with five(5) treatments replicated four (4) times each. Data was collected on number of insects per plot, number of leaves per plot, number of damaged leaves per plot, and yield weight (kg/ha). All data collected were subjected to analysis of variance (ANOVA) appropriate toRandomized Complete Block Design (RCBD) and means were compared using Least Significant Difference (LSD) at 5% level of significance (Statistix version 8.0). The result obtained from theexperiment showed that, neem seed, neem oil and fresh ginger are effective against onion thrip, especiallyThrip tabaci Compared to papper seed. Therefore, neem seed, neem oil and fresh ginger could be usedin managing plant onion thrip (Thrip tabaci) as an alternative to synthetic insecticides which have environmental hazard in an ecosystem apart from the cost involved in it, and harmful effectsto both human and animals.*

Keywords: Onion thrip (*Thrip tabaci)*, Onion (*Allium cepa*), neem, pepper, and ginger

INTRODUCTION

Onion (*Allium cepa*) is a widely grown herbaceous annual vegetable crop with crops-pollinated and monocotyledonous. Consumption of onion has been increasing significantly in the world party because of the health benefits they possessed (Waiganjo, 2008). In some African countries such as Nigeria, Niger, Ethiopia etc,it is important vegetable produced across a wide ranges latitudes. It is indispensable vegetables crops used as condiments most envisine in Africa. It is one of the oldest known and an important bulbous vegetable crop grown in Nigeria, Niger, Chad, Cameroon and Ethiopia. It is used in preparation of different foods. It has a great potential to produce every year for both local consumption and export with an average yield of 10.77 tons per hectare. (Jensen L, 2001)

The household level, onion cultivation is an important source of income and contribution to food and income security for producers. The onion is often the biggest source of cash income and helps to meet the needs of farmers(Jensen L, 2001).

Onion thrips*, (Thrips tabaci): L. (Theysanopterathripdae)* is polyphagousandhas been recorded on more than 300 species of plants (Gill,*et al.,* 2015).

It is a major insect pest in onion, thrips may cause crops to mature early and subsequent reduce yield. Adult and nymphal stages (immature) of thrips feed rasping the leave and other tissues of plants to release the sap. Which they then consume with punch and suck behaviour that removal leaf chlorophyll causing white to silver patched and streaves the major caused by thripraulping of the leaves enable various plant pathogens to gain entry, thus increasing diseases problems. (Founier *et al*., 2001).

In some of theWest African, thrips are present in all onion growing areas and can cause up to 50% loss in yield by direct feeding as well as reducing the quality and quantity by rasping the leaves and other tissues, onion crops to release the nutrients. Onion field can be destroyed by onion thrip especially in dry season and are the major problem on onion in Nigeria (Johnson, 2002).

Onion is an important vegetable crop and *Thripstabaci* is the major insect pest of onion several synthetic insecticides have been widely used to control onion thrips in field and effective in bringing down pest populations. These chemicalinsecticides are costly and unsafe to humans, animals and environment, particularly to small scale farmers who fail to follow practices of safe handling and application of pesticides more over most small increasing cost of pesticides. These lead to the search for the alternatives control measures which is plant extract that is less toxic, affordable, environmentally friendly and available.

MATERIALS AND METHODS

Experiment Site

The experiment was conducted at Teaching and Research Farm of Ramat Polytechnic Maiduguri, during the year 2019/2020 dry season. Maiduguri is geographically located at latitude 11.5°N and longitude 10.93°E. Maiduguri is climatically characterized by insideous wind, long dry season and short raining season which last for about 3-4 months starts from early July-September with total annual rainfall distribution of 500-600mm. The dry season starts from October and last up to May. Maiduguri temperature is ranges from 22.10°C - 30.90°C have been recorded in the months of April with the highest average temperature have been recorded in the months of January.

Materials used in the experiment are; rake, how, bucket, cutlass, rope, tape, ranging pole, ruller, plastic container, weighing balance, marker, pegs, neam seed, neem oil, fresh ginger and onion seedlings

Sample collection and preparation

The onion seedlings were purchased at Shokari Garden Adjacent to custom of Jere Local Government Area, Maiduguri, Borno State.

Neam (*Azadirachter indica)*seed were obtained at Ramat Polytechnic Maiduguri, the Neam seeds were shade dried then the shell was removed and grinded into powder form, the powdered were weighed using weighing balance in 40g then for the experiment.

The fresh ginger (*Zingiberofficinate*) wasobtained from Maiduguri Monday Market. The Gingerwas weight in 40g was then blended row and used for the experiment.

40g both ginger and neam seed were sucked in 1 liter of water and allow it for 24 hours, it was then filtered using funnel and filter paper, the clean liquid was then used for spraying the field (Experiment field) at the interval of one (1) week for six (6) weeks, using one (1) liter capacity hand held sprayer.

Experimental Design and Treatments

The experiment was laid in Randomized Complete Block Design (RCBD)which consists of (5) five treatments replicate (4) four times each. these are; neem oil 20 ml/L of water, neem seed 40g/L of water,Pepper seed 40g/L of water, fresh ginger 40g/L of water and Control (untreated).

Field Layout

The field was measured at 14×10m given 140m² and the land was demarcated into 20 plots measured in 2×2m each.

Measurement of plant Parameters(Data Collection)

The following parameters were measured and recorded;

- Number of insects per plot: number of insects was manually counted with hands and recorded
- Number of damaged leaves per plot: number of damaged leaves was manually counted with hands and recorded
- Plant height (cm): plant height was measured manually using a thread and transferred to measuring tape.
- Number of leaves per plot: number of t leaves was also manually counted with hands and recorded
- Yield weight per plot: yield weight was measured using sensitive electronic weighing balance.

Data Analysis

All data collected were subjected to analysis of variance (ANOVA) appropriate toRandomized Complete Block Design (RCBD) and means were compared using Least Significant Difference (LSD) at 5% level of significance (Statistix version 8.0) software.

RESULT AND DISCUSSION

Table 1: Effect of Fresh ginger, Pepper seed, Neem seed and oil on Number of Insect (*Thrip tabaci)* at different weeks on Onion plant

Treatments	1weeks	2weeks	3weeks	4weeks	5weeks
Neem oil 20 ml/L of water	0.00	0.00^{c}	0.00^{c}	0.33^{c}	1.00^{c}
Neem seed 40g/L of water	0.00	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{d}
Pepper seed 40g/L of water	0.00	1.00^{b}	1.67^{b}	2.67^{b}	3.00^{b}
Fresh ginger 40g/L of water	0.00	0.00^{c}	0.00^{c}	0.33^{c}	0.00^{d}
Control	0.00	2.67^{a}	4.33^{a}	5.67^{a}	8.67^{a}
CV	0.00	35.21	28.46	29.57	10.19
SE	0.00	0.21	0.28	0.43	0.21

Means in the column accompanied by the same letter (a) are not significantly difference at (P< 0.05%) using least significance different (LSD).

Table 1: shows effect fresh ginger, pepper seed, neem seed and oil onnumber of insect at different weeks. At one week, the result shows that, no insect was found in any plot including the control. The findings also shows that, there was no significant different among the plot treated with Neem seed 40g, neem oil 20mil and fresh ginger 40g at 2,3 and 4 weeks.

At 5 weeks, the result shows that, statistically there are significant different among the treatments except between fresh ginger 40g and neem seed 40g (Analysis of Variance at 0.5% level of Significant).

The findings depicts that highest number of insect presence was recorded under Control, followed by Pepper seed 40g. The least number of insects was recorded under Neem oil 20ml and fresh ginger 40g. However, there is no insect present in plot treated with Neem oil20ml at all weeks.

Table 2: Effect of Fresh ginger, Pepper seed, Neem seed and oil onNumber of damaged leaves at different weeks on Onion plant

Treatments	1weeks	2weeks	3weeks	4weeks	5weeks
Neem oil 20 ml/L of water	0.00^{b}	0.67^{bc}	1.17^{b}	0.67^{bc}	0.33^{bc}
Neem seed 40g/L of water	0.00^{b}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}
Pepper seed 40g/L of water	0.33^{b}	1.00^{b}	1.17^{b}	1.00^{b}	0.70^{b}
Fresh ginger 40g/L of water	0.00^{b}	0.33^{bc}	0.33^{c}	0.00^{c}	0.00^{c}
Control	2.17^{a}	2.83^{a}	3.50^{a}	5.50^{a}	6.43^{a}
CV	51.64	49.97	25.10	26.26	22.51
SE	0.21	0.39	0.25	0.31	0.27

Means in the column accompanied by the same letter (a) are not significantly difference at (P< 0.05%) using least significance different (LSD).

Table 2: shows the effect of fresh ginger, pepper seed, neem seed and oil onnumber of damaged leaves at different weeks on onion plant. At one week. The findingsshows that, statistically there are no significant different among all the treatments except in control. The

results also shows that, there are significant different among all reatments but, there is no significant different between need oil 20ml and fresh ginger 40g at 2 weeks. Furthermore, there are significant different among all treatments except neem seed 40g and fresh ginger 40g at 3 weeks. At 4 and 5 weeks, the finding shows that there are significant different among all the treatments accept neem seed 40g and fresh ginger 40g on number of leaves affected.

The result obtained shows that control appeared with highest number of leave affected followed by pepper seed 40g while the least leaves damage was recorded under fresh ginger 40g followed by neem Seed 40g. However, there is no number of damage leaverecorded underplot treated with neem seed 40g.

Table 3: Effect of Fresh ginger, Pepper seed, Neem seed and oil onNumber of plant height (cm) at different weeks on Onion plant

Treatments	**1weeks**	**2weeks**	**3weeks**	**4weeks**	**5weeks**
Neem oil 20 ml/L of water	6.00^{bc}	8.17^{b}	10.50^{b}	12.83^{b}	13.83^{c}
Neem seed 40g/L of water	6.93^{a}	9.83^{a}	13.67^{a}	15.67^{a}	19.00^{a}
Pepper seed 40g/L of water	5.33^{cd}	7.33^{c}	9.33^{c}	11.67^{c}	13.33^{c}
Fresh ginger 40g/L of water	6.27^{ab}	8.37^{b}	10.33^{bc}	12.67^{b}	16.00^{b}
Control	4.67^{d}	5.77^{d}	6.40^{d}	8.00^{d}	10.33^{d}
CV	7.83	5.15	5.84	4.04	3.93
SE	0.38	0.33	0.48	0.40	0.47

Means in the column accompanied by the same letter (a) are not significantly difference at (P< 0.05%) using least significance different (LSD).

Table 3: shows the effect of fresh ginger, pepper seed, neem seed and oil on plant height (cm) at different weeks on Onion. The result reveals that, at week one there are significant different among all treatment. At 2weeks, statistically there are significant different among the treatments except in plot treated with neem oil 20ml and fresh ginger 40g. However, at week 3 there are significant different among all the treatments. At week four no significant different exist between neem seed 20ml and fresh ginger 40g, but in other treatments there are significant different. While at 5 weeks significant different exist among all the treatmentson plant height (Analysis of variance at 05% level of significant).

The findings revealed that Neem Seed 40g recorded with highest plant height followed by fresh ginger 40g while control was recorded with least plant height followed by pepper seed 40g as well as neem Seed 20g.

Table 4: Effect of Fresh ginger, Pepper seed, Neem seed and oil onnumber of leaves at different weeks on Onion plant

Treatments	1weeks	2weeks	3weeks	4weeks	5weeks
Neem oil 20 ml/L of water	8.47[a]	9.10[a]	10.00[ab]	10.50[ab]	11.33[bc]
Neem seed 40g/L of water	10.27[a]	10.77[a]	11.60[a]	12.33[a]	14.67[a]
Pepper seed 40g/L of water	9.13[a]	9.33[a]	9.77[ab]	10.33[ab]	11.33[bc]
Fresh ginger 40g/L of water	8.60[a]	9.67[a]	10.27[ab]	10.50[ab]	11.67[b]
Control	7.67[a]	8.67[a]	9.17[b]	9.37[b]	9.60[c]
CV	18.00	11.94	10.87	10.59	8.95
SE	1.29	0.92	0.90	0.91	0.86

Means in the column accompanied by the same letter (a) are not significantly difference at (P< 0.05%) using least significance different (LSD).

Table 4: shows the effect of fresh ginger, pepper seed, neem seed and oil on Number of number of leaves at different weeks on onion. The finding revealed that, there are no significant different among all the treatment including control at week 1 and 2. At 3 and 4 weeks there are also no significant different among neem oil 20ml, pepper seed 40g and fresh ginger 40g. At 5 weeks there are also no significant different between neem oil 20ml and pepper seed 40g on number of leaves (Analysis of variance at 05% level of significant).

The result depicts that neem Seed 40g appeared with highest number of leaves, while control appeared with least number of leaves.

Table 5: Effect of Fresh ginger, Pepper seed, Neem seed and oil onyield weight (kg) on Onion after harvest

Treatments	Yield weight (kg)
Neem oil 20 ml/L of water	2.33[c]
Neem seed 40g/L of water	3.27[a]
Pepper seed 40g/L of water	1.83[d]
Fresh ginger 40g/L of water	2.83[b]
Control	1.23[e]
CV	5.61
SE	0.11

Means in the column accompanied by the same letter (a) are not significantly difference at (P< 0.05%) using least significance different (LSD).

Table 5: Shows the effect of fresh ginger, pepper seed, neem seed and oilon yield weight (kg) on Onion after harvest. The findings reveals that, there are significant different among all the treatments on yield weight.

The result shows that, the highest yield was recorded under plot treated with neem seed 40g (3.27kg) subsequently, followed by Fresh Ginger 40g (2.83kg) and Neem oil 20ml (2.33kg) followed by pepper seed 40g (1.83kg). However, control was recorded with least yield, (1.23kg).

Discussion

The result obtained from theexperiment showed that, neem seed, neem oil and fresh ginger are effective against onion thrip, especiallyThrip tabaci Compared to papper seed and control. These was in line with the report of Reddy et al. (2007) determined the efficacy of indigenous botanical extracts like neem seed kernel extract for the management of the onion thrips in a farmer's field at Kalshettihalli village of Chikmagalur district of Karnataka State, India. The authors reported that the neem extract was superior than wild tobacco leaf extract and carbosulfan (250g.a.i./hactare) in controlling thethrips on onion, obtain higher bulb yield and cost: benefit ratios in both the seasons. Their findings were in contrary to our botanical extract results that show the reverse and the bulb weight was found to be non-significant.

Khaliq,*et al*., (2014) encouraged onions invidious as a biological agent in the thrips niche obtained 96% thrips mortality by Humicolor and Neam (*Azadirachter indica*). Extracts used to control thrips.

Khaliq,*et al*., (2014) also mentioned that,*cymtopogancitrates* and *partheniumhysterophorous* were found effect on the onion *thrips*. According to Mohammad*et al.,* (2000) found that, the enthonal extracts of neam seed powder (N.S.P) evaluated against onion thrip reduced thrip population under field condition.

The observed behaviour ofonion bulb yield in the experiment was in line with the report of Dantata *et. al*., (2011).Found that, growth and yield of tomato was response to application of different plant extracts.

In Conclusion, The result obtained from this experiment showed that, neem seed, neem oil and fresh ginger are effective against onion thrip, especiallyThrip tabaci Compared to papper seed. Therefore, neem seed, neem oil and fresh ginger could be usedin managing plant onion thrip (*Thrip tabaci*) as an alternative to synthetic insecticides which have environmental hazard in an ecosystem apart from the cost involved in it, and harmful effectsto both human and animals.

Recommendation

Based on the above findings of the study, it was recommended that, farmers shouldadopt the using of plants plant extacts(neem seed, fresh ginger and neem oil) to serve as a means of controlling onion thrips (*Thrips tabaci*) under irrigation. Botanicals that are affordable,available, environmentally friendly and easy to handle by the farmers, as well as less or no toxicity toboth human and animals.

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Effects of Food and Agriculture Organisation Inputs Extension Intervention Programme on Farmers' Millet yield in Selected Boko Haram Affected Communities of Borno State, Nigeria

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Abstract: *This study assessed the effect of FAO input extension intervention programme on Millet (Pennisitum glaucum) yield in some selected Boko Haram affected communities in Borno State, Nigeria. A multistage sampling procedure (involving both purposive and stratified) was used to select 384 farmers for the study. Data were obtained with the aid of questionnaire and analysed using Descriptive and Inferential Statistics. Findings of the study reveal that majority (78.6%) of the farmers were males and married (85.7%). Their average age and household sizes were 44.52 years and 10 members respectively. The findings revealed that all the respondents (100%) received 8kg of millet seed and 25kg of fertilizer for millet production in Boko Haram affected communities. The result also indicated that majority (93.4%) of the respondents had access to extension services while only few (2.6%) had no access to extension services. Similarly, majority (91.9%) of the respondents had contact with extension agents once in every four weeks. Group teaching method was mostly used to teach farmers by the extension agents in the study area. Also, the teaching method of the extension agents were said to be successful and effective by the beneficiaries. Major constraints faced by the beneficiaries were late input distribution, inadequate capital and insecurity. The study recommended that the community members should liaise with the Army personnel and civilian JTF/hunters taskforce so as to curtail the menace of insecurity.*

INTRODUCTION

Pearl millet (*Pennisetum glaucum)* is a primary food grain crop consume by millions of people in the tropical and sub-tropical areas of Africa (Mason, Maman, and Pale, 2015). In most African countries where the cereal is grown and production is documented, pearl millet ranks high in terms of importance. In Niger, it ranks first in terms of total cereal cultivation and production (Ndjeunga and Nelson, 2005) and it is the most important staple cereal crop in Namibia (Chandra, Chandra and Sharma, 2016).

The future trends in millet production need increasing productivity and trade (regionally and internationally) through adding value to the products by improving/increasing, processing and utilization by the industries. In 2017, Food and Agriculture Organization (FAO, 2018) assisted more than 1.5 million people with inputs for millet production, focusing on internally displaced populations (IDP), returnees and host communities, in North Eastern States of Adamawa, Borno and Yobe state of Nigeria. (FAO, 2018). In an attempt to address food insecurity and restore livelihood among the people affected by insurgency, FAO provides support to the government of the affected area through provision of improved pearl millet varieties and other agricultural inputs. Also through addressing the food security issue, FAO introduced FAO response strategy which continued to strengthen resilience among food insecure communities. This FAO programme aims at developing relevant responses to food crises since 2014 by supporting the crises affected population with improved Agricultural inputs and livelihood assets such as early maturing crop verities, good quality fertilizer, irrigation and micro- gardening equipment and food processing assets. Thus, this effort by FAO was to build resilience of communities and a hunger free world through an Agricultural Input Support Programme (Ayuba, 2007).

FAO in collaboration with Borno State Agricultural Development Programme (BOSADP) distributed seeds of improved millet variety (SOSAT) and fertilizers to affected communities in 2017 and 2018. However, no research has been conducted to investigate the effect of FAO input extension intervention in the study area. It is in the light of the above mentioned problems that this study provides answers to the under listed research questions:

i. what are the socio-economic characteristics of beneficiaries of the FAO supported input intervention in the study area?
ii. what are the quantity of millet and fertilizer received by the beneficiaries of the programme in the study area?
iii. do the beneficiaries have accessed to extension services on millet production activities provided by FAO in the study area?
iv. what are the constraints faced by the beneficiaries in accessing inputs provided by FAO input extension intervention in the study area?

METHODOLOGY

The study was conducted in Mafa and Jere Local Government Areas of Borno State, Nigeria. The study area is located in the North- Eastern part of Nigeria; covering a land area of 3,737square kilometres. It is situated within Latitudes 11° 48' N and 12° 25' N of the equator, and Longitudes 11° 30' and 13° 55' East of the Greenwich meridian (Borno State Diary, 2008). The study area has a population density of approximately 170 persons per square kilometre. It has an estimated growth rate of 3.4% per annum and a projected population of 634,491 by 2020 (National Population Commission, 2006 ,). The study area is a component of Borno State which occupies the greater part of the Lake Chad Basin and shares borders with the Republics of Niger to the North, Chad to the North-East and Cameroun to the East. Similarly, Borno State shares boundaries with Adamawa, Gombe, and Yobe States to the South, West and North-West respectively (Baba and Maina, 2013).

Multistage sampling procedure was used to select respondents for this study. In the first stage, four (4) Local Government Areas were purposively selected from the six LGAs that benefited from the FAO input Extension Intervention Programme. In the second stage, 2 LGAs were purposively selected from the 4 LGAs who are dominantly millet producers. Thirdly, eight (8) wards were also purposively selected from the 2 LGAs based on the fact that these wards were the predominant areas of millet production and have high number of FAO input extension intervention beneficiaries. In the fourth stage, stratified sampling method was used to obtain three strata of beneficiaries from each ward. The sum of the three strata that is IDP, returnees and host families gave the total number of beneficiaries from each ward.

Data for the study were obtained through primary source with the aid of structured questionnaire administered to the respondents. Data collected were on the socio-economic characteristics, input provided, extension services, constraints and millet yield of the beneficiaries. The research instrument was designed to address the outlined objectives of the study. Secondary information were obtained from documented material such as Food and Agricultural Organization (FAO) publications, Borno State Agricultural Development Programmed (BOSADP), journals, books, and conference proceedings, seminar papers, published and unpublished projects and internet sources. Primary data were collected by the researcher with the assistance of trained extension agents. Data obtained for the study were analyzed using descriptive statistics such as frequency count, percentage, mean and standard deviation to achieve specific objectives i, ii, iii and iv.

RESULTS AND DISCUSSION

The socio-economic characteristic of the respondents' included in this study were: sex, age, marital status, major occupation, educational attainment, farm size, household size and farming experience. It also provides the information on descriptive analysis using frequency, percentage, mean and standard deviation which are presented in table 1.

Table 1: Socioeconomic Characteristics of Respondents

Variables	Frequency	Percentage	Mean	SD
Type of Farmer				
Returnee	99	25.8		
IDPs	74	19.3		
Host Families	211	55		
Sex				
Male	302	78.6		
Female	82	21.4		
Age (years)				
20-29	17	4.4		
30-39	81	21.1		
40-49	160	41.7	45	9.8
50-59	93	24.2		
60-69	28	7.3		
70 and above	5	1.3		
Marital Status				

Single	11	2.9
Married	329	85.7
Widows/widower	34	8.9
Divorced	10	2.6
Major Occupation		
Farming	359	93
Trading	19	5
Tailoring	6	2
Educational Attainment		
Primary	108	28.1
Junior Secondary	0	0
Senior Secondary	72	18.8
Tertiary	14	3.7
Qur'anic	190	49.5

Source: *Field Survey, 2020*

The result of the socioeconomic characteristics revealed that more than half (55%) of the respondents were host families, 25.8% of the respondents were returnees and only few (19.3%) of the respondents were IDPs. This implies that majority of the participants were host families. Results on sex showed that majority (78.6%) of the respondents were males while only few (21.4%) were females. This implies that majority of the respondents were males. This is in accordance with Okeke, Agul and Onogwu, (2014) who reported that male millet farmers constitutes 90% of the respondents and female farmers has low percentage which might be due to some cultural and religious laws which tends to restrict women from participating in laborious agricultural activities in the study area. Age of the respondents revealed that 41.7% of the respondents were within the age group of 40 to 49, 24% of the respondents were within the age ranges of 50 to 59. Majority (85.7%) of the respondents were married. This implies that majority of the respondents were married in the study area which could be due to the religious and traditions of the people in the study area where marriage is considered as a sign of adulthood and responsibility. This finding in line with Okeke *et al.*, (2014) in their study which revealed that 78.3% of the farmers were married, while 21.7% were single. Results on occupation reveal that majority (93%) of the respondents had farming as their major occupation. On their education level, about half (49.48%) of the respondents had attended Quranic education, This implies that majority of the respondents attended Qur'anic education in the study area. This finding is in contrast with that of Ndjeunga *et al.* (2011) who revealed that majority of farmers had primary education in both rain fed and irrigated situation.

Table 2: Teaching methods, access and contact with the extension agents ($n = 384$)

Variable	Frequency	Percentage
Access to Extension Service from FAO		
Yes	374	97.43
No	10	2.6
Contact with the Extension Agents		
One Week	1	0.3
Two Weeks	16	4.2
Three Weeks	14	3.6

Four Weeks	353	91.9
Extension Methods Used by Extension Agents		
Individual Method	0	0
Group Method	384	100
Mass Media	0	0
Rating of Teaching Method of the Extension Agents		
Not successful	1	0.3
Very successful	9	2.3
Successful	374	97.4

Source: Field Survey, 2020

Extension Services Provided by FAO

Table two above encompasses all the extension activities benefited by the beneficiaries in the study area which included access to extension services, contact with extension agents, teaching method used by the extension agents and rating of teaching methods used.

The results indicated that majority (93.4%) of the respondents had access to extension services. However, few (2.6%) had no access to extension services. This finding suggests that the respondents would be technically efficient and their productivity could also increased. Majority (91.9%) of the respondents had contact with extension agents once in every four weeks, This implies that majority of the extension agents had contact with respondents at least once in a month which in return helped the farmers to improve their agricultural produce. This is in line with the study of Ann (2013) who reported that farmers with regular extension contact readily adopt new innovations and have access to inputs thereby increasing agricultural productivity.

All (100%) of the respondents reported the group extension teaching method was used for teaching them by the extension agents in the study area. This is as a result of fewer extension agents available to large number of farmers in the study area. Findings also revealed that group extension teaching method is being used due to the fact that the extension agents visit farmers at least once in a month of which meetings are conducted to demonstrate different aspects of millet production to farmers to improve their productivity. The rating of extension methods showed that majority (97.4%) of the respondents considered the teaching method of the extension agents as successful.

Constraints Faced by the FAO Beneficiaries

Constraints faced by the FAO beneficiaries includes; late distribution of farm inputs, insecurity, inadequate capital, inadequate supply of fertilizer, inadequate extension agents, lack of pesticides and herbicides and inadequate seeds. The result is presented in Table 3 below.

Table 3. Constraints Faced by the FAO Beneficiaries

S/N	Constraints *	Frequency	Percentages	Rank
1	Late distribution of farm inputs	300	78.1	1^{st}
3	Inadequate capital	165	43.0	2^{nd}
2	Insecurity	160	41.7	3^{rd}

7	Inadequate seeds	127	33.1	4th
4	Inadequate supply of fertilizer	119	31.0	5th
5	Inadequate extension agents	92	24.0	6th
6	Lack of pesticides and herbicides	89	23.2	7th

Source: Field Survey, 2020

***Multiple Responses**

Table 4.5 revealed that majority (78.1%) of the beneficiaries of the FAO intervention had problem of late distribution of farm inputs. Also, 41.7 of the respondents had problem of insecurity, 43.0% of the respondents had problem of inadequate capital, 33.1% had problem of inadequate seed. Late distribution of farm input was the major problem faced by the beneficiaries in FAO intervention. Galadima, (2014) discovered that various factors such as low level of awareness, cultural barriers, inadequate capital and illiteracy which ranked 1st, 2nd, 3rd and 4th respectively as factors affecting the programme beneficiaries.

CONCLUSION AND RECOMMENDATION

Based on the findings of this study it is concluded that most of the beneficiaries in the study area depends on agriculture as a means of livelihood. Late distribution of farm inputs was the major constraint faced by the FAO beneficiaries in the study area. From the findings, the following recommendations were made:

1. FAO should ensure timely distribution of farm inputs and adequate quantity of fertilizer and improved millet seed should be provided to the farmers. to farmers;
2. The community members should liaise with the Army personnel and civilian JTF/hunters taskforce so as to curtail the menace of insecurity.
3. Extension Agents in BOSADP should encourage and motivate farmers to join cooperative associations to enable them have demand power to access productive inputs that will enable them to expand their farms and increase efficiency of resource usage.

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Determinants of Constraints to Information Sources of Agricultural Innovation by Farmers in Southern Borno Senatorial, Nigeria

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Abstract: *The study was conducted in southern Borno senatorial zone of Nigeria to a determine constraints to information sources by farmers in the study area. Multi-stage sampling procedure was adopted for the study. 16 farmers were randomly selected from each of the 10 farming communities to give a sample size of one hundred and sixty (160) respondents. Primary data for the study were collected using structured questionnaire. Data collected was analyzed using frequency account, percentage and ranking order to satisfy objectives 1, 2, 4, and While multiple regression analysis was used to satisfy objective 3. From the findings of the research, out of the 160 respondents in respect to socio-economic characteristics: it was revealed that 68.8 % of the respondents were male, while 31.2 % were female with ages ranging from 30-39 years. While 67.5% of the respondents were married. A good number (83.1%) of the farmers were educated. About 46.3 % of them had household size of 6-10 persons per household with majority operating on small scale farm holdings between 1-2 hectares and majority had farming experience (12-17years). Source of information used by farmers are farmers meeting (55.6%), cooperative society (47.5%), Extension agent (41.9%), neighbor and friend (35.0%) and drum (2.5%). Effect of farmers socio-economic characteristics on utilization of information sources in the study area shows that age, level of education, farm size, family size, member of association and primary occupation are significant at 1% level, while gender, marital status and farming experience are significant at 5% level. The constraints to utilization of modern information sources in the study area shows that inadequate fund is the highest which ranked 1st while language barrier is the lowest which rank 10th.The study recommended that, the farmers should try to form a cooperative association, the farmers should try to be using available information sources in order to help them in farming system and irrelevant information should not disseminated and the information in question should always reach the rural farmers in good time. More so, the feedback mechanism should be strengthened and the extension workers should learn how to adjust to the situations while there on the field.*

Keywords:*Determinants, Information, Sources, Constraints*

INTRODUCTION

Background of the Study

Agriculture which is the leading sector of the economy in most developing countries is one of the areas that information is constantly sought and used. In Nigeria, the importance of Agriculture to the economy cannot be over emphasized despite the growth of industries, oil and commerce, it had continued to be the principal economic activity carried out by most Nigerians (Lughlugh, 2020) and it is crucial to meet the information needs of farmers for the development of the sector (Demet, Nilay, Marco and Tunç, 2016). To interact with the other factors of production, agricultural information is an essential factor. The farmers decision-making is facilitated towards improved agricultural production, processing, trading and marketing through an effective and efficient release system of essential information and technology services (Anju and Satbir, 2017; Ukachi, 2015). Success in enhancing agricultural production, providing income and job opportunities and ensuring that the agricultural sub-sector performs its manifest function in furtherance of rural and overall national development, depends largely on the communication system adopted to implement various agricultural programmes (Saleh, Burabe, Mustapha & Nuhu, 2018; Idiake-Ochei, Onemolease & Erie, 2016). In fact, there is a positive relationship between the increased flow of knowledge and information and agricultural development (Anjou and Satbir, 2017).

Information is an indispensable factor in the practice of farming and it is the basis of extension delivery. Information plays a vital role in our present day society as a result of the advancement in information and communication technologies (ICTs). Information in its most restricted technical sense is an ordered sequence of symbols that record or transmit a message. It can be recorded as signs or conveyed as signal waves. It is defined by Adereti, Fapojuwo and Onasanya (2006) as data that have been put into a meaningful and useful context which is communicated to recipient who uses it to make decisions.

Information is an important commodity used in the realization of any objective set by an individual or group. Information equips one with the knowledge needed to overcome challenges and take the appropriate step at the right time. A community cannot develop without knowledge, and a community can only become knowledgeable if they recognize and use information as their tool for development (Olaniyi and Ogunkunle, 2018).

A good information dissemination source must be relevant, timely, accurate, cost effective, reliable, usable and exhaustive and of an aggregate level. Information source is a base from which information originates, the one who transfers information to the receivers after carefully putting one's thoughts into words. Lucky and Achebe (2013) further noted that information sources used to disseminate agricultural research findings to farmers for on farm activities include researchers, extension officers, knowledgeable farmers, research institutions; mass media, commercial and government agencies.

One of the important factors leading to poverty as identified by Khapayi and Celliers (2016) is poor access to information among farmers. Lack of information adds to the vulnerability of farmers; therefore, rural farmers need to have access to information that is efficient for their livelihoods. Therefore, there is the need to investigate the constraints of information sources available to the farmers and its influence on their accessing agricultural innovation.

In spite of the relevant of information to farmers and the survival of nation, the researcher's pre-observation indicate that farmers have no access to relevant information that will help them in decision making and to accept new innovation in farming. The study therefore, was meant to provide answer to the following questions?

i. What are the socio-economic characteristics of the respondents?
ii. What are the sources of information used by the respondents?
iii. What are the effects of farmer's socio-economic characteristics on utilization of information sources?
iv. What are the constraints to utilization of modern information sources?

Objective of the Study

The main objective of the study is to determine the constraints of information sources used for accessing agricultural innovation by farmers in southern Borno senatorial zone of Borno state, Nigeria. The specific objectives were to:

i. describe the socio-economic characteristics of the respondents;
ii. examine respondents' use of agricultural information sources;
iii. analyze the effect the socio-economic characteristics on utilization information sources and
iv. identify constraints to utilization of modern information sources.

METHODOLOGY

Study Area

The study was conducted in southern senatorial zone of Borno State, Nigeria. The Local Government Areas (LGAs) are Askira/Uba, Gwoza, Damboa, Chibok, Shani, Biu, Hawul, Kwayakusar and Bayo. The study area is located between Latitudes 10^o and 12^oNorth of the Equator and Longitudes 11^o and 14^o east of the meridian (Borno State Agricultural Development Programme (BOSADP) 1998). The study area covers a total area of 7,472 Km^2, population of 431,894 (NPC, 2006) projected to 723,573 by (2020). Numerous ethnic groups and cultures characterize the area with approximately 80 percent of the population being small-scale farmers. Agriculture and trading constitute the major economic activities of the people in the area (BOSADP, 1998).

