RESPONSE OF OKRA (*Abelmoschus esculentus* (L.)Moench) VARIETIES TO POULTRY MANURE RATE AND STAND DENSITY IN THE NORTHERN GUINEA SAVANNAH

BY

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APRIL, 2018

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE IN

AGRONOMY

DEPARTMENT OF AGRONOMY,
FACULTY OF AGRICULTURE,
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ZARIA

APRIL,2018

DECLARATION

I hereby declare that this dissertationtitled '**Response of Okra (*Abelmoschus esculentus* (L.) Moench) Varieties to Poultry Manure Rates and Stand Density in the Northern Guinea Savannah**' has been written by me and it is a record of my own research work. It has not been presented before in any previous application for a higher degree in any institiution and all cited references of published and unpublished literatures have been duly acknowledged.

Aisha Jummai SULAIMAN ---------- ----------

Name of Student (Signature) (Date)

CERTIFICATION

This is to certify that the thesis titled'Response of Okra (*Abelmoschus esculentus* (L.) Moench) Varieties to Poultry Manure Rates and Stand Density in the Northern Guinea Savannah' meets the regulations governing the award of the degree of M.Sc. Agronomy in Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This research work is dedicated to my late mother, Hajiya Salamatu Zubair and to all the Okra farmers in Africa and beyond.

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ABSTRACT

Two trials were conducted during the 2016 rainy season at two sites; namelythe Institute for Agricultural Research (IAR) farm, Samaru ($11^0$11'N, $7^0$38'E and 686m above sea level) and the experimental site for Kaduna Agricultural Development Project (KADP) located at Maigana, Soba Local Government Area ($11^0$39`N;$08^0$ 02` E, 500m above sea level) in the Northern Guinea Savannah zone of Nigeria to evaluate the Effect of Poultry Manure and Stand density on Okra Varieties. The treatments consisted of three Okra varieties (Yar`balla, Clemson spineless and Jokoso), four poultry manure rates (0, 2, 4 and 6 t ha^{-1})and two stand densities (1 and 2 plants per stand) which is equivalent to 37,777 and 75,555 plants per hectarerespectively. The experiment was laid out in a Randomized Complete Block Design (RCBD) with treatments combined and arranged factorially and replicated three times at both locations. Data was collected on parameters such as plant height, number of leaves per plant, number of branches per plant, leaf area index, number of fruits per plant, fruit length, fruit diameter, number of seeds per pod, number of fruits per plant, 100-seed weight, fresh and dry fruit yield. An increase was recorded in all the growth and yield components when poultry manure rate was increased from 2-6t ha^{-1} while the lowest values were noted in the control plots in both locations. Application of 6t ha^{-1} gave the highest fresh and dry fruit yields (3409.5and317.7) $kgha^{-1}$ in Samaru. Yar`balla variety produced the widest leaf area index, highest number of fruits per plant (16), number of branches (7.00) per plant, number of seeds per pod (119) and significantly lower 100-seed weight (5.65) in Samaru. Clemson spineless produced the longest fruit while Jokoso produced the widest fruit diameter and fresh fruit weight per plant in both trials. A significant and positive correlation between fresh fruit yield and dry fruit yield, plant height, number of leaves, number of branches and fruit length was obtained. The regression analysis for both locations were linear.Based on the result obtained in this study, Jokoso variety at 2 plants per stand (75,555 plants ha^{-1}) using 6 t ha^{-1} poultry manure gave higher yield compared to other varieties in Samaru and Maigana and could therefore be used by farmers to enhance okra production in both areas during the wet season.

TABLE OF CONTENTS

Cover page - - - - - - - - - - i

Title page - - - - - - - - - - ii

Declaration - - - - - - - - - - iii

Certification - - - - - - - - - - iv

Dedication - - - - - - - - - - v

Acknowledgements - - - - - - - - - - vi

Abstract - - - - - - - - - - vii

Table of Contents - - - - - - - - - - viii

List of Tables - - - - - - - - - - xi

List of Figures - - - - - - - - - - xii

CHAPTER ONE: INTRODUCTION

1.1 Origin and Distribution - - - - - - - 1

1.2 Soil and Climatic Requirement - - - - - - 1

1.3 Production and Economic Importance of Okra - - - - 2

1.4 Justification and Objectives of the Study - - - - - - 3

CHAPTER TWO: LITERATURE REVIEW

2.1 Growth and Yield of Okra Varieties - - - - - - 6

2.2 Effect of Poultry Manure on Growth and Yield of Okra - - - 6

2.3 Effect of Stand Density on Growth and Yield of Okra - - - 8

CHAPTER THREE: MATERIALS AND METHODS

3.1 Experimental site - - - - - - - - 10

3.2 Soil Sampling - - - - - - - - - 10

3.3 Poultry Manure Sampling and Analysis - - - -- - 10

3.4 Treatments and Experimental Design - - - - - - 10

3.5 Plot Size - - - - - - - - - 10

3.6 Varietal Description - - - - - - - - 11

3.6.1 Clemson spineless- - - - - - - - - 11

3.6.2 Yar`balla - - - - - - - - - 11

3.6.3 Jokoso - - - - - - - - - - 11

3.7 Cultural Practices - - - - - - - - 11

3.7.1 Land preparation - - - - - - - - 11

3.7.2 Manure incorporation - - - - - - - - 11

3.7.4 Seed treatment and sowing - - - - - - - 11
3.7.5 Weed control - - - - - - - - - 12
3.7.6 Pest and disease control - - - - - - - 12
3.7.7 Harvesting - - - - - - - - - 12
3.8 Meteorological Data - - - - - - - - - 12
3.9 Observations and Data collection - - - - - - 12
3.9.1 Growth and yield components - - - - - - 12
3.9.2 Plant height - - - - - - - - - 13
3.9.3 Number of leaves - - - - - - - - 13
3.9.4 Leaf area index (LAI)- - - - - - - - 13
3.9.5 Number of branches - - - - - - - - 13
3.9.6 Fruit length - - - - - - - - - 13
3.9.7 Fruit diameter - - - - - - - - - 13
3.9.8 Number of seeds per pod - - - - - - - 13
3.9.9 Number of fruits per plant - - - - - - - 13
3.9.10 Hundred - seed weight- - - - - - - - 14
3.9.11 Fresh fruit yields - - - - - - - - 14
3.9.12 Dry fruit yield - - - - - - - - - 14
3.10 Data Analysis - - - - - - - - - 14

CHAPTER FOUR: RESULTS

4.1 Soil and Manure Analysis - - - - - - - 15
4. 2 Plant Height - - - - - - - - - 15
4.3 Number of Leaves per Plant - - - - - - - 18
4.4 Number of Branches - - - - - - - - 18
4.5 Leaf Area Index - - - - - - - - 21
4.6 Fruit Length - - - - - - - - - 24
4.7 Fruit Diameter- - - - - - - - - 24
4.8 Number of Fruits per Plant- - - - - - - - 26
4.9 Number of Seeds per Pod- - - - - - - - 29
4.10 Hundred Seed Weight- - - - - - - - 32
4.11 Fresh and Dry Fruit Yield - - - - - - - 32
4.12 Correlation Studies - - - - - - - - 34
4.13 Regression Analysis - - - - - - - - 36

CHAPTER FIVE: DISCUSSION

5.1 Growth and Yield Characteristics of evaluated Okra Varieties. - - 40

5.2 Response of Okra Growth and Yield Characters to Poultry Manure Rates - 41

5.3 Response of Okra Growth and Yield Characters to Stand Density - - 42

5.4 Interaction - - - - - - - - - - - 44

5.5 Correlation Studies - - - - - - - - - 44

5.6 Regression Analysis- - - - - - - - - 45

CHAPTER SIX: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS- 46

References - - - - - - - - - - - 48

LIST OF TABLES

Table 1: Physical and chemical properties of soil in the Experimental sites at 0-30cm depth - - - - - - - - 16

Table 2: Elemental composition of poultry manure used for the experiment during 2016 rainy season at Samaru and Maigana - - - 17

Table 3: Effects of poultry manure and stand density on plant height of Okra varieties during the 2016 rainy season at Samaru and Maigana- 19

Table 4: Effects of poultry manure and stand density on the number of leaves per plant of Okra varieties during the 2016 rainy season at Samaru and Maigana - - - - - - - - 20

Table 5: Number of branches per plant of Okra varieties as influenced by poultry manure and stand density during the 2016 rainy season at Samaru and Maigana - - - - - - - 22

Table 6: Leaf area index of Okra varieties as influenced by poultry manure and stand density during the 2016 rainy season at Samaru and Maigana 23

Table 7: Effects of poultry manure and stand density on length of Okra fruit varieties during 2016 rainy season at Samaru and Maigana - 25

Table 8: Interaction effect between variety and stand density on length of Okra fruit during the 2016rainy season at Maigana- - - 25

Table 9: Effects of poultry manure and stand density on fruit diameter of Okra varieties during 2016 rainy season at Samaru and Maigana - - 28

Table 10: Interaction between poultry manure and variety on diameter of Okra fruit in Samaru - - - - - - - 28

Table 11: Interaction between variety and stand density on diameter of Okra fruit in Maigana - - - - - - - 28

Table 12: Effects of poultry manure and stand density on number of fruits of Okra varieties during 2016 rainy season at Samaru and Maigana - 30

Table 13: Effects of poultry manure and stand density on number of seeds per pod of Okra varieties during the 2016 rainy season at Samaru and Maigana - - - - - - - - 31

Table 14: Effects of poultry manure and stand density on hundred-seed weight of Okra varieties during 2016 rainy season at Samaru and Maigana - 33

