RESPONSE OF COMMON OKRA (*Abelmoschus esculentus* L. Moench) VARIETIES TO NPK FERTILIZER AND POULTRY MANURE IN NORTHERN GUINEA SAVANNA, NIGERIA.

BY

MUBARAK, Zamfara Ibrahim

(M.Sc./AGRIC./3412/2011-2012)

A thesis submitted to the Postgraduate School,

Ahmadu Bello University, Zaria in Partial Fulfillment of the Requirements for the Award of Master of Science in Agronomy.

AUGUST, 2014

DECLARATION

I declare that the work in this thesis entitled "Response of common Okra" (*Abelmoschus esculentus* L. Moench) Varieties to different levels of NPK fertilizer and poultry manure"has been performed by me in the Department of Agronomy under the supervision of Dr Adamu Ahmad, Professor Hamza Mani and Professor Mukhtar Mahmud and the information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree.

____________________	____________	__________
Mubarak, Zamfara Ibrahim	(Signature)	(Date)

Which is confirm by

____________________	____________	__________
Dr Adamu Ahmad	(Signature)	(Date)

CERTIFICATION

This thesis titled "Response of common Okra" (*Abelmoschus esculentus* L. Moench) Varieties to different levels of NPK fertilizer and poultry manure" meets the regulations governing the award of the degree of M. Sc. Agronomy of Ahmadu Bello University, and is approved for its contribution to knowledge and literacy presentation.

____________________________ _____________ ___________

Chairman, Supervisory Committee (Signature) (Date)

(DrAAhmad)

____________________________ _____________ ___________

Member, Supervisory Committee (Signature) (Date)
(Professor H. Mani)

____________________________ _____________ ___________

Member, Supervisory Committee (Signature) (Date)
(Professor M. Mahmud)

____________________________ _____________ ___________

Head of Department (Signature) (Date)
(Dr B.A Babaji)

____________________________ _____________ ___________

Dean, Postgraduate School (Signature) (Date)
(Professor Adebayo Joshua)

DEDICATION

This Research work is dedicated to the Almighty Allah and to the entire family of Malam Ibrahim Zamfara.

ACKNOWLEDGEMENTS

I want to express my profound gratitude to all those who contributed to the realization of this consolidating step in my academic pursuit. I wish to first and foremost express my appreciation Allah Almighty for the blessings, strength, guidance and favor during the research work. My sincere gratitude goes to my supportive supervisors, Dr Adamu Ahmad, Professor Mukhtar Mahmud and Professor Hamza Mani who in spite of their busy and tight schedules gave me the necessary assistance needed to complete this dissertation, in all aspects. I will also want to show my appreciation to the lectures, technicians and all other staff from the Department of Agronomy Ahmadu Bello University Zaria.

My lovely parents and siblings, yours is so special in a way that I can't even express, thanks for your relentless support and prayers all through my life. I will forever remain indebted, for your love, support and encouragement, not only in this, but to my whole carrier.

My colleagues and good friends:, Jafar Sani Bello, , Ibrahim Lasa, Muhammad Gana, Idrissa, M.M Maiyaki, Francisca Okonji, Hinjari Akumir, Haratu Dauda, Hosea Mattoh, Khausar Kabir, Grace Luka, for their contributions, selfless support and contribution towards the success of this work. My sincere gratitude also goes to my friends for being so support to my life for their friendly advices towards this work and my life

I will also like to show my gratitude to some people that add value to my work, My humble H.O.D, Dr B.A Babaji, Dr B.B Jakusko, Malam Santuraki, Malam Isa Shero, Malam Bala, Mr Gado and Malam Aliyu for their support, assistance, and intellectual contributions.

To the lady that gave another dimension to my life Jamila, i will forever be grateful to you, thank you for loving me and being there for me. To the entire Academic and non Academic staff Ahmadu Bello University and Institute for Agricultural Research Samaru Zaria. Thank you and Allah bless you all.