The study area is the most humid area in the State. With regard to crop and livestock production, it is the most productive part of state, having annual rainfall range of 900mm to 1,200 lasting for five months (June to October) (Amaza, 2016). These agro-climatic conditions make the zone conducive for the production of agriculture. In the study area, major crop grown are maize, sorghum, cowpea, groundnut, rice, and soybean. The livestock mainly comprises cattle's, sheep's and goats (Amaza, Olayemi, Adejobi, Bila and Iheanacho, 2007). The vegetation of the study area consisting of shrubs interspersed with trees and woodland. Most parts of the area are mountainous with rivers, which are, however, seasonal in nature (Amaza, 2016).

Sources of Data

Primary data and secondary source of information were used for the study; primary data was obtained from respondents with the use of structure questionnaires and interviews schedules. Secondary source of information were obtained from journal papers, textbooks, internet and publications.

Sampling Procedure and Sample Size

Multi-stage sampling procedure was used to select the respondents for the study. In the first stage, five LGAs (Askira/Uba, Gwoza, Damboa, Chibok Biu) were randomly selected out of the nine LGAs in southern senatorial zone of Borno State. Second stage, two farming communities were randomly selected from each of the five LGAs to give total of 10 farming communities for the study. In the third stage, 16 farmers were randomly selected from each village to give a total of one hundred and sixty (160) farmers.

Analytical Techniques

Descriptive and inferential were used to analyze the data. Descriptive statistics tools such as frequency count, percentage and ranking order were used to achieve objective i, ii, and iv. Multiple Regression analysis was used to achieve objective iii. The explicit model is express as follows:

$$Y= a + \beta_0 X_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + e$$

Where:

Y= level of information source used by farmers (%)

a= constant term

$\beta_1 - \beta_9$ = Regression Coefficients

$X_1 - X_9$ = Socio-economic characteristics of the respondents

X_1= Sex of farmer (male = 1, female =0)

X_2 = Age of farmer (years)

X_4 = Marital Status (Married = 1, Single = 0)

X_4 = Educational status (number of years spent in formal school)

X_5 = Total farm size (in hectares)

X_6= Household size (number of persons in the household)

X_7 = Member of association (member = 1, nonmember =0)

X_3 = Farming experience (number of years spent in farming)

X_9 = primary occupation

e = the error term.

RESULT AND DISCUSSION

Socio-Economic Characteristics of Farmers

The results of the socio-economic characteristics of the respondents are presented in table1. The result revealed that 68.8% of the respondents were male while 31.2% are female. This implies that, men take decision on farm management issues. The findings agreed with Pur and Gwary (2008) in their work access and application of information and communication technology (ICT) among farming household of north east revealed that majority (62.50%) were males. Indicates that male were participating more in agricultural activities and used these than female and also this is due to the fact that the study area is a parochial society where males are expected to head and take decision for the wellbeing of their families, while women and children are subordinated under men.

Table1: The age distribution of respondents revealed that majority (44.4%) fall between the age of (30 – 39 years), (21.3%) fall between 40 – 49 age bracket, (14.4%) fall between 20 -29 years, (12.5%) fall in the range of 50 years above. While the least (7.5%) fall below 20 years of age. This shows that most of the farmers are at the age of 30-39 years. This implies that, the respondents are middle aged and so still active and can participate adequately in farming activities. This findings agrees with Ommani and Chizani (2018) who stated that youths in their active years are energetic and innovative to participate more in agriculture.

It was equally observed in Table1 that 67.5% of the respondents were married and 32.5% were single. This shows that most of the respondents will have greater responsibility than the single, which may encourage respondents to be committed towards their participation in farming activities. As noted by Perez- Morales (1996), there is a trend for rural youth to start having responsibilities at an earlier age than urban youth. Hence, the tendency to marry early helps in building a virile farming population. This agree with Adamu (2016) who stated that about 90% of Nigerian population are engaged in agricultural production process of various types of regardless of their marital status.

Based on Table1: the level of education result shows that about (25.0%) attend primary education and (18.1%) had secondary education and (16.9%) had no formal education and (15.0%) attained Islamic education where (6.3%) of the respondents attend tertiary education in the study area. Such level of education is expected to have positive impact on the respondents' participation in the farming activities. Farmer's education generally has been found to enhance production among farmers apparently resulting from their efficiency in using new production technologies. This finding goes in line with (Ani, 2006) the belief is that education gives farmers the ability to perceive, interpret and respond to new information much faster than their counterparts without education.

Table1: indicate that (55.6%) of the respondents have the farm size 1-2ha, (26.9%) of the respondents have the farm size of 3-4 ha, (10.6%) of the respondents have the farm size of 5-6ha, while (7.5%) of the respondents have the farm size of 7ha and above. This shows the dominance of small farm size holdings in the study area. It is probable that most of the respondents had other source of income. The result shows that most farmers in the study area are still operating on a small scale farm which is due to shortage of resources for production such as land, finance and labour. This agree with Bereh (2012) who stated that most rural farmers had access to small portion of farmland which they use in farming activities.

Table1: Distribution of Socio-Economic Characteristics of Farmers (n= 160)

Socio-economic Characteristics	Frequency	Percentage
Gender		
Male	110	68.8
Female	50	31.2
Age		
Below 20years	12	7.5
20-29 years	23	14.4
30-39 years	71	44.4
40-49 years	34	21.3
50 and above	20	12.5
Marital Status		
Single	32	20.0
Married	108	67.5
Widow	12	7.5
Divorced	8	5.0
Level of education		
Non formal education	27	16.9
Adult education	30	18.8
Islamic education	24	15.0
Primary education	40	25.0
Secondary education	29	18.1
Tertiary education	10	6.3
Farm size		
1-2ha	89	55.6
3-4 ha	43	26.9
5-6 ha	17	10.6
7 ha and above	11	6.9
Family Size		
1—5persons	51	31.9
6—10 persons	74	46.3
11—15 persons	23	14.4
16 and above	12	7.5
Membership of association		
Yes	119	74.4
No	41	25.6
Farming experience		
1—5years	17	10.6
6—11 years	34	21.3
12—17 years	60	37.5
24 years and above	49	30.6
Primary occupation		
Farmer	102	63.8
Marketer	34	21.3
Civil servant	24	15.0

Source: Field Survey, 2021

Table1: indicate that (31.9%) of the respondents are having the family size of 1-5, (46.3%) of the respondents are having the family size of 6-10, while (14.4%) of the respondents are having the family size of 11-15. This implies that the large household size will ensure more net working for information and enhance more availability of information to farmers. In the tradition of African society, a household size is made up of a man, his wife/wives, children and number of dependents. This agrees with Olaniyi, (2013) who stated that farmers had opportunity to get agricultural information through electronic media consequently help in improving their family labour in relation to urban farming.

Table1 indicated that (74.4%) of the respondents are in a cooperative association, while (25.6%) of the respondents are not in a cooperative association. This shows that most of the respondents in the study area are members of cooperative. With this majority of respondents are membership cooperative association, it could be said that majority of the respondents have had long duration of experience as members of cooperative group which can facilitate understanding of agricultural information due to the interaction among members. This implies that farmer may had more access to resources and information that will improve their production practices and highlighting them the importance of some social capital involve in improving productivity.

The result in Table1 revealed that majority of the respondents has farmed for a reasonable number of years, (37.5%) had farming experience of 12-17years in the study area, where (30.6%) had farming experience of 24years, (21.3%) had experience of farming of 6-11years and (10.6%) had farming experience of less than 5years. These years of experience in the farming activities were expected to translate into better utilization and understanding of the agricultural information which may invariably result into better income as well a standard of living. The shows that the more the farmers have experience on farming the more they have technology ideas on how to face farm production problems. This research finding is in line with Abdulsalam *et al.,* (2018) findings that the higher the farming experience, the more the farmers would have gained more knowledge and technological ideas on how to tackle farm production problems and to increase his output and income.

The data in Table1. Indicates, the primary occupation of the respondents in the study area the result shows that (63.8%) are farmers, (21.3%) of the respondents are marketers, while (15.0) are civil servants, this result shows that most of the respondents are farmers. This is because they are into farming activities in the study areas and this reason is a pointer to the most-likely profitability of occupation in the study area.

Farmers Sources of Information in the Study Area.

The result from Table 2 shows the distribution of the respondents according to source of information used by farmers. Majority 55.6% obtained their information from farmers meeting, 47.5% obtained their information from cooperative society. It was also noted that 41.9% obtained their information from extension agent, 35.0% obtained their information from neighbor and friend, 33.8% obtained their information from television, 31.9% obtained their information from Handset, 25.0% obtained their information from contact farmers, 21.3% obtained their information from local leader, 21.3% obtained their information from Radio, 5.6% obtained their information from Posters, 3.1% obtained their information from family meeting, 2.5% obtained their information from Drum, 2.5% obtained their information from Newspapers. This applies that, using these media would have been faster ways of reaching farmers with little effort and much success. Agricultural information transfer, sourcing and usage thrive better in places where farmers are highly educated (FAO, 1993; Zijp, 1994). On the other hand, it should also be noted that internet and library are still an elitist communication media for most people.

Table 2: Distribution Based Sources of Information Used by the Farmers. (n= 160)

Source of information used by farmers	Frequency	*Percentage (%)
Town crier	8	5.0
Local leader	34	21.3
Television	54	33.8
Farmers meeting	89	55.6
Drum	4	2.5
Radio	34	21.3
Cooperative society	76	47.5
Handset	51	31.9
Extension agent	67	41.9
Neighbor and friend	56	35.0
Family meeting	5	3.1
Contact farmers	40	25.0
Newspapers	4	2.5
Posters	9	5.6

*Multiple responses

Source: Field Survey, 2021

The Effect of Farmers Socioeconomic Characteristics on Utilization of Information Sources

The effect of farmer's socioeconomic characteristics on utilization of information source the results was determine suing multiple regression analysis, the result are presented in table 3, the result revealed and estimated R^2 of 0.89 which accounted of about 89% of the variation of dependent variables were explain by the independent variables which shows the goodness of model.

Table 3: The Effect of Farmers Socioeconomic Characteristics on Utilization of Information Sources

Variables	Coefficient	Std. Err.	t-value
Gender	0.2563	0.1083	2.4**
Age	0.5389	0.0812	6.6***
Marital Status	0.0456	0.0231	2.0**
Level of education	0.0751	0.0229	3.3***
Farm size	0.2150	0.0748	2.9***
Family Size	0.2643	0.0524	5.0***
Membership of association	0.6650	0.0957	6.9***
Years of experience	0.1857	0.0905	2.1**
Primary occupation	0.7434	0.1298	5.7***
_cons	0.2397	0.1047	2.3**
R^2	0.89		

Source: Field Survey, 2021

Note: **, *** are significant at 5% and 1% respectively

The coefficient of gender was found to be positive and significant at 5% level which implies that they is positive and significant relationship between gender and utilization of information source that is, a respondent being a male uses source of information utilization more than their female counterpart.

The age of the age of the respondent: The coefficient of age was found to be positive and significant at 1% level. This implies that a unit increase in age result to an increase in source of information utilization. This is true because a young and active farmer will look for more information source to increase their agricultural production compare to less experience farmers. This agree with the finding of Ommani and Chizari (2018) who reported that the older farmer utilized less of extension information. Invariably, it means that the younger farmers utilized more of the extension information at their disposal probably due to their youthful exuberance and tendency for adventure.

The Marital status of the respondents: The coefficient of marital status was found to be significant at 5% level. This implies that increase in the marital status result to an increase in source of information utilization. This is because the farmers need to be active and also look for more information source to increase their agricultural production in order to help them have enough produce to use at home and sell.

The education level of the respondent: The coefficient of education level was found to be significant at 1% level that shows they is a highly significant relationship between education of the respondents and their access to agricultural information. This implies that there is a positive relationship; which indicates that with the increase in the educational level of the respondents, there was an increase in their access to information. The results of the present study are in line with those of Katungi (2006) who found in his study "gender, social capital and information exchange in rural Uganda" that more educated farmers had more access to information.

The farm size of the respondents: The coefficient of farm size was found to be significant at 1% level that shows they is a highly significant relationship between size of the land holding of the respondents and their access to agricultural information. They is a positive association between the variables; which indicates that with an increase in the size of land holding of the respondents, there was an increase in their access to agricultural information. The results of the present study are in line with those of Saadi *et al.* (2008) who found a highly significant relationship between land holdings of the respondents and their access to information.

The family size of the respondents: The coefficient of family size was found to be significant at 1% level, that shows they is a highly significant relationship between size of the family of the respondents and their access to agricultural information. They is a positive association between the two; which indicates that with an increase in the size of land holding of the respondents, there was an increase in their access to agricultural information.

The cooperative society of the respondent: The coefficient of cooperative society was found to be significant at 1% level that shows they is a highly significant relationship between cooperative society of the respondents and their access to agricultural information. A positive association was illustrated between the variables; which indicates that with an increase in the cooperative society of the respondents, there was an increase in their access to agricultural information. The results of the present study are in line with those of

Saadi *et al.* (2018) who found a highly significant relationship between cooperative society of the respondents and their access to information.

The farming experience of the respondent: The coefficient of farming experience was found to be 5% significant, that shows they is a highly significant relationship between farming experience of the respondents and their access to agricultural information. They is a positive association between the variables; which indicates that the higher the farming experience, the more the farmers would have gained more knowledge and technological ideas.

The primary occupation of the respondent: The coefficient of primary occupation was found to be significant at 1% level, that shows they is a highly significant relationship between primary occupation of the respondents and their access to agricultural information. They is a positive association between the variables; which indicates that with an increase in the primary occupation of the respondents, there will be an increase in their access to agricultural information.

Constraints faced by Utilization of Modern Information Sources

Various constraints were discovered which militate against information delivery to farmers such as, inadequate fund, improper awareness, incomplete/irrelevant information, information received, extension personality and timeliness of feedback, inadequate extension agent, inconsistency, inadequate facilities/professionals, complexity and language barrier.

From the survey, eleven (11) problems were identified. Results in Table 4 revealed that majority (89.4%) inadequate fund, also 76.3% of farmers indicated improper awareness which also affected the efficiency of agricultural practice and information use. While the least (7.5%) number of respondents indicated the Language barrier as constraints. Therefore, inadequate fund (89.4%), improper awareness (76.3%) and incomplete/irrelevant information (14.17%) were ranked as 1st, 2nd and 3rd constraints respectively to information sourcing. This implies that only fund is a major problem to information sourcing in the study area. It is also probable that the availability of fund may resolve most of the constraints identified. Moreover, the problem of fund probably explains why respondents indicated that they source for information mainly from the extension agents who they regard as credible source and who usually visited them to offer free services. The result in Table 4 also indicates that, language barriers with 7.5% which indicates that various sources of information to the farmers are in local language which is better understood by the farmers.

Table 4: Constraints to Utilization of Modern Information Sources.

Constraint	**Frequency**	**Percentage**	**Ranking**
Inadequate fund	143	89.4	1st
Improper awareness	122	76.3	2nd
Incomplete/irrelevant information	120	75.0	3rd
Information Received	100	62.5	4th
Extension Personality	95	59.4	5th
Timeliness of Feedback	90	56.3	6th
Inadequate extension agent	65	40.6	7th
Inconsistency	34	40.6	7th
Inadequate facilities/professionals	12	28.1	8th
Complexity	95	21.3	9th
Language barrier	45	7.5	10th

***Multiple Responses**
Source: Field Survey, 2021

CONCLUSION AND RECOMMENDATION

Conclusion

From the study, it could be concluded that, the sources to information to rural farmers were from; Farmers meeting, Cooperative society and extension workers. The finding also indicates that the effect of farmers socio-economic characteristics on utilization of information sources in the study area are shown as age, level of education, farm size, family size, member of association and primary occupation were found to be positively and significantly correlated to utilization of modern information sources and It was also discovered that constraints militating against the information utilization are; inadequate fund, improper awareness and incomplete/irrelevant information in the study area

Recommendation

The following recommendations are made based on finding from the study:

i. The farmers should try to form a cooperative association.
ii. The farmers should try to be using available information sources in order to help them in farming system.
iii. Irrelevant information should not disseminated and the information in question should always reach the rural farmers in good time. More so, the feedback mechanism should be strengthened and the extension workers should learn how to adjust to the situations while there on the field.

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Influence of Sowing Date and NPK Fertilizer Rate on the Growth and Yield Components of Sun Flower

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Abstract: *The field experiment was conducted at the Teaching and Research Farm of Ramat Polytechnic Teaching and Research farm Maiduguri during the dry season between February to April, 2018. Maiduguri i.e. on latitude 1 1.4°N and longitude 13.05°E it has the altitude of 354m above sea level Bashir., (2015).to evaluate the performance of sunflower as affected by different sowing dates and organic fertilizer application. The experiment was laid out Randomized Complete Block Design (RCBD). Sowing date significantly (P≤0.05) increased and reduced number of phonological days to flowering of early and late sown sunflower, respectively. Application of inorganic fertilizer significantly (P≤0.05) increased plant height of early and late sown sunflower. Delay in sowing till first week in December significantly (P≤0.05) reduced head diameter, number of seeds per head and seed yield of late sown sunflower. However, it significantly (P≤0.05) increased yield and yield attribute by 23% relative to the control in the late sown sunflower. Based on the comparatively high seed yield (850.45–1,525.78 kg/ha) recorded in our study, it is recommended that sunflower be sown in the early date is much better than other sown in middle and late date.*

Keywords: Inorganic fertilizer; sunflower; Nitrogen; Phosphorus; Potassium and Sowing date

Introduction

Sunflower (*Helianthus annuus* L.) occupies the fourth position among vegetable oilseeds after soybean, oil palm and canola in the world (Rodriguez *et al*., 2002 and Ahmad *et al*., 2011). Although sunflower is generally regarded as a temperate zone crop, it is currently cultivated on approximately 23 million hectares in 40 countries of the world, including some countries in the humid tropical Africa because it is quite rustic and can perform well under varying climatic and soil conditions (Seiler *et al*., 2008, Kaleem *et al*., 2011b). The major goal of growing sunflower is for its seed (achene) that contains oil (36–52%) and protein (28–32%) as reported by Rosa *et al*. (2009). The crop has been receiving steady attention by various scientists from diverse disciplines in recent past because sunflower oil is a premium oil with light colour and is widely used in the diets of heart patients because it contains very low cholesterol and high (90%) unsaturated fatty acid concentration (Flagella *et al*., 2002; Qahar *et al*. 2010). In recent past, there has been a steady increase in demand for organic foods globally because of the health risks posed by conventional method of production (Yiridoe *et al*., 2005). After reviewing 343 studies, it was revealed that organic crops and crop-based foods contain up to 60% higher key antioxidants than conventionally grown crops (Baranski *et al*., 2014). We therefore decided to explore the potential of organic sunflower in the transition zone. The productivity of sunflower in terms of seed yield, oil and protein output varies widely depending on multifarious factors of the environment such as radiation (Dosio *et al*., 2000), temperature (Kaleem *et al*., 2009 and 2011a), rainfall distribution (Lawal *et al*., 2011; Asbag *et al*., 2009; Olowe *et al*., 2013), agronomic practices like time of sowing (de la Vega and Hall, 2002; Lawal *et al*., 2011; Anjum *et al*., 2012), plant density and nitrogen nutrition (Ali *et al*., 2012), varying planting pattern (Yasin *et al*., 2013) and sowing of improved varieties and hybrids (Ali *et al*., 2011). Consequently, there is a disparity among the reported African (812 kg/ha) and Nigerian (1,000 kg/ha) averages by Olowe *et al*. (2013) and the world average of 1,520 kg/ha (USDA, 2012).Although much work has been done on sunflower agronomy in different agro-ecological locations of the world with a view to gaining insight into the effects of the cultural practices that enhance seed yield, there is still a dearth of information on the performance of newly released and improved, and locally adapted sunflower varieties as affected by organic fertilizers and varying sowing dates in the forest–savanna transition zone which is outside its traditional growing region (savanna). Earlier research works on sunflower agronomy in the tropics reported varying optimum rates of nitrogen fertilizer to be 60 kg N/ha in Nigeria (Olowe *et al*., 2005), 80 kgN/ha in India (Rasool *et al*., 2013), 150 kgN/ha at Islamabad, Pakistan (Bakht *et al*., 2010) and 180 kgN/ha at Faisalabad, Pakistan (Nasim *et al*., 2012b). Sunflower growers rarely apply organic fertilizers to sunflower despite the inherent advantage (slow nutrient release and potential improvement of soil structure and water holding capacity) of organic plot compared with the conventional plot (Posner *et al*., 2008). In fact, the resource-constrained farmers in the tropics seldom apply mineral fertilizers because of restricted access to the input and its exorbitant cost. Different brands of organic fertilizers using plant residues, municipal and abattoir wastes are now being produced in Nigeria for farmers' use in crop production and they are significantly cheaper that mineral fertilizers. Unfortunately, information is lacking on the response of sunflower to organic fertilizer application in humid tropical Africa. Recent work in India reported linear increase in seed yield as farmyard manure rate increased from 10 to 20 ton/ha, suggesting that an additional increase in seed yield with increase in rate of farmyard manure (Rasool *et al*., 2013). Similarly, plant population density (Olowe, 2005; Petcu *et al*., 2010) and planting ratio (Shakuntula *et al*., 2012) studies also indicated varying results in different locations. Optimum sowing date of sunflower as early and late season crops is relatively well known to be late May and July – Early August, respectively in the forest–savanna transition zone (Ogunemi, 2000). The seed quality of sunflower is a function of an inter play of the genetic, environmental and agronomic manipulations (Baydar and Erbas, 2005; Petcu *et al*., 2010; Olowe *et al*., 2013). However, most of the studies conducted in the humid tropics neither related the performance of sunflower to the phenology of the crop nor ascertained the quality of the seeds after imposing the various treatments. Furthermore, attempts have not been made to exploit the possibility of having two good quality sunflower crops in a year by staggering sowing dates. Consequently, part of what is still lacking now in the agronomy of sunflower in the humid tropics is a comparative study that will provide an insight into the effects of some weather parameters and manipulation of cultural practices on the phenology, seed yield and quality of sunflower. The hypothesis of the study was hinged on possibility of growing more than one crop of sunflower in a year. Therefore, this study was carried out to determine the effects of staggered sowing and organic fertilizer application on growth, development, seed quality and yield of two sunflower varieties in a forest–savanna transition zone of the tropics.

Materials and methods

Growth conditions

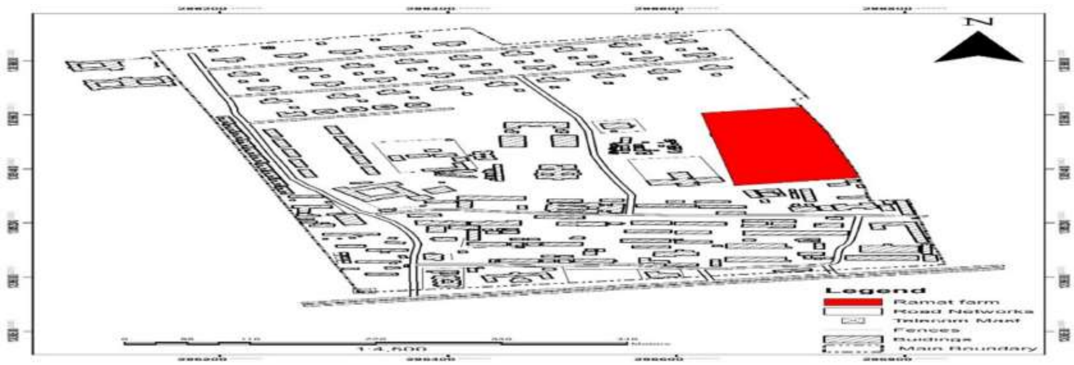
The field studies were conducted at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta (7° 15′ N, 3° 25′ E, altitude 140 m above sea level) in south western Nigeria on a loamy sand soil between June and November, 2012. The two test varieties were Funtua, a locally adapted, late-maturing variety (110–120 days) and SAMSUN-3, also late maturing (110–120 days), drought tolerant and contains good antioxidants (NASC, 2013). The soil characteristics of the two experimental plots are shown in Table 1. The soils of the experimental sites were loamy sand in texture and low to medium in nitrogen and phosphorus, and adequate in potassium based on rating for soil fertility classes as described by Anon (1989). The meteorological data for the growth period of the two experiments were collected from the Department of Water Resources Management and Agrometeorology located about 300 m away from the Research Farm. The experimental site was located in the forest–savanna transition zone with a traditional bi-modal rainfall distribution having peaks usually in July and September and a short dry spell often referred to as *august break*. Weather data during the two periods of experimentation in 2012 are presented in Tables 2–4. The months of July (155.4 mm) and October (184.7 mm) were the wettest months during the growing periods of early and late sown sunflower. The coolest and hottest months based on mean atmospheric temperature were August (25.4°C) and November (28.2°C). Relative humidity values, however, ranged between 77.5% (October) and 82.6% (August) as shown in Table 2. The amount of rainfall received by early and late sown sunflower, number of rainy days and daily sunshine duration decreased as sowing was delayed (Table 3). The growing degree days (GGD) values for early and late sown sunflower varieties during the four sowing dates are presented in Table 4. The values ranged between 2,073.39° and 2,423.07°C and 1,942.37° and 2,038.43°C for the early and late sown SAMSUN-3 variety, respectively. While for Funtua, the values were 2,067.90°–2,370.06°C and 2,052.29°–2,189.27°C for the early and late sown sunflower, respectively.

Table 1: Some Physico-chemical characteristics of the experimental fields (0–30 cm level)

Soil characteristics	Early sown field	Late sown field
Sand (%)	84.0	85.0
Silt (%)	7.0	7.0
Clay (%)	9.0	8.0
Textural class	Loamy sand	Loamy sand
pH (H_2O)	5.37	5.50
Carbon level (%)	0.5	0.85
Total *N* (%)	0.18	0.20
Available P (mg/kg)	1.49	0.80
Exchangeable K (cmol/kg)	0.23	0.67

2.0 Experimental Site Description

Field experiment was conducted at the Teaching and Research Farm, of the Ramat Polytechnic, Maiduguri, in the Sudano-Sahelian region of northern Nigeria. The site lies between latitude 1105 N and longitude 13009E (Kyari et al., 2014). The area is about 335m above sea level and lies within the lake Chad Basin formation, which is an area formed as a result of down –warping during the Pleistocene period (Waziri, 2007). It is in the tropical climate region and is characterized by three season's cool-dry season (October to March), hot season (April to June) and a rainy season (June to September)



2.1 Materials and Methods

2.2 Treatments and Experimental Design

The research was of two factorial and was laid out in a Randomized Complete Block Design (RCBD) with (20) Treatments were replicated three times, (5x4) factorial experiment with 5 rates of NPK fertilizer and 4 sowing dates 3 plots as control. A total of 63 plots was used with each plot measuring 3m×3m = 9m2.

2.2.1 Experiment (2):

Effect of rates of NPK fertilizer:

According fertilizer use and management practice for crops in Nigeria the recommended rate for NPK fertilizer in this region is;

a. 100kg Nitrogen
b. 50kg P_2O_3
c. 30 kg K_2O

Three types of fertilizers would be used namely:

a. NPK fertilizer (15:15:15)
b. Urea
c. Single super phosphate (SSP)

This would be used individually or collectively to obtain the various required rates. Full dose of P and K would be applied at the time of planting and half dose of N would be applied at planting time and the remaining half at bud initiation stage. The rates to be applied are;

FR1 = 25% of the recommended rate
FR2 = 50% of the recommended rate

FR3 = 75% of the recommended rate
FR4 = 100% recommended rate
FR5 125% of recommended rate

2.2.2 Experiment (2):

Effect of sowing date on sun flower:

The sowing date considered were at interval two weeks from the first sowing date which will be as follows:

SD1 = 16th Dec,2021.
SD2 = 30th Jan,2022
SD3 = 13th Feb ,2022.
SD4 = 27th March 2022

Control was first planting date without NPK fertilizer

2.3 Crop husbandry

The experimental sites were ploughed twice and harrowed once before marking out the plots. At each sowing date, seeds of the test varieties were sown at a spacing of 60 cm×30 cm which corresponded to 56,000 plants ha^{-1}. Three seeds of the test varieties were sown per hole and later thinned to one plant per stand at 2 weeks after sowing (WAS). Each experimental plot consisted of four rows 5 m in length and measured 1.8 m×5 m (9.0 m^2). No agro-chemicals were used during both experiments in order to simulate the usual practice of the resource-constrained farmers. Organic fertilizer was applied and incorporated into the soil during seedbed preparation a week before sowing. Manual weeding was done at 3 and 6 WAS and five randomly selected plants were tagged from the middle rows of each plot for plant height measurement at flowering (R5–when 30–80% of disk flowers have completed flowering on the inflorescence) and physiological maturity (R9–when the bracts are yellow and brown) as described by Schneiter and Miller (1981). The tagged plants were later harvested and used for yield component analysis. The crop was grown under rain-fed conditions which is the usual practice of the resource-constrained farmers. There were no incidences of pests and diseases during the early and late sown cropping. This could be attributed to the fact that sunflower is still alien to this agro-ecological zone.

2.4 Data collection

The characters determined on plot basis were number of phenological days to flowering (R5) and physiological maturity (R9), plant height (cm), i.e. height from the soil surface to the tip of the head at R5 and R9, head diameter (cm), head weight (g), number and weight (g) of seeds per head, 100 seed weight (g), seed yield (kg ha^{-1}), oil and protein contents (%) in the seed and oil yield (kg ha^{-1}). Plant height, seed yield and yield components were determined on the five earlier tagged plants on plot basis.

2.5 Data analysis

The data collected were statistically analysed using the MSTATC package (Freed *et al*., 1989) and significant (P<0.05; F-test) treatment means of the main effects and interactions were separated using the least significant difference method at 5% probability level.

2.6 Results of the Expirement

2.6.1 Effect of sowing date and NPK fertilizer application on phenology and height characteristics of early and late sown sunflower

As presented in (Table 2). Sowing date significantly ($P \leq 0.05$; F-test) affected number of phenological days to flowering of early and late sown sunflower and number of phenological days to physiological maturity of late sown sunflower. However, sowing date had no significant effect on height at flowering and physiological maturity of both early and late sown sunflowers. Organic fertilizer application significantly ($P \leq 0.05$; F-test) reduced number of phenological days to flowering of early sown sunflower and increased plant height at flowering and physiological maturity of both early and late sown sunflower.

Table 2: Effects of sowing date and NPK fertilizer application on plant height and number of phonological days to flowering (R5) and physiological maturity (R9) of early and late sown sunflower

Treatment	Early sown				Late sown			
	Days to		Height (m) at		Days to		Height (m) at	
	R5	R9	R5	R9	R5	R9	R5	R9
Sowing date (SD)								
SD1 = 16th Dec,2021.	70.8	110.8	2.29	2.35	79.0	111.7	2.18	2.27
SD2 = 30th Jan,2022	72.8	114.0	2.75	2.34	71.7	105.4	2.13	2.22
SD3 = 13th Feb ,2022.	77.4	116.0	2.30	2.35	69.7	101.2	2.28	2.38
SD4 = 27th March 2022	85.2	114.6	2.25	2.30	70.2	100.9	1.81	1.86
LSD 5%	2.57**	ns	ns	ns	6.82*	3.18**	Ns	ns
Fertilizer (F)								
100kg Nitrogen	77.7	114.3	2.18	2.25	72.0	104.4	2.00	2.09
50kg P2O3	75.3	113.4	2.38	2.44	73.2	105.2	2.21	2.27
LSD 5%	1.23**	ns	0.07**	0.06**	ns	ns	0.06**	0.06**

2.6.2 Effects of staggered sowing and organic fertilizer application on seed yield, some yield attributes and seed quality of early and late sown sunflower

As shown in (Table 3). Sowing date did not affect seed yield, yield attributes and quality of sunflower, except protein content ($P \leq 0.05$; F-test) of early sown sunflower. However, application of organic fertilizer significantly ($P \leq 0.05$; F--test) affected seed yield, yield attributes and quality of early sown sunflower, except oil yield. Application of organic fertilizer resulted in significantly ($P<0.01$) higher values for all the traits measured relative to the control, sunflower in the late season significantly ($P \leq 0.05$; F-test) affected head diameter, number of seeds per head and seed yield. Therefore, application of NPK fertilizer significantly ($P \leq 0.05$; F-test) increased seed yield, all yield attributes, and seed quality of late sown sunflower.