Table 15: Interaction between variety and stand density on hundred-seed weight of Okra pods during 2016 rainy season at Maigana- - - - 35

Table 16: Effects of poultry manure and stand density on freshand dry fruit yield of Okra varieties during the 2016 rainy season at Samaru and Maigana - - - - - - - - 36

Table 17: Correlation matrix showing relationship among yield, yield component and growth characters of Okra varieties as influenced by poultry manure rates and stand density during the 2016 rainy season field in Samaru- 37

Table 18: Correlation matrix showing relationship among yield, yield component and growth characters of Okra varieties as influenced by poultry manure rates and stand density during the 2016 rainy season in Maigana - - - - - - - - 38

LIST OF FIGURE

Figure 4.1: Response of fresh fruit yield of Okra varieties as influenced by poultry manure rate during the 2016 rainy season at Samaru and Maigana- - - - - - - 39

CHAPTER ONE

INTRODUCTION

1.1 Origin and Distribution of Okra

Okra (*Abelmoschus esculentus*(L.)Moench)originated in Ethopia in the year 120 BC. It is a common vegetable in tropical and sub-tropicalcountries, native to west and central Africa. It is known as a fast growing annual vegetable commonly grown in field and home gardens in Africa (Fayemi, 1999and Schippers, 2000). It belongs to the family,*Malvaceae* and was domesticated in West and Central Africa (Kochhar, 1986). It is known as 'Okro' in the Anglophone African countries. Okra is cultivated throughout the tropical and warm temperate regions of the world for its fibrous fruits (N.R.C., 2006). Okra is mainly cultivated in African countries such as Nigeria, Sudan, Egypt, Niger and Cameroun. It is also important in other tropical areas including Asia and South America.

1.2 Soil and Climatic Requirement

A range of soil types have been found suitable for okra production even though it thrives best in moist, friable, well- drained soils. Sandy loam soils high in organic matter are the most desirable.A pH of about 6.0 - 6.8 is recommended for Okra production.In Nigeria, production is mainly during the rainy season. Okra requires a moderate rainfall of about 800-1000mm. Studies on the optimum weather requirement for high yields ofOkra showed that it performs best (growth, flowering and fruiting) when the minimum and maximum temperatures are between 20^0 and 30^0 celsius, respectively.Okra is sensitive to low temperature and develops poorly below 15^0 Celsius. The seeds germinate in relatively warm soils only(Tindall *et al.*, 1986).

1.3 Production and Economic Importance of Okra

Okra ranks third in Nigeria in terms of production area andconsumption, following tomato and pepper in that sequence. India is the major producer of Okra, producing about 5,784, 000 metric tons per year (FAO, 2015). Production statistics of 2016 shows that Nigeria produces an estimated 1,978,286 tons ofOkra per annum,placing the country at second place after India.

In Nigeria, there are two distinct seasons for Okra production, the peak and lean seasons. During the lean season, okra fruit are produced in low quantities, scarce and expensive to get while in the peak season, it is produced in large quantities much more than the local populace can consume (Bamire and Oke, 2003).

The approximate nutrient content of edible Okra pod is as follows: water, 88%; protein, 2.1%; fat, 0.2%, carbohydrate, 8.0%; fiber, 1.7% and ash, 0.2% (Tindall, 1983).The green pods are rich sources of vitamins, calcium, potassium, and other minerals. In Nigeria, Okra is distributed and consumed either fresh (usually boiled, sliced or fried) or in a dried form (Fatokun and Chedda, 1983). Young leaves may also be used in cooked or processed forms. Fresh Okra fruits are used as vegetable while the roots and stems are used for preparing brown sugar (Chauhan, 1972). The protein found in Okra helps to build muscle tissue and constituent of enzymes which control all the hormone`s activities. The soluble fiber in Okra helps to lower serum cholesterol, reducing the risk of heart disease. The insoluble fiber helps to keep the intestinal tract healthy, reducing the risk of cancer especially colorectal cancer. Okra has also found medical application as a plasma replacement for the body.Nearly 10% of the recommended level of vitamin B6 and folic acid are present in half a cup of cooked Okra. The vitamin is required for good vision, proper circulation of blood, bone growth and normal digestion (Wolford and Banks, 2006). Okra is a good source of calcium which helps to keep bone strong and lessen the chance of fractures (Grubben and Denton, 2004). The seeds

however can be roasted and used as substitute for coffee (Farinde and Owolarafe, 2007). Okra mucilage is used industrially for glace paper production and is also used in making confectionaries. (Akinyele and Temikotan, 2007).

Interestingly, Okra's potential as an oilseed crop and its ability to tolerate drought in a world facing global climate change underscores its growing importance (Ibeawuchi, 2007). Oil content of Okra seed can be as high as that in poultry eggs and soybeans (Robert *et al*., 2011)

Okra fruits are considered to be of good quality in the Nigerian context when they are smooth, small, narrow and highly mucilaginous. Fruits that have exceeded physiological maturity rarely give these characteristics and are generally not commonly consumed. They are frequently left on the plants to dry and then preserved for seeds (Splittstoessor, 1990). Fruits are often sliced and dried to ease preservation when it cannot be sold in the market and has become hard or tough and unsuitable for use in fresh form.

1.4 Justification and Objectives of the study

The limiting factors in Okra production include the use of low yielding varieties, poor soil fertility and the use of sub-optimal stand density. Overtime, the cultivation of improved varieties of Okra by farmers have beennarrowed to only a few popular ones such as Yar`balla especially in the Northern Guinea savannah zone based on fruit size, fresh yield of fruit, taste and viscosity when processed. There is need to find out whether other available varieties could be cultivated efficiently with higher output.

Despite the high nutritive value of Okra, optimum yields have not been attained as a result of continuous decline in soil fertility and decreased use of organic amendments (Akanbi *et al*., 2010). There are concerns about the use ofinorganic fertilizers under intensive agriculture due to increased soil acidity, pollution of water bodies and nutrientimbalance. The extent to which farmers depend on inorganic fertilizer, is constrained by unavailability of the right type of fertilizer, high cost, lack of technical know-how and inadequate access to credit for

purchase (Chude, 1999). Hence, animal manure which is readily available is proving to be an alternative option for improvingOkra yield especially in the Guinea savannah of Northern Nigeria.Among organic manures, poultry manure has been found to have higher nutrient composition (Iken and Amusa, 2004). Poultry manure contains more nutrients relative to goat, sheep and cow dung, in addition, it is less bulky compared to other organic fertilizers. This makes transportation and handling easier and the needed amount smaller thanmany other types of organic manure. In addition, poultry manure is relatively cheap, readily available and helps in the improvement of soil physical and biological properties and also a source for most of the essential plant nutrients. On the other hand, the use of organic fertilizer as source of nutrient for vegetable crops assumed an increasing importance as there is an increasing demand for organic farm produce because of health benefits and long term positive effects on the environment.

Based on several research works and surveys, the World Bank has stated that enriching the soils with micronutrients by using organic fertilizers reducesoil nutrient deficiencies and enhances the nutritional condition of humans and animals through the food chain. The hazardous environmental consequences and high cost of inorganic fertilizers make them less desirable and out of reach to the poor farmers dominating the Nigerian agricultural sector (Shiyam and Binang, 2011). This has led to the increased use of organic manure, a readily available alternative which proves more environmentally friendly.

Under conditions of sufficient soil moisture and nutrients, higher population is necessary to utilize all growth factors efficiently and to subsequently produce high yieldsbecause land is a limiting factor in agricultural production.The yield of Okra could be as high as 30tha^{-1} but in most of the developing countries, it is as low as 1.8 tha^{-1}(Whitehead and Singh, 2000). Higher stand density and proper fertilization are critical elements in increasing the productivity of Okra. Siemonsma (1998) also stated that with increasing stand density, yield per unit area

increases up to certain limit, beyond which resources for plant growth and development becomes limited and yield decreases.Therefore, proper stand density is required to attain optimum growth and development of the crop that will result in higher yield.It is in view of this, that the study was designed to achieve the following objectives**;**

1. To study the performance of Okra varieties under varied poultry manure rates and stand density.
2. To determine the most suitable variety, poultry manure rate and the stand density that will result in higher yield of Okra.

CHAPTER TWO

LITERATURE REVIEW

2.1 Growth and yield of Okra Varieties.

The growth pattern of the plant appears to be independent of variety at the early stages of growth while at the later stages, they appear to differ. At Samaru in the Northern Guinea Savannah of Nigeria, Majambu (1985), tested two varieties of Okra and found out that NHAE 47-4 had significantly higher pod yield and number of pods per plant than white velvet. In an investigation on the performance of four exotic and one local variety of Okra, Zafar and Bux (1972) reported that the introduced Okra variety, Emerald out yielded the local variety by 42.2% during two seasons. When several characters were investigated in 29 varieties which included plant height, stem diameter and number of seeds per pod, Kuwada (1964) found out that variation in certain characters could be attributed to geographical origin of the varieties. For some characters, it was possible to group the varieties into three or four classes. Hefound out that variety Clemson spineless produced higher yield with oil and protein content. In an experiment to study the growth of two varieties of Okra, Falusi *et al*., (2010) observed that growth patterns in the variety Jokoso with higher dry matter content and leaf area was relatively more vigorous. An observation of the growth pattern showed early and faster accumulation of dry matter in Jokoso. Ortego and Franco (1999) reported highest yield from Cajun delight compared with three other varieties. Muoneke and Asiegbu (1997) also reported that NHAE 47-4 had higher leaf area index, growth rate and yield than V-35 and Agwu early.