ABSTRACT

Field and pot trials were conducted during the 2012 rainy season at the Research Farm of the Institute for Agricultural Research Samaru and in the Orchard of the Department of Agronomy, Ahmadu Bello University, Zaria to evaluate the effects of levels of NPK fertilizer (0, 50, 100 kg ha^{-1}) and poultry manure (0, 2, 4 t ha^{-1}) on the performance of two okra varieties (Clemson spineless and Ex-Samaru-4). The designs used were Randomized Complete Block Design (RCBD) and Complete Randomized Design for field and pot trials respectively, replicated and repeated three times in all possible factorial combinations. Results showed no significant difference in days to 50% flowering, 100-seeds weight, fruit length, fruit diameter and plant height when NPK fertilizer was varied from 0 to 100 kg ha-^{1}, but at 7 WAS, significantly increased, and gave higher number of leaves per plant (9.0 and 7.0), number of primary branches per plant (5.0), shoot fresh weight (44.9 g), number of fruits per plant (5.0), number of seeds per pod (80) and fruit weight (17 g) from 0 to 50 kg NPK ha-^{1} in both trials. Other parameters were significantly at par. Application of poultry manure from 0 to 2 t ha-^{1} significantly increased plant height, number of leaves per plant, shoot fresh weight and days to 50% flowering, a further increase to 4 t ha-^{1} gave parameters that were at par. But varying poultry manure from 0 to 4 t ha-^{1} significantly increased number of primary branches per plant and fruit yield in both field and pot trials. Significant interactions were observed on variety and poultry manure on number of fruits per plant, variety and NPK fertilizer on shoot dry weight, NPK fertilizer and poultry manure on number of primary branches per plant and between poultry manure and variety on number of leaves per plant. Okra variety Clemson spineless significantly gave taller plants, longer fruits and fewer days to 50 % flowering than variety Ex-Samaru-4, however both varieties were statistically at par on fruit yield kg ha-^{1} in both trials. A highly significant and positive correlation were obtained between okra fruit yield and plant height, number of leaves per plant, number of fruits per plant, fruit length and fruit weight. Regression analysis carried out indicated that NPK fertilizer variation resulted to linear response and poultry manure had a quadratic response in both trials. Based on the result obtained in this study, it could be suggested that for good growth and yield of okra at Samaru application of 3.5 t ha-^{1} poultry manure in variety Clemson spineless should be recommended.

TABLE OF CONTENT

Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER ONE

1 INTRODUCTION

1.1 Origin and Distribution

Common Okra (*Abelmoschus esculentus L. Moench*) is a popular vegetable in tropical and sub-tropical countries of the world; it is grown for its "pod" (Ogeniyi and Folorunso, 2003). It is a member of the hibiscus family, Malvaceae and has the typical floral characteristics of that family originating from Africa. It is now widely distributed in the tropics including Nigeria (National Research Council, 2006). It is an important vegetable crop occupying a land area of 277,000 hectares with a production of 731,000 metric tons worldwide and productivity of 2.63 t ha^{-1} in Nigeria (FAO, 2006). Okra is also believed to be found in its wild state on the alluvial banks of the Nile and the Egyptians were the first to cultivate it in the basin of the Nile (12th century BC). The crop is native to West Africa and has become established in the wild in some new world tropical areas. Okra was domesticated in West and Central Africa (Kochhar, 1986) and known as 'okro' in the Anglophone African countries as a fast growing common annual vegetable widely consumed in Africa (Schippers, 2000).

It ranks above other vegetable crops such as Amaranths, lettuce Cabbage etc (Babatunde *et al*., 2007), it is one of the home garden vegetables popularly grown and consumed in the tropics (Fayemi, 1999). According to CBN (1996), the average rate at which vegetables crop are grown including okra production in Nigeria between 1989 and 1993 was 14.0 % compared to 6.4 % of cassava and 3.8 % for maize. The plant is tolerant to drought stress (Majanbu *et al.*, 1985); however, supplementary irrigation may be necessary during extended drought periods for a satisfactory yield. In Nigeria, the widely cultivated okra is distributed and consumed either fresh (usually boiled, sliced or fried) or in a dried form (Fatokun and Chedda, 1983). The approximate nutrient content of the edible okra pod is as follows: water, 88%; protein, 2.1%; fat, 0.2%; carbohydrate, 8.0%; fibre, 1.7% and ash, 0.2% (Tindall, 1983). However, the nutritional quality of okra can be influenced by the application of organic fertilisers, such as liquid seaweed, with the following composition, according to Zodape *et al.*, (2008): carbohydrate, 7.39%; protein, 28.04%; and dietary fibre, 35.55%. The oil content in the seeds could be as high as that in poultry eggs and soybeans (Akinfasoye and Nwanguma, 2005).