Table 2: Effects of sowing date and NPK fertilizer application on sunflower seed yield and yield attributes

Treatment	Head diameter (cm)	Head weight (g)	No. of seeds per head	Weight	100 seed weight (g)

Treatment	Head diameter (cm)	Head weight (g)	No. of seeds per head	Weight	100 seed weight (g)
Sowing date (SD)					
SD1 = 16th Dec,2021.	16.4	87.5	1,150.6	79.2	7.9
SD2 = 30th Jan,2022	16.6	94.9	1,143.5	87.5	8.4
SD3 = 13th Feb ,2022.	16.3	90.5	1,158.9	82.8	7.9
SD4 = 27th March 2022	14.6	72.8	884.4	64.4	6.9
LSD 5%	1.28*	ns	93.25**	ns	ns
Fertilizer (F)					
100kg Nitrogen	15.3	80.1	1,017.0	70.6	7.3
50kg P2O3	16.6	92.8	1,151.7	86.4	8.3
LSD 5%	0.62**	5.25**	36.15**	6.77**	0.51**

2.7 Discussion of the Experiment

The productivity of sunflower is largely determined by the prevailing weather conditions throughout its life cycle and imposed cultural practices (Kaleem *et al*., 2011a). Cultural practices like sowing date and fertilizer application and some environmental factors (temperature and rainfall) are major factors which affect plant growth and development. In our study, varying responses were observed on the two test varieties to these factors. Although, temperature is not a limiting climatic factor in the tropics, delay in sowing resulted in lower values of GGD of late sown sunflower. The lower values could be attributed to heavier cloud cover in the tropics compared to the temperate region. As sowing was delayed, number of phenological days to flowering of early sown sunflower significantly ($P \leq 0.05$) increased. Whereas number of phenological days to flowering and physiological maturity of late sown (SD4) sunflower significantly ($P \leq 0.05$) decreased. This trend could be attributed to increased vegetative growth in early sown sunflower relative to the late sown crop. Early sown(SD1) flowered and was also significantly ($P \leq 0.05$) taller at flowering and physiological maturity in both early and late sowing dates. However, the application of NPK fertilizer significantly ($P \leq 0.05$) hastened number of phenological days to flowering of early sown sunflower by 2 days and also enhanced plant height of early and late sown sunflower. Among the seed yield attributes evaluated, only number of seeds per head, head diameter and head weight were significantly affected by sowing date×variety. Number of seeds per head had earlier been reported to contribute greatly to variation in sunflower oil yield by de la Vega and Hull (2002). Delay in sowing in both early and late sown sunflower did not affect oil yield even though sowing date has been reported to be the main source of variation for oil yield by de la Vega and Hull (2002). Application of inorganic fertilizer significantly ($P \leq 0.05$) increased oil yield by 23% relative to the control in the late sown sunflower. The seed yield range (852.45–1,525.78 kg/ha) recorded in our study was on par with the Nigerian (1,000 kg/ha), African (812 kg/ha) averages (Olowe *et al*., 2013) and world average (1,520 kg/ha) according to USAD (2012). This performance confirmed the potential of sunflower especially when sown in early December or second to third week in March.

3.0 Conclusion and Recommendations

Based on the results obtained it can be concluded that the application of sowing date SD1+ NPK F_1 kg/ha, resulted in higher growth and acquisition of the highest yield of sunflower in the study area. However, and significantly ($P\leq0.05$) hastened number of phenological days to flowering of early sown sunflower by 2 days and also enhanced plant height of early and late sown sunflower.

3.1 Recommendations

(i)Since this experiment is season study in a single environment, further research over seasons are required so as to develop reliable values.
(ii) The experiment should be repeated in similar agro-climatic condition in order to confirm findings.

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Evaluation of Tomatoe Varieties on Resistance to Flea Beetle and Fruits Worm in Semi Arid Zone Borno State of Nigeria

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Abstract: *The study was conductecd to assess the different tomatoe varieties resistance to fleabeetle and fruitworms on growth and yield of tomatoes[solanum lycopersicon]. The objective is to know which variety is tolerance to insect pest,to determine the improvement and adaptation among the varieties.The treatments are local variety,utc,and roma which was laid out in a Rondomized Completely Block Design which was replicated four times,the data was collected on plant height,number of insect observed and number of leaves damage and yield weight after harvest.The data was analysed using statistical 8.0 vision.The result of varieties after six weeks on plant height,number of insect abserved and number of leaves damage.The plant height at six weeks, the local variety with highest number of plant height with 39.275 and the least number of plant height is recorded under utc with 33.675,the number of leaves damage at five weeks,the result indicate that local variety have the highest number with 2.5000 while utc,0.8500 and roma,0.5000,while number of insect pest at five weeks are, local variety 7.6250,roma,1.4500 and utc,0.8500*

Keywords: *fleabeetle and fruitsworms, tomatoes varieties,resistance*

1.0 INTRODUCTION

Tomato (Solanum lycopersicum) is one of the most widely grown vegetable crops in the world, second to potato (Maerere *et-al,* 2006). Tomatoes are used not only for fresh table food, but also for Ketchup, pure, sauces and in many other ways. Tomatoes have been used for food by the in habitat of central and South Americans since prehistoric time. It originally came from tropical area from Mexico to Peru. All tomato varieties in Eurpe and Asia are said to be descendants of the seeds taken from Latin America to Europe and Asia by the Spanish and the Portuguese merchants during the 16 century. Africa tomatoes, on the other hand were introduce by European merchant or colonizers. Thus today, modern tomato cultivars and hybrid can be grown and can produce fruit in climates far different from the site of its origin. It has become one of the most popular vegetables in the tropics and other countries in Asia and the rest of the world (Villared, 1979).

Tomato is a warm season crops and plants cannot stand severe frost. The crop does well under an average monthly temperature of 21º to 23ºc but commercially I may be grown at a temperature ranging from 18º to 27ºc in most tropical countries, average yield range between 2 to 10 tons of fruit/ha, against yield of 20tons in south Korea 40tons in the USA 50tons in Japan and over 130tons in the Netherlands'. Tomato belong to the family nightshade family, the plant typically grows to 1 to 3 meter (3-10ft) in the height and has a weak stem that often sprawls over the ground and vines over other plants. It is a perennial in its native habitat, although often grown outdoor in temperature climate as annual crop. Tomato is the edible, often red fruit berry of the nightshade solanum, commonly known as tomato plant. Tomato is consumed in diverse ways as an drink while it is botanically a fruit. It is considered a vegetable for culinary purpose, which has caused some confusion. The fruit is rich in hycopence, which may have beneficial health effects. Tomato thrives in between temperature 10º and 30ºc and neither tolerant to high acidity can thrive on much kind of soil ranging from sand to heavy clayed. An average common tomato weights approximately 100grams (4oz). Tomato cannot be planted directly on the field but raised on nurseries before transplanting to the permanent site for adequate establishment and productivity. Under some condition, some cultivars can be seeded directly on the field. Tomato is now one of the popular and widely grows vegetables around the world. Tomato are most important vegetable commodity after patota planted to about 6000 hectares which is grow in summer and winter in frost –free areas. Similarly, tomato belongs to one of the most important easy varietals, method of cultivation and processing (purse glove, 1968)

In Egypt tomatoes to as infected with different pest wild caused considerable damage in both quality and the quantity of the species are known to be of great economics importance as bennaci tabaci (germ) my nz pesicae (sulzer) tedranyekus cuticar kock and tetranychs cucurbitacearum (soyed). They cause many indirect damage by transmitting several micro-organisms such as viral, fungus and pathogen. Photoperiods mited are of economic importance as natural enemies of various photophygous miles on many crops. Considered main insect pest infesteting tomato, cause serious damage the plat and yield

Tomato has high level of susceptibility to infestation by insect pests, which are responsible for decline in quantity or quality and germination potentials. The cultural control method by screening the varieties that are resistant to the insect pests attack are more environmentally friendly.

3.0 MATERIAL AND METHOD

3.1 The Study Area

The study was conducted in Ramat polytechnic teaching farm, Maiduguri is located at latitude 11.15ºN and longitude 13.15ºN about 354m above the sea level (wikipedia 2013). It is dry sub-humid in native characteristics by a unimodal rainfall pattern and the hottest month being March and April and coolest month being November and December, the minimum range is 37-45ºc (wikipedia 2013). The rainy season is usually short normally from the month of May to October with relative humidity and annual rainfall is 440-600mm.

3.2 Sourcing of Material

Three seed varieties seed of tomatoes (Roma, Utc and Local variety) was sourced from BOSAP office opposite of BRTV area of Maiduguri. Borno state

3.3 Nursery Preparation

Seeds are sown in a seed bed, preferably of fertilizer soil. Raised beds are prepared, it should be avoided using some place for nursery preparation for every year. The nursery bed of 15cm height and 0.8cm depth and then convenient length beds are prepared and sown sparsely along the line of 0.5cm depth and then covered by a thin layer of straw or dried grasses. Germination occurs within 7-8 days after which the straw cover are removed and beds irrigated directly. When seedling became crowded they are thinned to avoid competition for resources.

3.4 Land Preparation and Field Layout

Plunging and digging is necessary to prepare the land for a new crop. It improves the structure and water holding capacity. There after hoe, tape, rope, and pegs will be used to demarcate each plots.

3.5 Transplanting of Seedlings

The nursery seedling was transplanted when it reached the planting period. The seedling of tomatoes will be transplanted to each (12) plots with a spacing size of 0.5m interspaces, 0.5working alley and 0.5 outside the border will be cleared, harrowed and ridged. The tomato seedlings were gently uprooted with their roots covered with soil to prevent transplanted at 2.5cm depth at a spacing 60x60cm in labeled plots. One week after transplanting of the seedling, the failed stands were filled to maintain existing gaps and plant populations. Weeded as at when due anorganic manure fertlizer was applied at the rate of 15kg per plots.

3.6 Irrigation

The supply of adequate water to the root of a tomato plant is critical. The seedling were watered early morning and late evening by means of irrigation.

3.7 Experimental Procedure and Design

The experiment was conducted in a randomized complete block design with the three treatment replicated four times. The treatment comprised of (ROMA, UTC, and LOCAL VARIETY). The experiment plots consist of 12 plots at a spacing of 2x2m and 0.5 working alley 0.5 borders was cleared harrowed and ridged.

3.8 Data Collection

i. The number of flea beetle species count

Data were collected on insect pest species, number that found attacking the tomatoes varieties were counted counting and recorded.

ii. The damage leaves was counted

This should be done 3 weeks after seedlings establishments on each plot at weekly interval. The number of damage leaves per plant was counted to study the effects of the treatments on fruit worm and flea beetles.

iii. Plant height and of laves size was measured

Data on tomato plants height was obtained by measuring plots from the each randomize selected stand per plot from the ground level to the growing tips using a plastic measuring tape.

iv. The yield per plots

The yield per plot was collected from each plot at an interval of 7 days and weight.

3.9 Data Analysis

All data collection were subject to analysis of variance (ANOVA) use statistical software\ (statistical version 8.0). The different between mean were compared and separated using least significant different (LSD) 5% level of probability.

4.0 RESULT AND DISCUSSION

4.1 RESULTS

Table 1: Shows plant height (cm) of three cultivars (local variety, Roma and UTC) of tomato at different weeks

Treatments	1Week	2 Week	3 Weeks	4 Weeks	5 Weeks	6 Weeks
LV	19.625[a]	23.100[a]	26.475[a]	30.875[a]	34.925[a]	39.275[a]
ROMA	14.475[a]	16.900[b]	20.950[ab]	24.475[ab]	27.975[a]	33.850[a]
UTC	14.675[a]	16.525[b]	19.900[b]	23.250[b]	27.200[a]	33.675[a]
CV	19.22	17.82	16.77	15.48	16.21	9.49
SE	2.2097	2.3741	2.6614	2.8686	3.4429	2.3892

Means in the column accompanied by the same letter (a) are not significantly difference at ($P< 0.05\%$) using least significance different (LSD).

<u>Week 1</u>

The result shows that at week there are not significant different among the treatments, however, their height number of plant height as recorded under local variety with 19.625, followed by (Roma with 14.475 and UTC with 14.675.<u>Week2</u>

The result shows that there were significant different among the treatments, however, their highest number of plant was recorded under local variety with 23.100, followed by the (Roma with 16.900 and UTC with 16.525, the find reveal that there are significant different of plant height which was found under local variety with 23.100.<u>Week3</u>

The result shows that there are significant different among the treatments, however their highest number of plant height was recorded under local variety with 26.475, followed by (Roma with 20.950 and UTC with 19.900.At week 3 there are significant different among the treatments, which was found under local variety with 26.475.Week4

The result shows that there are significant different among the treatments, however, their highest number of plant height was recorded under local variety with 30.875, followed by (Roma with 24.475 and UTC with 23.250. At week 4 finding reveals that there are significant different of the plant height which was found under local variety with 30.875.Week5

The result shows that at week 5 there are no significant different among the treatments, however, their highest number of plant height was recorded under local variety with 34.925, followed by (Roma with 27.975 and UTC with 27.200.Week 6

The result shows that at week 6 there were no significant different among the treatments, however, their highest number of plant height was recorded on local variety with 39.275, followed by (Roma with 33.850 and UTC with 33.675

Table 2: Shows the number of leaves damage of three tomato cultivar at different weeks

Treatments	One week	Two weeks	Three weeks	Four weeks	Five weeks
LV	0.2500^{a}	0.7500^{a}	1.5000^{a}	2.0000^{a}	2.5000^{a}
ROMA	0.0000^{a}	0.0000^{a}	0.0000^{b}	0.0000^{b}	0.5000^{b}
UTC	0.2500^{a}	0.6500^{a}	0.0000^{b}	0.5000^{b}	0.8500^{b}
CV	173.21	100.25	66.67	40.00	21.26
SE	0.2041	0.3308	0.2357	0.2357	0.1929

Means in the column accompanied by the same letter (a) are not significantly difference at (P< 0.05%) using least significance different (LSD)

The result shows that the number of leave damage on different tomatoes varieties, there were no significant different among all the treatments, however, the highest number of convert damage was in local variety with 0.2500, followed by (Roma with 0.0000 and UTC with 0.2500.Week2

The result shows that the number of leave damage on three different tomato varieties, there are no significant different among the all treatments, however, the highest number of converts damage was local variety with 0.7500, followed by (Roma with 0.0000 and UTCwith 0.6500.Week 3

The result shows that the number of leave damage of three different varieties of tomatoes, there are significant different which the highest number of leave damage was recorded on local variety with 1.5000, followed by (Roma with 0.0000 and UTC with 0.000.Week 4

The result shows that the number of leave damage on three different varieties of tomatoes, there are significant different which the highest number of leave damage was recorded under local variety with 2.000, followed by (Roma with 0.0000 and UTC with 0.5000.Week 5

The result shows that the number of leave damage on three different varieties of tomatoes, there are significant different which the highest number of leave damage was recorded under local variety with 2.5000, Roma with 0.5000 and UTC with 0.8500.

Table 3: Shows the number of Insect (fruit worms) on three cultivars of tomato at different weeks

Treatments	One week	Two weeks	Three weeks	Four weeks	Five weeks
LV	2.5000[a]	3.0000[a]	3.7500[a]	5.5000[a]	7.6250[a]
ROMA	1.0500[b]	0.4500[b]	0.2000[b]	1.5500[b]	1.4500[b]
UTC	0.3500[b]	0.2500[b]	0.1500[b]	0.6500[c]	0.8500[b]
CV	62.44	31.86	17.42	16.06	21.86
SE	0.5740	0.2779	0.1683	0.2915	0.5114

Means in the column accompanied by the same letter (a) are not significantly difference at (P< 0.05%) using least significance different (LSD).

Methods adopted by, Dobson *et al.,* [2002]reported African boll worm,is one of most distructive insect pest of tomatoes.

The result shows that the number of insect (fruit worm) on three different tomatoes at weeks, there are significant different among the three varieties of tomatoes. However result reveals that the highest number of insect was found to be in with local variety with 2.5000, Roma with 1.0500 and UTC with 0.3500.

Week2

The result shows that the number of insect on three different tomatoes, there are significant different among the all varieties of tomatoes, the highest number of insect was found on local variety with 3.0000, Roma with 0.4500 and UTC with 0.2500.

Week3

The result shows that the number of insect on three different tomatoes, there are significant different among the treatments, however, the highest number of insect was found on local variety with 3.7500, Roma with 0.2000 and UTC with 0.1500.

Week4

The result shows that the number of insect three different tomatoes, there are significant different among the treatments however, highest number of insect was found on local variety with 5.5000, followed by (Roma with 1.5500 and UTC with 0.6500.

Week5

The result shows that the number of insect on the three different varieties of tomatoes, there are significant different among the all treatments, however, the highest number of insect was found on local variety with 7.6250, followed by the Roma with 1.4500 and UTC with 0.8500.

Table 4: Shows the yield weight (Kg) of three tomato cultivars after harvest

Treatments	Yield weight (Kg)
LV	1.3000^{a}
ROMA	1.8000^{a}
UTC	1.8250^{a}
CV	25.34
SE	0.2942

Means in the column accompanied by the same letter (a) are not significantly difference at (P< 0.05%) using least significance different (LSD).

The result shows that the yield weight of three different tomatoes after harvest. At reveals that the highest number of yield among the different tomatoes there are no sgnificant among the all the treatment in yield. However, the highest number of yield was registered under local variety which found to be with 1.3000, followed by the Roma with 1.8000 and UTC with 1.8250. Analysis variable (ANOVA at 05% level].The methods adopted by fayaz,*et al.,*[2001],different in total fruits yield might be due to different fresh fruit yield and nature of fruits.

4.1 Discussion

Table 1: Shows plant height (cm) of three cultivars (local variety, Roma and utc,

At week six the result shows that there were no significant different among the treatments, however, the highest number of plant height was recorded on local variety with 39.275, followed by (Roma with 33.850 and UTC with 33.675,the methods adopted by sharma and restogi[1993],who reported on significance variation among cultivars for number of branches and fruit per plant.

Table 2: Shows the number of leaves damage of three tomato cultivar at different weeks

At week five the result shows that the number of leave damage on three different varieties of tomatoes, there are significant different which the highest number of leave damage was recorded under local variety with 2.5000, Roma with 0.5000 and UTC with 0.8500.

Table 3: Shows the number of Insect (fruit worms) on three cultivars of tomato at different weeks.

Week one result shows that the number of insect (fruit worm) on three different tomatoes at weeks, there are significant different among the three varieties of tomatoes. However result reveals that the highest number of insect was found to be in with local variety with 2.5000, Roma with 1.0500 and UTC with 0.3500,method adopted by Dobson et a.,.[2002]African boll worm, is one of the most distructive insect pest of tomatoes.

Week two the result shows that the number of insect on three different tomatoes, there are significant different among the all varieties of tomatoes, the highest number of insect was found on local variety with 3.0000, Roma with 0.4500 and UTC with 0.2500.

At week three the result shows that the number of insect on three different tomatoes, there are significant different among the treatments, however, the highest number of insect was found on local variety with 3.7500, Roma with 0.2000 and UTC with 0.1500.

At week four the at result shows that the number of insect on three different tomatoes, there are significant different among the treatments however, highest number of insect was found on local variety with 5.5000, followed by (Roma with 1.5500 and UTC with 0.6500.

At week five the result shows that the number of insect on the three different varieties of tomatoes, there are significant different among the all treatments, however, the highest number of insect was found on local variety with 7.6250, followed by the Roma with 1.4500 and UTC with 0.8500.

Table 4: Shows the yield weight (Kg) of three tomato cultivars after harvest.

The result shows that the yield weight of three different tomatoes after harvest. At reveals that the highest number of yield among the different tomatoes there are no

significant among the all the treatment in yield. However, the highest number of

yield was registered under local variety which found to be with 1.3000, followed by

the Roma with 1.8000 and UTC with 1.8250. Analysis variable (ANOVA at 05% level of significant).The method adopted by fayaz, et al.,[2001], different in total fruits yield might be due to different fresh fruit yield and nature of fruits.

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Performance of Sunflower (*Helianthus annuus* [L.]) as Affected by NPK Rates and Sowing Dates in Sudan Savanna Region of Borno State, Nigeria

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Abstract: *Field experiment was conducted to study the performance of sunflower (*Helianthus annus.*) as affected by NPK rates and sowing dates in Maiduguri, Sudan savannah region of Borno state. The trial was conducted during the wet seasons of 2021 at the Teaching and Research Farm of Department of Agricultural Technology, Ramat Polytechnic Maiduguri (11 59' N, 13 16' E). The experiment consisted of four sowing dates: 29th June, 9th July, 19th and 29th July of 2018 and 2019 and six rates of NPK: 0:0:0 KgNPK/ha, 25:12.5:7.5 KgNPK/ha, 50:25:15 KgNPK/ha, 75:37.5:22.5 KgNPK/ha, 100:50:30 KgNPK/ha and 125:62.5:37.5 KgNPK/ha. The treatments were laid out in a split plot design and replicated three times. Sowing dates were allocated to the main plots and NPK rates to the sub plots. Growth, yield and yield components: plant height, leave area, number of leaves, days to first flowering, days to 50% flowering number of heads/plant, head diameter, dry weight/head, number of grains/head, 1000 grain weight, yield (kg/ha); as well as oil quality parameters: % oleic, % linoleic, % palmitic, % stearic and % myristic were measured. The results indicated that first sowing date of 29th June gave significantly the highest plant height, leave area and number of leaves/plant as well as yield and yield parameters except for days to: first flowering and 50% flowering. The last sowing of 29th July favoured early flowering and days to 50% flowering. The sowing of 29th June (first planting) was also best for oil quality parameters. The NPK rate of 100:50:30 KgNPK/ha was found to be optimum for all the growth, yield and yield parameters measured except for days to: first flowering and 50% flowering. The supply of 0:0:0 KgNPK/ha favoured early flowering and days to 50% of plants with flowers. Also the supply of 100:50:30 KgNPK/ha was optimum for oil quality parameters. The combination of 29th July planting with 100:50:30 KgNPK/ha was optimum for yield and yield components. Thus from the results of the present study farmers could be encouraged to plant sunflower around 29th July and supplied with 100:50:30 KgNPK/ha to get optimum yield and oil quality is recommended.*

Keywords: *Sunflower, NPK, Sowing, Borno, Rates*

INTRODUCTION

Sunflower (*Helianthus annuus* [L].) belongs to the family *Compositae* and it's of temperate origin though it is now grown under different climatic conditions. The place of origin of sunflower is still under contention but it was first domesticated in Central United States of America (Summons, 1976). It was introduced into Europe from America in the 16th century and to Russia in the 18th century. Hurt (1946) further reported that sunflower grains were found to exist in archeological sites of American Indians as food stuff, dated 300 years before the cultivation of corn and it is now grown in the tropics and subtropical countries from latitude 55°N (Purseglove, 1968). It is mainly cultivated in the Sudan, guinea and derived savanna regions of Nigeria with monomodal rainfall pattern (Olowe *et al.,* 2005). However, due to its high potentials, its cultivation is now rapidly expanding in other agro-ecological zones of Nigeria. Sunflower grows best on well drained, loam and sandy loam soil with high organic matter content. It is essential that the rain should be evenly distributed during its early growing period although its efficient tap root system enables it to grow in areas where soils are relatively dry for many crops to perform. Sunflower grows well within a temperature range of 20-25 ^{o}C but under controlled condition, reports indicated 27-28 ^{o}C as optimum. Tolerance of 8-34 ^{o}C by sunflower indicated its adaptation to the regions with warm days and cold nights. Prolonged high temperature reduces the time of maturity and high temperature is known to affect the seed oil content, seed and oil characteristics. In general, temperature above 25 ^{o}C at flowering reduces seed yield and its oil content. Low temperatures below 16 ^{o}C can also reduce seed set and oil content (Prasad *et al.*, 2001). Sunflower was developed first as important commercial oil seed crop in the former Soviet Union (FSU). The oil has gained wide spread acceptance as a high quality, edible oil throughout the world. In 1981-1982 USSR was ranked first with 4.69 million metric tones annually followed by Eastern Europe with 2.25 million metric tones. USA was third with 2.04 million annual metric tones followed by Argentina, China, France, Spain and others with total annual world production figure of 14.82 million metric. In 1986-1987, USSR was ranked first with 5.26 million metric tones followed by Eastern Europe with 2.56 million metric tones, Argentina with 2.50, France with 1.90 million metric tone, China with 1.54, USA with 1.26 million metric tones, followed by Spain and other countries; and the total world production was 19.25 million metric tones. In 1991-1992, USSR was ranked fist with average production figure of 5.65 million metric tones, followed by, Argentina with 3.30 million metric tones, France with 2.56 million metric tones, Eastern Europe with 2.19 million metric tones, USA with 1.64 million metric tones, China and Spain with 1.10 and 0.90 million metric tones, respectively and the total world production was 20.67 million metric tones (Zhera 2011). In 2013, world production of Sunflower was 44.5 million metric tones. Ukraine was ranked first with 11.0 million metric tones followed by Russia with 10.6 million metric tones. Argentina was third with 3.1 million metric tones followed by China and Romania with 2.4 and 2.1 million tones respectively (FAOSTAT, 2013). In Africa, Tanzania is the leading producer with annual grain production of 20,000 tones, and this is followed by Kenya and Zimbabwe (Zhera 2011). However, Adebayo *et al.,* (2012) mention that there was a clear upward trend in sunflower cultivation in Nigeria, there is no statistical data on its production tonnage up to present time in the country. Sunflower is an important oil crop in the world particularly because of its very low oil cholesterol. It is a new crop in the semi arid environment of Nigeria and suitable agronomic practices for its production, most importantly the nutrient requirements, in this environment is yet to be fully established. Farmers in this zone depend mostly on inorganic fertilizers to produce crops. The inorganic fertilizers are expensive, yet the little that is acquired is not used appropriately. Thus the present study will attempt to establish the most optimum (NPK) rate and suitable sowing date for the crop in order to step up its productivity in the semi arid environment.

MATERIALS AND METHODS

Description of the Experimental Site

The experiments were conducted during the wet seasons of 2018 and 2019 at the Teaching and Research Farm, Department of Agricultural Technology, Ramat Polytechnic Maiduguri (Longitude 13^o 12' 36.02" E and Latitude 11^o 48' 2.32" N and on an altitude of 354 m above sea level). Maiduguri is located in the Sudan savannah region of Borno state, under a semi arid environment characterized by sparse vegetation with an average annual rainfall of 650 mm, spanning 4 – 5 months (May - September). The average temperature is 28.5^{o}C with relatively low humidity during the dry season and high humidity during the wet season.

Experimental Material

Source of NPK

The fertilizers were purchased from Borno State Agricultural Development Program (BOSADP).

Source of sunflower seeds

The sun flower seeds were purchased from Sasakawa Global 2000, Kano, Kano State

Treatments and experimental design

The experiment consist of six rates of NPK; 0:0:0 kgNPK/ha, 25:12.5:7.5 kgNPK/ha, 50:25:15 kgNPK/ha, 75:37.5:22.5 kgNPK/ha, 100:50:30 kg NPK/ha and 125:62.5:37.5 kgNPK/ha and four sowing dates; 29th June, 9th July, 19th July and 29th July. The treatments were laid out in split plot design replicated three times. Sowing dates was allocated to the main plot and NPK rates to the sub plots. The experiment covered a total land area of 840 m^2 (56 m x 15 m). The sub plots sizes were 9 m^2 (3 m x 3 m), the main plots sizes were 168m^2 (56m x 3m), and the alleys between main plots and sub plots were 1m apart. The inter and intra row spacing was 75 cm x 25 cm, respectively and data were not collected on plant at outmost rows in the sub plots. Thus the net plot was 5.62m^2

Cultural Practices

Land preparation

The experimental site was cleared and harrowed. The land was then properly leveled and the beds marked out according to specification in 3.4.3 above. The edge of each of the bed was raised to prevent fertility drift.

Sowing and fertilizer application

The different NPK treatments as presented in 3.4.3 were obtained through the use of fertilizers presented in 3.4.1. Full dose of P and K were applied at time of planting and half dose of N was applied at time of planting and the remaining half at bud initiation stage.

Weed, pest and disease control

Weeding was done three times to control the weeds, these was manually done using hoe. Pest and diseases were monitored and controlled appropriately.

Collection of Data

Data for growth yield and quality parameters were measured and recorded as follows:

Plant height (cm)

Five plants were randomly selected from the net plots and tagged. The tagged plants were measured using meter rule from the ground level up to the apex at 4, 6, 8 and 10 WAS; Average plant height for each plot was recorded.

Number of leaves per plant

This was also taken from the five tagged plants in 3.6.2 above. Only green and photosynthetically active leaves were counted and this was done at 4 WAS and continued at 6, 8 and 10 WAS. The average for each plot was recorded.

Leave area per plant (cm^2)

Leave area was taken at 4, 6, 8 and 10 WAS from each plot (tagged plants). It was measured using grid method by taking ten leaves at random from the net plots and leaves were placed on a graph paper and traced using pencil. The number of full and half squares covered by each leave was counted and their average was evaluated as leaf area per plant (Pal and Murari, 1985).

Days to flowering

This was determined by regular field inspection and recording number of days taken from sowing to the attainment of first flowering in each plot.

Days to 50% flowering

This was obtained by daily field inspection and recording the total number of days taken for 50% plant population to attainment of flowering from the date of sowing.

1000-grain weight (g)

This was obtained at harvest by random selection of 1000 grains which was obtained from net plots and weighed on an electronic balance.

Grain yield per hectare (g)

The heads of all plants from net plots was collected, threshed and weighed after winnowing to obtain grain yield per net plot area and the value was converted to yield per hectare for each plot as follows:

$$\text{Grain yield ha}^{-1} = \frac{\text{Grain weight (t ha}^{-1})}{\text{Net plot area (m}^2)} \times 10{,}000 \text{ m}^2$$

Analysis for oil fatty acid contents (%)

The various fatty acid profiles (oleic, linoleic, palmetic and steric acids) of the oil will be analysed using oil and fats extraction by trans-esterification method as determined by Hamilton and Rosselle (1986).

Data Analysis

All data recorded was subjected to analysis of variance (ANOVA) using statistical package, "statistix" 8.0, and the difference between treatment means was identified using Duncan's multiple range test (DMRT) at 5% level of probability. (Duncan,1955)

Results and Discussions

Table 1: Effect of Sowing Dates and NPK Rates on Plant Height (cm) of Sunflower.

Sowing Dates (A)	4WAS	6WAS	8WAS	10WAS
29th June	15.15^{a}	39.32^{a}	110.18^{a}	160.79^{a}
9th July	14.66^{a}	36.57^{b}	98.62^{b}	146.66^{b}
19th July	13.71^{b}	30.50^{c}	88.54^{c}	138.57^{c}
29th July	13.56^{b}	30.96^{c}	88.72^{c}	127.31^{d}
SE ±	0.36	0.40	0.97	1.82
NPK Rate (B)				
0:0:0	9.26^{e}	19.46^{e}	47.40^{c}	85.53^{c}
25:12.5:7.5	11.80^{d}	27.80^{d}	67.74^{d}	110.12^{d}
75:37.5:22.5	15.08^{b}	37.02^{b}	110.30^{b}	150.75^{b}
100:50:30	17.59^{a}	45.93^{a}	132.04^{a}	192.79^{a}
125:62.5:37.5	18.15^{a}	46.88^{a}	134.04^{a}	196.25a
SE ±	0.33	0.55	1.75	3.77
Interaction				
A x B	**	**	**	**

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (p≤ 5%) according to Duncan Multiple Range Test

Table 2: Interaction Effect of Sowing Dates and NPK Rates on Plant Height (cm) of Sunflower.

Sowing Dates (A)		NPK Rates	4WAS	6WAS	8WAS	10WAS
29th June	X	0:0:0	11.17^{jl}	29.97^{g}	67.73^{i}	121.00^{ef}
29th June	X	25:12.5:7.5	13.33^{ht}	36.10^{a}	93.20^{fg}	143.83^{ed}
29th June	X	50:25:15	15.07^{fg}	38.60^{c}	104.00^{e}	130.43^{e}
29th June	X	75:37.5:22.5	16.50^{be}	44.40^{b}	123.43^{d}	179.03^{b}
29th June	X	100:50:30	19.37^{a}	54.30^{a}	152.90^{a}	244.80^{a}
29th June	X	125:62.5:37.5	20.77^{a}	56.03^{a}	154.5^{a}	248.07^{a}
9th July	X	0:0:0	7.90^{m}	11.20^{i}	22.97^{i}	25.27^{k}
9th July	X	25:12.5:7.5	9.00^{i}	14.97^{o}	34.87^{k}	41.24^{jo}
9th July	X	50:25:15	15.50^{eg}	38.90^{c}	107.07^{e}	132.00^{c}
9th July	X	75:37.5.22:5	16.10^{ef}	44.90^{b}	124.50^{d}	174.30^{b}
9th July	X	100:50.30:	17.63^{b}	45.73^{b}	147.20^{b}	237.50^{a}
9th July	X	125:62.5;37.5	19.30^{a}	43.167^{b}	149.43^{ab}	233.33^{a}
19th July	X	0:0:0	8.17^{a}	15.67^{hi}	33.37^{k}	75.93^{i}
19th July	X	25:12.5:7.5	10.73^{ki}	24.47^{g}	54.90^{i}	113.60^{fg}
19th July	X	50:25:15	11.77^{k}	17.67^{h}	55.33^{i}	65.60^{i}
19th July	X	75:35.5:22.5	13.20^{hi}	24.23^{g}	86.97^{gh}	96.67^{h}

19th July	X	100:50:30	7.33^{bd}	35.17^{c}	135.53^{c}	186.57^{b}
19th July	X	25:62.5:37.5	17.53^{bc}	44.97^{d}	137.37^{c}	188.63^{b}
29th June	X	0:0:0	9.83^{i}	25.03^{g}	65.53^{i}	119.93^{eg}
29th June	X	25:12.5:7.5	13.33^{hi}	35.67^{d}	88.20^{fgh}	141.80^{ed}
29th June	X	50:25:15	12.63^{ij}	28.60^{f}	83.67^{h}	131.93^{de}
29th June	X	75:38/5:22.5	14.53^{gh}	34.57^{d}	106.30^{e}	153.00^{c}
29th June	X	100:50:30	15.16^{eg}	30.60^{ef}	93.20^{fg}	105.57^{gh}
29th June	X	125:62.5:37.5	15.90^{df}	31.30^{e}	94.37^{f}	11.63^{fg}
SE ±			0.66	1.11	3.40	7.50

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (p≤ 5%) according to Duncan Multiple Range Test

Table 3: Effect of Sowing Dates and NPK Rates on Leaves Area of Sunflower.