2.2 Effect of poultry manure on growth and yield of Okra.

The organic matter in soil which can be replenished and maintained by the application of poultry manure has been reported by Roddy and Reddi (1995) as the store house ofplantnutrients. The nutrients contained in poultry manure and other organic sources are

released more slowly and are stored for longer period in the soil. This provides longer residual effects, improves root development and produces higher crop yield of Okra (Sharma, 1991). Ajari *et al.*(2003) reported that the production of Okra with poultry manure could increase plant height and number of branches, thus indicating the importance of poultry manure on the vegetative growth of Okra. This is also in conformity with the findings of John *et al*. (2004) who reported that poultry manure contains essential nutrients which are associated with high photosynthetic activities that promote root and vegetative growth. Manure application could also increase yield and development of Okra due to its easy solubilisation effect, nutrient release and water holding capacity of the soil. This is in agreement with the findings of Premsekhar and Rajashree (2009) who also reported a higher yield response of Okra crop due to organic manure application.Dauda *et al*. (2005) made similar observations in Okra in their separate studies. Application of varying rates of organic fertilizers on the green house Okra plants showed that $10tha^{-1}$ of organic fertilizer led to significant increase in microbial activities in the root zone, producing the highest pod yield. However, application of $5tha^{-1}$ of organic based fertilizer led to significant increase in the number of Okra pods.

Poultry manure plays a vital role in the contribution of nutrient to Okra production. It also acts as a store house for cation exchange and as a buffering agent against undesirable pH fluctuation. Poultry manure provides a source of all necessary macro and micro-nutrients in available forms thereby improving the physical and biological properties of the soil which could enhance growth and development of Okra plants (Abou El- Magd *et al.,* 2006).

Odeleye*et al*. (2005) found that manure applicationhas a significant effect on dry matter accumulation and fruit yield of Okra. Vegetative growth and crop yield (Fruit yield and fruit weight, number of leaves, plant height and stem girth) of Okra have been found to increase by the application of organic based nitrogen fertilizer sources. While the unfertilized plots

showed consistently shorter plant height, smaller stem girth and lower number of leaves when compared with those that were fertilized.

Ajari *et al.* (2003) also reported that application of poultry manure at the rate of 10tha^{-1} gave an optimum yield of Okra at Owu, south west Nigeria. Poultry manure could increase plant height, number of leaves, number of branches as well as shoot weight of Okra.

2.3 Effect of stand density on growth and yieldof Okra.

Albregts and Howard (1973) using stand density of 1, 2 and 3 plants per stand reported that stand density was not consistent in its effect on growth of Okra. However, a significant increase in plant height was recorded with increase in stand density. This however contradicts the report ofAlbregts and Howard (1976) who reported a decrease in fruit yield with increase in stand density. This disparity may be attributed to either varietal difference or environmental factors. Pod number and fruit yield per plant decreased with increasing stand density. Rhandawa and Pannum (1969) using three stand densities (1, 2 and 3) plants per stand on Okra reported the highest yield with the highest stand density. Patterson and Marlock (1980) stated that Okra cultivars Lee and Clemson spineless produced higher yields at a higher density of 2 plants per stand.

Muoneke and Asiegbu (1997) reported that pod yield per plant and yield components decreased with increasing stand density. Yield per hectare increased up to 111,111 plants per hectare and there after increased at 166,666 plants per hectare. The effect of three stand densities (1, 2 and 3) plants per stand on Okra intercropped within maize showed that plant height and leaf area index increased as stand density increased while number of branches decreased with increasing stand density. Aliyu (2002) reported that pepper yield per hectare increased with increasing density of up to 60,000 plants per hectare. The effect of three planting densities (28,000, 56,000 and 111000 plants ha^{-1}) on Okra intercropped between or within maize rows showed that plant height and leaf area index increased as the stand

densityincreased in sole or intercropped Okra while the number of branches per plant decreased with increasing plant density (Muoneke and Asiegbu, 2008).

Odeleye *et al.* (2005) stated that increasing the stand density from 1to 3 plants per stand (41,667- 125,000 plants per hectare) enhanced stem elongation at all growth stages while number of branches, leaves and leaf area declined with increase in Okra plant per stand.

Muoneke and Asiegbu, (2008) also reported that the number of branches of Okra intercropped with maize decreased with increasing stand density. The widest plant spacing consistently gave least values in all the vegetative parameters measured except plant height. It was also observed that decreased plant densities from 9.5 to 4.8 and 3.2 plant m^{-2} was associated with corresponding and successive increments in the average seed yield per plantand seed index.

Ekwu and Nwokwu, (2012) reported that 1 plant per stand (37000 plants ha^{-1}) resulted in maximum number of matured pods per plant, highest weight of matured pods and seed yield per plant. The length and weight of pods was highest at the closest plant spacing of 50x25(cm**)**. Weight of Okra pods decreased as the plant spacing increased from 50 cm x 25 cm to 50 cm x 75 cm. However, three plants per standproduced the highest weight ofpods while one plant per stand produced the lowest.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental Site

Trials were conducted during the 2016 rainy season at two experimental sites; namely the Institute for Agricultural Research (IAR) farm, Samaru ($11^0$11'N, $7^0$38'E and 686m above sea level) and the experimental site of Kaduna Agricultural Development Project (KADP) located at Maigana, Soba Local Government Area ($11^0$39`N;$08^0$ 02` E, 500m above sea level) in the Northern Guinea savannah zone of Nigeria.

3.2 Soil Sampling and Analysis

Compositesoil samples were collected using an Auger at 0-30cm depth at 4 different points prior to land preparation from each experimental site and analysed in the laboratory for its physico-chemical properties as described by Black, (1965).

3.3 Poultry Manure Sampling and Analysis

The poultry manure from layer chicken was gotten from a farm in Shika. The sample was analysed in the laboratory to determine its chemical constituents.

3.4 Treatments and Experimental Design

The treatments consisted of three varieties of Okra (Jokoso, Clemson spineless and Yar`balla), four rates of Poultry manure (0, 2, 4 and 6) tha^{-1} and two Stand densities(1 and 2)plants per stand (37,777 and 75,555 plants ha^{-1}). The experiment was laid out in a Randomized Complete Block Design (RCBD) with treatments combined, arranged factorially and replicated three times at both locations.

3.5 Plot Size

Each gross plot was 4.5m x 3m long (13.5m^2) at 75cm and 35cm inter and intra row spacing respectively. Each plot consisted of 6 ridges with the two inner ridges constituting the net plot.

3.6 Varietal Description

3.6.1 Clemson spineless

This variety takes 50-52 days to reach physiological maturity. It attains a height of about 45-50cm at maturity. It has medium sized dark green angular pods and broad leaves which are narrower at the edge. It`s fruit length is about 10-12cm with fruit diameter of about 3cm. It has a potential yield of 5-7tha^{-1}.

3.6.2 Yar`balla

It takes 48-52 days to reach physiological maturity. It attains a height of about 30-35cm at maturity. It produces small sized dark green angular pods with broad leaves. It`s fruit length is 6-8cm and has fruit diameter of about 2-3cm. This variety has a potential yield of 3-4tha^{-1}.

3.6.3 Jokoso

This takes 45-50 days to reach physiological maturity. It attains a height of about 35-45cm at maturity. It haslarge sized dark green angular pods with broad leaves. It has a fruit length of about 8-10cm with a fruit diameter of about 4-6cm. It has a potential yield of 5-7tha^{-1}.

3.7 Cultural Practices

3.7.1 Land Preparation

The experimental sites were harrowed and ridged at75cm apart before planting. A border of 0.5m separated each plot from another while one unplanted ridge separated the replicates.

3.7.2 Manure Incorporation

Poultry manure was incorporated into the soil on treatmentbasis. The ridges were opened at about 15cm depth at the sideand manure was measured and incorporated into the soil two weeks before sowing.

3.7.4 Seed Treatment and Sowing

Okra seeds were dressed with Apron Star 50DS at the rate of 10g per 4 kg for each variety before sowing. Five seeds were sown per hole at intra row spacing of 35cm on the ridges at

both sites. The seedlings were thinned on treatment basis to 1 and 2 plants per stand at two weeks after sowing in both locations. Sowings were done on 23rd June and 7thJuly at Samaru and Maigana respectively.This was done after soaking the seeds in warm water (35^0C)for 6 hours toaccelerate and enhance uniform germination.

3.7.5 Weed Control

Glyphosate at 1.4kg ai ha^{-1} was applied prior to land preparation at the rate of 300ml in 20L of water to control the emerged weeds before sowing was done at both sites. During the growing period, hoe weeding was done to control emerged weeds at 3, 5 and 7 WAS.

3.7.6 Pest and Disease Control

A broad spectrum insecticide, Permethrin, was applied at the rate of300ml of the formationto 20litres of water and applied five times during plant growth at five dayinterval due to heavy insect pest infestation.It started at 3 weeks after emergence and ended before fruiting (about 6WAS).

3.7.7 Harvesting

Harvesting started at 6 WAS with a picking interval of four days. It terminated at about 9 WAS with a total of 6 harvests in each location.

3.8 Meteorological Data

Meteorological data was obtained from the Institute for Agricultural Research(IAR) Meteorological Station, Samaru, Zaria and from Kaduna Agricultural Development Project (KADP) in Maigana, Soba Local Government Area.

3.9 Observations and Data Collection

3.9.1 Growth and yield components

Five plants were randomly tagged from each plot in both sites. Observation on growth parameters were carried out on tagged plants at 3, 5, and 7 weeks after sowing, while yield and yield related parameters were recorded at time of harvest.

3.9.2 Plant Height (cm)

Plant height was determined by measuring the height of the tagged plants with a meter rule from the top soil level to the tip of the terminal bud and the average recorded for each of the treatments at all the sampling periods.