1.2 Soil and Climatic Requirements

Okra requires a moderate rainfall of 80 – 100 cm well distributed to produce its young edible fruits. An average temperature of 20°C to 30°C is considered optimum for growth, flowering and fruiting (Rice *et al*.,1987). Seeds will only germinate in relatively warm soils, no germination occurs below 16^0C. A monthly average temperature range of 20^0 – 30^0C is considered appropriate for growth, flowering and development (Tindall *et al*., 1986). A wide range of soil types has been found suitable even though it was found that it thrives best in a moist friable, well-drained soil (Eke *etal*., 2008). In Nigeria, production is mainly during the warm season, although it can be grown all the year round depending on the varieties. The pH of about 6.0 to 6.8 is recommended for okra production (Kochlar, 1981).

1.3 Cultivation

The land on which okra is to be cultivated should be well ploughed and harrowed in order to create a favourable environment for its growth. In the dry season, it is grown on ridges or on beds at a favourable environment for its growth. While in the wet season, it is grown on ridges or on beds at a spacing of 40-45 cm at a rate of three seeds per hole and later thinned to one plant per stand. Okra is predominantly grown in Nigeria during the wet season; it is limited to the irrigation sites during the dry season especially in Fadama (Daniel and Kalko, 1982). The cultivation of okra is mostly done by small scale farmers and the harvests are sold for some extra income which also helps for the cultivation of staples, after the need for subsistence has been adequately met. It is grown mainly as an intercrop with maize, groundnuts, yams, cassava, melon or other vegetables (Nath, 1976). In most cases the crop is intercropped with other field crops at a population lower than the 10,000 plants ha^{-1} recommended for okra production (Udoh *et al*., 2005). In some regions, it is grown as sole crop during the late wet season. The late season crop when harvested may be dried and stored for the use in the dry season when fresh pods are not likely to be readily available in the market. In the fresh form, okra fruits are highly perishable except when stored frozen.

1.4 Uses

Okra is mainly cultivated for its “pods” which are cooked and eaten in African countries like Nigeria, Egypt and Sudan. It is also important in other tropical areas including Asia and South America, fresh okra fruits are used as vegetable while the roots and stems are used for preparing brown sugar (Chauhan, 1972). Okra pods are used for oil extraction.

The protein found in okra is very important in human diet, it helps to build muscle tissue and make up enzymes which control all the hormones that control the organ. The soluble fibre in okra helps to lower serum cholesterol, reducing the risk of heart disease, the other half is insoluble fibre which helps to keep the intestinal tract healthy decreasing the risk of some form of cancer especially colorectal cancer. Nearly 10% of the recommended level of vitamin B6 and folic acid are present in half a cup of cooked okra, vitamins are required for good vision, help bone growth, proper circulation of blood and aids 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). Although okra fruits are one of the most commonly harvested fruits in Africa, there are places where the leaves are at least as important as the fruits. This is the case in Eastern Nigeria and in the Bongor region in western Chad. People mainly collect small, young leaves, or new sprouts after the fruit have been collected, the leaf yield in this area is 3-6 t/ha (Dupripez *et al.*, 1989). Fresh green fruits of okra considered to be good quality in the Nigerian context, should be smooth, short and highly mucilaginous. Fruits that are over matured are generally not fit for consumption and therefore, are preserved for seeds (Splittstoessor, 1990).Fruits are normally sliced and dried when okra cannot be sold at the market and has become tough or hard and unsuitable for use in raw form, but processing allows these fruits to be preserved for later use

.