Sowing Dates (A)	4WAS	6WAS	8WAS	10WAS
29th June	34.24^{a}	70.51^{a}	143.12^{a}	366.41^{a}
9th July	30.26^{b}	67.16^{b}	135.75^{a}	345.08^{b}
19th July	27.13^{c}	51.66^{c}	110.28^{c}	279.42^{c}
29th July	16.95^{d}	44.72^{d}	97.68^{d}	194.82^{d}
SE ±	4.30	0.69	0.50	4.45
NPK Rate (B)				
0:0:0	8.72^{c}	23.56^{c}	73.43^{c}	149.00^{c}
25:12.5:7.5	12.05^{c}	34.62^{d}	88.06^{d}	196.34^{d}
50:25:15	16.90^{c}	56.30^{c}	111.06^{c}	253.42^{c}
75:37.5:22.5	33.30^{b}	68.60^{b}	123.22^{b}	337.47^{b}
100:50:30	45.85^{a}	85.60^{a}	169.98^{a}	418.95^{a}
125:62.5:37.5	55.05^{a}	86.39^{a}	170.48^{a}	423.42^{a}
SE ±	4.89	1.21	1.39	4.88
Interaction				
A x B	**	**	**	**

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (p≤ 5%) according to Duncan Multiple Range Test

Table 4: Interaction Effect of Sowing Dats and NPK Rates on Leaves Area of Sunflower.

Sowing Dates (A)	NPK Rates	4WAS	6WAS	8WAS	10WAS
29th June X	0:0:0	12.07^{gf}	33.03^{g}	117.33^{j}	250.97^{i}
29th June X	25:12.5:7.5	15.47^{fg}	48.20^{h}	138.63^{h}	314.57^{gh}
29th June X	50:25:15	21.63^{fg}	78.43^{f}	136.30^{g}	370.07^{f}
29th June X	75:37.5:22.5	45.80^{bd}	90.40^{c}	171.27^{e}	512.50^{d}
29th June X	100:50:30	63.47^{ab}	102.80^{ab}	231.97^{ab}	671.50^{a}
29th June X	125:62.5:37.5	97.77^{a}	111.23^{a}	237.03^{a}	661.13^{a}
9th July X	0:0:0	7.47^{g}	11.07^{i}	14.80^{r}	14.27^{a}
9th July X	25:12.5:7.5	6.57^{g}	13.77^{i}	17.73^{r}	19.57^{n}

9th July X	50:25:15	22.33^{fg}	80.00^{ef}	164.67^{f}	400.13^{e}
9th July X	75:37.5.22:5	46.43^{bd}	92.20^{c}	178.43^{d}	539.37^{c}
9th July X	100:50.30:	62.60^{be}	100.97^{b}	211.57^{c}	605.50^{b}
9th July X	125:62.5;37.5	63.07^{bc}	105.00^{b}	227.30^{b}	619.13^{a}
19th July X	0:0:0	7.47^{g}	18.73^{k}	54.47^{o}	109.60^{i}
19th July X	25:12.5:7.5	11.57^{fg}	30.10^{j}	70.40^{n}	156.57^{k}
19th July X	50:25:15	7.67^{g}	18.73^{k}	28.53^{q}	32.73^{mn}
19th July X	75:35.5:22.5	42.33^{ce}	28.40^{j}	37.27^{f}	45.00^{m}
19th July X	100:50:30	43.53^{be}	100.97^{b}	136.37^{h}	304.40^{gh}
19th July X	25:62.5:37.5	11.67^{fg}	105.00^{b}	138.63^{h}	317.97^{g}
29th June X	0:0:0	10.90^{fg}	31.43^{g}	107.13^{k}	221.17^{j}
29th June X	25:12.5:7.5	14.60^{fg}	46.43^{h}	125.47^{i}	294.67^{h}
29th June X	50:25:15	16.00^{fg}	48.07^{B}	94.53^{i}	210.73^{h}
29th June X	75:38.5:22.5	29.33^{df}	63.40^{g}	103.93^{k}	253.00^{i}
29th June X	100:50:30	15.00^{fg}	38.00^{ii}	76.03^{m}	94.40^{i}
29th June X	125:62.5:37.5	15.87^{fg}	41.00^{i}	78.99^{m}	94.97^{i}
SE ±		9.7	2.42	2.78	9.76

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (p≤ 5%) according to Duncan Multiple Range Tes

Table 5: Effect of Sowing Dates and NPK Rates on Number of Leaves of Sunflower.

Sowing Dates (A)	4WAS	6WAS	8WAS	10WAS
29th June	5.85^{a}	8.90^{a}	15.55^{a}	21.95^{a}
9th July	5.42^{b}	8.51^{b}	14.32^{b}	20.49^{b}
19th July	5.37^{b}	8.42^{b}	14.68^{b}	19.19^{c}
29th July	5.17^{b}	8.09^{c}	13.97^{c}	18.96^{d}
SE ±	0.11	0.12	0.14	0.29
NPK Rate (B)				
0:0:0	2.91^{c}	5.12^{c}	9.30^{c}	13.98^{c}
25:12.5:7.5	$3.77d^{c}$	6.36^{d}	11.38^{d}	16.10^{d}
50:25:15	4.95^{c}	7.41^{c}	12.73^{c}	18.60^{c}
75:37.5:22.5	6.10^{b}	9.42^{b}	15.85^{b}	20.96^{b}
100:50:30	7.40^{a}	11.27^{a}	19.97^{a}	26.60^{a}
125:62.5:37.5	7.44^{a}	11.29^{a}	20.03^{a}	25.65^{a}
SE ±	0.14	0.19	0.21	0.27
Interaction				
A x B	**	**	**	**

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (p≤ 5%) according to Duncan Multiple Range Test

Table 6: Interaction Effect of Sowing Dates and NPK Rates on Number of Leaves of Sunflower.

Sowing Dates (A)		NPK Rates	4WAS	6WAS	8WAS	10WAS
29th June	X	0:0:0	3.47^{i}	6.07^{a}	10.00^{ij}	16.73^{hb}
29th June	X	25:12.5:7.5	40.40^{b}	6.97^{gh}	12.27^{g}	18.70^{h}
29th June	X	50:25:15	5.07^{fg}	7.87^{ef}	13.37^{cf}	21.00^{ag}
29th June	X	75:37.5:22.5	6.50^{a}	9.87^{cd}	17.37^{ef}	23.57^{d}
29th June	X	100:50:30	7.80^{a}	11.73^{a}	21.73^{a}	28.83^{a}
29th June	X	125:62.5:37.5	7.60^{a}	11.47^{d}	21.17^{d}	28.17^{ab}
9th July	X	0:0:0	2.40^{k}	4.23^{i}	8.23^{b}	9.67^{a}
9th July	X	25:12.5:7.5	3.17^{ij}	5.47^{k}	10.20^{a}	11.70^{ab}
9th July	X	50:25:15	5.20^{af}	7.93^{af}	14.73^{d}	22.00^{c}
9th July	X	75:37.5.22:5	6.70^{cd}	10.10^{c}	18.03^{c}	24.10^{d}
9th July	X	100:50.30:	7.63^{a}	11.63^{a}	21.43^{d}	26.07^{c}
9th July	X	125:62.5;37.5	7.47^{ab}	11.20^{ab}	19.57^{b}	27.33^{b}
19th July	X	0:0:0	2.60^{jk}	4.33^{i}	9.20^{i}	13.33^{i}
19th July	X	25:12.5:7.5	3.37^{i}	6.27^{jk}	11.20^{h}	13.37^{k}
19th July	X	50:25:15	4.53^{gh}	6.50^{hj}	11.16^{h}	13.03^{i}
19th July	X	75:35.5:22.5	5.47^{ef}	8.43^{e}	13.13^{g}	14.93^{k}
19th July	X	100:50:30	7.47^{ab}	11.17^{ab}	19.57^{b}	25.63^{c}
19th July	X	25:62.5:37.5	7.30^{ac}	11.30^{ab}	21.50^{c}	28.27^{ab}
29th June	X	0:0:0	3.20^{ij}	5.87^{k}	9.80^{ij}	16.20^{ij}
29th June	X	25:12.5:7.5	4.17^{h}	6.77^{gh}	11.87^{gh}	18.63^{h}
29th June	X	50:25:15	5.03^{fg}	7.37^{gh}	12.17	18.37^{h}
29th June	X	75:38/5:22.5	5.73^{e}	9.30^{d}	14.73^{d}	21.27^{ef}
29th June	X	100:50:30	6.87^{bd}	10.63^{dc}	17.37^{c}	19.97^{g}
29th June	X	125:62.5:37.5	7.27^{bc}	11.13^{ab}	17.30^{c}	20.73^{fg}
SE ±			0.28	0.39	0.43	0.55

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (p≤ 5%) according to Duncan Multiple Range Test

Results from this experiment revealed the effects of sowing dates and NPK rates on plant height, leave area and number of leaves of sunflower in Maiduguri. Planting on 29th June which represents earliest planting, gave significantly tallest plants, largest leave area and most number of leaves in Maiduguri. The least plant height, leave area and number of leaves was obtained from 29th July late planting (last planting) at the end of sampling period [10 weeks after sowing (WAS)]. The 100:50:30 and 125:62.5:37.5 KgNPK/ha produced the tallest plants, leave area and number of leaves than other NPK treatment rates and are not statistically different from each other in both years and combined mean at all stages of sampling. Thus the 100:50:30 KgNPK/ha. The least plant height, leave area and number of leaves was obtained at NPK rate of 0:0:0 KgNPK/ha by the end measurement period (10WAS). There was significant interaction between planting dates and NPK rates on plant height of sunflower. The earliest planting (29th June) in combination with 100:50:30 or 125:62.5:37.5 KgNPK/ha gave significantly taller plants, larger leave area and most number of leaves at all stages of sampling than the other treatment combinations. Baghdadi *et al*., (2014) and Ahmed *et al*., (2015), reported that vegetative parameters of sunflower increased with first sowings and higher ammonium nitrates and decreased when there was a delay in sowing date and decrease in inorganic fertilizer rates. Lawal *et al*., (2011) and Soleymani *et al*., (2013) also reported that maximum plant height, number of leaves per plant and leave area was obtained at early sowing supplied with higher inorganic nutrients supplied.

Table 7: Effect of Sowing Dates and Different in NPK Rates on Days to First Flowering and Days to 50% Flowering of Sunflower.

	Days to First Flowering	Days to 50% Flowering
Sowing Dates (A)		
29th June	51.61^{a}	58.48^{a}
9th July	48.33^{b}	54.59^{b}
19th July	45.88^{b}	50.33^{c}
29th July	45.11^{d}	50.33^{c}
SE ±	0.27	0.24
KgNPK HA (B)		
0:0:0	45.58^{E}	48.50^{c}
25:12.5:7.5	42.25^{d}	51.08^{d}
50:25:15	46.83^{c}	53.00^{c}
75:37.5:22.5	48.41^{d}	54.41^{b}
100:50:30	51.08^{a}	56.66^{a}
125:62.5:37.5	51.25^{a}	57.58^{a}
SE ±	0.21	0.27
Interaction		
A x B	**	**

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (p≤ 5%) according to Duncan Multiple Range Test

Table 8: Interaction Effect of Sowing Dates and NPK Rates on Days to First Flowering and Days to 50% Flowering of Sunflower.

			Days to First Flowering	Day to 50% Flowering
Sowing Dates (A)		NPK Rates		
29th June	X	0:0:0	49.66^{f}	57.66^{fg}
29th June	X	25:12.5:7.5	50.56^{h}	60.66^{e}
29th June	X	50:25:15	51.66^{g}	61.33^{e}
29th June	X	75:37.5:22.5	51.56^{fg}	63.33^{d}
29th June	X	100:50:30	57.00^{a}	65.00^{b}
29th June	X	125:62.5:37.5	57.00^{a}	66.33^{a}
9th July	X	0:0:0	42.66^{i}	48.33^{k}
9th July	X	25:12.5:7.5	45.33^{k}	58.33^{f}
9th July	X	50:25:15	53.33^{d}	60.00^{e}
9th July	X	75:37.5.22:5	55.00^{be}	63.00^{d}
9th July	X	100:50.30:	56.00^{ab}	63.6^{cd}
9th July	X	125:62.5;37.5	56.00^{b}	64.56^{bc}
19th July	X	0:0:0	36.00^{o}	34.66^{a}
19th July	X	25:12.5:7.5	37.33^{n}	34.33^{m}
19th July	X	50:25:15	45.00^{k}	46.00^{b}
19th July	X	75:35.5:22.5	46.00^{k}	47.33^{k}
19th July	X	100:50:30	52.00^{de}	56.66^{g}

19th July	X	25:62.5:37.5	54.00[d]	56.66[g]
29th June	X	0:0:0	33.56[e]	35.00[p]
29th June	X	25:12.5:7.5	35.33[o]	37.00[o]
29th June	X	50:25:15	47.33[j]	48.00[i]
29th June	X	75:38.5:22.5	48.33[i]	50.66[g]
29th June	X	100:50:30	49.66[gh]	58.33[i]
29th June	X	125:62.5:37.5	49.66[gh]	57.55[i]

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (p≤ 5%) according to Duncan Multiple Range Test

Table 9: Effect of Sowing Dates and Different in NPK Rates on 1000 Grain Weight (g) and Yield (kg/ha) of Sunflower.

	1000 grain weight(g)	Yield (kg/ha)	
Sowing Dates (A)			
29th June	64.73[a]	400.16[a]	
9th July	59.39[a]	386.55[b]	
19th July	53.83[c]	301.53[c]	
29th July	36.68[d]	231.24[d]	
SE ±	0.64	3.94	
KgNPK HA (B)			
0:0:0	21,51[e]	168.09[c]	
25:12.5:7.5	3187[d]	251.00[d]	
50:25:15	39.85[c]	291.61[b]	
75:37.5:22.5	62.19[b]	361.45[b]	
100:50:30	85.69[a]	456.94[a]	
125:62.5:37.5	86.84[a]	464.13[a]	
SE ±	0.71	6.53	
Interaction			
A x B	**	**	**

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (p≤ 5%) according to Duncan Multiple Range Test

The effects of sowing dates and NPK rates on days to first flowering and days to 50% flowering of sunflower shows that planting on 29th July, which is the last planting gave significantly earliest days to first flowering and days to 50% flowering. The longest days to first flowering and days to 50% flowering was obtained from 29th June early planting (first planting). The earliest days to first flowering and days to 50% flowering was obtained at NPK rate of 0:0:0 KgNPK/ha. The 100:50:30 and 125:62.5:37.5 KgNPK/ha took longer days to first flowering and days to 50% flowering than the other NPK treatment rates and are not statistically significant from each other. There was significant interaction between planting dates and NPK rates on days to first flowering and days to 50% flowering of sunflower. The last planting (29th July) in combination with 0:0:0 KgNPK/ha gave significantly shortest days to first flowering and days to first flowering.

Table 10: Interaction Effect of Sowing Dates and Different NPK Rates on 1000 Grain Weight and Yield of Sunflower

		1000 grain weight (g)	Yield ($KgHa^{1}$)
Sowing Dates (A)	NPK Rates		

29th June	X	0:0:0	25.27^{ho}	68.60^{no}
29th June	X	25:12.5:7.5	28.90^{m}	85.27^{n}
29th June	X	50:25:15	29.53^{m}	211.53^{i}
29th June	X	75:37.5:22.5	37.60^{k}	268.6^{k}
29th June	X	100:50:30	123.27^{a}	676.4^{a}
29th June	X	125:62.5:37.5	123.35^{a}	686.6^{a}
9th July	X	0:0:0	10.70^{g}	116.5^{n}
9th July	X	25:12.5:7.5	14.53^{g}	120.5^{m}
9th July	X	50:25:15	57.97^{i}	431.7^{f}
9th July	X	75:37.5.22:5	85.20^{f}	549.0^{d}
9th July	X	100:50.30:	104.4^{c}	603.9^{c}
9th July	X	125:62.5;37.5	107.5^{b}	624.5^{b}
19th July	X	0:0:0	35.07^{i}	277.7^{k}
19th July	X	25:12.5:7.5	47.83^{j}	385.7^{h}
19th July	X	50:25:15	48.00^{j}	397.5^{gh}
19th July	X	75:35.5:22.5	75.10^{g}	496.2^{c}
19th July	X	100:50:30	90.23^{e}	416.5^{g}
19th July	X	25:62.5:37.5	92.20^{d}	427.2^{f}
29th June	X	0:0:0	15.03^{q}	41.57^{p}
29th June	X	25:12.5:7.5	27.53^{mn}	56.6^{op}
29th June	X	50:25:15	18.90^{p}	141.5^{m}
29th June	X	75:38.5:22.5	84.23^{o}	206.6^{i}
29th June	X	100:50:30	34.57^{i}	315.2^{j}
29th June	X	125:62.5:37.5	64.23^{a}	355.0^{i}
SE ±			1.43	13.0

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (p≤ 5%) according to Duncan Multiple Range Test

Table 11: Effect of Sowing Dates and Different NPK Rates on Fatty Acids of Sunflower.

Sowing Dates (A)	Oleic (%)	Linoleic(%)	Palmitic (%)	Stearic (%)	Myristic(%)
29th June	0.058	0.63	8.87	7.32	0.07
9th July	0.061	0.62	8.02	6.68	0.06
19th July	0.038	0.59	6.46	5.03	0.04
29th July	0.025	0.44	5.95	4.80	0.03
SE ±					
KgNPK HA (B)					
0:0:0	0.023	0.40	5.54	4.81	0.03
25:12.5:7.5	0.027	0.47	5.93	4.09	0.04
50:25:15	0.039	0.51	6.22	5.22	0.05
75:37.5:22.5	0.048	0.56	7.60	5.97	0.05
100:50:30	0.061	0.64	8.81	6.99	0.07
125:62.5:37.5	0.060	0.62	8.78	7.01	0.06
SE ±	0.001	0.03	0.35	0.14	0.003
Interaction					
A x B	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (p≤ 5%) according to Duncan Multiple Range Test

The effects of sowing dates and NPK rates on 1000 grain weight, yield and oil quality of sunflower indicates that early planting on 29th June (first planting date) gave significantly the heaviest 1000 grain weight, highest yield and best oil quality than the other planting dates.

The least 1000 grain weight, yield and oil quality was obtained from 29th July late planting (last planting). The 100:50:30 and 125:62.5:37.5 KgNPK/ha significantly produced the greater 1000 grain weight, yield and oil quality than the other NPK rates and are not statistically different from each other. There was significant interaction between planting dates and NPK rates on 1000 grain weight, yield and oil quality of sunflower had no interaction because it was non significant statistically. The earliest planting (29th June) in combination with 100:50:30 or 125:62.5:37.5 KgNPK/ha gave significantly greater 1000 grain weight, yield and oil quality in both years and combined mean. The application of fertilizers consisting of nutrients like nitrogen, phosphorus and potassium can increase sunflower growth and yield (Sandras, 2006; Prasad, *et al,* 2002 and Kho, 2000); and N, P and K ratio in soil is an important indices in crop production, and balanced application of fertilizer therefore is important for optimum performance of sunflower. Quality characters like oil yield, protein, fatty acids and carbohydrate contents of sunflower grain are all influenced by NPK; inorganic fertilizer application (Abou-Bakr and Omar, 1996). Total protein, nitrogen and oil contents of sunflower grain have significantly increased with increased nitrogen and phosphorus interaction and farm yard manure (Singh *et al.,* 1996), Muhammad (2006) found higher percentage protein and oleic acid of sunflower grain with combined application of 50-75 kg N, P_2O_5/ha, respectively and 50 kg K_2O ha $^{-1}$.

Conclusion

Based on the results obtained in this study, it can be concluded that early planting of 29th June with supply of 100:50:30 KgNPK/ha is best for sunflower production in the study area.

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Economic Implications of Food Grain Losses on Farming Households in Developing Countries: A Review

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Abstract: *The study reviewed the analysis of economic implications of food grain losses on farming households in developing countries. The data for the study was obtained from secondary sources such as journals, conferences, dissertations and thesis. The review indicates that reduction in food loss will increase the amount of food availability for human consumption and enhance food security. Food loss is occurring at a time of increasing food prices and worsening food insecurity. The issue of food loss is of high importance in the effort to convert hunger, food insecurity, malnutrition and poverty. Food loss seduction complements efforts to improve food availability through improved farm level productivity, thus tending to benefits producers and more specifically the poor. Grain loss in sub-Saharan Africa was estimated to be 20% of the total production. The annual value of the loss was estimated at US $4billion.This amount exceeds the value of total food and sub-Saharan Africa received over the last decade, equates annual value of cereal imports of sub-Saharan Africa which had an annual range of US $3-7billlion over 2000-07 period and equivalent to annual calorie requirement of at least 48million people at 2,500 kilo calorie per person per day. Millions of tons of food grains end up in trash cans or spoil on the way to market and has induced poverty in farming households which creates unequal income distribution in the households.*

Keywords: *Economic, Implication, Food, Grain, Farming, Households, Developing, Countries*

INTRODUCTION

Food is any substance, whether processed, semi-processed or raw, which is intended for human consumption and includes drinks, chewing gum and any substance which has been used in the manufacture, preparation or treatment of "food" but does not include cosmetics or tobacco or substance used only as drugs. Food loss refers to edible parts of plants and animals that are produced or harvested for human consumption but not ultimately consumed by people. In particular, food loss refers to food that spills, spoils, incurs an abnormal reduction in quality such as bruising or wilting or gets lost before reaching the consumer. Food loss is the unintended result of an agricultural process or technical limitation in storage, infrastructure, packaging or marketing. Although food waste is a component of food loss, it is important to distinguish food waste from food lost. Food waste refers to the food that is of good quality and fit for human consumption but does not get consumed because it is discarded either before or after it spoils. Food waste is the result of negligence or conscious decision to throw food away (Lipinski *et al*., 2013). Lowering food loss is one of the potential measures for overcoming hunger (Morisaki, 2011).

The Food and Agriculture Organization of the United Nations (FAO) estimates that 32% of all food produced in the world was lost in 2009. In 2013 about 1.3 billion tons of food were globally lost. The estimate was based on weight, when converted into calories, global food loss amounted to approximately 24% of all food produced (FAO, 2013). Food loss has many negative economic implications. These include negative implications on rural income, food security and poverty among others. Grains are very important food staples in Sub-Saharan Africa where grain losses amount to about 20% of total production.

Current world population is expected to reach 10.5 billion by 2050 (UN, 2013). This development will further add to global food concerns. This increase will translate into 33% more human mouths to feed with the greatest demand growth in the poor communities of the world. Alexandratoz and Bruinsma (2012) reported that there is the need to increase food supplies by 60% (estimated at 2005 food production levels) in order to meet the food demand in 2050. Food availability and accessibility can be increased by increasing production, improving distribution and market infrastructure as well as reducing prices of inputs. Reducing household food losses is a critical component of ensuring future global food security. One percent reduction in annual losses could amount to about US $4billion, with producers as key beneficiaries (Segre *et al.,* 2014). Viewed from a different perspective, the annual value of the loss (estimated at US $4billion): Reduction or elimination of these losses will increase the amounts of food available for human consumption and enhance food security (Gustavasson et al., 2011).

Food and Agriculture Organization of the United Nations, FAO (2011) reported that food loss is occurring at a time of increasing food prices and worsening food insecurity. The issue of food loss is of high importance in the effort to combat hunger, food insecurity, malnutrition and poverty. Food loss reduction complements efforts to enhance food security through improved farm level productivity, thus tending to benefit producers and more specifically the poor. Grain food loss in sub-Saharan Africa which amounts to 20% of total production. The annual value of the loss (estimated at US $4billion):

- exceeds the value of total food aid Sub-Saharan Africa (SSA) received over the last decade,
- equates the annual value of cereal imports of Sub-Saharan Africa (SSA) which had an annual range of between US $3-7 billion over 2000-07 period.
- equivalent to the annual calorie requirement of at least 48 million people (at 2,500 kcal per person per day) (Segre, *et al*., 2014). This implies reduction in foreign exchange spending, thus, improving the economy and per capita income.
- Millions of tons of food grains end up in trash cans or spoil on the way to market and has induced poverty in farming households.
- Creates unequal income distribution in the households.

The food problem may become more serious in the coming years if the food supply does not meet the rate of population growth. However, an efficient household food conservation will help to bridge the food deficit gap. This is particularly important with regard to food grains which are important food staples in many developing countries. Therefore, there is the need to review food grain losses to establish its economic implications. This review will therefore cover concept of food losses, food losses among farming households, economic implications of food losses, grain storage technologies and factors responsible for food losses.

Concept of food losses

Food loss refers to a decrease in quantity or quality of food. Food loss in the production and distribution segments of the food supply chain is mainly caused by the functioning of the food production and supply system or its institutional and legal frame work. An important part of food loss is called food waste, which refers to the removal of food which is fit for consumption or which has spoiled or expired from the food supply chain. Food wastage is mainly caused by economic behaviour, poor stock management or neglect (FAO, 2014).

In recent years the topic of Food Loss and Waste (FLW) has been gaining importance, both in the public and private sectors of the global food systems. Many initiatives are being undertaken world-wide to reduce food loss and waste (FLW). Many definitions and terminologies are being used by various actors and stakeholders in the global food systems. Therefore, FAO's Global Initiative on Food Loss and Waste Reduction' has taken a coordinating role, to enhance information exchange, collaboration, synergy and harmonization of strategies and methodologies. In this respect, it is important to agree on, and accept, a common definition of food loss and waste. It will provide an opportunity for achieving a globally harmonized approach to improving data collection, data comparability, and evidence-based regulatory and policy decisions for food loss prevention and reduction (FAO, 2014).

Food loss has an impact on food security, on local and national economies, on the natural resource base, as well as on waste streams and the environment. One thing became very apparent in the process: a definition on FLW is not a mathematical or physical law. It has many different logics which are equally good, and therefore it is just a matter of choice on what to accept as the definition. FAO offers this definition as a global reference for any stakeholder dealing with FLW, and to use it within the context of their operations.

Essential terms and concepts in this definition are:

- Food is any substance intended for human consumption.
- Food waste is a part of food loss, however not sharply distinguished; the term “food loss and waste” is nevertheless maintained in regular communication.
- ‘Intended for human consumption’ (already embedded in the Codex definition of ‘Food’).
- Plants and animals produced for food contain ‘non-food parts’ which are not included in FLW.
- Food redirected to non-food chains (including animal feed) is food loss or waste.
- Quantitative FLW = the mass (kg) reduction.

- Qualitative FLW = reduction of nutritional value, economic value, food safety and/or consumer appreciation (FAO, 2014).

It has to be noted that the supplementary notes are an integral part of the definition and are as important as the actual definition points.

- Food loss (FL) in the production and distribution segments of the Food Supply Chain (FSC) is mainly caused by the functioning of the food production and supply system or its institutional and legal framework.
- An important part of food loss is called food waste (FW), which refers to the removal from the FSC of food which is fit for consumption, or which has spoiled or expired, mainly caused by economic behaviour, poor stock management or neglect.
- Food waste is not sharply defined. However, it is still recognized as a distinct part of food loss, because the underlying reasons, economic framework and motivation of the FSC actors for wasting food are very different from the unintended food loss, and subsequently the strategies on how to reduce food waste are conceived in a different, targeted manner. Although the term ‘food loss’ encompasses “food waste”, the term ‘food loss and waste’ (FLW) will continue to be used to emphasize the importance and uniqueness of the waste part of food loss.
- Quantitative food loss can also be referred to as physical food loss. It does not include the reduction of mass resulting from food processing operations such as drying, heating, ripening, and fermentation. It does however include the removal of food for cosmetic or other market reasons by food processing operations such as grading and sorting.
- The decrease of quality attributes results in the reduction of nutritional value, economic value, food safety and/or consumers’ appreciation:
  - Economic value refers to the price that any supplier in the FSC receives from its buyer, in a way that it affects the revenue of the supplier.
  - Food safety refers to the absence, or presence in acceptable levels, of microbiological, chemical or physical hazards in food to prevent risks to the health of the final consumer.
  - Consumers’ appreciation refers to the perception of the food by the consumer, with regard to sensorial attributes such as appearance, texture, smell, taste.
- Consumption’ refers to the ingestion of food by the final consumer.
- ‘Intended’ refers to the original purpose for the product in the food supply chain, even if certain actors in the FSC may intentionally discard a wholesome part of the product or divert it to a non-food supply chain. Example: the whole potato is food, even if a french-fry manufacturer disposes of a fraction when slicing the product into uniform sizes.

If at the early stages of the supply chain it is not determined, or not yet known, whether a product will be destined for food or not, absolute food losses can be assessed from percentage losses and statistical information on the fraction of that product which in a specific region and year finally enters a human food market.

- Whether plants, animals and their parts or products are intended for food depends on the FSC, the food system, and its geographical and cultural context.

- Fish discards are the portion of total catch which is thrown away or slipped. It comprises the following components:
  - Species which are intended to be caught, but get spoilt and rendered unfit for consumption by the act of catching; these discards are food loss.
  - Species which are intended to be caught, but do not meet the regulatory or quality standards, such as size; these discards are food loss.
  - Species which are not intended to be caught, but which are fit for entering the FSC; these discards are food loss.
  - Species which are not intended to be caught, and which are not considered food; these discards are not food loss. Fish includes fish, shellfish and cephalopods.
- Non-food parts of FPA are parts which are inedible, or could be edible but in the specific FSC are not destined to be consumed.
  - The FSC starts from the moment that:
  - crops are harvest-mature or suitable for their purpose;
  - animals are ready for slaughter;
  - milk has been drawn from the udder;
  - eggs are laid by the bird;
  - aquaculture fish is mature in the pond;
  - wild fish have been caught by the fishing gear.

The end point of the food supply chain is defined by when food is a) consumed; or b) removed from the food supply chain.

Food losses among farming households

Food loss can be qualitative and quantitative loss along the supply chain starting at the time of the harvest till its consumption or other end uses (Hodges *et al.,* 2011). Food loss is the inadvertent loss in food quality because of infrastructure and management limitations of a given food value chain. Food loss can either be the result of a direct quantitative loss or arise indirectly due to qualitative loss. Food loss can be quantitative as measured by decreased weight or volume or can be qualitative such as reduction in nutrient value and unwanted changes to taste, colour, texture or cosmetic features of food (Buzby and Hyman, 2012).

Quantitative loss can also occur as a result of drying (a necessary post-harvest process for all grains) (FAO, 2012). Although this process involves considerable reduction in weight, there is no loss of food value and therefore, should not be counted as loss.

The qualitative loss can occur due to incidence of insect pest, mites, rodents and birds or from handling, physical or chemical changes in fat, carbohydrates and protein and by contamination of mycotoxins, pesticides residues, insect fragments, or excreta of rodents and birds and their dead bodies. When this qualitative deterioration makes food unfit for human consumption and is rejected, this contributes to food loss.

- Food loss can occur upstream of the food chain, mainly during sowing, cultivation, collection, treatment and conservation. There are four major sources of loss:
- Food loss occur at the level of production and harvest due to bad weather, diseases or infestations, defect in the system of cultivation and defect in transportation system.
- It can occur during processing of the products.

- It can also take place during the wholesale distribution, where food remain unsold, because it does not correspond to the aesthetic and quality of buyers.
- At last, food loss occurs at the catering and domestic consumption. They create food waste before the expiry date and difficult to interpret the label and the information relating to the consumption.

Begum *et al*. (2012) in their post-harvest study in Northern Region of Bangladesh, reported that post-harvest grain losses were estimated at household level in two major food grains, viz; rice and wheat in Rangpur and Dinazpur districts of Bangladesh. The result of the study revealed that household grain losses were high due to late harvesting of the crops (1.95kg/quintal in wheat). The household size and food losses of the farmers in both districts had negative and significance relationships in their probability of food security which implies that the household are food secured in both areas.

Basappa *et al.* (2007) reported that post-harvest losses of rice and wheat in India at different stages of post-harvest operations and the household post-harvest losses were estimated. Descriptive analysis was used to estimate the postharvest household food losses. The result of the study indicated that 3.82kg/quintal of rice and 3.28kg/quintal of wheat were lost. The losses have been highest during storage in both crops. Bala *et al.,* (2010) observed that the postharvest losses of grains at farm level for rice in Bangladesh were 9.16 percent, 10.10 percent and 10.17 percent for Aman, Boro and Aus respectively. The study further revealed that household losses were 33.92 to 40.99 percent of total losses at farm level. The storage loss of rice was 3.45-4.14 percent and it is followed by drying (2.19-2.37 percent), harvesting (1.60-1.19 percent) and threshing (1.10-1.79 percent). The estimated total losses of rice during household processing in Bangladesh were 1.30 percent, and 1.13 percent for Aman, Boro and Aus respectively.