3.9.3 Number of Leaves

All leaves on each of the tagged plants were counted and the average value was recorded for each of the treatment at all the sampling periods in both locations.

3.9.4 Leaf Area Index (LAI)

This is a ratio of the leaf area to the area of the ground covered. Leaf area index was measured at all the sampling periods in both locations using the Leaf areaSeptometer.

3.9.5 Number ofBranches

This was determined by counting all the branches on each of the five tagged plants and the mean values were recordedfor all the sampling period in both locations**.**

3.9.6 Fruit Length (cm)

Five fruits were collected from the net plot in each site at harvest. The fruits were measured from the distal to the proximal end and the average, recorded.

3.9.7 Fruit Diameter (cm)

At harvest, the diameter of five fruits from the tagged plants in the net plots was measured with a Vernier caliper and the average was recorded for each plot.

3.9.8 Number of Seeds per Pod

Seeds were countedfrom five dry pods in each net plot and the average was recorded for each plot.

3.9.9 Number of Fruits per Plant

The fresh fruits harvested from each of the tagged plants in the net plots were counted and the mean was recorded on per plot basis.

3.9.10 Hundred Seed Weight

One hundred seeds were counted from the pods of the tagged plants that were dried in the field. The seeds (100) for each plot was weighed using the Mettler ToledoJS3002G weighing balance.

3.9.11 Fresh Fruit Yield ($kgha^{-1}$)

The sum of weights of six harvests per net were weighed using Mettler ToledoJS3002G balance and recorded after converting to kilogram per hectare.

3.9.12 Dry Fruit Yield ($kgha^{-1}$)

The sum of weights of six harvests per net plot were dried and weighed. It was later converted to kilogram per hectare.

3.10 Data Analysis

The data collected were subjected to Analysis Of Variance (ANOVA) using F-test and the significant differences among the treatment means were compared using Duncan Multiple Range Test (DMRT) as described by Duncan (1955). The relationship between the growth and yield parameters was determined by correlation analysis as stated by Little and Hills (1978).

CHAPTER FOUR

RESULTS

4.1 Physical and Chemical Properties of Soil and Poultry Manure used

Both physical and chemical properties of the soil at the experimental sites at 0-30 cm depthand elemental composition of the poultry manure used are presented in Tables1 and 2 respectively. The results of the soil analysis indicated that the textural class for the soils at Samaru and Maigana were loam soils. The analysis showed that the soil used in Samaru was moderately acidic while that of Maigana was slightly acidic. The soils were moderate in organic carbon and phosphorus and low in total nitrogen. Exchangeable bases in Samaru were higher than those in Maigana. Calcium and potassium were moderate in both locations while magnesium and sodium were high in samaru, cation exchange capacity was low in Maigana. Chemical properties of the poultry manure (Table 2) used showed a moderate amount of potassium, calcium, phosphorus and sodium while magnesium was low. The nitrogen content in the poultry manure was high.

4.2 Plant Height

The effects of poultry manure andstand density on plant height of Okra varieties during the 2016 rainy season at Samaru and Maigana are shown in Table 3. The result shows thatClemson spineless significantly produced taller plants than Jokoso while Yar`balla produced the shortest plants at all the sampling periods in both trials.

Application of varied rates of poultry manure had significant effect on plant height in both locations. At Samaru and Maigana, the rate of poultry manure used had similar effects on plant height at 3, 5 and 7WAS. Each increase in manure rate from 2 t ha^{-1} to 6 t ha^{-1} increased plant height at both locations although 4 t ha^{-1} and 6 t ha^{-1} did not differ significantly at 5WAS in Samaru and 7WAS in Maigana.

Table 1: Physical and Chemical Properties of Soil in the Experimental Sites at 0-30cm depth.

Physical properties	**Samaru**	**Maigana**
Sand	430	530
Silt	460	350
Clay	110	120
Textural class	Loam	Loam
Chemical composition		
PH in water (1:2.5)	5.83	6.05
PH in 0.01M$CaCl_2$ (1:2.5)	5.28	5.89
Organic carbon (g kg^{-1})	1.26	1.10
Total nitrogen (g Kg^{-1})	0.43	0.60
Available phosphorus (mg Kg^{-1})	18.31	17.36
Exchangeable bases (cmol Kg^{-1})		
Calcium (Ca)	3.60	3.22
Magnesium (Mg)	1.70	0.80
Potassium (K)	0.22	0.17
Sodium (Na)	0.40	0.23
Cation Exchange capacity (CEC)	6.04	4.42

Analyses conducted by Agronomy Departmental laboratory, ABU, Zaria.

Table 2: Elemental Composition of Poultry Manure used for the Experiment during 2016 rainy season at Samaru and Maigana.

Nutrients	Amount %
Total K	1.67
Total C	1.73
Total Mg	0.62
Total Na	1.45
Total N	2.87
Total P	2.10

Analyses conducted by Agronomy Departmental laboratory, ABU, Zaria.

At the two locations, 2 plants per stand density resulted in taller plants compared to 1 plant per stand. No significant interaction was observed due to treatment effects on plant height throughout the sampling periods at both locations.

4.3 Number of Leaves per Plant

The effects of poultry manure and stand density on number of leaves of Okra varieties during the 2016 rainy season in Samaru and Maigana are shown in Table 4. The result shows that Yar`balla produced significantly highest number of leaves at all the sampling periods in both locations. Clemson spineless and Jokoso produced results which were statistically similar at 3WAS and 5WAS in both locations while at 7WAS, Clemson spineless produced significantly higher number of leaves than Jokoso.

With varying poultry manure rates, there was significant difference in the number of leaves per plant at all the sampling periods in both locations. Application of higher rate of poultry manure produced significantly higher number of leaves than the control. Furthermore, there was a linear increase in number of leaves with increase in manure rate except at 7 WAS where the yield increase was up to 4 t ha^{-1}.

Increase in plant density from 1 to 2 plants per hectare showed a significant increase in number of leaves at all sampling periods in Maigana and Samaru. The stand density of 2 plants per stand gave the highest number of leaves in both locations. None of the treatment interactions on number of leaves were significant.

4.4 Number of Branches

The effects of poultry manure andstand densityon number of branches per plant of Okra varieties during 2016 rainy season in Samaru and Maigana are shown in Table 5. The result shows that Yar`balla variety produced significantly highest number of branches at 5 and 7 WAS. Statistically lower number of branches were produced by Clemson spineless and

Table3:Effects of Poultry Manure and Stand Density on Plant Height of Okra Varieties during the 2016 rainy season at Samaru and Maigana.

	Plant height (cm)					
	Samaru			Maigana		
Treatment	**3WAS**	**5WAS**	**7WAS**	**3WAS**	**5WAS**	**7WAS**
Variety						
Yar`balla	12.83c	15.38c	31.00c	10.82c	13.29c	27.73c
Clemsonspineless	16.84a	20.19a	46.77a	13.97a	19.99a	43.52a
Jokoso	14.67b	18.06b	39.30b	11.25b	17.65b	36.47b
SE ±	0.406	0.479	2.847	0.444	0.667	2.851
Poultrymanure (tha^{-1})						
0	11.51d	16.07c	41.12d	9.67d	14.96d	39.25c
2	14.00c	17.63b	44.10c	10.92c	16.33c	42.38b
4	14.90b	18.63a	48.48b	12.03b	17.68b	48.77a
6	15.37a	19.19a	52.70a	14.09a	18.83a	51.00a
SE ±	0.469	0.553	3.053	0.512	0.544	2.757
Standdensity						
1	14.25b	17.29b	45.89b	11.29b	16.58b	45.43b
2	15.30a	18.46a	48.16a	11.87a	17.57a	47.24a
SE ±	0.332	0.332	2.150	0.362	0.836	1.949
Interaction						
M x V	NS	NS	NS	NS	NS	NS
M x D	NS	NS	NS	NS	NS	NS
V x D	NS	NS	NS	NS	NS	NS
M x V x D	NS	NS	NS	NS	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability V = Variety, M = Poultry manure, D = Stand density, NS = Not Significant.

Table 4: Effects of Poultry Manure and Stand Density on the Number of Leaves per Plant of Okra Varieties during the 2016 rainy season at Samaru and Maigana

	Number of leaves per plant					
	Samaru			Maigana		
Treatment	**3WAS**	**5WAS**	**7WAS**	**3WAS**	**5WAS**	**7WAS**
Variety						
Yar`balla	4.00a	9.00a	13.00a	4.00a	8.00a	11.00a
Clemson spineless	3.00b	7.00b	11.00b	3.00b	6.00b	10.00b
Jokoso	3.00b	7.00b	10.00c	3.00b	6.00b	9.00c
SE $\pm$	0.161	0.134	0.363	0.098	0.195	0.057
Poultry manure (tha^{-1})						
0	2.00d	6.00d	9.00d	2.00d	5.00d	8.00c
2	3.00c	7.00c	10.00c	3.00c	6.00c	9.00b
4	4.00b	8.00b	11.00b	4.00b	7.00b	11.00a
6	5.00a	9.00a	12.00a	5.00a	8.00a	11.00a
SE $\pm$	0.186	0.155	0.420	0.113	0.225	0.276
Stand density						
1	3.00b	8.00b	11.00b	3.00b	6.00b	7.00b
2	4.00a	9.00a	12.00a	4.00a	7.00a	8.00a
SE $\pm$	0.131	0.110	0.297	0.080	0.552	0.195
Interaction						
M x V	NS	NS	NS	NS	NS	NS
M x D	NS	NS	NS	NS	NS	NS
V x D	NS	NS	NS	NS	NS	NS
M x V x D	NS	NS	NS	NS	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability V = Variety, M = Poultry manure, D = Stand density, NS = Not Significant

Jokoso at 5WAS in Samaru, 5WAS and 7WAS at Maigana while at 7WAS in Samaru, Clemson Spineless produced the lowest number of branches.