1.5 Justification and Objectives of the study

The use of inorganic fertilizer has not been helpful under intensive agriculture; because it is often associated with reduce crop yield, soil acidity and nutrient imbalance **(**Ojoniyi, 2000). The extent, to which farmers can depend on this, is constrained by unavailability of the right type of inorganic fertilizer at the right time, high cost, lack of technical know-how and lack of access to credit (Chude, 1999). Hence animal wastes that result to animal manure is better alternative and a necessary option for improved okra production especially in the Guinea savannah of Northern Nigeria. Poultry manure is relatively cheap, readily available and tend to be higher than inorganic fertilizer in terms of yield and improvement of soil physical properties. The use of inorganic and organic fertilizers as source of nutrient for vegetable crops assumed an increasing importance. Use of inorganic fertilizer is still desirable since the land under cultivation is limited, high land use intensity as a result of high population, so the demand for higher production is pressing. This is particularly more so in vegetable production because it is usually in small land scale holdings among many farming families between 0.2 to 2 t ha^{-1}in either sole, but mostly mixed cultivation. The increasing demand for organic farm produce for its attendant health benefits and risk- free characteristic is another dimension to the use of organic manure in Agriculture especially in vegetables and fruits production. Investigations have indicated that Nigerian Savannah soils are largely deficient in major essential nutrients like N, P and K, making it is necessary to supply or enrich the soil with other source of nutrients like poultry, cow and goat manures but among all these, poultry manure has been found to have higher nutrient concentration (Iken and Amusa, 2004). Nutrient elements have specific function in crop growth, development and yield but no single nutrient can produce any meaningful plant growth on its own. The addition of organic fertilizers is necessary due to its readily available nutrient concentration and relative ease of handling and application. However, in terms of quantity, the amount of poultry manure required for cultivation is less, compared to that of cow, goat and sheep manure. This made transportation and handling of the poultry manure easier than the rest of the organic manures, the nutrient concentration is also higher than that in cow manure. This helps our small scale farmers who are the majority to obtain high yield with less production cost because the poultry manure is cheaper than the NPK fertilizer.

In Nigeria the limiting factors in okra production and other vegetables among others include weed management, fertilize soil, tillage practice, low yielding varieties and Sub-optimal planting density (Iyagba *et al.,* 2012). Fertilizer application among the various agronomic practices also influenced the growth and green pod yield in okra. Tropical soils are adversely affected by sub-optimal soil fertility and erosion, causing deterioration of the nutrient status and changes in soil organic population (Economic Commission for Africa, 2001). Use of NPK fertilizer can improve crop yields, total nutrient content, and nutrient availability. Babatola (2006) recorded an increased yield in okra due to NPK fertilizer application. Recommended rates of NPK fertilization vary greatly depending on the variety and environment. Windham (1966) recommended between 27 and 54 kg ha^{-1} N for Clemson spineless okra variety depending on the soil type. Majanbu *et al*. (1985) recommended either 35 or 70 kg ha^{-1} of N depending on the variety. Several authors have also reported the importance and different response of okra varieties to different rates of NPK fertilizer (Blenner Hassett and El-zaftawi 1986, Khan *et al*., 2002).

Dademel *et al.* (2004) also reported that higher NPK fertilizer dose of about 150 kg ha^{-1} will cause an increase in the nutrient uptake and hence tends to increase crop yield. Based on these

The objectives of this study therefore are:

(i) To determine the effect of NPK fertilizer and poultry manure on growth, yield and yield components of okra.

(ii) To assess the performance of two okra varieties under the climatic conditions of Samaru.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Organic Manure

Organic fertilizers are materials added to the soil to supply the essential plant growth, development and enhance optimum productivity. The best known organic manure is the waste from mixed arable and livestock farming called farmyard manure. Farmyard manure is partially rotted straw containing urine and faeces. Other rotting plant remains is usually called composts. Un-decomposed materials like straw, organic wastes from industrial processes, town refuses and sewage sludge are also referred as manures,FAO (1998) highlighted the role of organic matter in sustaining the fertility of soil for good production of vegetables by binding the soil, but best performance is obtained on well drained fertile soil with adequate organic matter content. Organic fertilizer is a very active and important component of the soil. It is the nitrogen reservoirs and furnishes large portion of the soil phosphorus and sulphur. It protects soil against erosion and supplies the cementing substance for desirable aggregate soil formation. It loosens the soil from all available organic fertilizer (Timdal, 1998).

Adediran *etal.* (1999) reported that animal manure contains more concentrate than that of plant manure. Organic fertilizer must be applied in large quantity to the crop because the nutrient concentrate in organic manure is very low compared with that of inorganic fertilizer. Manures are usually applied at higher rates, they give residual effects on growth and yield of succeeding crops (Makinde and Ayoola, 2008), improvement of environmental conditions as well as the need to reduce cost of fertilizing crops are reasons for advocate use of organic materials (Bayu *et al*., 2006). Organic manures improve soil fertility by activating soil biomass (Ayuso *et al.*, 1996).