Food loss is problematic for a number of reasons, including the loss of potentially valuable food source or resource for use in other processes (e.g. energy generation or composition). Nohman et al. (2012) reported that 1.4 million tons of food is wasted by South African Household each year. This equates to 15 percent of the total household waste generated. The cost of total household food loss and disposal was R 21.7 billion per annum. This equates to 0.8 percent of GDP or 10 percent of annual sales by food retailers in South Africa.

FAO (2012) estimated that approximately 1.3 billion tons of food were lost or wasted globally in 2007 which was equivalent to approximately one-third of the food produced for household consumption at that time. The result of the study further revealed that food losses and waste not only deprived the poor from accessing food but also caused significant depletion of households on resources such as land, water and fossil fuel, and increase the greenhouse gas emissions show quantitatively that reduction in household food losses in developed regions will decrease the number of undernourished people in rural areas by up to 63 million leading to decrease in the harvested area, water utilization and greenhouse gas emissions associated with food production efforts to feed households.

It was observed that close to one third of the edible food produced for household consumption was lost or wasted globally, equivalent to 1.3 billion tons per year (Rutten 2013). This study disclosed that the amount of household food losses and waste were estimated to be around 30 percent for cereals, 40 to 50 percent for root crop, fruits and vegetables, 20 percent for oil seeds, meat and dairy and 30 percent for fish. Food losses and waste in industrials and developing countries were roughly the same in terms of quantity (670 and 630 million tons respectively) but greatly vary in terms of value (US $680 and US 310 billion respectively).

Lipinski *et al*. (2013) observed that if the current rate of food loss were cut by half from 24 percent to 12 percent by the year 2050, the world would need about 1.314 trillion Kilocalories (Kcal) less food per year. The savings of 1.314 trillion kcal is roughly 22 percent of the 6,000 trillion Kcal per year between food available today and that needed in 2050.Access to household food storage remains one of the most problematic issues throughout the post-harvest chain, because devastating pests such as the Large Grain Borer (LGB) can cause up to 30 percent Dry Weight Losses (DWL) in six month of household grain storage (Boxall, 2002 and Golab, 2002). In Benin, major threat to household food security is post-harvest food losses. Household losses was estimated to be 15 to 30 percent depending on the region (ADA, 2010). The drier Sudan Savanna in the North records 2.5 percent while in the Guinea savanna average household food losses reached 10 percent (Ada et al., 2002). In contrast, higher average losses were observed over a cropping year in the more humid southern Benin where high insect pressure existed due to favourable environmental conditions of high air moisture and temperature. Household food losses in the south reached 20 to 50 percent after six month of household food storage with traditional structures (Maboudou *et al*. 2004).

Economic implication of food losses

Current world population is expected to reach 10.5 billion by 2050 (UN 2013). This increase translates into 33% more human mouths to feed with the greatest demand growth in the poor communities of the world. Alexanda and Briunsma (2012), food supply would need to increase by 60% (estimated at 2005 food production levels) in order to meet the food demand in 2050. Food availability and accessibility can be increased by increasing production, improving distribution and reducing losses. Thus, reduction of food losses is a critical component of ensuring future global food security.

Food and Agriculture Organization of the United Nations predicts that about 1.3 billion tons of foods are globally lost per year (Gustavasson *et al.,* 2011). Reduction in these losses will increase the amount of food available for human consumption and enhance global food security. A reduction in food loss improves food security by increasing the real income for all the consumers (World Bank, 2011). In addition, crop production contributes significant proportion of typical incomes in certain regions of the world (70% in Sub-Saharan Africa) and reducing food loss can directly increase the real incomes of the producers (World Bank, 2011).

Reducing food losses could potentially prevent global poverty. Basavaraja *et al.,* (2007) reported that total food loss is 1.3 billion tons of food per year, and this amount results in 3.3 billion tons of greenhouse gasses entering the atmosphere. This amount of food loss cost the World $750 billion dollars annually. The United States of America losses $161 billion a year, while it is estimated that $265 billion per year is enough to put an end to poverty and hunger by 2030 all over the world. Food loss reduction improves the economy and reduces poverty in individuals, households and the nation at large and the result is a positive impact

(Basavaraja et al., 2007). Poverty and food security are intricately interlinked. Without an income or resources to grow food and prevent its losses people are likely to become ill and unable to work to produce food or earn an income.

The magnitude and pattern of food losses vary across countries based on their stage of economic development. In high and middle income countries, significant losses occur in the early stages of food supply chain. Field losses at early stages may reflect economic decisions by the farmer to forgo harvesting due to market conditions or grading perfections demanded by the consumers. Minor losses occur at the other stages of the supply chain (Hodges *et al.,*2011). Food losses in the developed countries is generally low in the middle stages of the food supply chain. This can be attributed to more efficient farming systems, better transport, better management, storage and processing facilities which ensure that a larger proportion of harvested output is delivered to the market. The extensive and effective cold chain systems prevalent in these countries also help to prolong the shelf-life of food products (Hodges *et al*., 2011).

In contrast, food losses in the low income countries mainly occur in the early and middle stages of the food supply chains with proportionately less amount at the consumer level. Food losses in these countries are the results of in advertent losses due to poor state of the supply chains. Premature harvesting, poor storage facilities, lack of infrastructure, lack of processing facilities and inadequate market facilities are the main reasons for high food losses along the entire food supply chain. Food loss among different countries, or groups can be attributed to the changing food demand patterns at different income levels. Increase in per capita income levels of households across the world are contributing to major changes in food demand patterns (Regimi *et al.*, 2001). As consumers become wealthier, they tend to demand special quality attributes in the food they consume. In responds to these demands, food suppliers have implemented stringent quality standard and certification programs. Products unable to satisfy these standards even if nutritious and safe for human consumption become discarded-contributing to food losses. Furthermore, as food comprises a small share of the budget for consumers in developed countries do not have strong incentive to avoid wasting food. In contrast, as food is a large share of the household budget for consumers in low income countries, purchase behaviors tend to be more frugal, contributing to less food loss (Regimi *et al.,* 2011).

With significant food grain loss across all food grains, per capita food loss in Europe and North America was reported to be high at about 95-115kg/year, where as in sub-Saharan and South East Asia is much lower at about 6- 11kg/year (Jaspreet and Regimi 2013). It is estimated at about 1.6 million tons of food grains are lost in the United Kingdom because they do not meet the retailer standards (Jaspreet and Regimi 2013). In addition, UK households estimated to loss another 6.7 million tons of food grains each year. Similarly, food losses are high in other developed countries with estimate indicating that about 30 percent of all food produced in the United States is lost (Buzby and Hyman 2012). Although food waste accounts for a very small portion of the total loss, food loss is significant in the developing countries. Total food loss in the Sub-Saharan Africa are estimated to worth $4 billion per year, an amount which can feed 48 million people (FAO, 2013). Losses on cereals are estimated to be as high an account for about 25% of the total crop harvested, (Voices Newsletter, 2006).

Millions of tons of food end up in trash cans or spoil on the way to market. This must be avoided so as to end poverty. Poverty is the principal cause of hunger. The causes of poverty include lack of resources, and extremely unequal income distribution in the households and within specific country. World Hunger News (2017) revealed that 233 million people in sub-Saharan Africa were hungry in 2014-2016 (its most recent estimate), 795 million people were hungry worldwide. Sub-Saharan Africa was the area with second largest number of hungry people as Asia had 512 million, principally due to the much larger population of Asia when compared to sub-Saharan Africa. There has been the least progress towards reducing hunger in sub-Saharan region, where more than one in four remain poor and undernourished. The highest prevalence of poverty varies among regions of the world. In 2012, 501 million people or 47 percent of the world's population are poor. The principal factor in causing widespread hunger is poverty, (WHES,2015).

International Food Policy Research Institute (2015) estimates the economics of food grain losses in Malawi. It was estimated that 12 percent of maize produced each year was lost due to flooding in the southern region. Average crop loss due to droughts are 28 percent for small and medium scale farmers compared to 1.3 percent for large scale farmers. Out of 12.1 million Malawians, 52.4 percent or 6.3 million people are considered poor. Drought cause poverty increases directly through its impact on household incomes and indirectly through its consumer prices. At the national level drought causes 0.7 percent increase in poverty rate. This rises to as much as 16.9 percent during a severe drought (IFPRI, 2014). On the average, poverty is 1.3 percent higher due to drought affecting 154,000 people.

Poverty rates are twice as high in rural than in urban areas. Given the importance of agriculture in rural economy, it is not surprising that the rural poor are found to be more sensitive to food loss. Small and medium scale farming households are particularly vulnerable.

Factors Responsible for Household Food Losses

Zakari *et al.* (2014) observed in a study on factors influencing household food losses in southern Niger, that drought, high food prices, poverty, soil infertility, diseases and insect attacks were the main causes of household food losses. Morisaki (2011) in his study pattern of food losses in households in Japan reported that Japanese households generated approximately 11 million tons of edible as food loss. Food loss happens in both developed and developing countries despite food shortage in the later. He opined that educational attainment does not affect food waste behavior. Seventy-five percent of the respondent's impulse buying, while housewives' who were working or employed as well as others who were impulse buyers tended to waste more food. Households in the study area generate about 115g per person a day of food wastes higher than japans national average. Morisaki (2011) further disclosed that the total amount of food waste was 19 million tons and the food loss is estimated at 5-9 million tons which is 30 percent to 50 percent of the total food waste. This amount of loss is more than what is required to feed the worlds hungry which is about 7.5 million tons. In 2005 alone, households in Japan produced almost 11,000,000 tons of food waste and among them the food loss was about 2,000,000 – 4,000,000 tons. The portion of the household food loss was 40 percent of the whole food loss when both industrial and household food waste are considered.

Samuel *et al.* (2011) observed in a study post-harvest food losses reduction in maize production in Nigeria that the field where the crop was grown among others were identified as sources of insect infestation of the stored maize grains. This resulted in poor quality and loss of market grains. In a similar study on post-harvest losses of maize in Akure North Local Government area of Ondo state, Nigeria Folayan (2013) observed that major factors affecting household's food losses in the study area were inadequate finance, insect pest attack, high cost of transportation and price instability among others.

Banwat *et al.* (2012) in their study on factors affecting household food loss in rural community in north central Nigeria, the result showed that 66.2% of the household grew most of their consumed food on their farm land, 43.8% of the households spent between 25-50% of their monthly income on feeding their household members. Majority of the households (72.9%) dry and bag their farm produce after harvest.

Traditional household food storage technologies remain the prevailing storage methods in many rural communities in Nigeria. These technologies vary in shape and structure, and from one place to another depending on the agroclimatic conditions, ethnic and some socioeconomic factors (Adegbola, 2007). Wooden granaries are found in southern Nigeria and they are categorized into two types called the Ago and the Ava. The conical roofing of Ago is made up of straws and the body is made up of palm tree branches, while the Ava granaries have only a clinical body and straw roofing (Adegbola, 2007).

Adegbola (2010) observed that farmers used several traditional methods to preserve grains from insect attacks. These methods included exposition of maize cobs to the sun and use of products such as ash and leaves and placing of maize cobs over the fire place, where the smoke will dry the cobs and repell insects. Beside, some households spray pesticides on stored grains.

Kadjo *et al.* (2013) reported that several projects and technologies were designed to reduce food losses among which are the Danish project called programme of Appui au Development du sectuer Agricole (PADSA). These projects disseminated projection measures such as chemical and integrated control methods of pest. The introduction of the improved storage structures had brought about significant reduction in household food losses to 5 percent and 1 percent respectively for improved wooden and hay made granaries.

Maboudou *et al.* (2004) in a post-harvest study in Benin, Nigeria opined that quality of the road, access to rural areas throughout the year and membership of association are some of the factors responsible for grain losses. Likewise, membership of an association may ease the transfer of information about household grain handling innovations and play a vital role in social safety for food security.

Adegbola (2010) also reported that storage protectant is presumed endogenous because studies and field observations revealed that many farmers face severe access constraints in obtaining improved technologies. He pointed out that protectant access constrained the adoption of new technology of grain handling practice. The most recommended chemical in protecting grains at household level is sofragrain, but in practice many farmers have access to farm pesticides and other uncertified chemicals to preserve grains at household levels which could endanger the health and lives of consumers.

Kadjo *et al*. (2013) observed that nearly 10 percent of the chemicals used were cotton pesticide applied on maize and there is statistical significance difference depending on the region and the type of grains handling technology used. Farmers who used chemicals have a lower expected losses ratio (P value 5%). In the south, the mean expected losses was close to 11 percent and can reach more than 50 percent.

Household food losses depend on farmer's storage technology. The rate of household food losses were eight percent on the average and approximates 11.5 percent in the southern part of Benin. Food losses increases from the south to the north. Farmers who apply chemical report a lower average rate of loss (around 6 percent) than the other farmers (8.5%). This difference was statistically significant at less than 1 percent (P value and T test) (Kadjo, *et al.* 2013).

Fulgie (2014) reported that only one variable among the household grain storage technology covariates is highly significant. The coefficient for plastic bags was negative and significant at P value less than 5 percent. Farmers who used polypropylene bags preserved less grain as they are used for multi-purpose such as transporting grain to market rather than storing for later use in household during the year. Chemicals used on the grains have the expected positive sign on food losses and the result are marginally significant (P values less than 13 percent). The Coefficient indicates that farmers who use storage protectant increase quality of maize preserved by nearly 196 Kilograms on average. The average amount kept at household by a respondent is about 2000 kilograms. The use of chemicals will therefore increase quantity kept by about 10 percent.

Barago (2013) observed in his study on factors affecting household food security in Miwara region of Tanzania, that 56.8 percent of all food was sold immediately after harvest. The study revealed that 75 percent of household storage structure were kitchen ceiling and 24.2 percent polythene bags. About 79.1 percent did not treat food before storage. About 33.5 percent of all food stored was destroyed during storage. About 61.5 percent of the households lost between 100-200kg, 27.2 percent lost between 2 01-400kg, 5.2 percent lost between 401-600kg while 6.1 percent lost more than 601kg. The study concluded that poor farming technology, excessive selling and poor storage facilities contributed to the household food losses in the study area. In their study reasons for household food waste, observed that packaging affects food waste in households. The study examined reasons of food waste in households and to what extend packaging influenced the amount of food waste. The result of the study revealed that about 20-25 percent of household food waste could be attributed to packaging. Three packaging dominate the packaging related waste; Packages that the consumer noted as being too long; packages that were difficult to empty and wastage because of passed "best before date" (Williams *et al.* 2012).

CONCLUSION

This Paper reviewed literature on economic implication of food grain losses on farming households in developing countries. Reduction in these losses will increase the amount of food availability for human consumption and enhance food security. This paper has highlighted the importance of reducing postharvest food losses as a necessary step in ensuring future global food security in a sustainable manner. Given the challenges posted by climate change and limited use of land and water resources, attention needs to be given to measures to reduce losses along the farm to consumer chain. Reduced losses not only reflect an increase in food available for human consumption but they also reflect more judicious use of our limited natural resources. This implies reduction in foreign exchange spending, thus, improving the economy and per capita income. The annual value of food loss (estimated at US $4billion) exceeds the value of total food aid Sub-Saharan Africa (SSA) received from 2000-2007 (estimated at US $3-7billion), equivalent to annual value of cereal imports in Sub-Sharan Africa. It also equates to caloric requirement of 48million people at 2500 Kcal per person per day.

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System Productivity of Sesame Varieties and Seed Rates Intercropping With Millet in the Nigerian Savanna

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Abstract: Field experiment was conducted at the Lake Chad Research Institute, research station Maiduguri (Lat: 11^0 $50^{'}$ N; Long: 13^0 $10^{'}$ E) and Biu (Lat: 10^0 $36^{'}$ N; Long: 12^0 $11^{'}$ E) during 2011 cropping season. The aim was to identify the best sesame variety, optimum sesame seed rate and best system productivity of the crop mixture for the diverse Sudan and Northern Guinea savannah agro-ecologies of Nigeria. Treatments comprised of four sesame varieties (NCRIben 02M, Kenana-4, Ex-Sudan and Gwoza local) at five seed rates (2.0, 3.0, 4.0, 5.0 and 6.0 kg/ha). These were factorially combined and laid out in a Randomized Complete Block Design with three replications. Results showed significant ($P<0.05$) difference among the four intercropped sesame varieties for most of the assessed parameters, in which Ex-Sudan, followed by NCRIben 02M significantly out-yielded the local cultivar, Gwoza local at both locations. The local cultivar took significantly longer days to flower and mature. The highest system productivity for Maiduguri and Biu were obtained when millet was intercropped with Kenana-4 (1.28) at 4.0 kg/ha seed rate and NCRIben 02M (1.29) at 5.0 kg/ha, respectively. However, Ex-Sudan intercrop consistently gave competitive yield advantage (1.26) at 4.0 and 5.0 kg/ha sesame seed rate for Maiduguri and Biu, respectively. In conclusion, millet intercrop with Ex-Sudan is recommended for the broad Sudan and Northern Guinea Savannah belt, at 4.0 and 5.0 kg/ha sesame seed rate, respectively. Sesame Varieties Kenana-4 and NCRIben 02M are recommended for intercropping with millet at seed rates of 4.0 and 5.0 kg/ha specifically for Sudan and Northern Guinea Savannah, respectively.

Keywords: *Millet, Sesame, Seed Rate, Intercropping. Savannah*

1.0 Introduction

System productivity of millet-sesame intercrop could be enhanced by appropriate choice of variety and optimum seed rate. Cereal-legume mixtures have been a traditional practice in the Nigerian Savannah, which serves the crop diversity need of the farmers and insurance against total crop failure (Mortimore *et al*. 1997; Shinggu *et al.* 2009; Shamili *et al.* 2021; Deborah *et al.* 2022). Intercropping is an agricultural intensification strategy proposed to increase food production while addressing some environmental issues (Midmore, 1993). Intercropping systems produce as much as 15–20% of the world's food supply and can increase food security while reducing risk (Javaid *et al.* 2015 and Sagar *et al.* 2020).Thus, adoption of proper intercropping system could play a vital role in increasing the productivity of the associated component crops. The choice of component crop, crop density as well as spatial arrangement, determine the efficiency of land use in an intercropping system (Rowe *et al.* 2005; Zhang *et al.* 2007;Delaquis *et al.* 2018).Past research efforts had been mostly devoted to the major legumes, groundnut and cowpea, with little or no attention to minor legumes like sesame, especially in culture with millet (Emechebe, 1998 and Nweke, 2018). Sesame is gaining significance in Nigerian agriculture because of its importance as cash crop in the world market. It is an important cash and food crop that is widely cultivated in at least thirteen states of northern Nigeria. There are indications that sesame yield can be enhanced by variety selection, optimum seed rate, under appropriate cropping system (Ali and Omojor, 1998, Kālu and Adeyemo (2009). Although, sesame yields higher when grown under sole crop, higher system productivity (LER) had been reported in mixture (Ali, 1998; JARDA, 1998; Iwo and Idowu, 2002; Sharmili and Parasuraman, 2018; Ajiboola and Kolawale. 2019). More so, the continued cultivation of local cultivars of sesame by farmers, which are low-yielding (400 - 530 kg/ha), and sthe wide range of seed rate used by farmers from as low as 1 - 2 kg/ha and as high as 17 kg/ha seed (Voh, 1998; Katanga and Buba. 2014; Lakew *et al.* 2018) suggest the need for further research. Improved sesame varieties with advantages over farmers' local in terms of higher yield, early maturity, white-brown seed colour and good plant growth characteristics are now available (NCRI, 2009). Thus, there is need to develop an appropriate sesame-millet intercropping system and optimum seed rate that would be most adaptable to intercropping conditions. The objectives of the present study are to identify the variety that does best in the intercrop and determine the optimum seed rate of sesame for intercrop with millet.

2.0 Materials and methods

The field trial was conducted during the 2011 rainy season at Maiduguri (Lat: 11^0 $50^{'}$ N; Long: 13^0 $10^{'}$ E) and Biu (Lat: 10^0 $36^{'}$ N; Long: 12^0 $11^{'}$ E) in Sudan and northern Guinea Savannah agro-ecological zones of Nigeria, respectively. Soils, rainfall and temperature were the major discriminating factors among the locations. Soil types of the two respective locations are sandy loam and clay loam, and meteorological information indicate that total annual rainfall for the year at Maiduguri and Biu were 330.6 mm and 812.4 mm, while rainfall received during the trial period were 266.1 mm and 587.2 mm, respectively. Mean annual temperature at the Maiduguri and Biu locations were 30.0±1.10 ^{0}C and 27.5±0.46 ^{0}C, with recorded effective temperature during the growth period of 29.8±0.84 ^{0}C and 27.9±0.58 ^{0}C, respectively.

2.1 Experimental Site Description

The experiment was laid out in randomized complete block designed (RCBD) replicated three times. Four sesame varieties NCRIben 02M, Kenana 4, Ex-Sudan and Gwoza local and five seed rates 2.0, 3.0, 4.0, 5.0 and 6.0 kg/ha), four sole of sesame and a sole of millet (SOSAT C-88) were obtained by factorial combination Plot size of 6.0 m x 6.0 m (36.0 m^2), in which each plot comprised of eight rows spaced at 0.75 m apart; while the net plot had four rows of 6.0 m x 3.0 m (18.0 m^2).

The site was prepared with a tractor-driven harrow; both seeds of sesame and pearl millet were separately dressed with Apron Star 42 WS at rate of one sachet (10 g) to 3 kg of seeds. Both pearl millet and sesame were simultaneously sown on flat on 15^{th} and 22^{nd} July, 2011 at Maiduguri and Biu at 2: 1 respectively. The pearl millet component received 30 kg N, 30 kg 205 and 30kg K_20 ha^{-1} two weeks after sowing (WAS) nitrogen, second dose of 30kg N/ha was applied at 5 WAS using urea (46%). The recommended rate of 20 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha was applied to sesame half dose of N and all P and K were applied at planting, while the remaining half dose of N (10 kg) was top dressed using urea (46%) sesame at 6 weeks after sowing (NOMA, 2002). All plots were manually hoe- weeded at 3 and 6 WAS. Harvesting was done manually after the crops have matured and dried the pearl millet was first harvested and sesame was harvested later. Agronomic and yield data were collected and the benefit of intercropping was assessed using land equivalent ratio (Mead and Willey 1980), as the relative land area under sole crops that is required to produce the yields achieved by intercropping under the same level of management conditions.

Mathematically, LER was computed as:

$$LER = Ym/Ysm + Ys/Yss$$

Where:

LER = Land equivalent ratio

Ym = Yield of pearl millet in intercrop

Ysm = Yield of sole pearl millet

Ys = Yield of sesame in intercrop

Yss = Yield of sole sesame

2.2 Data collection

All data collected were subjected to analysis of variance (ANOVA) with the help of statistical software, Statistix 8.0. The treatment means were compared using Least Significant Difference (LSD at 5% level of probability when F –Value were significant (Gomez and Gomez, 1984).

3.0 Results and Discussion

Table 1 results of rainfall received during the growth in Maiduguri (266.1 mm) could therefore be termed low, whereas that at Biu (587.2 mm) was twice as much and exceeds the minimum rainfall requirement for effective crop performance (table1). Sesame thrives well where rainfall is as low as 400 mm per annum (Kolo and Daniya, 2006; Hussain *et al.* 2020). Similarly, growth environment temperature at Maiduguri (29.8±0.84 ^{0}C) was relatively higher than at Biu (27.9±0.58 ^{0}C). Thus, the high productivity from system with sesame at Biu could be attributed to the relatively higher rainfall and lower temperature, which further enhanced the performance of the variety NCRIBEN 02M that has the highest grain weight. Previous reports had also observed differences in sesame and millet performance to climatic factors and attendant biotic factors of pests and diseases (Hudu, 2000; Gworgwor *et al.* 2001; Altinok *et al.* 2005; Rouamba, *et al*. (2021) The result also show better performance of the millet component at Maiduguri and the sesame component at Biu, suggesting further difference in the adaptation of the component crop. Earlier reports had linked the high performance of millet in the Sudan Savannah to drought tolerance and low incidences of pest and diseases on one hand, while rainfall regime in Guinea Savannah is beneficial to sesame on the other hand (Dugje, 2004; Desai and Pujari, 2007; Kalu and Adeyemo, 2009; Osabohien and Ogunbiyi. 2019).

Table 1: **Mean Monthly Rainfall and Temperature for Maiduguri and Biu, 2011**

	Rainfall (mm)		**Temperature (^{0}C)**	
Month	Maiduguri	Biu	Maiduguri	Biu
April		30.00	35.15	26.24
May		49.80	35.35	29.39
June	64.50	145.40	33.71	29.67
July	60.25	231.40	30.99	27.94
August	157.50	191.9	27.71	27.58
September	45.00	106.20	29.20	26.64
October	3.25	57.70	31.28	29.36
Total Recorded	330.6	812.40	30.00	27.5
Cropping period	266.1	587.20	29.80	27.9

Sources: Lake Chad Research Institute, Automatic weather station and Ministry of Agriculture, Department of Meteorological services Biu.

The effect of intercropping on millet growth and yield parameters at Maiduguri and Biu are presented in (Table 2). Results showed that intercropping had significant effect on growth and yield parameters of millet accept stand count and days to Physiological maturity at Biu and Maiduguri. The stand count ranged from 14-15 and 10-11 with mean of 14 and 11 at Maiduguri and Biu respectively. The number of days to 50% flowering days ranged from 63-65 and 63-67 with mean of 63 and 64 at Maiduguri and Biu respectively. Plant height ranged 264.9-282.4 and 191.7-200.9 cm with mean of 275.3 and 196.0 cm at Maiduguri and Biu respectively. The physiological maturity days ranged from 77 and 78-79 days with mean of 77 and 78 days at Maiduguri and Biu respectively. Grain yield varied from 1686 – 1992 and 1188 – 1269 at Maiduguri and Biu respectively. The result showed better performance of the millet component at Maiduguri than Biu this could be attributed to difference in the adaptation to environmental factors of the component crop millet to drought tolerance and low incidences of pest and diseases in Sudan Savannah. Previous reports had also observed differences in sesame and millet performance to climatic factors and attendant biotic factors of pests and diseases (Hudu, 2000; Gworgwor *et al.*, 2001; Altinok *et al.,* 2005; Rouamba, *et al*. (2021).The effect of sesame seed rate on the number of days to 50% flowering, Plant height, number of days to physiological maturity and yield were not significant at both locations. Interaction of seed rate to the variety was not significant.

Table 2: Effect of stand count, days to 50% flowering, plant height and days to maturity of sesame millet intercrop with millet/sesame seed rate on the growth parameters of Sesame during 2011 cropping season.

Treatments	**Stand count**		**Days to 50% flowering**		**Plant height (cm)**		**Days to maturity**		**Grain yield kg/ha)**	
	Maiduguri	**Biu**	**Maiduguri**	**Biu**	**Maiduguri**	**Biu**	**Maiduguri**	**Biu**	**Maiduguri**	**Biu**
Intercrops(I)										
SOSAT-C88 + NCRIben 02M	14	11	63	63	275.6	199.7	77	78	1836.6	1207.1
SOSAT-C88 + Kenana-4	15	10	63	63	282.4	200.9	77	78	1991.8	1268.9
SOSAT-C88 +Ex-Sudan	14	10	63	63	264.9	191.7	77	79	1685.7	1207.4
SOSAT-C88 +Gwoza local	14	10	65	67	278.5	191.7	77	78	1824.9	1188.0
Mean	14	11	63	64	275.3	196.0	77	78	1834.8	1217.9
LSD(0.05)	0.4	NS	1.4	1.4	10.0	3.0	NS	0.9	45.6	30.8
Seed rate (S) kg/ha	SE		0.7	0.6	4.9	1.5	0.9	0.4	22.6	15.3
1.0	11	10	63	62	271.6	190.0	75	78	2021.4	1150.1
2.0	11	11	63	63	273.5	195.7	76	79	1861.0	1046.1
3.0	10	11	63	64	275.5	188.6	77	79	1928.8	986.3
4.0	10	11	66	68	280.0	189.3	76	80	1674.2	1143.5
5.0	11	11	63	65	277.0	195.8	77	77	1893.8	1073.8
6.0	33	11	63	61	274.4	216.6	77	77	2629.3	1907..3
Mean	11	11	63	64	275.3	196.0	77	78	1834.3	1217.9
LSD 0.05	0.5	NS	1.7	1.5	1.5	3.7	NS	1.1	55.8	37.8
Interaction	SE		0.9	0.7	6.0	1.9	1.1	0.5	27.7	18.8
I X S	*	NS	*	*	*	*	NS	*	*	*

KEY: ***Variety:*** *V_1=NCRIBEN 02M x Millet (SOSAT-C88), V_2=Kenana-4 x Millet (SOSAT-C88), V_3=Ex-Sudan x Millet (SOSAT-C88), V_4=Gwoza local x Millet (SOSAT-C88)* ***Seed rate:*** *R_1 = 2.0 kg/ha, R_2 = 3.0 kg/ha, R_3 = 4.0 kg/ha, R_4 = 5.0 kg/ha, R_5 = 6.0 kg/ha.*

The effect of intercropping sesame seed rate on growth and yield parameters at Maiduguri and Biu is presented in (Table 3). Results showed significant differences in all the parameter studied in both locations except plant height at Maiduguri location. Stand count ranged from 83 – 107 and 134 – 163 with means of 94 and 150 respectively. The number of days to 50% flowering ranged from 44 - 52 and 45 - 52 with means 46 and 47 at Maiduguri and Biu respectively. Millet grown in combination with Gwoza local took significantly longer number of days attained 50 % flowering compared to other improved sesame varieties grown in combination with millet The variety Gwoza local took significantly longer time to flower than the other varieties at both locations this could be due to adverse climatic conditions and poor genetic traits as reported by (Omojor, 1998; Kolo and Daniya, 2006; Hussain *et al.* 2020).Plant height ranged from 196.5 – 121.6 with means of 138.2 and 141.1 at Maiduguri and Biu locations. The number of days to physiological maturity ranged from 83 - 125 and 87– 130 with means 94 and 98 at Maiduguri and Biu respectively. The local sesame cultivar (Gwoza local) grown in combination with millet took more number of days to attained physiological maturity compared to improved varieties grown in the mixture with millet. Millet intercropped with Kenana-4 and NCRIben 02 was comparably taller than with Ex-Sudan at Maiduguri and Biu. However, there was no significant difference in the heights of millet grown in association with other improved sesame varieties at Maiduguri but significant at Biu location. This could be attributed to adverse competition effects of the taller and earlier sown millet component on the later intercropped shorter sesame crop (Ong, 1996 and Rowe *et al*. 2005, Adieniyan *et al.* 2014, Asiimwe *et al.*, 2016, Delaquis *et al*. 2018)) Observed that space and shading effects, coupled with competition for soil and water resources are main causes for low productivity of under crops. The effect of sesame seed rate on Interaction of seed rate to the variety was significant. This could be attributed to varying seed rate and timing of sowing as reported by (Enwezor *et al.* 1989, Iwo and Idowu., 2002) and FAO, 2004). Interaction was significant in stand count, days to flowering, plant height and maturity (Delaquis *et al*. 2018)

Table 3. Effect of stand count, days to 50% flowering, plant height and days to maturity of Sesame Intercrop with millet/sesame seed rate on the growth parameters of Sesame during 2011 cropping season.

Treatment	Stand count		Days to 50% flowering		Plant height (cm)		Days to maturity	
	Maiduguri	Biu	Maiduguri	Biu	Maiduguri	Biu	Maiduguri	Biu
Intercrop (I)								
SOSAT-C88 + NCRIben 02M	83	134	46	46	121.6	141.9	85	87
SOSAT-C88 + Kenana-4	87	160	44	46	196.5	141.6	83	87
SOSAT-C88 +Ex-Sudan	107	142	44	45	117.5	142.2	84	87
SOSAT-C88 +Gwoza local	99	163	52	52	117.7	138.6	125	130
Mean	94	150	46	47	138.2	141.1	94	98
LSD 0.05	3.0	3.1	1.5	0.4	NS	2.2	1.0	0.3
Seed rate (S) kg/ha								
1.0	74	169	45	46	112.1	143.8	84	87
2.0	71	128	45	47	113.6	142.7	85	88
3.0	95	129	47	46	113.0	137.5	85	87
4.0	91	151	47	46	115.3	142.2	85	87
5.0	99	166	46	47	116.3	143.6	85	87
6.0	137	157	48	49	119.6	137.1	87	88
Mean	94	150	46	47	138.2	141.1	94	98
LSD 0.05	3.6	0.5	1.1	0.5	NS	2.7	1.2	0.4
Interaction								
I X S	*	*	*	*	*	*	*	*

KEY:* Variety:** *V_1=NCRIBEN 02M x Millet (SOSAT-C88), V_2=Kenana-4 x Millet (SOSAT-C88), V_3=Ex-Sudan x Millet (SOSAT-C88), V_4=Gwoza local x Millet (SOSAT-C88)* ***Seed rate: *R_1 = 2.0 kg/ha, R_2 = 3.0 kg/ha, R_3 = 4.0 kg/ha, R_4 = 5.0 kg/ha, R_5 = 6.0 kg/ha.*

The effect of intercropping sesame seed rate on yield and yield components at Maiduguri and Biu are presented in (Table 4). Results showed significant differences in all the parameter studied except 1000 test weight interaction at Biu location. Number of branch per plant ranged from 4 – 5 and 3 - 6 with mean of 5 and 4 at Maiduguri and Biu respectively. The varieties Ex-Sudan and Gwoza local had more number of branches than the other improved sesame varieties in both locations. However, in Biu, Gwoza local gave significantly higher number of branches than all other varieties. Number of capsule per plant ranged from 9 – 15 and 70 – 98 with mean of 12 and 87 at Maiduguri and Biu respectively. The Ex-Sudan gave significantly more capsules than all the tested varieties followed by NCRIben 02M while the least was recorded from Kenana -4 and Gwoza local. The varieties NCRIben 02M recorded the highest 1000 seed weight followed by Gwoza local and the lowest from Ex – Sudan and Kenana - 4 at Maiduguri while at Biu was not significant. The Grain yield ranged from 119.2 – 360.0 and 315.8 - 503 kg/ha with means of 223.2 and 421.6 kg/ha at Maiduguri and Biu respectively. There was significant differences among the sesame varieties grown in mixture with millet at both locations. The variety, Ex-Sudan significantly recorded the highest grain yield followed by NCRIben 02M and the least from Gwoza local in both locations. This could be attributed to number of branches per plant, number of capsule per plant, 1000 seed weight (Patra, 2001; Okpra *et al*. 2007; Shehu *et al*. 2010). There was significant interaction between numbers of branches, capsules number; test weight at both locations except Biu test weight was not significant

Table 4. Effect of intercropping millet/sesame and Seed Rate on the Yield and Yield components of Sesame during 2011 cropping season.