Increasing poultry manure application from 0-4 t ha^{-1} at 5 WAS in Samaru showed no significant difference in the number of branches. However, when 6tha^{-1}poultry manure was applied, the number of branches increased. At 7WAS in Samaru, number of branches increased with an increase in poultry manure from 2-6$tha^{-1.}$ At Maigana, application of 2 and 4t ha^{-1} produced equal number of branches. More branches at 5 and 7 WAS were observed when 6tha^{-1} of poultry manure was applied.

There was a significant increase in the number of branches as density increased from 1 to 2 plants per stand at all the sampling periods in both locations. None of the treatment interactions were significant on number of branches.

4.5 Leaf Area Index

The effects of poultry manure and plant population on leaf area index of Okra varieties during the 2016 rainy season in Samaru and Maigana is shown in Table 6. The result shows that there was significant difference between the varieties at both locations. Yar`balla produced the highest leaf area index while Jokoso and Clemson spineless produced lowest leaf area index that was statistically at par at all sampling periods in both locations.

There was significant difference in leaf area index at all the sampling periods when application of poultry manure was increased from 0tha^{-1} to 6 tha^{-1}. There was a significant increase in leaf area index when density was increased from 1 to 2 plants per stand at all the sampling periods in both locations.

None of the treatment interactions were significant on leaf area index.

Table5:Number of Branches per Plant of Okra Varieties as influenced by Poultry Manure and Stand Density during the 2016 rainy season at Samaru and Maigana.

	Number of branches per plant			
	Samaru		Maigana	
Treatment	**5WAS**	**7WAS**	**5WAS**	**7WAS**
Variety				
Yar`balla	5.00a	7.00a	4.00a	6.00a
Clemsonspineless	3.00b	4.00c	3.00b	4.00b
Jokoso	3.00b	5.00b	3.00b	4.00b
SE ±	0.417	0.455	0.313	0.308
Poultry manure (tha^{-1})				
0	3.00b	4.00c	2.00c	3.00c
2	3.00b	4.00c	3.00b	4.00b
4	3.00b	5.00b	3.00b	4.00b
6	4.00a	6.00a	4.00a	5.00a
SE ±	0.135	0.295	0.131	0.125
Stand density				
1	2.00b	4.00b	2.00b	3.00b
2	3.00a	5.00a	3.00a	4.00a
SE ±	0.196	0.308	0.192	0.188
Interaction				
M x V	NS	NS	NS	NS
M x D	NS	NS	NS	NS
V x D	NS	NS	NS	NS
M x V x D	NS	NS	NS	NS

Means followed by the some letter within a treatment group are not significantly different at 0.05 level of probability V = Variety, M = Poultry manure, D = Stand density, NS = Not Significant.

Table6:Leaf Area Index of Okra Varieties as influenced by Poultry Manure and Stand Density during the 2016 rainy season at Samaru and Maigana.

	Leaf area index					
	Samaru			Maigana		
Treatment	**3WAS**	**5WAS**	**7WAS**	**3WAS**	**5WAS**	**7WAS**
Variety						
Yar`balla	0.29a	0.76a	1.39a	0.28a	0.55a	0.72a
Clemson spineless	0.28b	0.65b	1.30b	0.26b	0.53b	0.67b
Jokoso	0.28b	0.63b	1.25b	0.27b	0.47b	0.65b
SE ±	0.022	0.049	0.067	0.015	0.049	0.059
Poultry manure (tha^{-1})						
0	0.19d	0.46d	1.03d	0.19d	0.31d	0.46d
2	0.23c	0.56c	1.17c	0.24c	0.46c	0.59c
4	0.30b	0.75b	1.40b	0.31b	0.52b	0.77b
6	0.37a	0.96a	1.65a	0.40a	0.78a	0.92a
SE ±	0.018	0.057	0.077	0.025	0.056	0.146
Stand density						
1	0.27b	0.63b	1.26b	0.27b	0.46b	0.58b
2	0.29a	0.74a	1.36a	0.31a	0.57a	0.79a
SE ±	0.012	0.040	0.054	0.018	0.040	0.048
Interaction						
M x V	NS	NS	NS	NS	NS	NS
M x D	NS	NS	NS	NS	NS	NS
V x D	NS	NS	NS	NS	NS	NS
M x V x D	NS	NS	NS	NS	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability
V = Variety, M = Poultry manure, D = Stand density, NS = Not significant at 5% level.

4.6 Fruit Length

The effects of poultry manure and stand densityon fruit length of Okra varieties during 2016 rainy season in Samaru and Maigana is shown in Table 7. At both locations, similar responses were observed in terms of varietal differences. Clemson spineless produced significantlylonger fruits followed by Jokoso and then the shortest fruits were produced by Yar`balla.

There was a significant increase in fruit length when poultry manure was increased from 0-2tha^{-1} in Samaru and Maigana where the control and 2 t ha-^{1} were at par ut significantly shorter than 4 t ha-^{1} which was also shorter than 6 t ha -^{1}.

There was no significant difference in fruit length when stand density was increased from 1 to 2 plants per stand in both locations.

The result also shows that there was significant interaction between variety and population on okra fruit length at Maigana. Significantly longer fruits were obtained at 1 plant per stand with Clemson spineless(Table 8). At both 1 and 2 plants per stand density, Clemson spineless was found to have statistically longer fruits followed by Jokoso and the shortest fruits were observed with Yar`balla in Maigana.

4.7 Fruit Diameter

Table 9 shows the effect of poultry manure and stand densityon fruit diameter of Okra varieties during the 2016 rainy season in Samaru and Maigana. There was significant difference in fruit diameter among the varieties in both locations. At Samaru, statistically larger fruits were produced with Jokoso followed by Clemson spineless and Yar`balla. At Maigana Yar` balla had statistically similar fruit diameter with Clemson Spineless which were statistically smaller than Jokoso variety.Increased application of poultry manure from 0-6 tha^{-1} statistically increased fruit diameter of Okra.

Table 7: Effects of Poultry Manure and Stand Density on Length of Okra Fruit Varieties during 2016 rainy season at Samaru and Maigana.

	Fruit length (cm)	
Treatment	**Samaru**	**Maigana**
Variety		
Yar`balla	7.33c	6.89c
Clemson spineless	12.05a	10.12a
Jokoso	10.75b	9.43b
SE ±	0.259	0.412
Poultry manure(tha^{-1})		
0	9.50c	8.95c
2	9.54c	9.06c
4	10.44b	9.61b
6	11.43a	10.56a
SE ±	0.299	0.476
Stand density		
1	10.31	9.92
2	10.15	9.61
SE ±	0.212	0.336
Interaction		
M x V	NS	NS
M x D	NS	NS
V x D	NS	*
M x V x D	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability V = Variety, M = Poultry manure, D = Stand density, NS = Not Significant, * = Significant.

Table 8: Interaction Effect between Variety and Stand Density on Length of Okra Fruit during the 2016 rainy season at Maigana.

	Stand density	
Treatment	1	2
Variety		
Yar-balla	8.10d	8.06d
Clemson spineless	11.60a	9.65b
Jokoso	8.95c	8.92c
SE ±	0.580	

Means followed by unlike letter(s) are significantly different at 5% level of probability.

There was no significant difference in fruit diameter when stand density was increased from 1 to 2 plants per stand in both locations.

None of the treatment interactions were significant on fruit diameter in Samaru. The interaction of varieties with poultry manure, and variety with stand density on okra fruit diameter was significant at Maigana. Holding variety constant, it was found that fruit diameter increased with increase in poultry manure from 2-6tha^{-1} in Jokoso (Table 10). When different levels of poultry manure was assessed against varieties, it was observed that Jokoso and Clemson spineless had larger and similar fruit diameter compared to those obtained from Yar`balla, except at 6t ha$^{-1}$ where Jokoso was larger than Clemson spineless which was in turn, larger than Yar`balla.

There was a significant interaction between variety and stand density on fruit diameter in Maigana only. The interaction between variety and stand density on fruit diameter in Maigana is shown in Table 11. Holding variety constant, the result shows that Yar`balla produced statistically similar fruit diameter when density was increased from 1 to 2 plants per stand. However, Clemson spineless and Jokoso produced higher fruit diameter at lower stand density of 1plant per stand.

4.8 Number of Fruits per Plant

The effects of poultry manure on number of fruits per plant of Okra varieties during the 2016 rainy season in Samaru and Maigana are shown in Table 12. The result shows a significant difference in okra fruit number per plant between the three varieties at both locations. Yar`balla and Jokoso produced statistically the highest and lowest number of fruits per plant respectively in both locations.

Table 9: Effects of Poultry Manure and Stand Density on Fruit Diameter of Okra Varieties during 2016 rainy season at Samaru and Maigana.

Treatment	Fruit diameter (cm)	
	Samaru	**Maigana**
Variety		
Yar-balla	2.98c	2.68b
Clemson spineless	3.12b	2.66b
Jokoso	3.18a	2.93a
SE ±	0.056	0.072
Poultry manure (tha^{-1})		
0	2.88d	2.54d
2	2.96c	2.69c
4	3.07b	2.81b
6	3.45a	2.98a
SE ±	0.064	0.083
Stand density		
1	3.10	2.78
2	3.08	2.74
SE ±	0.045	0.059
Interaction		
M x V	NS	*
M x D	NS	NS
V x D	NS	*
M x V x D	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability. V = Variety, M = Poultry manure, D = Stand density, NS = Not Significant, * = Significant.

Table 10: Interaction between Poultry Manure and Variety on Diameter of Okra Fruit in Samaru.