2.1.1 Poultry manure

Poultry manure is an efficient organic fertilizer and also an important source of plant nutrient, its addition improves the physical properties of the soil (Reddy and Reddi, 1995). Its average nutrient content is 3.03 % N, 2.63 % P_2O_5 and 1.4 % K_2O. It has been reported that 30% of nitrogen from poultry litter is in urea or ammonium form and hence readily available (Sunassce, 2001). Poultry manure also increased soil organic matter, nitrogen, pH, phosphorous and cation exchange capacity Adeniyan, (2003) and Ayeni *et al*. (2008). Poultry manure has a fairly high nutrient composition when compared with other sources of animal manure. The quantity of NPK in the poultry manure in 1 tonne is considered to be 30 kg/ ton N, 4 kg/ ton P and 24 kg/ ton K respectively (Kari 2000). Poultry manure is a good source of major mineral elements that are capable of enhancing soil fertility (Thomas, 1997). The fertility of the soil could be sustained with the addition of poultry manure; its application in the soil may contribute to combat soil organic matter decline and soil erosion (Van-camp *et al.*, 2004)).

2.1.2 Effect of poultry manure on growth and yield of okra

The organic matter of the soil which can be replenished and maintained by the application of poultry manure has been reported by Roddy and Reddi, (1992) as the store house of plant nutrients. Nutrients contained in poultry manure and other organic source are released more slowly and are stored for longer period in the soil, thereby ensuring longer residual effects, improved root development and higher crop yield of okra

(Sharma, 1991). Ajari *et al*. (2003) reported that 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 improved yield and development of okra due to its easy solubilisation effect of released plant nutrient, leading to improved nutrient status 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. Aliyu, (2000) and Dauda *et al.* (2005) made similar observations on okra in their separate studies. Poultry manure play a vital role in the contribution of nutrient in okra production, it also act as a store house for cation exchange capacity and as a buffering agent against undesirable pH fluctuation (Adepetu and Covey, 1987). Poultry manure provide a source of all necessary macro and micro-nutrients in available forms, thereby improving the physical and biological properties of the soil which could enhanced growth and development of okra plants (Abou El-Magd *et al*., 2006).

Alasiri and Ogunlela (1999) also reported that application of poultry manure at the rate 10 t ha^{-1} gave an optimum yield of okra at Owu Southwest Nigeria. Poultry manure could increase plant height, number of leaves, number of branches as well as shoot weight of okra Ajari *et al*. (2003). Increase in poultry manure application has a significant effect on the vegetative growth of okra plant. This is in contrary to the findings of Onwu *et al*. (2008) that an increase in the application of poultry manure led to an increase in plant height and other growth attributes in okra plant. However poultry manure could be used for soil management as it improves soil nutrient status and could be used for sustainable production of okra. In support of this, Ano and Agwu (2006) had reportrd that poultry manure increase soil pH, macro nutrients, phosphorus and cation exchange capacity of the soil which improved okra production. Poultry manure when efficiently and effectively used, ensure sustainable okra productivity by immobilizing nutrients that are susceptible to leaching (Ogunkeye 1999). Manures are usually applied at higher rates, relatively higher than inorganic fertilizers. When applied at high rates they give residual effects on the growth and yield of succeeding crops (Makinde and Ayoola 2008). Maerere *et al.* (2001) also reported that poultry manure was frequently used by farmers in most of the developing countries for obtaining good quality and quantity of okra. Application of poultry manure helps in plant metabolic activity through the supply of some important micro nutrients in the early vigorous stage of okra growth, which in turn increase yield at the later stage (Anburani and Manivannan 2002)

2.2 Inorganic Fertilizers

Inorganic fertilizers are synthetic, chemical, artificial material added to the soil that supplies one or more required materials for plant growth. Inorganic fertilizers are one of the major inputs in crop production. They play a vital role in the improvement of soil fertility and enhancement of crop growth and yields. Fertilizer application to crops is a necessary condition for good yield of crops in Nigeria due to inherent low fertility status of the soils, particularly in the savannah regions the stability of production depends on replenishing nutrients removed from the soil by crops, maintaining desirable physical condition of the soil, preventing an increase in soil acidity and toxic elements and minimizing or preventing erosion, use of fertilizers is reported to be responsible for over 50% yield increase in crops (Ayodele, 1993).