Treatment	Number of branch/plant		Number of capsule/plant		1000 test weight (g)		Grain yield (kg/ha)	
	Maiduguri	Biu	Maiduguri	Biu	Maiduguri	Biu	Maiduguri	Biu
Intercrop (I)								
SOSAT-C88 + NCRIben 02M	5	4	15	97	4.0	4.0	237.8	465.8
SOSAT-C88 + Kenana-4	4	3	9	70	3.8	4.0	175.6	401.6
SOSAT-C88 +Ex-Sudan	5	4	17	98	3.8	4.0	360.0	503.1
SOSAT-C88 +Gwoza local	4	6	9	81	3.9	4.0	119.2	315.8
Mean	5	4	12	87	3.9	4.0	223.2	421.6
LSD 0.05	1.0	0.3	0.5	2.6	0.1	NS	2.6	8.7
Seed rate (S) kg/ha								
1.0	6	4	11	68	3.8	4.0	118.8	393.3
2.0	3	5	8	69	4.0	4.0	258.2	333.2
3.0	4	4	15	92	3.9	4.0	222.2	390.4
4.0	5	4	15	84	4.0	4.0	287.2	458.2
5.0	4	4	13	90	3.8	4.0	221.7	491.9
6.0	6	7	13	117	3.9	4.0	230.1	462..9
Mean	5	4	12	87	3.9	4.0	223.2	421.6
LSD 0.05	1.1	0.3	0.6	3.2	0.1	NS	3.2	10.6
Interaction								
I X S	*	*	*	*	*	NS	*	*

3.1 Mixture Productivity and Land Equivalent Ratio (LER)

Table 5 showed the results of Land Equivalent Ratio (LER) computed that intercropping caused yield reduction in both locations. The highest reduction for sesame was in Maiduguri compared with Biu. However, the combined LER of millet and sesame intercrop exceeded the sole crop performance in both locations. Similar advantage of more effective land utilization has been reported with sorghum/soybean Mead and Willey, 1980; Dhima *et al.*

2007; Mohammed, et *al.* 2000; Delaquis *et al.*2018). Results from comparison of the mixture grain yield of the component crops with sole crops indicated that increasing millet seed rate in the mixture resulted in an increased in the LER of millet while LER of sesame decreased with increase in its seed rate in both locations. Sesame seed rate 4.0 kg/ha and 5.0 kg/ha (millet/sesame) produced the highest yield advantage of 42 and 27 percentage in both locations respectively, reflecting superiority of this mixture to sole cropping of either millet or sesame. This agrees with earlier reports that yield increased with plant population, and high planting density suppressed weed better, but these benefits on yield decreased after reaching a certain point (Busari *et al.* 1998; Ndarubu *et al.* 2003; Imoloame *et al.* 2004).

Table 5: Relative productivity of millet/sesame mixture (Land Equivalent Ratio) at Maiduguri and Biu, 2016 rainy season

Treatment	Millet yield kg/ha		Sesame yield kg/ha		Partial LER Millet		Partial LER Sesame		Total LER	
	Maiduguri	Biu	Maiduguri	Biu	Maiduguri	Biu	Maiduguri	Biu	Maiduguri	Biu
V_1R_1	5445	3389	382	1164	0.79	0.59	0.26	0.58	1.05	1.17
V_1R_2	5333	2843	444	999	0.77	0.50	0.31	0.50	1.08	1.00
V_1R_3	6222	2941	333	889	0.90	0.51	0.23	0.44	1.13	0.95
V_1R_4	4889	3721	556	1221	0.71	0.65	0.39	0.61	1.10	1.27
V_1R_5	6222	3111	444	1000	0.90	0.54	0.31	0.50	1.21	1.04
V_2R_1	7445	3233	382	833	1.08	0.57	0.34	0.39	1.42	0.96
V_2R_2	6888	3333	278	629	1.00	0.58	0.25	0.31	1.25	0.89
V_2R_3	6111	4055	278	944	0.89	0.71	0.25	0.45	1.14	1.16
V_2R_4	5111	3112	402	1223	0.74	0.54	0.36	0.58	1.10	1.12
V_2R_5	6000	3386	382	1056	0.87	0.59	0.34	0.50	1.21	1.09
V_3R_1	5556	3678	218	1167	0.81	0.64	0.14	0.55	0.95	1.20
V_3R_2	5556	2889	216	1111	0.81	0.50	0.13	0.53	0.94	1.03
V_3R_3	5222	2223	278	1389	0.76	0.39	0.17	0.66	0.93	1.05
V_3R_4	4455	3889	611	1111	0.65	0.68	0.38	0.53	1.04	1.08
V_3R_5	4666	3333	382	1389	0.68	0.58	0.25	0.66	0.93	1.24
V_4R_1	5789	3501	556	1056	0.84	0.61	0.27	0.49	1.11	1.11
V_4R_2	5890	3488	444	1056	0.86	0.61	0.22	0.49	1.08	1.10
V_4R_3	5555	2667	556	1167	0.81	0.47	0.27	0.54	1.08	1.01
V_4R_4	5778	3000	556	1289	0.84	0.52	0.27	0.60	1.11	1.12
V_4R_5	6000	3056	666	1277	0.87	0.53	0.32	0.59	1.19	1.12
Sole Millet	6888	5722			1	1				
Sole V_1			1444	2000			1	1		
Sole V_2			1122	2111			1	1		
Sole V_3			1611	2111			1	1		
Sole V_4			2056	2166			1	1		

***KEY:* Variety:** *V_1=NCRIBEN 02M x Millet (SOSAT-C88), V_2=Kenana-4 x Millet (SOSAT-C88), V_3=Ex-Sudan x Millet (SOSAT-C88), V_4=Gwoza local x Millet (SOSAT-C88)*

Seed rate: *R_1 = 2.0 kg/ha, R_2 = 3.0 kg/ha, R_3 = 4.0 kg/ha, R_4 = 5.0 kg/ha, R_5 = 6.0 kg/ha.*

3.3 Conclusion and recommendation

In conclusion, millet intercropping with Ex-Sudan is recommended for the broad Sudan and Northern Guinea Savanna belt, at 2.0 and 4.0 kg/ha sesame seed rate, respectively. Thus, while Kenana-4 and NCRIBEN 02M expressed specific adaptation for intercropping in Maiduguri and Biu, respectively, Ex-Sudan showed adaptation in guinea savannah.

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Different Levels of Sodium Fertilizer Application to Pasture 1: Effects of Soil Types on the Acclimation and Productivity of Rain-Fed *Brachiaria Decumbens* in Semi-Arid Sokoto State, Nigeria

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Abstract: *An on farm study was conducted at the college farm, Umaru Ali Shinkafi Polytechnic Sokoto in late rainy season (April 202l-March 2022), to examine the effects of different levels of Sodium (Na+) fertilizer application on the acclimation and productivity of Brachiaria decumbens on different soils. The research consisted of 2x1m factorial combination of two soil types and four treatments (High, Medium, Low and Nil Na+/300kg NPK/ha/y^{-1}) in three replicates at each location. Laid out in a Completely Randomized Block Design (CRBD) with herbage cover and growth rates (leaf number/stand; leaf length/stand; stem height/stand; number of tillers/stand; and leaf width) as variables. The results indicated significant differences (P<0.05) of soils particle sizes between soil depths and locations. The values for particle sizes obtained indicated sandy and loamy sand soil types respectively of upland and lowland areas. There were significant differences (P<0.001) of chemical content of soils between depths and locations. The range of soil pH (5.4 – 6.2) recorded in all depths were within the range considered adequate for most crops. The range of soil EC (24.7-37.0 meg/100l) obtained indicated non to very low salinity. The range of CEC values (5.03-6.80 meg/100l) were lower than <6 in upland soil, and 6-12 in lowland soil indicating very low and low nutrients holding capacities respectively. The generally low nutrients recorded indicated low organic matter content in the soils. The results for leaf number differed significantly (P<0.05) in low and 0Na+ levels in upland soil however, did not differ significantly (P>0.05) in high and medium Na+ levels between locations, the values for means stem height obtained in upland soil did not differ significantly (P>0.05) within treatments, however, differed significantly (P<0.05) between locations. The generally higher means stem heights obtained in lowland soil were due to higher soil-moisture retaining capacity of the soil. The results for the number of tillers, leaf length and width indicated no statistical differences (P>0.05) between treatments and locations. The values for leaf length (11.7–13cm) recorded at one month fall within the range of 10-20cm density pubescent leaf length considered important component for adaptation to drought-prone environments. The foliage covers in 0Na+ in both locations differed significantly (P<0.05) with Na+ added to fertilizer. The values in both locations tended to increase linearly with decreasing levels of sodium indicating sensitivity of Brachiaria decumbens to Na+ without exhibiting toxicity symptoms. It was concluded from this study that the levels of Na+ added to fertilizer did not affect the productivity of rain-fed Brachiaria decumbens. Thus, the plant shows promising to shorten the hardships of feed's scarcity and quality for livestock in dry semi-arid Sokoto State. Soil salinity tests, mild irrigation between rainy days at high ambient temperature, and moderate nitrogenous fertilization in both locations are recommended in late rainy season*

***Keywords**: Brachiaria decumbens, Semi-Arid, Soil salinity, Acclimation, Productivty*

INTRODUCTION

Ruminant's livestock in Nigeria are mostly produced on rangelands (Kallah, 1992), which is the worldwide cheapest source of feeds for herbivores (Akinola, 2019). The productivity of rangelands however is low with declining soil fertility and erratic precipitation (Bello, 2011). The quantity and quality of herbage decline linearly with physiological maturity and seasons of the year (Malami, 2005), affecting livestock productivity (Bello *et al.,* 2014). This phenomenon is more pronounced in the extreme Northern Nigeria, in these areas rainy season is characterized by 3-4 months, and 8-9 months of dry seasons (SABAS, 1996). The herbage are dominated by annual species, mostly unpalatable thus avoided by grazing animals in rainy seasons (Shaefer *et al.,* 1998). However, these plants species are cherished in dry seasons (Malami, 2005), in the absence of any other feed (Michael *et al.,* 1990; Bello, 2011).

Tropical soils vary in their physical and chemical composition (Kyiogwom *et al.*, 1998). The ability of the soils to retain water and supply it to plants is the major limiting factor affecting tropical agriculture. Seasonal forage productivity is related to plant species, soil fertility and precipitation (Ribeizo *et al.,* 2009). In the savannah areas, soils were reported to be predominantly sandy, at least in surface horizon (Kowal and Kassan, 1978), as well as in different profiles (Lokotoro and Singh, 2000). However, loamy sand soils, as well as silt loamy and clay soils were reported in fadama areas of Sokoto State (Sharu and Yahaya, 2020). The soils are usually acidic with pH values 5 – 6.5 occupying large proportion of the upland areas (Yakubu and Ojanuga, 2013). In their salinity study of the soils in fadama areas of Sokoto State Obinna and Mohammed (2021) reported saline-sodic soil, with Magnesium bicarbonate and calcium chloride identified as the major contributors to absolute salt concentration. Spatial and seasonal variations in soil nutrients were also reported in tropics (Sunday *et al.*, 2020). Most authors agreed that the acid reaction of soil indicates its poor nutrients status (Bello, 2011). However, flood-plain soils are fairly rich in the three primary nutrients (SADP, 2016).

The abundance of palatable perennial herbage species on the range is one of the indicators of a very good range condition (Nbaya *et al.,* 2014). Most perennial herbage species worldwide used for pasture establishment are not recommended in Sudano-Sahelian ecological zones due to rainfall pattern (Onifade and Agishi, 1990). Most authors concluded that efforts need to be intensified to find appropriate perennial herbage cultivars, and other means to reduce the long hardship of herbage quantity and quality in dry semi-arid areas (Bello *et al.*, 2014).. *Brachiaria decumbens* (Signal grass) is one of the promising perennial herbage species. It is a medium lived (5 years), and reported to grow on a wide range of soils, including those with low fertility status (pH 3.5) (Deifel *et al.,* 2006). Its optimal growth occurs between temperatures 30 – 35^{0}C, and 1000-1500mm rainfall (FAO, 2016). However, it was reported to have a drought tolerance of up to 4-5 months in humid areas, and mild flood (FAO, 2016). Although Signal grass has low leafy stands on infertile soils, it response excellently and produce DM yield (10-30t/ha/yr^{-1}) with heavy fertilization and adequate moisture regime (Cook *et al.,* 2005).

Sodium (Na+) deficiency in pasture occurs in many parts of world especially in tropical Africa and Australia (McDonald, 1988). Although Na+ is not considered an essential element to plants due to its trace requirement (Broodwick *et al.,* 2021), Na+ can be beneficial in many conditions, particularly when soil is deficient in potassium, and in plants located in areas with high level of precipitation due to its mobile nature in soil (Frans *et al.,* 2014). However, a group of some C4 plants such as Atreplex spp, Millet, Corn, Sorghum and a number of C4 grasses Na+ at trace level can be classified an essential nutrient (Frans *et al.,* 2014). Apart from physiological function of Sodium in plants and animal's body, it play very important roles in ruminant digestion (Bello, 1990), increases rumen volume and outflow when given as NaCl2 (Weidmier *et al.,* 1987), increases rumen pH and proportion of cellulolytic microbes when fed as Sodium bicarbonate (Bello, 1990). Increased in herbage growth rate was also observed when Na+ fertilizer was applied as NaCl2 (Webb, 1988), however variability on plant's salt tolerance and stress were reported in different plants (Broodwck *et al.,* 2021). Researches on temperate soils indicated Na+ added to fertilizer on pastures increased herbage Na+ content (Chiy *et al.,* 2006), grazing time and drinking frequency increased linearly with increased Na+ fertilization (Phillips and Bello, 1991; Chiy *et al.,* 2006). The study aimed to examine the effects of soil types at different levels of Na+ added to fertilizer on the productivity of rain-fed *Brachiaria decumbens,* to shorten the inherent feed scarcity and quality for livestock in long dry season of Sokoto State.

MATERIAL AND METHODS

Study Area

The research was conducted at the college farm, Umaru Ali Shinkafi Polytechnic Sokoto, Nigeria. The study area is located between latitude 12^0 54' and13^0 02' North and Longitude 4^0 52 and 5^0 00 East/ The climate in the area consists of a short rainy season (April – September) and long dry season (October – March). The mean annual rainfall hardly exceed 731.2mm (SADP, 2016). The rainfall is frequently erratic and poorly distributed with wide gaps between rains are common (Adamu *et al.,* 1998). The temperature varies widely (15 - 40^0C). The soil is moderately deep and well drained (Bello *et al.,* 2014).

TREATMENTS AND EXPERIMENTAL DESIGN

The research consisted of a two streams 2x1m factorial combination of two soil types (Upland and Lowland) in four treatments sequences of High Sodium fertilizer (HSF) 64kg Na+/ 300kg NPK/ha/yr^{-1}; Medium Sodium fertilizer (MSF) 32kg Na+/ 300kg NPK/ha/yr^{-1}; Low Sodium fertilizer (LSF) 16kg Na+ /300kg NPK/ha/yr^{-1}and Nil Sodium fertilizer (0SF) Na+ /300kg NPK/ha/yr^{-1} as control in three replicates at each location. The research was laid out in a Completely Randomized Block Design (CRBD) with herbage cover and growth rate (leaf number/stand; leaf length/stand; stem height/stand; number of tillers/stand; and leaf width) as variables in late rainy season (July – September).

METHODOLOGY

Soil Sampling and Analysis

The study area was used as upland soil, while the Fadama soil was brought to the site to simulate lowland area. Soil samples from undisturbed fadama soil were collected before excavation at Kwalkwalawa area Sokoto. Five soil samples at each location were randomly collected for the depths of 0-20cm and 20-40cm respectively using graduated Soil Auger (0 – 20cm) (SADP, 2016). The samples from the two soils / depths were mixed separately and three composite samples from each depth per location were collected for laboratory analysis. Sample for texture analysis was analyzed in triplicate using Hydrometer method. The values for sand, silt and clay were compared to soil texture triangle and determined the soil types as described by Ritter (2006). The composite samples for the two soil depths at each location were also subjected to triplicate chemical analysis. Electrical conductivity (EC) of the soils was determined by conductivity meter (IITA, 1982); Hydrogen ion concentration (pH) of the soils was read using Gallenkamp pH meter (IITA, 1982). Nitrogen content of the soils were determined according to macro Kjeldah method (IITA, 1982); Calcium (Ca) and Magnesium (Mg) of soil samples were determined by Atomic Absorption Spectrophotometry method (IITA, 1982), while the Sodium and Potassium were determined by flame Photometry Method (IITA, 1982). Available phosphorus was determined by Bray 1 Method.

LAND PREPARATION AND TRANSPLANTING

Twelve 2x1m plots (beds) with irrigation channels at each location (upland and lowland) were prepared. For lowland soil, all the 12 plots were excavated to the depth of 0.5m and filled with fadama soil. Plots at each location were initially fertilized with equal quantity of cow dung manure to maintain pH levels and increased proportion of micronutrients in soils (Sharu and Yahaya, 2020). All plots were initially watered using irrigation. Young seedlings of *Brachiaria decumbens* sourced from National Animal Production Research Institute Shika (NAPRI) ABU Zaria were sorted and transplanted. One seedling / hole was transplanted at the distance of 0.3m between stands and rows in all treatments. The seedlings were trimmed to the height of 10cm from the soil surface (Naflalul, 2015) and watered daily until the stem of each seedling turned green. Dead seedlings were replaced before sodium fertilization commenced. Sodium Chloride (NaCl2) fertilizer was applied to each treatment two weeks later accordingly. All plots were subsequently irrigated if it did not rain within three days. First, second and third weeding were conducted at two weeks intervals. Data for herbage cover and growth rate were obtained at two weeks intervals monthly.

STATISTICAL ANALYSIS

Data collected was analyzed using ANOVA procedure using SPSS model software. Where means were found significant Duncan's Multiful Range Test was used to separate the means at 5% level.

RESULTS AND DICUSSION

Table 1: Physical properties of upland and lowland soils and soil types in the study areas

	Upland				**Lowland**				
Depths	Sand	Silt	Clay	Soil types	**Sand**	**Silt**	**Clay**	**Soil types**	**SEM**
0-20 cm	83.60	10.10	7.27	Sandy soil	**81.70**	**7.16**	**11.13**	**Loamy sand soil**	**1.08**
20-40 cm	81,96	10.47	8.57	Sandy soil	**84.53**	**5.90**	**9.57**	**Loamy sand soil**	**1.08**
Sig.	0.05	0.00	0.01		**0.05**	**0.00**	**0.01**		

Table 1 presents the means physical status of soils used for the study. The result shows significant difference (P<0.05) for sand, silt and clay content of soils between depths and locations (Upland and Lowland). The higher values of sand content of soils recorded in this study (Table 1) were in agreement with the findings of most authors (Bello *et al.,* 2014). The generally low values of silt and clay content of soils (Table 1) obtained agreed with the findings of Kowal and Kassan (1978) who reported silt and clay content of soils in semi-arid tropics were remarkably low. The values for soil particles size recorded in upland soil indicated sandy soil type (Table 1), probably due to sand deposited from dessert encroachment. Sokoto state was among the states in Nigeria that are prone to desertification (Ignatius and Adie, 2021). The values of sand obtained in lowland soil indicated loamy sand type (Table 1), probably due to sand deposited mainly from the flooding rivers. Similar findings were also reported by most authors (Lokotoro and Singh, 2000).

Table 2: Chemical content of soils from different depths and locations in the study area

Parameters	Upland soil		Lowland soil			
Depths	0-20 cm	20-40 cm	0-20 cm-	20-40 cm	SEM	Sig
pH	5.7	5.4	6.2	6.0	0.19	**
EC meg/100L	27.9	24.7	37.0	33.3		**
CECmeg/100L	5.36	5.03	6.80	6.30		***
N (mg/kg)	0.08	0.07	0.12	0,09		***
P (mg/kg)	0.78	0.62	0.83	0.81		NS
K (mg/L)	0.37	0.25	0.26	0.23		***
Mg (mg/L)	3.23	2.50	5.80	7.40		***
Ca (mg/L)	6.71	6.93	15.70	17.20		***
Na (mg/L)	0.21	0.21	0.53	0.33		***

** = Significant at (0.05) level; *** = Significant at (0.001), NS = Not significant

Table 2 presents the means chemical content of soils from different depths and locations. The results indicated significant differences (P<0.001) of chemicals content of soils between depths and locations. The range of soil electrical conductivity (EC) (24.7-37.0 meg/100l) obtained in all depths and locations (Table 2) indicated non to very low saline status of the soils (Sunday *et al.* 2020). The range of CEC values (5.03-6.80 meg/100l) in different depths and locations were lower than <6 in upland soil, and 6-12 in lowland soil reported as very low and low nutrients holding capacities respectively (Hazelton and Murphy, 2007). The chemical content of soils with exception of Mg+ and Ca+ in this study decreased with depths in all locations. Similar findings were also reported by most authors probably due to low organic matter content (Sharu *et al.,* 2020) The generally low values of soils nutrients recorded in this study indicated low organic matter content in the soils. Low organic matter of soils was reported to decrease soil pH and EC content (Sharu *et el.,* 2020) consequently affecting soil fertility. There were no apparent symptoms of salt toxicity observed in all treatments. The non-toxicity symptoms of Na+ exhibited by *Brachiaria decumbens* was probably due to low exchangeable ions recorded in the present study. Most authors agreed that the ions responsible for soils salinity are Na^+, Ca^+, K^+ Mg^+ and Cl^-2 (Webb, 1988).

Table 3: Means productivity of *Brachiaria decumbens* on different NaCl2 levels and soil types:

	Upland				Lowland			
Parameters	HSF	MSF	LSF	0SF	**HSF**	**MSF**	**LSF**	**0SF**
Leaf number	3.7^{cd}	4.3^{c}	5.7^{a}	5.0^{ab}	$4,3^{bc}$	4.0^{cd}	6.3^{a}	4.7^{bc}
Leaf length (cm)	13.0^{a}	12.7^{ab}	11.5^{abc}	12.0^{ab}	14.0^{ab}	15.0^{a}	14.0^{ab}	14.9^{a}
Stem height (cm)	11.3^{abc}	10.0^{bc}	10.0^{bc}	12.0^{ab}	10.7^{c}	7.8^{cd}	19.0^{a}	14.7^{b}
Number of tillers	0.3^{d}	1.3^{ab}	1.6^{ab}	1.0^{bc}	3.0^{abc}	3.0^{abc}	3.0^{abc}	3.0^{abc}
Leaf width (mm)	10.1^{abc}	9.5^{d}	10.3^{ab}	10.5^{ab}	10.3^{ab}	10.2^{abc}	10.3^{ab}	10.4^{a}
Foliage cover (%)	23.6^{cd}	24.3^{bc}	25.3^{cd}	33.6^{a}	25.2^{c}	26.8^{bc}	24.5^{cd}	37.9^{a}

Means within columns and rows with different superscripts differed significantly using Duncan's Multiple Range Test at 5% level

HSF = High Sodium fertilizer; MSF = Medium Sodium fertilizer; LSF = Low Sodium fertilizer; 0SF = Nil Sodium fertilizer

Table 3 presents the means productivity of *Brachiaria decumbens* on different NaCl2 levels and soil types: in dry semi-arid Sokoto State. The results of this study indicated the leaf number in high and medium Na+ levels did not differ significantly (P>0.05) within treatments and locations (upland and lowland soils) however, differed significantly (P<0.05) with low and zero Na+ fertilizer levels in upland soils (Table 3). The higher leaves number recorded in low and zero Na+ fertilization compared to high and medium Na+ fertilization (Table 3) was probably due to salt sensitivity of *Brachiaria decumbens* reported by most authors (Deife *et al.,* 2006). Data is not readily available for the range of leaf number recorded (3.7- 6.3) at one month in the present study for comparison. There were no statistical differences (P>0.05) for leaf length within treatments, and between locations (Table 3). The higher means of leaf length obtained in the lowland soil indicated high fertility status of the fadama soil compared to upland soil (Lokotoro and Sign, 2000. Bello *et al.,* 2014). The range of leaf length values obtained (11.7 – 13cm) in this study fall within the range of 10 – 20 cm reported as density pubescent leaf length considered important component for adaptation to drought-prone environment (Dus and Deyun, 2009). The values for means stem height obtained in upland soil did not differ significantly (P>0.05) with treatments, however, differed significantly (P<0.05) between locations (Table 3). The generally higher means stem heights obtained in lowland soil compared to the upland soil were probably due to soil-moisture retaining capacity of the lowland soil (Lokotoro and Singh, 2000). Data for the range of stem height (7.8-19cm) recorded at 1month in the present study is not readily available for comparison. The result of the present study shows no significant difference (P>0.05) between treatments and locations for leaf width (Table 3). The values (9.5-10.5mm) for leaf width obtained in this study fall within the range of 8-10 mm reported (Husson *et al.,* 2008). The foliage cover in zero Na+ fertilizer did not differ significantly (P>0.05) with corresponding zero Na+ fertilizer between locations, however differed significantly (P<0.05) with different Na+ levels in both locations (Table 3). The values for foliage cover in this study tended to increased linearly with decreasing Na+ fertilization in all locations. The generally higher foliage covers recorded in lowland soil compared to upland soil was probably due to higher soil moisture retaining ability of the fadama soil compared to upland soil. The moisture retaining capacity of the fadama soil was probably due to high clay content of the soil (SADP, 2016) as well as organic matter content of the soils (Sharu *et al.,* 2020).

CONCLUSION

It was concluded from this study that there was no sufficient rainfall for planting in early rainy season (April-June) in the study area. Sandy and loamy sand soils were the types of soils respectively of upland and lowland areas. The values for pH contents of soils fall within the range considered adequate for most crops. The values for soil conductivity indicated non to very low saline status. The generally low values of soils nutrients recorded in this study indicated low organic matter content in soils. The levels of Na+ added to fertilizer did not affect the productivity of rain-fed *Brachiaria decumbens* in all locations. Thus, the plant shows promise to shorten the hardships of feed scarcity and quality for livestock in dry semi-arid Sokoto State. Soil salinity tests, mild irrigation between rainy days at high ambient temperature, and moderate nitrogenous fertilization in both locations are recommended in the late rainy season

*******Malami Buwai (Late) Ph. D in Range Management (USA) was a former Chief Range Management officer Sokoto State and Minister, Federal Republic of Nigeria. He had gone through and made useful suggestions during the course of this research. May his soul rest in peace***

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Bacteriological Quality of Chicken Meat Produced Under Different Processing Conditions

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Abstract: The bacteriological quality of chicken meat produced under different processing conditions was analyzed to ascertain the microbial load and the distribution of bacteria that may be present and hence to deduce the danger of such bacteria on the chicken. The results obtained showed a total bacterial count of 5.78×10^4 in fresh chicken, 4.04×10^4 in frozen chicken, and 2.60×10^2 in fried chicken. The outcome might be as results of different treatments confer on the meat. Bacterial isolated from the samples are *Bacillus* species, *Streptococcus* species, *Escherichia coli and, Staphylococcus*. the microbial load and as well as the isolate showed the chicken are exposed to contamination an indicator as well as potential pathogens as a result, there is need for good hygiene practice during processing and handling of the chicken.

Keywords: Bacteria, Chicken, Pathogens

INTRODUCTION

Animal proteins such as meat and fish products are usually considered as high threat commodities in respect of pathogen contents, fecal *coliforms, staphylococci,* sulfate-reducing anaerobic germs, and *Salmonella* natural toxins, and other possible contaminants and adulterants (Adamou *et al,* 2020 *and* Yosuf *et al,* 2008). Foodborne infections and illnesses are some major international health problems with consequent economic reduction. It is a major cause of illness and death worldwide (Abebe et al, 2019). Recognizing this, the world health organization (WHO) developed its global strategy for food safety (Adak *et al,* 2005). In the developing world, food-borne infection leads to the death of many children and results in diarrhea (Zerabruk *et al*, 2019). The disease can have long-term effects on children's growth as well as on their physical and cognitive development (Adak *et al,* 2005). In the industrialized world, food-borne infection causes considerable illness heavily affecting the health care system (Adak *et al,* 2005). According to (Clarence *et al,* 2009) Foodborne diseases are diseases resulting from the ingestion of bacteria, toxins, and cells produced by microorganisms present in food. The intensity of signs and symptoms may vary with the amount of contaminated food ingested and the susceptibility of the individuals to the toxin (Clarence *et al,* 2009).

Meat is the most perishable of all important foods since it contains sufficient nutrients needed to support the growth of microorganisms (Magnus, 1981). The chief constituents of meat are water, protein, fat, phosphorus iron, and vitamin are also contained in meat. The major primary unit of meat is called carcass. It represents the ideal meat after head, hide, intestine and blood. The edible parts of the carcass include lean flesh, fat flesh and edible glands or organs such as the heart, liver kidney, tongue and brain. Meat is considered the most nutritive source of protein consumed by human. Age and sex of animal has a major influence on the quality of meat that is produced from animal (Rao *et al*, 2009). Most meats have high water content corresponding to the water activity of approximately 0.99 which is suitable for microbial growth (Rao *et al,* 2009).

In recent years, demand and consumption of poultry meat and its products have increased due to advantages such as easy digestibility and availability. Pakistan's poultry industry is also growing day by day and broiler meat production has considerably increased up to 480 tones in 2006-07 as compared to 463 tones in the fiscal year 2005-06 (Economic survey 2006-07). Due to the increased demand and production, the routine monitoring of quality of poultry meat is required for production of a safer produced according to established standard for the consumption of public.

Processing of poultry carcass required intensive microbiological quality control procedures as contamination of food with pathogens is a major public health concern worldwide (Mead *et al,* 1994). Most countries all over the world are trying hard to improve food quality to overcome foodborne illnesses and rising consumer concern. In the united state approximately 76 million food borne illness are reported each year (Mead *et al,* 1999).

Microbial food safety and food borne infection are important public health concern world wide. There have been a number of foods borne illness resulting from the ingestion of contaminated foods such as chicken meats. Most of the pathogens that play a role in food borne disease have a zoonotic origin (Busani *et al,* 2006). Raw meat remain an important and probably the major source of human food borne infection with pathogenic bacteria. In spite of decades of effort it has been difficult to obtain food animals free of pathogenic bacteria.

Meat and poultry carcasses and their parts are frequently contaminated with pathogens which reach the carcasses from the intestinal tract or from fecal material on feed and feathers. Cross-contamination is a particular problem and several recommendations have been published to control pathogens throughout, the chain from hatcheries to the preparation in the home (Dincer and Baysa, 2004).

The microorganism including pathogens present on the surface increase in, number during slaughtering, processing and handling. Several studies have indicated that consumption of poultry meat has been associated with incidence of outbreaks of food borne Infection including salmonellosis (Prakash *et al*., 2005). Compylobacteriosis (Berrang and Dickens, 2000).

The results of numerous investigation of the bacteriology of food poisoning show that contamination with pathogenic bacteria primarily refer to Salmonella species, Campylobacter species, Staphylococcus species, Listeria species and then Yersinia enterocolitica, Escherichia coli and Clostridium perfringens.(Zivkovic, 1998).

Against such a background and recognizing an increase in consumer concerns and pressure in term of reducing such human societal and economic costs, there is considerable interest in the development and wider application of more robust and secure methods within poultry production and processing system. Special attention in poultry production is paid to the fact that live animals are hosts to a large number of different micro organisms residing on the skin feathers or in the alimentary tract. During slaughter most of these microorganisms are eliminated, but subsequent contamination is possible at any stage of the production process. From feather plucking, evisceration and washing to storage by cooling or freezing. Micro organisms from the environment equipment and operators hand can contaminate meat during the process the microflora change from, in general, gram-positive rods and micrococci to, most frequently gram-negative bacteria in final products including entarobacteria, pseudomonas species, (Lidija *et al,* 2006) (Javadi and Safarmashsei, 2011).