	Poultry manure (tha^{-1})			
Treatment	0	2	4	6
Variety				
Yar-balla	2.70j	2.74ij	2.82hi	3.33bc
Clemson spineless	2.92gh	3.05ef	3.16de	3.36b
Jokoso	2.99fg	3.14de	3.24cd	3.65a
SE± 0.113				

Means followed by unlike letter(s) are significantly different at 5% level of probability.

Table 11: Interaction between Variety and Stand Density on Diameter of Okra Fruit in Maigana.

	Density (plants per stand)	
Treatment	1	2
Variety		
Yar-balla	2.69e	2.67e
Clemson spineless	2.91c	2.73d
Jokoso	2.95a	2.59b
SE± 0.103		

Means followed by unlike letter(s) are significantly different at 5% level of probability.

Application of poultry manure was observed to significantly increase number of fruits per plant up to 6t ha^{-1} at Samaru while at Maigana, the control and 2 tha^{-1} were similar but significantly lower than 4tha^{-1} which was also lower than 6 tha^{-1}.

There was no significant difference in the number of fruits per plant when stand density was increased from 1 to 2 per stand at both locations. The treatment interactions were not significant in both locations.

4.9 Number of Seeds per Pod

The effects of poultry manure and stand density on number of seeds per pod of Okra during the 2016 rainy season at Samaru and Maigana is presented in Table 13. The result shows that Yar`balla produced the highest number of seeds per pod followed by Clemson spineless and Jokoso at both locations.

There was significant difference in the number of seeds per pod with varying poultry manure rates in both locations. Application of 4 and 6tha^{-1} poultry manure produced statistically equal and highest number of seeds per pod in Samaru. However, this was not the case in Maigana where application of 6tha^{-1}produced the highest number of seeds per pod while 2 and 4t ha^{-1} application produced statistically equal number of seeds per pod.The control produced the lowest number of seeds in both locations.

A significant increase was observed in number of seeds per pod when stand density was decreased from 2 to 1 plant per stand in Samaru. This was in contrast with the case in Maigana where there was no significant difference in the number of seeds per pod when stand density was varied. The treatment interactions were not statistically significant in both locations.

Table 12:Effects of Poultry Manure and Stand Density on Number of Fruits of Okra Varieties during 2016 rainy season at Samaru and Maigana.

	Number of fruits per plant	
Treatment	**Samaru**	**Maigana**
Variety		
Yar`balla	16.00a	14.00a
Clemson spineless	15.00b	12.00b
Jokoso	14.00c	11.00c
SE ±	0.648	0.562
Poultry manure (tha^{-1})		
0	13.00d	11.00c
2	14.00c	11.00c
4	15.00b	13.00b
6	17.00a	14.00a
SE ±	0.748	0.650
Stand density		
1	15.00	12.00
2	15.00	12.00
SE ±	0.529	0.459
Interaction		
M x V	NS	NS
M x D	NS	NS
V x D	NS	NS
M x V x D	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability.V = Variety, M = Poultry manure, D = Stand density, NS=Not Significant.

Table 13: Effects of Poultry Manure and Stand Density on Number of Seeds per Pod of Okra Varieties during the 2016 rainy season at Samaru and Maigana.

	Number of seeds per pod	
Treatment	**Samaru**	**Maigana**
Variety		
Yar`balla	119.00a	99.00a
Clemson spineless	100.00c	91.00c
Jokoso	108.00b	96.00b
SE ±	3.335	4.119
Poultry manure (tha^{1})		
0	107.00b	84.00c
2	109.00ab	95.00b
4	111.00a	98.00b
6	111.00a	105.00a
SE	3.851	4.756
Stand density		
1	111.00b	96.00
2	107.00a	95.00
SE ±	2.723	3.363
Interaction		
M x V	NS	NS
M x D	NS	NS
V x D	NS	NS
M x V x D	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability V = Variety, M = Poultry manure, D = Stand density, NS=Not Significant.

4.10 Hundred Seed Weight

The effects of poultry manure andstand density on 100-Seed weight of Okra varieties during the 2016 rainy season at Samaru and Maigana is presented in Table14. The result shows that Yar`balla and Clemson spineless produced statistically equal 100- Seed weight which was heavier than that of Jokoso in both locations.

Application of 0 and 2t ha-^{1} poultry manure produced statistically equal hundred seed weight in Samaru. However, this was not the case in Maigana where 0 t ha-^{1} poultry manure application produced significantly lower 100- Seed weight. Application of 6 t ha-^{1} produced the heaviest 100-Seed weight in both locations.

There was a significant decrease in 100-seed weight when stand density was increased from 1 to 2 plants per stand.

A significant interaction was observed between variety and stand density at Maigana. The interaction between variety and stand density on hundred Seed weight of Okra varieties during the 2016 rainy season in Maigana is presented in Table 15. The result shows significant decrease in weight in all the varieties when stand density was increased. Under one plant per stand, Yar`balla and Clemson spineless were at par but were significantly heavier than Jokoso. However, at 2 plants per stand, Yar`balla was heavier than Clemson spineless which was also heavier than Jokoso.

4.11 Fresh and Dry Fruit Yield

Table 16 shows the effects of poultry manure and stand densityon fresh fruit yield of Okra varieties during the 2016 rainy season in Samaru and Maigana. The result shows that statistically higher fruit yield was obtained with Jokoso followed by Clemson spineless and lower yield was recorded with Yar`balla in both locations.

Table 14: Effects of Poultry Manure andStand Density on 100 Seed Weight of Okra Varieties during 2016 rainy season at Samaru and Maigana.

	100 seed weight (g)	
Treatment	**Samaru**	**Maigana**
Variety		
Yar`balla	5.65a	5.26a
Clemson spineless	5.56a	5.22a
Jokoso	5.43b	5.21b
SE ±	0.092	0.118
Poultrymanure (tha^{1})		
0	5.19b	5.04c
2	5.38b	5.21b
4	5.57b	5.39ab
6	6.03a	5.68a
SE ±	0.106	0.136
Stand density		
1	5.59a	5.39a
2	5.49b	5.28b
SE ±	0.075	0.096
Interaction		
M x V	NS	NS
M x D	NS	NS
V x D	NS	*
M x V x D	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability. V = Variety, M = Poultry manure, D = Stand density, NS = Not Significant * = Significant.

Table 15: Interaction between Variety and Stand Density on 100 Seed Weight of Okra Pods during 2016 rainy season at Maigana.

	Stand density	
Treatment	1	2
Variety (v)		
Yar`balla	5.53a	5.48b
Clemson spineless	5.51a	5.36c
Jokoso	5.46b	5.28d
SE ± 0.167		

Means followed by unlike letter(s) are significantly different at 5% level of probability.

Increased poultry manure application from 0-6 t ha-^{1} significantly increased fresh fruit yield of okra in Samaru and Maigana. The highest fresh fruit yield was obtained with 6tha^{-1}application while the control (unfertilized plots) gave the least fruit yield.

There was a significant increase in fresh fruit yield when density was increased. Density of 2 plants per standproduced significantly higher fresh fruit yield than 1 plant per stand at both locations.The treatment interactions were not statistically significant in both locations.

Table 16also shows the effects of poultry manure and stand density on dry fruit yield of Okra varieties during the 2016 rainy season at Samaru and Maigana. The result shows that there was significant difference in the dry fruit yield of all the varieties at both locations. Yar`balla and Jokoso produced statistically lowest and highest dry fruit yield at both locations respectively.

Application of 0 and 2t ha-^{1}poultry manure showed statistically similar dry fruit yield of Okra in Maigana while 4 and 6 t ha-^{1} poultry manure application produced dry fruit yield which were statistically at par in both locations.

A significant increase was observed in dry fruit yield when stand density was increased from 1 to 2 plants per stand at both locations.None of the treatment interactions were significant on dry fruit yield.

4.13 Correlation Studies

Table 17 shows the association between Okra fresh fruit yield and some of the growth and yield parameters of Okra in Samaru. A highly significant and positive correlation was observed between fresh and dry fruit yield. Correlation between fresh fruit yield and plant height, number of leaves, number of branches and length of Okra fruit were all positive and significant.

Table 16:Effects of Poultry Manure andStand Density on Fresh and Dry Fruit Yield of Okra varieties during the 2016 rainy season at Samaru and Maigana.

	Fresh Fruit Yield (kg ha^{-1})		Dry Fruit Yield (kg ha^{-1})	
Treatment	**Samaru**	**Maigana**	**Samaru**	**Maigana**
Variety				
Yar`balla	3372.4c	2997.3c	291.5c	278.7c
Clemson spineless	4001.1b	3574.7b	301.4b	293.5b
Jokoso	4058.0a	3664.0a	311.2a	302.9a
SE±	52.771	48.322	7.205	6.527
Poultrymanure(tha-^{1})				
0	2956.9d	2589.1d	302.5b	269.3b
2	3024.0c	2660.5c	308.8ab	274.7b
4	3184.9b	2888.9b	315.0a	284.2a
6	3409.5a	3109.7a	317.7a	286.5a
SE ±	70.361	64.430	9.607	8.703
Stand density				
1	2811.0b	2512.3b	212.4b	188.8b
2	3476.7a	3111.8a	409.6a	368.6a
SE ±	35.180	32.215	4.803	4.351
Interaction				
M x V	NS	NS	NS	NS
M x D	NS	NS	NS	NS
V x D	NS	NS	NS	NS
M x V x D	NS	NS	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability. V = Variety, M = Poultry manure, D = Stand density, NS=Not Significant at 5% level.

Also, correlation between fresh fruit yield and leaf area index, fruit diameter, number of pods per plant and hundred seed weight were not significant in Samaru. However, there was a negative correlation between Okra fresh fruit yield and number of pod per plant.