2.2.1 Effect of NPK fertilizer on growth and yield of okra

Fertilizer is a very essential input in crop production. The application of fertilizer is necessary in enhancing the soil nutrient status and increasing crop yield. Okra requires nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sodium (Na) and Sulphur (S) for fertility maintenance and crop production. These nutrients are specific in function and must be supplied to plants at the right time and at the right quantity. Lack of sufficient amounts of these nutrients result in poor performance of the crop with growth been affected resulting to low yield (Shukla and Naik, 1993). Majanbu et al (1986) repoted that NPK are the most important macro-nutrients that okra required for proper growth and yield. NPK fertilization among the various agronomic practices also influenced the growth and yield of okra. Babatola (2006) reported an increased in okra yield due to NPK fertilizer application even thought the recommended rates of NPK fertilization vary greatly depending on the variety and the environment. Application of 22.5 kg ha^{-1} N, 22.5 kg ha^{-1} P and 22.5 kg ha^{-1} P is recommended for effective okra production Philip *et al*. (2010).

A study was conducted at the Teaching and Research Farm (University of Ado-Ekiti) to determine the effect of NPK fertilizer application rates and method of application on growth and yield of okra (*Abelmoschus esculentus L. Moench)*. Okra seeds (variety LD88) were treated with three levels of NPK fertilizer (0, 150 and 450 kg NPK ha^{-1}) and two methods of fertilizer application (ring and band method). The result indicated that NPK fertilizer application significantly increased growth parameters (plant height, leaf area, number of leaves) , yield and yield components with optimum yield of okra obtained at 150 kg NPK ha $^{-1}$ and ring method of fertilizer application was found to be better for okra production (Omotosa and Shittu, 2007).

Babatola and Olaniyi, (1999) reported a better performance of okra when NPK fertilizer was applied and this was in agreement with the findings of Akanbi *et al*. (2005) who observed a great increase in growth and yield of various okra varieties when NPK fertilizer was applied. Babatola *et al*. (2002) and Kolowole *et al*. (2008) also reported that increasing the rate of NPK fertilizer led to an increase in the growth and performance of okra varieties to a great extent. Somkuwar *et al* (1997) also reported that yield components in okra such as fresh fruit yield, fruit weight and number of fruits were increased with the application of NPK fertilizer. Application of 250 kg ha^{-1} level of NPK (20:10:10) proved effective in ensuring better performance in okra (Babatola and Olaniyi, 1997). Which is also consistent with the report of federal fertilizer department (2002) who recommended the application of 250 kg ha^{-1} level of NPK fertilizer (20:10:10) for better performance of okra. This is in contrary to the findings of Obi *et al*. (2005) for reported no significant increase in both fresh fruit yield and weight of okra plants with increasing NPK fertilizer treatments. However Akintunde *et al.* (2000) reported least yield components without the application of NPK fertilizer. This showed that application of these nutrients are important for enhance yield of okra. This is also in line with the findings of Sing (1995) who also reported a great increase in yield of okra with increased application in NPK fertilizer.