One such system is hazard analysis and critical center point (HACCP) a systematic science based approach to process control designed to prevent, reduce or eliminate identified hazards in food products (Kukay *et al,* 1996). It is generally accepted that the HACCP approach is the most effective way of reducing or eliminating contamination during food processing.

susceptible to microbial contamination which can cause its to spoilage and food borne infections in human, resulting in economic and health losses (Komba *et al,* 2012). A great diversity of microbes inhabits fresh meat generally but different types of may become dominant depending on PH composition, texture, storage, temperature, and transportation means of raw meat (Erolini *et al,* 2006).

SAMPLE COLLECTION

Three sample of different kind of processed chicken where purchased in the market (Monday market) in Maiduguri metropolis Borno State Nigeria (fried, frozen and fresh) chickens respectively. The sample were aseptically collected in a clean polythene bag and were transported immediately to laboratory for further bacteriological analysis and it was carried out as described by the method of (Fawole and Oso, 2004).

SAMPLE PREPARATION

Ten (10) gram of each part of the sample of the three different kinds of processing chicken were cut using sterile blade and weighed out and homogenized in 90ml of sterile distilled water using a sterilized blender. Ten-fold serial dilution of the homogenates were made using sterile pipette as described by the method of (Fawole and Oso, 2004).

CULTURING, INOCULATION AND ISOLATION

All the chemical and reagent used were of analytical grades, media used in this study included nutrient agar as general media, other media with selective and differential media characteristic used were MacConkey agar, blood agar eosin methylene blue, and manitol salt agar. All media were prepared according to manufactures specification and were sterilized at 121oc for 15mins.

From the ten fold serial dilution the sample were plated in replicate on nutrient agar using a pour plate method and was then incubated at 37^{o}C for 24hrs. At the end of the incubation period colonies were counted using colony counter and was express as colony forming unit of the suspension (cfu). Discrete colony were picked from the nutrient agar and sub-cultured onto blood agar, macConkey agar, manitol salt agar and eosine methylene blue, it was then incubated at 37^{o}C for 24 hours, colonies were identified base on their growth and further gram staining and biochemical test was conducted to ascertained the isolates (Fawole and Oso, 2004). Biochemical tests such as catalase, coagulase and urease was performed to ascertain the isolates

RESULT PRESENTATION

TABULATION OF RESULT

TABLE 1; Total heterotrophic bacterial count on nutrient agar plate

Sample	Total bacterial count (cfu)
Fresh chicken	$5.78x10^4$
Frozen chicken	$4.04x10^4$
Fried chicken	$2.60x10^2$

Table 2: bacterial isolates

Sample	Bacterial isolates
Fresh chicken	*Escherichia coli*, *Bacillus* species, *Streptococcus species, and Staphylococcus aureus*
Frozen chicken	*Escherichia coli and Staphylococcus aureus*
Fried chicken	Bacillus species, Streptococcus species

DISCUSSION OF RESULT

Table 1 showed a total bacterial count of $5.78x10^4$ in fresh chicken, $4.04x10^4$ in frozen chicken and $2.60x10^2$ in fried chicken. The outcome might be as results of different treatment confer on the meat. Bacterial isolated from the sample in table2 are *Bacillus* species*, Streptococcus* specie*s, Escherichia coli and Staphylococcus* species by comparing the morphological and biochemical characteristic with standard reference organism. Bacteria isolated from this study have been found earlier in foods, environment and other places and their pattern is similar to previous (Clerence *et al,* 2009). According to Doyle (2007), food borne disease are diseases resulting from ingestion of bacteria toxins and cells produced by microorganism present in food during food handlers as poor hygiene is a factor. *Escherichia coli* and *Staphylococcus aureus* are normal flora in human and animals their presence in foods are indicated of the excessive human handling

The presence of these organisms in the fresh, frozen and fried chicken sample depicts a deplorable state of poor hygienic and sanitary practice employed in slaughtering processing, and packaging of chicken from the result obtain fresh chicken sample were contaminated with high level of *Staphylococcus aurues, Escherichia coli, Streptococcus* species and *Bacillus* species. This agrees to the previous reported by (Clarence *et al,*2009) who reported *Staphylococcus* species*, Ecoli*, *Bacillus* species, *Salmonella* species, and *Citrobacter* species. The frozen chicken sample were contaminated with *Staphylococcus aureus* and *Escherichia* species, this is similar to the reported by(okonko *et al,*2009) *Enterobacter* species, *Staphylococcus* species and *Ecoli* in palm of all frozen seafood processors/ handlers and water use by them. The fried chicken sample were contaminated with high level of *Bacillus* species an *Staphylococcus aureus* .

CONCLUSION

It is concluded that all the chicken meat samples analyzed appears to be contaminated with at least two bacteria but fresh chicken posses the highest microbial load. This is perharps because fried and frozen are at least subjected to some physical treatments.

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Growth Performance of Sorghum (*Sorghum bicolor* L. Moench) as Influenced by Variety and Weed Control Treatment in a Semi-Arid Ecology of Nigeria

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Abstract: *Field trials were conducted at two different locations during the 2020 rainy season to determine the growth performance of sorghum as impacted by variety and weed control in a semi-arid ecology of Nigeria. The experimental treatments comprised three varieties (var. ICSV-400, Local Kaura and Zauna inuwa [SAMSORG-47]) and eight weed control treatments (Weedy check, hoe weeding at 3 & 6 WAS, pendimethalin at 1.5 kg a.i.ha^{-1}, pendimethalin at 2.0 kg a.i.ha^{-1}, pendimethalin at 1.5 + glyphosate at 1.5 kg a.i.ha^{-1}, pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS, glyphosate at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, glyphosate at 1.5 + pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS. The treatments were arranged in a split plot design with varieties and weed control treatments assigned to the main and sub plots, and was replicated three times. Findings reveals that the application of glyphosate at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, glyphosate at 1.5 + pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS produced significantly ($P \leq 0.05$) more growth parameters (plant height, number of leaves plant^{-1}, leaf area and leaf area index) of sorghum. It also significantly ($P \leq 0.05$) produced shorter number of days to 50% booting, heading and flowering compared to other weed control treatments, while on the other hand, it also significantly ($P \leq 0.05$) recorded higher weed control index and treatment efficiency index of sorghum alongside Zauna inuwa and Kaura varieties by smothering the growth of weeds. Based on findings from this study, farmers in the Sudan and the Northern Guinea Savanna region of Nigeria can adopt the cultivation of the zauna inuwa (SAMSORG 47) variety with application of either glyphosate at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, glyphosate at 1.5 + pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS, for effective weed control in sorghum production to increase food supply for the teaming human population in both locations.*

Keywords: *Growth, varieties, sorghum, weed control, semi-arid*

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench), which has a special adaptation to the climate of Africa, evolved there. According to Paterson (2008), it is the fifth-most significant cereal crop in the world and follows maize as the second-most significant cereal crop in Africa and Nigeria (Borrell *et al.,* 2014; FAOSTAT, 2015). In many developing nations in the semi-arid tropical regions of Africa, it is a staple food for small-scale farmers and is also grown as a forage crop (Mace *et al*., 2013). With an estimated 26 MT output in Sub-Saharan Africa, where Nigeria is the largest producer in Africa and second internationally after the United States, grain sorghum is cultivated on 42 million hectares worldwide (USDA, 2017). Because of its ability to grow in areas where maize does not do well, more of its grains are used as local food in a variety of ways, including semi-leavened bread, couscous, dumplings, fermented and non-fermented porridges, alcoholic and non-alcoholic beverages, and straws for livestock feed and house fencing (Abdelghafoor *et al*., 2011; Adegbola *et al*., 2013; Hariprasanna & Rakshit, 2016). In the manufacturing of syrup, sugar, and molasses among are other uses (Berenji *et al*., 2011; Cole *et al*., 2017; Jiang *et al*., 2020). Nevertheless, depending on the varieties grown in various ecologies, sorghum contributes significantly to the battle against hunger and food insecurity (Mathur *et al*., 2017). The increased market awareness of the crop as a result of its industrial potential in the milling, malting, and brewing industries has also brought about competition between grain for human consumption and grain for industrial usage (Ajeigbe *et al*., 2017; KFFC, 2018). Sorghum production is unfortunately constrained by a number of biotic (weeds, insect pests, illnesses, pathogens, choice of cultivar) and abiotic factors (marginal soils, unpredictable rainfall, tillage techniques, irrational/inadequate fertilizer use, etc.). One of the most severe biotic pressures is weed infestation from striga and other weed biotypes, which lowers grain yield and biomass and prevents the attainment of food security yields (Ball *et al*., 2019). Infestations of weeds are a barrier to any crop production venture (Gage & Schwartz, 2019; Nwosisi *et al*., 2019), compete favorably with crops for limited growth resources like moisture, nutrients, space, and light, and can also harbor pests and diseases that infest crops (Abraham *et al*., 2021; Tibugari *et al*., 2020), among other negative effects. However, according to a study by Ndjeunga *et al*. (2015), only roughly 20% of Nigeria's total sorghum production area is planted with improved cultivars. The need to overcome the limitations of weed infestation and cultivar selection becomes essential in order to raise demand for sorghum and assure food security. Therefore, the studies were conducted with the aim of evaluating the growth performance of some varieties of sorghum as influenced by weed control treatments in the Sudan and Northern Guinea Savanna ecologies of Nigeria.

MATERIALS AND METHODS

Field experiment was carried out at the Research and Teaching farm of the Faculty of Agriculture, Bayero University, Kano (Lat. 11^{O}.58" N and Long. 8^{O}.26' E, 460m *above sea level*) and at the Abubakar Tafawa Balewa University, Bauchi Teaching and Research Farm, Gubi, (Lat. 10^{o} 45' N and Long. 9^{o}.82' E, 616m *above sea level*); situated in the Sudan and Northern Guinea savanna ecological zones, respectively. The experiments comprised of three sorghum varieties; ICSV-400, Local Kaura and Zauna inuwa (SAMSORG 47) and eight (8) weed control treatments; Weedy check (control), Hoe weeding at 3 & 6 WAS, Pendimethalin 1.5 + Glyphosate 1.5 kg a.i.ha^{-1}, Pendimethalin 2.0 kg a.i.ha^{-1}, Pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS, pendimethalin 1.5 + Glyphosate 1.5 kg a.i.ha^{-1}, Glyphosate 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, Glyphosate 1.5 + Pendimethalin 1.5 kg a.i.ha^{-1}+ SHW at 6 WAS. The experimental treatments were replicated three times and arranged in a split plot design with variety assigned to the main plots while weed control treatment were assigned to sub plots. The land in both locations were cleared and prepared into ridges then marked into the required number of plots each of gross plot size of 3 m x 4 m (12 m^2) and net plot size of 1.5 m x 3m (4.5 m^2). The ally between main plots, sub-plots and replicates were 1.0 m, 0.5m and 1.5m and five (5) seeds were sown at the spacing of 0.75m × 0.25 m inter and intra row spacing, respectively. Pre emergence herbicides (pendimethalin and glyphosate) were applied a day after sowing using a Knapsack sprayer while nutrients at the rate of 64 N, 30 P_2O_5 and

30 K_2O Kg ha^{-1}. Basal application of 30 N-30 P_2O_5-30 K_2O Kg using NPK 15:15:15 fertilizer was done at sowing while the remaining balance of 34 Kg N was side placed at 4 WAS using Urea (46% N). Weeding was carried out in plots with supplementary hoe weeding as well as hoe weeded plots. All other agronomic practices were duly observed and carried out as at when due. Data were collected on growth and weed parameters of sorghum varieties using standard agronomic procedures. The growth parameters recorded were plant height, number of leaves, leaf area, leaf area index, days to 50% booting, heading and flowering, leaf chlorophyll content and seedling vigor while the weed parameters include weed specie composition, treatment efficiency index, weed index and weed control index. Data collected were subjected to analysis of variance (ANOVA) using Genstat (17th edition). Significant means were separated using the Student-Newman Keuls (SNK) at 5% probability level.

RESULTS AND DISCUSSION

The physico-chemical analysis of the soil of the experimental sites revealed that the textural classes of the soil in two locations were sandy loam with a pH value of 6.37 and 5.94 (slightly acidic) for Kano and Bauchi, respectively. Organic carbon, on the other hand, was found to be low with a value of 1.80 and 2.24g kg^{-1} for both locations, respectively. The total nitrogen content of the soil in Kano (0.24 gkg^{-1}) and Bauchi (0.99 gkg^{-1}) was high, while the available phosphorus was found to be low in Kano (4.87) but high in Bauchi (10.09). The mean of the combined analysis on the influence of location, weed control and variety on plant height at 6, 8, 10 and 12 WAS of sorghum is shown in Table 1. Weed control was significant at 6, 8, 10 and 12 WAS, whereas variety was significant at 8, 10, and 12 WAS, but location and interaction effects were not significant ($P \geq 0.05$) during the sampling periods. At 6 WAS, the application of pendimethalin at 2.0 kg a.i.ha^{-1}, Pendimethalin 1.5 + Glyphosate at 1.5 kg a.i.ha^{-1}, pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS, and Glyphosate 1.5 + Pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS significantly ($P \leq 0.05$) resulted in producing shorter plant compared to weedy check, hoe weeded at 3 and 6 WAS, pendimethalin at 1.5 kg a.i.ha^{-1}, and Glyphosate 2.0 kg a.i.ha^{-1} + SHW at 6 WAS that significantly ($P \leq 0.05$) produced taller plants. At 8 and 10 WAS, unweeded and hoe-weeded at 3 and 6 WAS significantly ($P \leq 0.05$) produced taller plants, though on par with the rest of the weed control treatments which produced shorter plants. Similarly, at 12 WAS, the unweeded significantly ($P \leq 0.05$) produced taller plants, which was comparable with the remaining treatments. Plant height may have grown in unweeded plots due to interspecific and intraspecific competition between sorghum and weeds for scarce growth resources. Growing taller is a strategy for competing with weed biotypes for moisture, space, and sunshine as a result of this struggle for survival and superiority. The phytotoxic action of the herbicide, especially pendimethalin, either alone or in combination with glyphosate, which is capable of lowering crop growth indices, might be responsible for decreases in plant height as observed in herbicidal treated plots. Nevertheless, as the season progresses, the phytotoxic effect becomes less, giving the crop a greater competitive edge and producing more robust plants. The results of Shittu (2015) and Shittu *et al*. (2021), who independently reported on the phytotoxicity of pendimethalin on sorghum and roselle, are corroborated by this finding. The ability of Kaura variety to produced significantly ($P \leq 0.05$) taller plants over other variety could be due to variation in growth habit as it is in their genetic makeup. Varieties ICSV-400 and Zauna inuwa attained their maximum heights and stopped increasing in height while Kaura continued to increase in height. This was in line with Abdulsalam *et al*. (2018) who attested to the fact that differences exist among sorghum varieties on the basis of height of the plants due to their inherent genetic composition. The ability of the Kaura variety to produce significantly ($P \leq 0.05$) taller plants than other varieties could be due to variation in growth habits which is traced to their genetic makeup. The ICSV-400 and Zauna inuwa varieties reached their top heights and ceased growing, whereas the Kaura variety kept growing. This was in line with the findings of Abdulsalam *et al*. (2018), who confirmed that differences in sorghum varieties' plant height occur due to their innate genetic makeup.

The mean of combined analysis on the influence of location, weed control and variety on the number of leaves plant^{-1} at 6, 8, 10 and 12 WAS of sorghum is shown in Table 2. The number of leaves plant^{-1} had significant effect at 6 and 8 WAS only. Application of glyphosate at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS significantly ($P \leq 0.05$) produced a greater number of leaves compared with pendimethalin at 2.0 kg a.i.ha^{-1}, which resulted in a less number of leaves plant^{-1} at 6 WAS. Additionally, at 8 WAS, the application of glyphosate at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS significantly ($P \leq 0.05$) produced higher number leaves plant^{-1} although at par with the other weed control treatments. This was presumably owing to the phytotoxic action of pendimethalin rather than glyphosate on sorghum, which translates to less number of leaves at the early growth stages, yet the crop was able to detoxify the active ingredients and compete favorably with other herbicidal treatments. This is consistent with the findings of Bandyopadhyay and Choudhury (2009), who discovered that in light sandy loam soil, pendimethalin can penetrate to the root zone and exert phytotoxic effects in the presence of enough moisture. According to Zain *et al*. (2020), pendimethalin can inhibit plant root and shoot growth regardless of application rate. Zauna inuwa at 6, 10 and 12 WAS significantly ($P \leq 0.05$) produced a greater number of leaves than other varieties, while at 8 WAS, zauna inuwa and kaura varieties significantly ($P \leq 0.05$) recorded a greater number of leaves plant^{-1} than ICSV-400. There was no significant ($P \geq 0.05$) effect noticed with respect to location and interactions.

The results of a mean combined analysis on the effects of location, weed control, and variety on the leaf area and leaf area index of sorghum at 6, 8, 10, and 12 WAS are presented in Tables 3 and Table 4. The outcomes demonstrated that weed control was notable at 6, 8, and 12 WAS. Despite being at par, the remaining weed control treatments resulted in generating larger leaves compared with the unweeded which substantially ($P \leq 0.05$) produced smaller leaves. Sorghum's decreased leaf area and leaf area index can be attributed to unchecked weed competition for the available resources for growth, which forced the crop to divert its assimilates to grow taller in order to compete for space and sunlight at the expense of leaf area expansion. The phytotoxic action of pendimethalin, which was previously reported by Zain *et al*. (2020) and Shittu *et al*. (2021) on the number of leaves and plant height, respectively, while glyphosate was found to be less toxic, could be explained by the fact that glyphosate produced significantly ($P \leq 0.05$) larger leaves than pendimethalin rates and its combination. However, the crop was able to counteract pendimethalin's phytotoxicity as the season progressed, thereby performing similar to glyphosate either alone or in combination. A similar observation was noted by Hameed *et al*. (2017) and Jantar *et al.* (2017) and when they reported higher growth and yield performance of cotton and sorghum due to herbicide application, respectively. Zauna inuwa significantly ($P \leq 0.05$) produced larger leaves than the remaining varieties at 8, 10 and 12 WAS, respectively. Nonetheless, the genetic makeup of the variety's stay-green characteristics and lately maturity than other varieties make this conceivable. Similar to this, at 10 and 12 WAS, zauna inuwa and local kaura substantially ($P \leq 0.05$) generated larger leaf indices than ICSV-400. This is most likely because these varieties mature later than ICSV-400, which matured sooner. Thus, all growth indexes come to an end. Conley *et al*. (2005) and Thakur *et al*. (2009) discovered that greater leaf area provides a bigger surface for the interception of radiation and other growth resources, compensating for inter- and intra-crop competition and resulting in increased productivity. For leaf area and leaf area index, however, there were no location- and interaction-related effects that were significant ($P \geq 0.05$) across the sampling periods.

Table 5 shows the mean of the combined analysis on the impact of location, weed control, and variety on the number of days to 50% booting, heading, and flowering. The findings demonstrated that days to 50% booting, heading, and flowering had a substantial impact on weed control, variety, and location. Unweeded plots required considerably more days to reach the stages of 50% booting, heading, and flowering than alternative weed control treatments, which required fewer days to achieve these stages. This may be a result of weed competition in the weedy check plots, which hinders the sorghum from booting and flowering early, as well as weed suppression from other weed control treatments, which reduced weed populations and enhanced crop development and yield in sorghum during the study period. Pacanoski and Mehmeti (2019) and Kanataz *et al*. (2020) showed similar findings in wheat and soybean, respectively. Due to the variety's late maturation and longer time to reach the reproductive stage compared to its co-varieties ICSV-400 and Kaura, which reach the reproductive stage ealier, Zauna Inuwa substantially ($P \leq 0.05$) recorded the greatest days to 50% booting, heading, and flowering. This was consistent with the National Committee on Variety Naming, Registration, and Release of Nigeria's (2018) reports, which identified the variety as a late maturing one. In a similar vein, Gosh *et al*. (2015) also noted that the sorghum variety with the tallest plants and the most delayed maturation had the best yield. Sorghum has responded differently to the times of booting, heading, and flowering in each location. Sorghum grown in Kano significantly ($P \leq 0.05$) took a longer number of days to attain the 50% booting, heading, and flowering periods than those grown in Bauchi. This could be attributed to prevailing climatic conditions across the two locations. The genetic response of sorghum accessions to different agro-ecologies could be determined by the inherent and flower, which can also be influenced by varying climatic conditions across the savanna ecologies (temperature, late drought). Drought has been shown to reduce nutrient uptake by roots and induce nutrient deficiency by decreasing the diffusion rate of nutrients from soil to root, creating restricted transpiration rates and impairing active transport and membrane permeability, thus resulting in a longer number of days to resume physiological reproductive activities. Similar findings were reported by Msongaleli *et al*. (2015) and Reddy (2019) on sorghum.

Table 5 shows the mean of the combined analysis on the influence of location, weed control, and variety on weed control index, treatment efficiency index and weed index of sorghum. The findings demonstrated that weed control considerably affected WCI, TEI, and WI, while variety significantly affected TEI and WI. Other weed control methods were closely followed by the application of Glyphosate at 1.5 + Pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS, which resulted in a much higher WCI. The weedy check, however, record a zero TEI and WCI. While other treatments produced lower WI, the unweeded (control) had a much greater WI than other treatments. Higher WCI and TEI values were achieved due to the efficacy of weed control treatments in significantly covering weed development when compared to unweeded plots that recorded zero index due to continuous weed competition. Mardhavi *et al*. (2013), Ehsas *et al*. (2014), and Kumar *et al*. (2017) reported similar findings in maize. Higher TEI was significantly ($P \leq 0.05$) produced by the Zauna inuwa and kaura varieties, whereas a higher weed index was notably produced by ICSV-400. Variation in sorghum cultivar genetic make-up may be responsible for Zauna inuwa and kaura producing larger leaf surfaces and growing taller for intercepting sunlight which can as well smoother growth of weeds within its vicinity than ICSV-400, which lacks such property. Separate reports on morphological variation in sorghum landraces were made by Muui (2015), Muhammad *et al*. (2017), and Mathur *et al*. (2017). Location did not appear to have any significant ($P \geq 0.05$) effects, however there was a significant interaction with TEI where Zauna inuwa in glyphosate at 1.5 + pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS significantly ($P \leq 0.05$) produced higher TEI though at par with Kaura in same treatment compared with the rest of the interaction effects. This is, however, possible due to the efficacy of the weed control treatments with varieties that are effective in smothering the growth of weeds, thereby enhancing the efficiency of the treatments. Galon *et al*. (2016) reported a similar finding concerning the selectivity and efficiency of herbicides in weed control on sweet sorghum varieties in Brazil. Similarly, Vinothini and Arthanari (2017) reported the efficacy of pre-emergence herbicide plus hand weeding for effective weed management on irrigated kodo millet in India.

CONCLUSION AND RECOMMENDATIONS

The application of all the weed control treatments comparable resulted in producing taller plants, while kaura varieties produced the tallest plant than other cultivar. The application of glyphosate at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, glyphosate at 1.5 + pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS produced significantly ($P \leq 0.05$) more number of leaves plant while Zauna inuwa variety had more number of leaves than other varieties under investigation. Similarly, the application of glyphosate at 1.5 + pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS significantly resulted in producing larger leaf area and leaf are index, shorter number of days to 50% booting, heading and flowering compared to other treatments, while on the other hand, it also significantly ($P \leq 0.05$) recorded higher weed control index and treatment efficiency index of sorghum alongside Zauna inuwa and Kaura varieties by smothering the growth of weeds. Based on findings from this study, farmers in the Sudan and the Northern Guinea Savanna region of Nigeria can adopt the cultivation of the zauna inuwa variety with application of either glyphosate at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, glyphosate at 1.5 + pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS, for effective weed control in sorghum production to increase food supply for the teaming human population.

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Table 1: Mean of combined analysis across locations on plant height at 6, 8, 10 and 12 WAS of sorghum varieties as influenced by weed control during 2020 rainy season

Treatments	Plant height (cm)			
	Weeks after sowing (WAS)			
	6	8	10	12
Weed Control (W)				
Unweeded	80.9a	120.2a	165.6a	181.8a
Hoe weeding at 3 and 6 WAS	80.9a	114.0a	160.5a	176.1ab
Pendimethalin 1.5 kg a.i.ha^{-1}	85.2a	90.1bcd	129.8ab	166.1ab
Pendimethalin 2.0 kg a.i.ha^{-1}	53.6b	86.9cd	120.3b	164.4ab
Pendimethalin 1.5 + Glyphosate at 1.5 kg a.i.ha^{-1}	57.8b	79.2d	136.3ab	158.0ab
Pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	53.8b	103.0abc	158.4ab	154.8ab
Glyphosate 2.0 kg a.i.ha^{-1} + SHW at 6 WAS	94.1a	110.1ab	153.5ab	167.7ab
Glyphosate 1.5 + Pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	53.8b	80.8cd	135.5ab	145.5b
P of F	<.001	<.001	0.008	0.043
SE±	4.39	6.01	9.71	8.06
Variety (V)				
ICSV-400	66.8	94.6b	129.7b	140.5b
Kaura	74.1	105.9a	169.8a	203.6a
Zauna Inuwa (SAMSORG 47)	69.6	93.6b	135.3b	145.0b
P of F	0.162	0.037	<.001	<.001
SE±	2.69	3.68	5.95	4.94
Location (L)				
Kano	68.9	96.4	143.4	161.6
Bauchi	71.5	99.6	146.5	164.5
P of F	0.410	0.453	0.656	0.603
SE±	2.20	3.01	4.86	4.03
Interaction				
V x W	0.470	0.606	0.913	0.772
V x L	0.991	0.996	1.000	0.999
W x L	1.000	1.000	1.000	1.000
W x V x L	1.000	1.000	1.000	1.000

Means followed by common letter(s) in a column are not significantly different at 5% according to Student-Keuls test (SNK); WAS = Weeks after sowing, SHW = Supplementary hoe weeding.

Table 2: Mean of combined analysis across locations on number of leaves at 6, 8, 10 and 12 WAS of sorghum varieties as influenced by weed control during 2020 rainy season

Treatments	Number of leaves plant^{-1}			
	Weeks after sowing (WAS)			
	6	8	10	12
Weed Control (W)				
Unweeded	6.67b	7.50abc	8.89	8.94
Hoe weeding at 3 and 6 WAS	7.00b	8.33ab	8.61	9.11
Pendimethalin at 1.5 kg a.i.ha^{-1}	5.44c	6.89c	8.89	8.78
Pendimethalin at 2.0 kga.i.ha^{-1}	5.44c	7.11bc	8.67	9.56
Pendimethalin at 1.5 + Glyphosate 1.5 kg a.i.ha^{-1}	5.56c	7.00bc	8.28	8.89
Pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	4.89c	6.67c	8.06	8.44
Glyphosate at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS	7.56a	8.67a	9.28	9.61
Glyphosate at 1.5 + Pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	6.56b	7.89abc	8.22	8.44
P of F	<.001	<.001	0.395	0.122
SE±	0.184	0.344	0.415	0.341
Variety (V)				
ICSV-400	5.79b	6.81b	7.17c	6.83c
Kaura	5.63b	7.58a	8.71b	8.23b
Zauna Inuwa (SAMSORG 47)	7.00a	8.12a	9.96a	11.85a
P of F	<.001	<.001	<.001	<.001
SE±	0.113	0.210	0.254	0.209
Location (L)				
Kano	6.14	7.51	8.58	8.90
Bauchi	6.14	7.50	8.64	9.04
P of F	1.000	0.955	0.850	0.566
SE±	0.092	0.172	0.207	0.170
Interaction				
V x W	0.011	0.455	0.992	0.019
V x L	1.000	0.997	0.991	0.785
W x L	1.000	1.000	1.000	1.000
W x V x L	1.000	1.000	1.000	1.000

Means followed by the same letter(s) in a column are not significantly different at 5% according to Student-Newman-Keuls test (SNK). WAS = Weeks after sowing, SHW = Supplementary hoe weeding.

Table 3: Mean of combined analysis across locations on leaf area (cm) at 6, 8, 10 and 12 WAS of sorghum varieties as influenced by weed control during 2020 rainy season

Treatments	Leaf area (cm^2)			
	Weeks after sowing (WAS)			
	6	8	10	12
Weed Control (W)				
Unweeded	107.9d	245.6c	371.0	325.0b
Hoe weeding at 3 and 6 WAS	234.0ab	401.4a	441.0	466.0a
Pendimethalin at 1.5 kg a.i.ha^{-1}	250.7ab	347.0abc	390.0	411.0ab
Pendimethalin at 2.0 kg a.i.ha^{-1}	209.0abc	310.9ab	431.0	474.0a
Pendimethalin at 1.5 + Glyphosate 1.5 kg a.i.ha^{-1}	187.5bcd	263.0bc	362.0	405.0ab
Pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	134.6cd	291.8abc	365.0	419.0ab
Glyphosate at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS	286.2.0a	371.7ab	431.0	508.0a
Glyphosate at 1.5 + Pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	119.0cd	264.9bc	367.0	404.ab
P of F	<.001	<.001	0.691	0.002
SE±	24.27	28.11	41.9	30.4
Variety (V)				
ICSV-400	180.0	268.1b	346.0b	320.0c
Kaura	183.0	307.5b	282.0b	381.0b
Zauna Inuwa (SAMSORG 47)	210.7	360.5a	555.0a	578.0a
P of F	0.279	0.001	<.001	<.001
SE±	14.86	17.22	25.7	18.6
Location (L)				
Kano	190.1	310.9	393.	425.
Bauchi	192.3	313.2	396	428.
P of F	0.900	0.909	0.926	0.900
SE±	12.13	14.06	21.0	15.2
Interaction				
V x W	0.187	0.144	0.919	0.513
V x L	0.999	0.995	0.999	1.000
W x L	1.000	1.000	1.000	1.000
W x V x L	1.000	1.000	1.000	1.000

Means followed by the same letter(s) in a column are not significantly different at 5% according to Student-Newman-Keuls test (SNK). WAS = Weeks after sowing, SHW = Supplementary hoe weeding.

Table 4: Mean of combined analysis across locations on leaf area index at 6, 8, 10 and 12 WAS of sorghum varieties as influenced by weed control during 2020 rainy season

Treatments	Leaf area index			
	Weeks after sowing (WAS)			
	6	8	10	12
Weed Control (W)				
Unweeded	1.57d	2.26c	2.69c	2.78c
Hoe weeding at 3 and 6 WAS	2.82ab	3.66ab	4.19a	4.73a
Pendimethalin at 1.5 kg a.i.ha^{-1}	3.25a	4.09a	4.33a	4.59ab
Pendimethalin at 2.0 kg a.i.ha^{-1}	2.08cd	3.15b	3.69ab	4.43ab
Pendimethalin at 1.5 + Glyphosate 1.5 kg a.i.ha^{-1}	1.98cd	2.82bc	3.49ab	4.05b
Pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	2.52bc	3.14b	3.89ab	4.48ab
Glyphosate at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS	2.90ab	3.60ab	4.28a	4.74a
Glyphosate at 1.5 + Pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	2.50abc	3.23b	3.94ab	4.67ab
P of F	<.001	<. 001	0.006	0.016
SE±	0.192	0.223	0.215	0.199
Variety (V)				
ICSV-400	2.42	3.09	3.57b	3.90b
Kaura	2.45	3.32	3.99a	4.60a
Zauna Inuwa (SAMSORG 47)	2.49	3.33	4.20a	4.84a
P of F	0.922	0.381	0.005	<.001
SE±	0.118	0.136	0.132	0.122
Location (L)				
Kano	2.39	3.18	3.886	4.364
Bauchi	2.52	3.32	3.890	4.526
P of F	0.363	0.375	0.978	0.250
SE±	0.096	0.111	0.108	0.099
Interaction				
V x W	0.952	0.981	0.918	0.904
V x L	1.000	0.985	0.999	0.994
W x L	1.000	1.000	1.000	1.000
W x V x L	1.000	1.000	1.000	1.000

Means followed by the same letter(s) in a column are not significantly different at 5% according to Student-Newman-Keuls test (SNK). WAS = Weeks after sowing, SHW = Supplementary hoe weeding

Table 5: Mean of combined analysis across locations on number of days to 50% booting, heading and flowering
of sorghum varieties as influenced by weed control during 2020 rainy season

Treatments	Days to 50% booting	Days to 50% heading	Days to 50% flowering
Weed Control (W)			
Unweeded	91.78a	95.78a	97.72a
Hoe weeding at 3 and 6 WAS	80.61c	84.83c	87.72c
Pendimethalin at 1.5 kg a.i.ha^{-1}	85.61b	90.22b	92.17b
Pendimethalin at 2.0 kg a.i.ha^{-1}	82.39c	87.39bc	89.22bc
Pendimethalin at 1.5 + Glyphosate 1.5 kg a.i.ha^{-1}	82.28bc	87.00bc	89.94bc
Pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	81.83bc	86.67bc	88.00c
Glyphosate at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS	80.61c	85.61c	87.39c
Glyphosate at 1.5 + Pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	80.33c	85.56c	87.72c
P of F	<.001	<.001	<.001
SE±	1.075	1.080	1.024
Variety (V)			
ICSV-400	72.04b	78.10b	80.73b
Kaura	72.94b	76.46b	79.77b
Zauna Inuwa (SAMSORG 47)	104.62a	109.08a	110.46a
P of F	<.001	<.001	<.001
SE±	0.658	0.662	0.627
Location (L)			
Kano	84.00a	88.92a	90.82a
Bauchi	82.40b	86.85b	89.15b
P of F	0.038	0.008	0.024
SE±	0.538	0.540	0.512
Interaction			
V x W	0.293	0.338	0.356
V x L	0.992	0.994	0.825
W x L	1.000	1.000	0.993
W x V x L	1.000	1.000	1.000

Means followed by the same letter(s) in a column are not significantly different at 5% according to Student-Newman-Keuls test (SNK). WAS = Weeks after sowing, SHW = Supplementary hoe weeding

Table 6: Mean of combined analysis across locations on weed control index, treatment efficiency index and weed index of sorghum varieties as influenced by weed control during 2020 rainy season

Treatments	Weed control index (%)	Treatment efficiency index (%)	Weed index (%)
Weed Control (W)			
Unweeded	-	-	64.89a
Hoe weeding at 3 and 6 WAS	79.89b	5.94b	-_
Pendimethalin at 1.5 kg a.i.ha^{-1}	50.89c	4.13b	35.11c
Pendimethalin at 2.0 kg a.i.ha^{-1}	52.56c	4.60b	34.44c
Pendimethalin at 1.5 + Glyphosate 1.5 kg a.i.ha^{-1}	58.00c	4.56b	38.44b
Pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	67.33b	4.70b	19.56d
Glyphosate at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS	52.56c	6.36b	18.89d
Glyphosate at 1.5 + Pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	77.22a	8.25a	15.56e
P of F	<.001	<.001	<.001
SE±	2.160	0.593	0.938
Variety (V)			
ICSV-400	60.14	3.29b	35.38a
Kaura	64.57	5.82a	31.19b
Zauna Inuwa (SAMSORG 47)	63.19	5.34a	30.67b
Level of probability	0.229	<.001	0.042
SE±	1.536	0.363	1.021
Location (L)			
Kano	49.9	4.45	33.2
Bauchi	49.9	5.18	32.8
P of F	1.000	0.087	1.000
SE±	1.441	0.297	1.344
Interaction			
V x W	0.627	<.001	0.510
V x L	1.000	0.981	1.000
W x L	1.000	0.999	1.000
W x V x L	1.000	1.000	1.000

Means followed by the same letter(s) in a column are not significantly different at 5% according to Student-Newman Keuls test (SNK). WAS = Weeks after sowing, SHW = Supplementary hoe weeding.