Tables 18 shows the association between fresh fruit yield and some of the growth and yield parameters of Okra in Maigana. A highly significant and positive correlation was observed between fresh and dry fruit yield of Okra. Correlation between fresh fruit yield and plant height, number of leaves, number of branches and length of okra fruit were all positive and significant while those of leaf area index, fruit diameter, number of seed per pod, number of pod per plant and 100 seed weight were not significant.

4.14 Regression Analysis

The regression analysis between Okra fresh fruit yield and poultry manure rate was linear in both locations. This implies that the optimum poultry manure rates for Samaru and Maigana were not achieved. The coefficient of determination (R^2) for Samaru (1.00) shows a perfect fit while that of Maigana (0.99) was extremely close. The result further suggests that the optimum poultry manure

rates for both locations were not achieved.

Table 17: Correlation Matrix showing Relationship among Yield and Growth Characters of Okra Varieties as influenced by Poultry Manure Rates and Stand Density during the 2016 rainy season in Samaru.

S/N	1	2	3	4	5	6	7	8	9	10	11
1	1.00										
2	0.502**	1.00									
3	0.256*	0.286*	1.00								
4	0.0288*	0.075	0.128	1.00							
5	0.112	0.01	0.352**	0.087	1.00						
6	0.249*	0.429**	0.094	0.201	0.231						
7	0.249*	0.592**	0.146	0.219	-0.118	1.00	1.00				
8	0.082	0.212	0.362**	0.208	0.268*	0.287*	0.455**	1.00			
9	-0.147	-0.386**	-0.067	0.105	-0.001	0.234*	-0.294*	-0.110	1.00		
10	0.110	0.112	0.251*	0.284*	0.154	0.182	0.113	0.270*	0.200	1.00	
11	0.096	0.109	0.074	0.341**	0.400**	0.242*	0.322**	0.280**	0.113	0.327**	1.00

Key

1. Fresh fruit weight (kg ha^{-1})
2. Dry fruit weight (kg ha^{-1})
3. Plant height (7WAS)
4. Number of leaves (7WAS)
5. Leaf area index (7WAS)
6. Number of branches (7WAS)
7. Fruit length
8. Fruit diameter
9. Number of seed per Pod
10. Number of pod per plant
11. 100 Seed weight

Table 18: Correlation Matrix showing Relationship among Yield and Growth Characters of Okra Varieties as influenced by Poultry Manure Rates and Stand Density during the 2016 rainy season in Maigana.

S/N	1	2	3	4	5	6	7	8	9	10	11
1	1.00										
2	0.498**	1.00									
3	0.268*	0.382**	1.00								
4	0.256*	0.045	0.257*	1.00							
5	0.112	0.228	0.263*	0.447**	1.00						
6	0.0288*	0.614**	-0.140*	0.147	0.041	1.00					
7	0.249*	0.499**	0.443**	0.190	0.151	-0.134	1.00				
8	0.143	0.164	0.406**	0.251*	0.297*	-0.048	0.580**	1.00			
9	0.024	-0.084	0.262*	0.287*	0.309**	0.164	0.059	0.102	1.00		
10	0.077	0.043	0.261*	0.195	0.233*	0.223	0.093	0.270*	0.218	1.00	
11	0.017	-0.005	0.234*	0.175	0.192	0.041	0.248*	0.381**	0.277*	0.129	1.00

Key

1. Fresh fruit weight (kg ha^{-1})
2. Dry fruit weight (kg ha^{-1})
3. Plant height (7WAS)
4. Number of leaves (7WAS)
5. Leaf area index (7WAS)
6. Number of branches (7WAS)
7. Fruit length
8. Fruit diameter
9. Number of seed per Pod
10. Number of pod per plant
11. 100 Seed weight

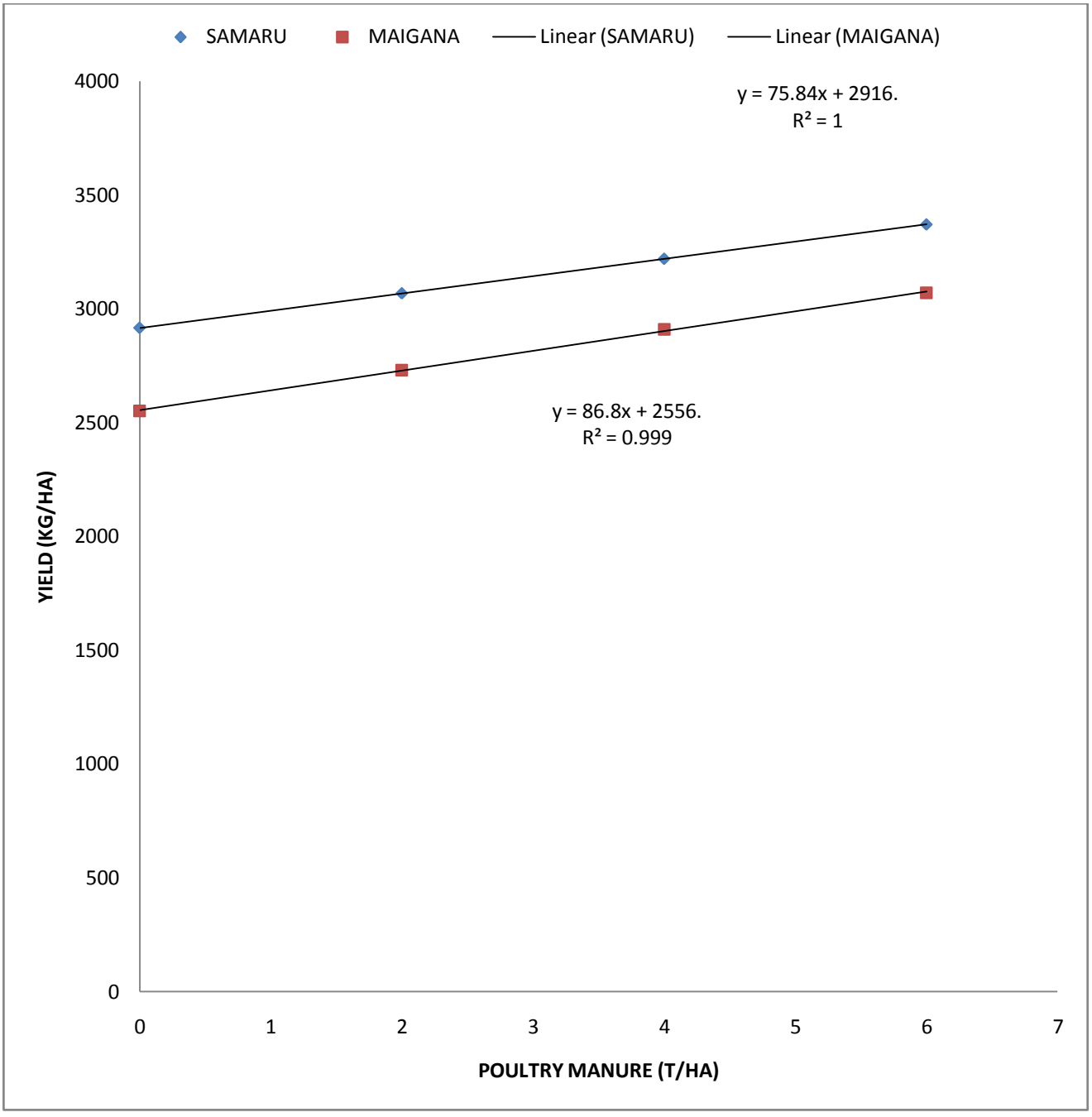


Figure 1: Fresh Fruit Yield of Okra Varieties as influenced by Poultry Manure Rate during the 2016 rainy season at Samaru and Maigana.

CHAPTER FIVE

DISCUSSION

5.1 Growth and Yield Characteristics of Evaluated Okra Varieties.

The significant differences recorded among the three Okra varieties in terms of their growth and yield components such as plant height, number of leaves per plant, number of branches, leaf area index, number of fruits per plant, fruit length, fruit diameter, number of seeds per pod, 100seed weight, fresh and dry fruit yield of Okra is attributed to differences in the genetic composition of the varieties used.This is in line with the study of Akinfasoye *et al*. (1997) who reported that differences in yield parameters of crops are attributed to the cultivars grown and their genetic makeup.

Yar`balla produced more number of branches, leaves, seeds and number of fruits per plant as well as wider leaf area index. The superiority of Yar`balla with respect to these characters enabled the variety to intercept more solar radiation for the production of more assimilates. This enhanced the production of higher number of fruits per plantthat would have been translated to higher yieldbut for its smaller size relative to the other varieties used in the study.

Jokoso produced fruits with the widest diameter and highest yields while Clemson spineless produced significantly taller plants andlonger fruits at both locations. Apart from the genetic composition of the variety which plays an important role in the potential yield of the fruits, the differences in the rate of nutrient absorption and utilization among the three varieties could lead to production of fruits of various sizes. This holds true for Jokoso variety which has larger and longer fruits and although it produced fewer fruits than Yar`balla, its fruit has the widest diameter. The wider diameter of the fruit must have compensated for the numerous fruits produced by Yar`balla and Clemson spineless in terms of weight.This is in line with the study of

Saifullah and Rabbani (2009), who reported that larger Okra fruits although fewer in number are able to compensate for their weight when compared to smaller fruits with higher number.The effect of the climatic conditions (rainfall and temperature) and soil factors may affect the growth and yield characters (Mader *et al*. 2002).The outcome of the soil analyses may exert an influence on the growth and yield characters of the varieties in both locations. The physical and chemical properties of the soil (Table 1) shows that the Cation Exchange Capacity (useful indicator of soil fertility) for the soil in Maigana was low as compared to that of Samaru which was moderate. This is in line with the studies of Hazleton and Murphy (2007) who stated that Cation Exchange Capacity is an essential soil property that influences nutrient availability, soil pH and soil`s reaction to fertilizers which are all important determinants of crop growth and development.