Table 6: Interaction effect of variety and weed control on treatment efficiency index of sorghum during 2020 rainy season combined location

	Weed control							
Variety	T1	T2	T3	T4	T5	T6	T7	T8
ICSV-400	_	4.4d-g	3.1fg	3.3efg	3.7d-g	4.0d-g	4.5d-g	5.7def
Kaura	_	5.7def	4.8d-g	4.8d-g	5.3d-g	6.0cde	8.8bc	13.1ab
Zauna inuwa	_	8.0bc	4.8d-g	4.9d-g	5.3d-g	6.23cd	6.3cd	14.1a
SE±				1.027				

T1 = Weedy check; T2 = Hoe weeding at 3 & 6 WAS; T3 = Pendimethalin at 1.5 + Glyphosate 1.5 kg a.i.ha^{-1}; T4 = Pendimethalin at 2.0 kg a.i.ha^{-1}; T5 = Pendimethalin 1.5 kg a.i.ha^{-1}; T6 = Pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS; T7 = Glyphosate at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS; T8 = Glyphosate at 1.5 + Pendimethalin 1.5 kg a.i.ha^{-1} + SHW at 6WAS.

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Reproductive Performance of Rabbit Feed With Graded of Balsam Apple (*Momordica balsamina*)

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Abstract: *This research was carried out at the Demonstration farm, College of Agriculture, Umaru Ali Shinkafi Polytechnic Sokoto. Sixty (60) rabbits were purchased, constituting 45 does and 15 bucks. The animals were housed in 15 pens containing 3 Does (female rabbit) and 1 buck each. Body weight of the animal was taken at the beginning of the research, subsequently, the animal was weighed for body weight changes. The Does were also weighed during gestation, also the kid were weighed pre and post weaning. Research ingredient such as maize, soya beans, wheat offal's and salt were being purchased from the Sokoto central market. Fresh M. balsamina was sourced from villages close to the Polytechnic. Bone meal and blood meal were sourced from the abattoir, milled and separately bagged for diet formulation. M. balsamina was dried under shade in an open air and fed coarsely along with concentrate. Five experimental diet was fed along with cowpea hay as balsal diet. M. balsamina was included 5,10,15 and 20% inclusion levels and designed as diet l,2,3,4 and 5 respectively. All the experimental animals were tagged, allowed two weeks pre-conditioning period and medicated against common disease like coccidiosis. They are also given prophylactic coccidiostat (Ample-vitracycline) via drinking water at the rate of one teaspoon into 4liters of water.The data was generated and subjected to analysis of variance (ANOVA) using general linear model in SAS (2002). Duncan multiple range test was used in separating the means where significant difference was recorded.*

Key words: *Reproductive, Performance, Rabbit, Balsam-apple, ANOVA*

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INTRODUCTION

The animal protein content of a typical Nigerian diet is about 17% of the total protein requirement, which is lower than 60% in the United Kingdom and 71% in New Zealand (World Bank, 2001). Pagot (1992) predicted a decline in protein intake to 5.3g per head per day by the year 2010 which would be the lowest in the world. The myriad attempt aimed at solving low protein intake and poverty alleviation by Nigerian government still remains a mirage (Nworgu and Hammed, 2009).

The reasons behind this inadequate intake of animal proteins includes short supply of animal products (such as, meat milk and egg) due to poverty, general economic recession and low level of production of the indigenous breeds of animals (Ogunbosoye and Babayemi, 2010).

In order to maximize food production and meet protein requirements in Nigeria, viable options need to be explored and evaluated (Owen *et al*., 2008). Amongsuch alternatives is the use of livestock species such as rabbit that have great potential for improved production.

Improved rabbit production can help in boosting the protein supply in Nigeria. Animal protein production from cattle, sheep and goat require much capital as compared to rabbit which has small body size and short gestation interval. Fast-growing animals such as rabbits possess a number of features that might be of advantage to the small holder subsistence – type integrated farming especially in developing countries. The potentials and attributes of rabbit which makes it unique among farm animals include, high growth rate, high efficiency of conversion, short gestation period, high prolificacy, low cost of production, high quality (meat which includes low fat, sodium, and cholesterol levels). Rabbit meat has a high protein level (about 20.8%) and its consumption is bereft of cultural and religious biases. (Jibir *et al.,* 2014). Rabbit meat is of high quality, it is high in protein and low in fat content (Mailafia *et al*., 2010).

Increasing demand and subsequent high cost of conventional animal feed ingredients coupled with increase in human population has created the need for sustainable alternatives, particularly natural feed resources. The use of forages and other agricultural by-products such as *Tridax precumbens*, Moringa (*Moringa oleifera*) (Odeyinka *et al*., 2008), Acacia (*Acasia nilotica*) (Abdu *et al*., 2011), composite cassava meal (Ukachukwu *et al*., 2011), and*Commelina benghalensis*, *Leucerna leucocephala, Boerhavia diffusa,* Impomia triloba (Yakubu *et al*., 2012) have been documented.

The physiology of farm animals is affected by several factors, one of which is nutrition (Ajao *et al.,* 2013). Nutritional status of an individual is dependent on dietary intake and effectiveness of metabolic processes. These can be determined by combinations of chemical, anthropometric, biochemical or dietary methods (Bamishaiye *et al.,* 2009). Feed is an important aspect of livestock production. The importance of feed supplementation in animal production has increased in the last few years (Sharifi *et al.,* 2011). Increase in meat production can be achieved through proper nutrition and inclusion of feed ingredients at normal or required levels (Etim and Oguike, 2010). Addass *et al.* (2012) posited that nutrition affects blood values of animals. Processing of feed could have effect on haematological parameters of farm animals (Aya *et al.,* 2013). Dietary content affects the blood profile of healthy animals as reported by (Herbert, 2002 Kortuglu *et al.,* 2005).

Isaac *et al.* (2013) stated that haematological components which consists of red blood cells, white blood cells or leucocytes, Mean Corpuscular Haemoglobin and Mean Corpuscular Haemoglobin Concentration are valuable in monitoring feed toxicity, especially, with feed constituents that affect the blood as well as the health status of farm animals. Aro and Akinmoegun (2012) and Aro *et al.* (2013) reported that haematological parameters like haematocrit value, haemoglobin concentration, white blood cell count and red blood cell count are used in routine screening for the health and physiological status of livestock and even humans. Aderemi (2004) reported that haematological traits especially Packed Cell Volume (PCV) and Haemoglobin (Hb) are correlated with the nutritional status of the animal. Isaac *et al.* (2013) stated that RBC is involved intransport of oxygen and absorbed nutrient. Blood viscosities are however, also affected by nutrition, especially, when processed agro-industrial wastes are taken into consideration. Livestock blood, for instance, may be subjected to hyperviscosity syndrome consequent on the feed they consume which may ultimately affect other blood values including haematocrit and erythrocyte sedimentation rate (Rosencranz and Bogen, 2006; Aro *et al.,* 2013).

M. balsamina L is commonly known as African pumpkin (or African cucumber), Balsam apple (or balsam pear) and locally called "Garahuni" (Hausa language), (Roger, 2007). It is a very good source of seventeen essential amino acids (Hassan and Umar, 2006). The plant is a perennial herb with soft stems and tendrils that climbs up shrubs, boundary fields and fences. The green leaves are deeply palmately 5-7 lobes about 12cm long with toothed and stalked margine. *M. balsamina* produces spindle shaped fruits (dark green when unripe and bright to deep orange when ripe). The seeds are embedded into a sweet edible red fleshy pulp testing like watermelon (Welman, 2004).

MATERIALS AND METHODS

The experiment was conducted at the College of Agriculture Demonstration farm, Umaru Ali Shinkafi Polytechnic Sokoto, Nigeria which is located at the main campus of the Polytechnic.

Experimental feed Sources

Experimental ingredients that were used in this experiment includes: maize, soya bean, wheat offal and salt which are all purchased from the Sokoto central market. Bone and Blood meal are sourced from the Sokoto metropolitan abattoir, milled and separately bagged for diet formulation. Fresh *M. balsamina* will be sourced from villages around Sokoto metropolis. The plant is dried under the shade in an open air.

Formulation of Experimental Diets

Four experimental diets were formulated and fed along with cowpea hay as basal diet. *M. balsamina* was included at 0, 2.5, 5 and 7.5%, inclusion levels. The diets were designated as diet 1, 2, 3, and 4 respectively in the experiment.

Table 1: Gross composition of the experimental diets (%)

		Treatment		
Ingresients%	1	2	3	4
M.balsamina	0	2.5	5.0	7.5
Maize	37.6	37.45	36.2	36.1
Cowpea hay	25.0	24.5	27.5	25.5
Soy bean	1.3	1.3	1.3	1.3
Meal				
Blood meal	10.0	9.5	9.5	9.5
Rice offal	12.4	11.2	6.7	6.8
Wheat offal	10.1	10.1	10.4	10.4
Bone meal	2.5	2.5	2.5	2.5
Premix	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5
Total	**100**	**100**	**100**	**100**
Calculated Chemical Composition				
Energy (ME/Kg)	2500.09	2500.40	2500.99	2500.30

Experimental Animals and Their Management

All the experimental rabbits were tagged. They were dipped with cinatic powder base on the instruction given by the manufacturer. Daily washing of feeders and drinkers, and disinfecting of the pens were also carried out.

Thirty adult mixed breed rabbits comprising of Chinchilla, New Zealand white and Dutch with an average weight of 2kg were purchased, constituting of 40 does and 20 bucks. The animals were housed in 20 pens containing 2 does and 1 buck each. The pens were made of concrete floor and zinc roofing and was partitioned into 12 pens. The rabbits were fed twice a day (morning and evening). Clean water and experimental diet were provided *ad-libitum*, plastic bowls were used as feeders and drinkers.

Experimental layout

Randomized Complete Block Design (RCBD) was used with four treatments replicated three times with 3 animals per replicate making a total of 60 rabbits.

Data collection

The data collected was in three phases, as follows:

Phase I

Reproductive performance of rabbits was taken at the end of the experiment. Subsequently the number of gestations does and total number of kittens produced per pen was counted and recorded. each rabbit will be weighed weekly. Feed intake will be recorded daily by subtracting the left over from the quantity of feed offered to the animals the previous day. Feed conversion ratio will be determined using feed intake and body weight gain.

Feed intake (g/rabbit) = Feed offered (g) – Leftover (g)

Feed conversion ratio (FCR) FCR = DM intake (g)/ live weight gain (g)

Average daily gain (ADG) = (final body weight-initial body weight)/total days of the experiment.

Phase II

Haematological assay

At the end of the experiment, all the males (4 males/ treatment) were humanely slaughtered for collection of 10 ml whole blood for haematology. Each 10ml blood sample was collected in a labelled ethylene-diamine tetra acetic acid (EDTA) bottle which serve as anti-coagulant Labeled samples (5ml each) and taken to the haematology laboratory, Usmanu Danfodiyo University Teaching Hospital Sokoto, for analysis.

Analytical technique

Analytical techniques are methods used in determining the following set parameters:

Haematological indices

Packed cell volume (PCV) and haemaglobin (Hb) concentration was determined by the microhematocrit and cyanmethaemaglobin methods respectively as described by Ewuola and Egbunike(2008). Erythrocyte was determined by the haematocytometry method as described by Ewuola and Egbunike (2008). Total white blood cells (WBC) and differential count was determined as described by Coles (1989). Erythrocyte indices including mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) was derived from the values obtained from red blood cells (RBC) count, haemaglobin concentration and PVC values (Mitruka and Rawnsley, 1977; Lamb, 1981; Jain 1986; Duncan *et al*., 1994). Derived as follows:

$$\text{MCV (fl)} = \frac{\text{PCV}}{\text{RBC Count in } 10^6/\text{mm}^3} \times \underline{10}$$

$$\text{MCH (pg)} = \frac{\text{Hb (g/dl)}}{\text{RBC (in } 10^6/\text{mm}^3)} \times \underline{10}$$

$$\text{MCHC (g/dl)} = \frac{\text{Hb (g/dl)}}{\text{PCV (\%)}} \times \underline{10}$$

Data Analysis

The data generated was subjected to analysis of variance (ANOVA) using general linear model in SAS, (2000). Least significant difference (LSD) was used in separating the means where significant differences existed among treatments at 5% probability level.

RESULTS AND DISCUSSION

Table 2: Gross composition of the experimental diets (%)

	Treatment			
Ingredients %	**1**	**2**	**3**	**4**
M. balsamina	0	2.5	5.0	7.5
Maize	37.6	37.4	36.2	36.1
Cow pea hay	25.0	24.5	27.5	25.0
Soy bean meal	1.3	1.3	1.3	1.3
Blood meal	10.0	9.5	9.5	9.5
Rice offal	12.4	11.2	6.7	6.8
Wheat offal	10.1	10.1	10.4	10.4
Bone meal	2.5	2.5	2.5	2.5
Premix	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5
Total	**100**	**100**	**100**	**100**
Energy (ME/Kg)	2500.09	2500.40	2500.99	2500.30
CP (%)	17.40	17.12	17.40	17.40
CF (%)	11.90	12.14	13.50	13.07

Chemical Analysis of Experimental Diet

Formulated experimental diets were analyzed for proximate components (crude protein, nitrogen free extract, crude fiber, ether extract, ash, energy and dry matter), as outlined by the Association of Official Analytical Chemists AOAC (2005).

Also, in the course of the experiment the test ingredient, *M. balsamina* was evaluated for toxins such as alkaloids, saponins and tannins content as outlined by AOAC (2005).

Experimental Animals and their Management

All the experimental rabbits were identified, allowed two weeks pre-conditioning period to acclimatize them, and medicated against coccidiosis and mange. They were given prophylactic coccidiostat (Ampro-vitracycline), via drinking water based on manufacture's recommended dose. They were dipped with cinatic powder base on the instruction given by the manufacturer. Daily washing of feeders and drinkers, and disinfecting of the pens were also carried out.

Thirty-six adult mixed breed rabbits comprising of Chinchilla, New Zealand white and Dutch with an average weight of 2kg were purchased, constituting 24 does and 12 bucks. The animals were housed in 12 pens containing 2 does and 1 buck each. The pens were made of concrete floor and zinc roofing and were partitioned into 12 pens. One m^2 per rabbit was used, based on Wayne (2009).

The rabbits were fed twice a day (morning and evening). Clean water and experimental diet were provided *ad-libitum*, plastic bowls were used as feeders and drinkers.

Chemical Composition of Experimental Diet

Proximate composition of the experimental diet showed that crude fibre is higher for treatment 4 and 3. The dry matter and nitrogen free extract composition of the diet decreased with increasing level of *M. balsamina.* The value for energy and crude protein were not comparable between the treatments (Table 3). Also, the phyto-chemical analysis of the test ingredient (*M. balsamina*) showed that there were some anti-nutritional factors present (Table 4).

The initial diet formulation was 0, 5, 10 1nd 15% inclusion levels of *M. balsamina*. In the course of the experiment, problem of abortion was encountered in treatment 3 and 4 at the second week of the experiment, which was attributed to the high level of the test ingredient. The diet was then amended by reducing the levels of the test ingredient to 0, 2.5, 5, and 7.5% inclusion levels.

Table 3: Proximate Composition of the Experimental Diets

Parameter	Treatment			
	1	2	3	4
Crude protein	17.34	18.06	15.36	16.08
Ether extract	2.86	2.78	4.75	3.39
Moisture	5.00	4.08	5.06	5.50
Fibre	8.03	9.10	10.82	12.88
Ash	9.85	9.95	10.95	8.35
Dry matter	95.00	95.92	94.94	94.50
Nitrogen free extract	56.92	56.03	53.06	53.80
Energy kcal/kg	2867.73	2856.67	2813.97	2755.26

Table 4: Phyto-chemical Components of *M. balsamina*

Parameter	Results
Flavonoids	-
Tannins	+
Saponin	+
Glycoside	+
Cardiac Glycoside	-
Steroid	+
Alkaloids	+
Saponin glycoside	+
Anthraquines	-
Phytate	4.65mg%
Oxalate	5.4mg%
Cyanide	0.06mg%
Tannins	1.89mg/ml
Nitrite	1.3ug/ml

Reproductive Performance of Rabbit Fed Graded with *M. balsamina*

Results indicate there is significant difference in reproductive performance between Rabbits fed with *M. balsam* and control group. The results shows that the higher the content of *M.balsam* in the feed the higher the number of kittens in a pen.

Table 5: Reproductive Performance of Rabbits Fed Graded Levels of *M. balsamina*

	Treatments			
Parameter	1	2	3	4
Feed intake (g/day)	228.56[a]	215.70[ab]	193.35[b]	186.14[b]
Number of gestation does	6	7	9	2
Number of kittens	10	14	17	3

CONCLUSION

The findings in this research concluded that *M.balsmina* is a herb that is rich in amino acids minerals. Hence, inclusion of it in the diet of rabbits indicates the increase in the reproductive performance of rabbits.

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Effect of Post-Harvest Losses on Food Security: A Review

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Abstract: *Food loss study in developing countries that fulfills the food demand of an increasing population remains a major global concern. More than one third of food is lost in postharvest operations. Household food security depends on a regular, sufficient and sustainable supply of food throughout the year. Food loss tends to reverse the gains made in producing enough food to achieve food security. Postharvest food losses are among the leading causes of food insecurity, thus an adequate food system is needed, together with efficient food distribution system from farm to consumer to reduce losses and improve income. In developing countries like Nigeria, post-harvest losses have been highlighted as one of the determinants of food shortage. Proper post-harvest storage, packaging, transport and handling technologies are practically insufficient for perishable crops like vegetables, thereby allowing considerable loss of produce.*

Key words: *Food Security, Handling, Loss, and Post-Harvest*

Introduction

According to Food and Agriculture Organization (FAO, 2014), food loss reduction complements effort to enhance food security. Reducing the incidence of postharvest losses along the marketing chain will contribute to improving food availability among farming households by making more income available, resulting in an increased economic access to food through job creation and income generation. The Democratic People Republic of Korea (DPRK) has implemented a mitigating postharvest losses control method to enhance food security (FAO, 2014). Food security and insecurity are terms used to describe whether or not households have access to sufficient quality and quantity of food. Food security is perceived at global, national, household and individual levels. One definition says that food security is a condition in which all people have access at all times to enough food of an adequate nutritional quality for healthy and active life (Adebayo, 2010). Household food security exists when all members of a household at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active healthy life (Abafita and Kim, 2014).

Household food security depends on a regular, sufficient and sustainable supply of food throughout the year. Food loss tends to reverse the gains made in producing enough food to achieve food security. Postharvest food losses are among the leading causes of food insecurity (FAO, 2006), thus an adequate food system is needed, together with efficient food distribution system from farm to consumer to reduce losses and improve income.

Concepts of Food Security

Food security is defined as a situation that exists when all people, at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Four dimensions of food security have been identified. These are food availability, accessibility, utilization and stability. All four of these dimensions must be achieved to have full food security (Babatunde *et al.,* 2007). More recent development in food security studies emphasize the importance of food sustainability which may be considered as the long-term (fifth) dimension to food security.

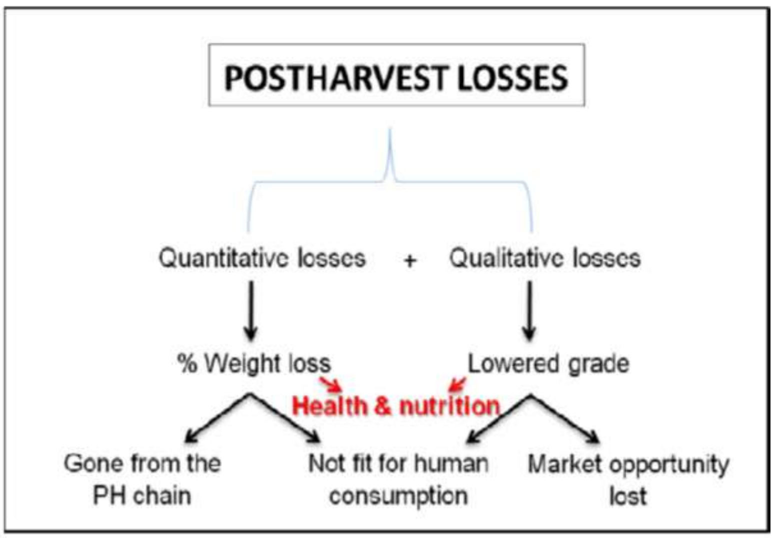
Peng and Benny (2019) are of the opinion that food security is best considered as a causal, linked pathway from production to consumption, through distribution to processing recognised in a number domain, rather than as four "pillars" or dimensions. Food security and food insecurity are dynamic, reciprocal and time dependent and the resultant status depends on the interaction between stresses of food insecurity and the coping strategies to deal with them. Measuring food security at the household level involves five categories of indicators including dietary diversity and food frequency, spending on food, consumption behaviours, experiential indicators and self-assessment measurements (Peng and Berry, 2019). This study adopts the food accessibility pillar as its concept of food security. It looks at the ability of households to purchase available food in sufficient quantities to meet household's food needs. This is related to the food spending of food category of Peng and Berry (2019).

Concept of Postharvest Food Losses

Postharvest loss can be defined as the degradation in both quantity and quality of a food produced from immediately after harvest to consumption. Quality losses include those that affect the nutrient/caloric composition, the acceptability and the edibility of a given product. These losses are generally considered in developed countries (Kader, 2002). Quantity losses refers to those that result in the loss of a portion of the amount of a given food product. Loss of quantity is more common in developing countries (Kitinoja, 2010).

Postharvest food loss (PHL) is the measurable qualitative and quantitative food loss along the supply chain, starting at the time of harvest till its consumption or other uses (Hodges, 2014). Postharvest loss can occur either due to food waste or due to inadvertent losses along the way. Thus, food waste is the loss of edible food due to human action or inaction such as throwing away wilted produce, not consuming available food before its expiry date, or taking serving sizes beyond one's ability to consume. Food loss on the other hand is the inadvertent loss in food quantity because of infrastructure and management limitations of a given food value chain. Food losses can either be the result of a direct quantitative loss or arise indirectly due to qualitative loss. Food loss and food waste contributed to postharvest food losses. Food loss can be quantitative as measured by decreased weight or volume or can be qualitative, such as reduction in nutrient value and unwanted changes in taste, colour, cosmetic features and texture of food (Buzby and Hyman, 2012). Quantitative food loss refers to the reduction in weight of food available for human consumption. The qualitative food loss can occur due to incidence of insect pest, mites, rodents and birds or from handling, physical changes or chemical changes in fat, carbohydrate and protein and by contamination of mycotoxins, pesticide residues, insects, fragments of excreta of rodents and birds and their dead bodies. When this qualitative deterioration makes food unfit for human consumption and is rejected, it contributes to food loss (Bada, 2016).

Postharvest losses (PHLs) consist of qualitative and quantitative losses (see Fig. 1). Qualitative losses occur as a result of either altered physical condition, perceived substandard value, deterioration in texture, flavor and or nutritional value whereas quantitative losses refer to physical losses of food as unfit for human consumption and hence readily discarded. Another aspect of postharvest loss is economic losses which apply when products of higher quality are restricted to lower markets. Only quantitative loss would be considered in the present study.



Source: Adapted from Morris and Kamarulzaman (2014)
Figure 1: Schematic diagram showing types of postharvest losses

Postharvest tomato loss refers to the degradation in both quantity and quality of tomato from harvest to consumption. Quality losses include those that lower the grade of the tomato quality and may affect the nutrient/caloric composition, the acceptability and the edibility of the given product (Kader, 2002). Quantity losses refer to tomato losses that result in the loss of weight/quantity of a product. Postharvest losses could also result in reduced nutrition and edibility. Loss of quantity is more common in developing countries while loss of quality is more common in developed countries (Kitinoja, 2011).

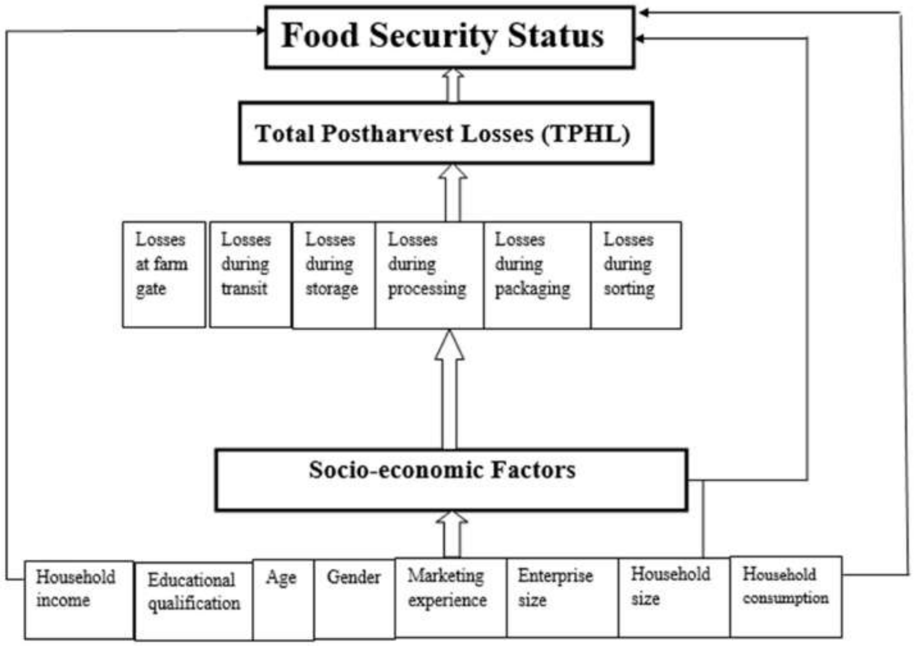


Figure 2: **Conceptual Framework for Postharvest Food Loss and its effect on food security**

Food security status is influenced by socio-economic factors such as household income, educational qualification, gender, age, marketing experience, enterprise size, household size and household consumption. Also, losses at various stages such as losses at farm gate, losses during transit, storage, processing, sorting and packaging are influence by the socio-economic factors of marketers. The state of socio-economic characteristics of marketers will eventually give rise to the total postharvest losses the greater the total postharvest losses the more the negative impact on the food security status of marketing households.

Morris (2014), de-categorize all activities in the postharvest system (postharvest handling and marketing) of the commodity in question into their tiniest bits and then directly measured their contribution to the overall losses. This study also described a similar framework for such assessment of postharvest losses in the supply chain where losses are broken down to losses at farm gate, transit storages, process packaging of salting as in Fig 2.2. A fact for typical agri-food marketing is that fresh produce quantity and quality reduce as products travels down the marketing chain. Heavily deteriorated products end up being discarded as food waste while partially deteriorated produce may end up at reduced price values. The discarded produce and those provoking price reduction due to perceived reduced quality represents the quantitative and qualitative losses respectively. Both kinds of losses (qualitative and quantitative) when added, give the total amount of losses along the marketing chain. This total loss is the PHLs for that particular marketing chain and can be expressed as:

$$\text{Total Postharvest losses (PHLs)} = (\sum \text{Quantitative} + \sum \text{Qualitative}) \text{ losses}$$

$$\% \text{ PHLs} = \frac{Postharves\ \ Losses}{Total\ Production}\ x\ 100 \ \ldots\ldots\ldots\ldots\ \text{Equation 2.1 ((Moris, 2014)}$$

It is noteworthy that every horticultural produce has a shelf life (postharvest life) following harvest. The shelf life of a product expires when the product is no longer useable and therefore discarded. Nevertheless, the quality at harvest may influence the level of effectiveness of the postharvest handling and marketing towards shelf life. This is because agricultural produce could be manipulated to prolong its shelf life; however, its quality cannot be improved after harvest but only maintained (Hodges, 2012).

Effect of Postharvest Losses on Food Security Status

Global Food Security Index GFSI (2014) reported in its special report that cereals comprise the largest share of global food loss by caloric content (53%) when considering calories; the USA is particularly losing an estimated 1,520 calories per person per day. Europe and Asia loose less than half of that amount, or fewer than 750 calories per person per day. FAO (2013) reports that the world produces enough food to feed everyone, yet at the same time an estimated one in eight people or 870 million people suffer from chronic undernourishment. The many consequences of food loss on food security, the economy or the environment and its causes vary significantly among regions, stages of the food supply chain and type of food product that are lost (FAO, 2013).

GFSI (2014) reported that food loss has strong relationship with overall food security. Lower levels of food loss were correlated (correlation = -0.59) with a higher overall score given the negative impact of food loss on food availability. Among all the indicators, food loss shared the strongest relationship (correlation = -0.49) with agricultural infrastructure. The findings confirm the role that infrastructure plays in determining food loss and linking it to food security (GFSI, 2014).

Some 815 million people have insufficient food to meet their nutritional needs today, which means that one in eight of the current world population is chronically undernourished (UN, 2014). Access to food is an important determinant of good health and studies have emphasized that food insecurity is associated with compromised individual and population health (Seligman, *et al*. 2010). Under-nutrition is estimated to be the underlying cause in 45% of all deaths among children under five years of age (FAO, 2014). The world population is projected to grow by another two billion by 2050. Thus, global food demand in 2050 will have to increase by at least 60% above 2006 levels to feed this population (Rosen, *et al*. 2016). Paradoxically, at a time of projected severe food shortages, it is estimated that roughly one third of food produced for human consumption is lost globally, amounting to about 1.3 billion tons per year (FAO, 2016). Consequently, if food loss can be minimized, this would make a very significant contribution to meeting the demands of the food insecure (Cribb, 2010 and Campbell, *et al*. 2012).

FAO (2014) stated that if food losses could be halved, the required increase of available food to feed the world population by 2050 would only need to be 25% and not 60% as currently projected, thus, reducing food loss can be part of broader systematic changes towards more sustainable food systems and global food security.

Kumar & Kalita (2017) reported in a food loss study in developing countries that fulfilling the food demand of an increasing population remains a major global concern. More than one third of food is lost in postharvest operations. Reducing the postharvest losses especially in developing countries, could be a sustainable solution to the problem of food availability, elimination of hunger and improving livelihoods and in general providing food security.

Kader (2015) observed in his postharvest study that qualitative losses such as loss of caloric and nutritive value, loss of acceptability by consumer and loss of edibility are more difficult to measure than quantitative losses of fresh fruits and vegetables. Reduction of quantitative losses is a higher priority than qualitative losses in developing countries like Nigeria. The opposite is the case in developed countries where consumers' dissatisfaction with product quality result in a greater percentage of the total postharvest losses, providing consumers with fruits and vegetables that taste good can greatly increase their consumption of the recommended minimum of five servings per day for better health (Kader, 2015).

Conclusion

Postharvest loss is a major challenge hampering food availability in most developing countries. Postharvest loss is a large and serious problem which needs to be addressed urgently and is particularly acute in developing countries where food loss reduces income by at least 15% for over 470 million smallholder downstream value chain actors, exposing them to inadequate expenditure on food leading to food insecurity.

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