5.2 Response of Okra Growth and Yield Characters to Poultry Manure Rates.

Allthe growth and yield characters examined significantly increased with increase in poultry manureapplication at both locations.This could be attributed to the high nitrogen content in the poultry manure used as indicated in Table 2 and the beneficial role of manure inenhancing soil essential nutrients like nitrogen, phosphorous and potassium which is essential for vegetable growth and chlorophyll formation as well as promoting root development. This resulted in efficient assimilate production and translocation to sink (Brady, 1974). The positive effect of poultry manure on these growth attributes could be due to the contribution made by the manure to fertility status of the soils. Manure when decomposed, increases both micro and macro nutrients as well as enhances physico-chemical properties of the soil. This could have led to its high vegetative growth (Akanbi *et al*., 2010). Poultry manure has been reported to be rich in nitrogen which supports vigorous vegetative growth in crops. Dademol *et al.* (2004) reported that nitrogen content in organic fertilizers enhanced leaf area production, flowering and seed

formation in Okra. This could lead to high level assimilate production that is mobilized for fresh fruit yield of Okra. This is supported with the findings of Ajari *et al*., (2003) who reported that poultry manure could increase plant height in Okra. This could be attributed to the fact that poultry manure contains appreciable amounts of magnesium which promotes chlorophyll synthesis that drives photosynthesis.

Decomposition of manure increases macro and micro nutrients as well as enhancement of physico-chemical properties of the soil which helps to boost morphological growth.Perhaps another possibility for increased yield ismineralizationof somecompounds present in the poultry manure used which increased uptake of nitrogen, phosphorous and potassium which are essential for plant growth and development. (Sendurkunaran *et al*., 1998). This result is in agreement with the findings of Nehra *et al*. (2001)who stated that higher yield response due to organic manure application is attributed to the improvement of physical and biological properties through mineralization of the soil which resulted in better supply of nutrients that led to better crop yield.

5.3 Response of Okra Growth and Yield Characters to Stand Density.

A significant increase was observed in growth parameters like plant height, number of leaves, number of branches and leaf area index with increase in stand density from 1 to 2plants per stand (37,777 to 75,555 plantsper hectare).Higher stand density could have given rise to increased growth due to greater competition for light which induced etiolation resulting in spindly plants. Also,increase in stand density exerts effect on the development of buds from which branches and leaves develop as a result of vigorous competition for light and other favorable factors for growth. This agrees with the findings of Aliyu, (2002) who observed increase in plant height, number of leaves and branches with increase in stand density. Efficient utilization of applied

nutrients occasioned by increased stand density probably induced optimum morphological growth that caused the increase in growth characters of the crop.

A significant increase was recorded in yield parameters such as number of seeds per pod and 100 seed weight when stand density was increased from 1 to 2 plants per stand. This could also be as a result of the higher efficiency of the leaf area to intercept solar radiation needed for the production of photosynthate required by Okra for fruit production. This supports the view of Harper (1983) and Yayock *et al*. (1988) who stated that light interception and subsequent growth rate are functions of leaf area and stand density. Treatments with denser stands hadfavorable growth conditions that enhanced vegetative growth and number of leaves per plant. Fruit length and diameter reduced with increase in density from 1 to 2 plants per stand.From the study, it is observed that increase in fruit length could be due to the fact that lower stand density responded better in terms of competition which favored metabolic activities in plant resulting in the production of longer pods. It is obvious that fewer stands resulted in better growth performance of plants due to reduced competition for resources and hence, an increased fruit weight per plant. Similar results were reported by Ghoneim (2000) where minimum fruit length was recorded from denser plant stands.There was no significant difference in number of fruits per plant, fruit diameter in both locations and fruit length in Samaru when density was increased from 1 to 2plants per stand. Inspite of the fact that yield per plant was not affected, the total yield per hectare was higher with higher density due to more number of plants per unit area that gave additional weight for more yield when compared to one stand. This might be attributed to the fact that the number of plants per stand appears to be adequate for the unit land area occupied. This could be attributed to adaptation of the varieties to 2 plants per stand in this study which was lower than 83,333 plants ha^{-1} at which Odeleye *et al*. (2005) recorded maximum dry fruit

yield. This result is in line with the result of Frezgi (2007), who reported that weight of pods significantly increased with increase in population up to 96,666 plantsha^{-1}. It is likely that the optimum stand density for Okra may be beyond the 2 plants per stand(75,555 plantsha^{-1}) evaluated in this current study.

5.4 Interaction

The significant interaction between varieties and poultry manure rates on fruit diameter in Maigana could be due to the fact that the growth habits of the different varieties are a manifestation of their genetic potential which also influences how best the varieties access nutrients and convert them to assimilates. As a result of this, they tend to differ in their growth and yield characters which may be the case with the fruit diameter. This is in line with the studies of Majanbu*et al.* (1985) who evaluated two varieties of Okra and observed that NHAE 47-4 performed better than white velvet. This may also be related to the presence of appropriate proportions and quantity of nutrient required for fruit growth and development. Similar findings were reported by Abebe *et al.*(2005) who observed significant increase in the diameter of Okra fruit when poultry manure was increased.It could also be as a result of edaphic factors and the influence exerted by the surrounding environment.

Significant interaction between variety and stand density in the length of Okra fruit in Maigana could be as a result of the differences insoil factors on these characters and the contrasting responses of different varieties to the surrounding environment. This is in line with the studies of Koti *et al.* (2005) who reported that prevailing climatic (rainfall and temperature) and soil factors and their interactions ay affect the growth and yield characters of crops.

5.5 Correlation Studies

The positive and significant correlation observed between fresh fruit yield and parameters such as plant height, number ofleaves, number of branches, fruit length and dry fruit yield signifies that they are important attributes to yield. It was observed that significant increase in each of these parameters lead to an increase in the total fresh fruit yield. This is in agreement with the findings of Raji (2002) and Dauda *et al.* (2008) who reported positive and significant relationship between some growth and yield components of Okra and garden egg.

5.6 Regression Analysis

The regression analysis showed a linear response of poultry manure against fresh fruit yield in both trials. This means that yield increased with increase in poultry manure application in both locations. This also indicates that the optimum rate of poultry manure was not obtained in both locations and hence, higher rates of poultry manure may be used in further study of the present work in order to attain the optimum level. However, an earlier study by Alasiri and Ogunkeya(1999) reported the application of 10t ha^{-1}as the optimum level of poultry manure compared to the other rates used.

CHAPTER SIX

SUMMARY AND CONCLUSIONS

The trials were conducted at the Institute for Agricultural Research (IAR) farm, Samaru ($11^0$11'N, $7^0$38'E and 686m above sea level) and Kaduna Agricultural Development Project (KADP) farm located at Maigana, Soba Local Government area ($11^0$39`N;$08^0$ 02` E, 500m above sea level) to evaluate the effects of poultry manure and stand density on Okra varieties. The treatments consisted of three Okra varieties (Yar`balla, Clemson spineless and Jokoso), four levels of poultry manure (0, 2, 4, and 6 tha^{-1})and two stand densities(1 and 2 plants per stand). The treatments were laid in a randomized complete block design and replicated three times in all possible factorial combinations. The data collected included growth components such as plant height, number of leaves per plant, leaf area index and number of branches. Yield components such as number of fruits per plant, fruit length, fruit diameter, number of seeds per pod, 100 seed weight, and fresh and dry fruit yields were also taken. In both trials, the trend of growth and yield components examined were consistent and showed increase with increased application of poultry manure. Application of $6tha^{-1}$poultry manure gave the highest fresh fruit yield (3409.5 $kgha^{-1}$) in Samaruwhile fruit yield of (3109.7 $kgha^{-1}$) was obtained in Maigana.Yar`balla produced more number of leaves and fruits per plant. Clemson spineless produced the tallest plants and longest fruits while Jokoso produced the largest fruit diameter and fresh fruit weight in both trials. Increased stand density was consistent with increase in plant height, number of leaves, branches, number of seeds per pod, fresh and dry fruit yield. Correlation showed some of the growth and yield characters such as plant height, number of leaves, number of branches and fruit length as important attributes to yield. The regression analyses for both locations were linear indicating that the optimum poultry manure rate was not achieved.

In conclusion, Jokoso variety at 2 plants per stand using 6 tha^{-1} poultry manure gave higher yield compared to Yar`balla and Clemson spineless varieties in Samaru and Maigana and may therefore be used by farmers to increase Okra production in both areas during the wet season.

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Appendix I: Samaru Meteorological observation in 2016 wet season

Month	Rainfall (mm)	Temperature (0^0C) Max	Min	R/humidity (%)		Sunshine (hrs)
June	44.0	31.4	23.2	75.5	65.4	7.1
July	71.0	30.8	22.9	80.4	71.5	5.9
August	87.0	30.6	21.9	81.9	74.3	6.7
Total	202					

Source: Meteorological unit, Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria.
NA – Not Available.

Maigana Meteorological observation in 2016 wet season

Month	Rainfall (mm)	Temperature (0^0C) Max	Min	R/humidity (%)		Sunshine (hrs)
July	22.25	32.3	23.0	85.3	70.3	NA
August	250.0	31.92	21.2	86.5	79.6	NA
Total	472.5					

Source: Kaduna Agricultural Development Project office, Maigana.
NA - Not Available.