2.3 Effects of NPK fertilizer and poultry manure on growth and yield of okra

Mixing organic and inorganic fertilizers may be a sound soil fertility management strategy in many countries. Apart from enhancing crop yields, the practice has a greater beneficial residual effect that can be derived from use of either organic or inorganic fertilizers applied alone. Okra responds well to the application of poultry manure and NPK fertilizer. Makinde *et al*. (2001) reported that okra (*Abelmoschus esculentus*) yields obtained from the application of a combination of synthetic fertilizer and poultry manure improved yield over that from manure alone. Akande *et al*. (2003) also reported that combined use of inorganic fertilizer applied together with poultry manure significantly improved growth and yield of Okra (*Abelmoschus esculentus L Moench*) compared to application of each material separately. Lombin *et al*. (1991) and Katung *et al*. (1996) reported that the use of inorganic fertilizers in combination with organic materials was able to give higher and sustainable crop yields than the sole use of inorganic fertilizer or animal manure. Agriculture in the present day requires the supply of addition nutrients for optimum crop performance. Complimentary use of organic with inorganic fertilizer is widely known to be reliable and sustainable soil fertility management strategy. Palm *et al*. (1999) gave the importance of organic and inorganic fertilizers as essential tool in okra production; he reported that, the growth of okra plant was markedly influenced by the application of poultry manure and NPK fertilizer as observed from the increased plant height and number of leaves. Akanbi *et al*. (2005) also reported that great increase in yield of okra when N fertilizer was combined with organomineral fertilizer, application of poultry manure and NPK fertilizer greatly enhanced the growth and development of okra compared to the untreated controls. Okra grown under combination of poultry manure and inorganic fertilizer tend to improve the fruit yield, and led to a balance in nutrient supply. Murmira and kirchmann, (1993) reported that the nutrient use efficiency of okra crop is better with mix of poultry manure and NPK fertilizer, nutrients seemed more readily available to okra plants with the mixes than the poultry manure or NPK fertilizer alone. Application of NPK fertilizer and poultry manure can be used to sustain okra production in the tropics. Sing *et al.* 2004 and Steiner (1991) reported an increase in growth components of okra when NPK fertilizer and poultry manure were applied in combined. Increased in fruit number, fruit weight and fruit yield of okra was observed in the application of 112 kg NPK ha^{-1} and 6 t ha^{-1} poultry manure (Ogunlana, 1995). This could be due to the optimum availability of the nutrients to the crop, adequate nutrients availability had been indicated to improve growth and yield parameters of okra plant. It is reported that when NPK is not limiting, dry matter production, assimilates partition as well as organic compound production would not be disturbed. However a shortage in any of the nutrient requirements may cause profound effect in the physiological processes in the crop (Alasiri 2009). This explains the general higher performance of okra plant resulting from the application of NPK fertilizer and poultry manure.

CHAPTER THREE

3 MATERIALS AND METHODS

3.1 Experimental Site

Field and pot trials for the 2011 rainy season were conducted at the Research Farm of the Institute for Agricultural Research, Samaru ($11^0\ 11^N$, $07^0\ 38^0$ E and 686m above sea level) and in the Orchard of the Department of Agronomy, Ahmadu Bello University Zaria respectively.

3.2 Soil Sampling

Composite soil samples were taken from 0-30 cm depth prior to land preparation from I.A.R field to determine the physico-chemical properties of the soil. Composite soil sample at 0-30 cm depth for the pot trial was obtained from area BZ Farm of A.B.U Zaria for analysis in the laboratory.

3.3 Manure Sampling and Analysis

Poultry manure sample of broiler chicken collected from Haf-sabil farm house and analysed using routine analysis in order to determine the chemical properties of the manure.

3.4 Treatments and Experimental Design

The treatments consist of two okra varieties (Clemson spineless and Ex-Samaru-4), three levels each of NPK fertilizer 20:10:10 (0, 50 and 100 kg ha^{-1}) and poultry manure (0, 2 and 4 t ha^{-1}). The field experiment was laid out in Randomized Complete Block Design

(RCBD) with treatments arranged in all possible factorial combinations giving a total of 18 treatments and replicated three times. For the pot trial it was laid out in Complete Randomized Design (CRD) in the Departmental orchard repeated three times.

3.5 Plot Size

Each gross plot was 4.5 m ×4 m long (18 m^2) and comprises of 6 ridges. While the net plot area was 3 m × 4 m (12 m^2) comprising of 4 ridges, at 75 and 40 cm inter and intra row spacing.

3.6 Varietal Description

3.6.1 Ex-Samaru-4

This variety was obtained from Department of Agronomy I.A.R, Samaru. It is a short local variety with broad leaves and few number of branches. It fruits well, but the fruits are small in size and posses spines. It is highly mucilaginous and produced few flowers compared to some improved varieties. The variety posses fewer number of leaves of about 6-7 per plant with 52-54 days to maturity. The variety has a yield potential of fresh fruit yield of up to 4 to 6 t ha^{-1}.

3.6.2 Clemson spineless

The variety was obtained from Department of Crop Protection I.A.R, Samaru. It is a variety with medium dark green, angular pods. The fruits are a little bit longer in size than in the other varieties, with small diameter. The plant is also a short variety type, with broad leaves, but narrower at the edge. The variety is not as mucilaginous as variety Ex-

Samaru-4. It posseses fewer number of leaves per plant, fewer days to maturity of 50 to 52 and number of branches per plant than most of the varieties. It has a yield potential of fresh fruit yield of about 5 to 7 t ha^{-1}.

3.7 Cultural Practices

3.7.1 Land preparation

The land was, harrowed and ridged at 75 cm apart before planting, and for the pot trial gravels where available were separated from the soil each plastic pot of 490 cm^2 cubic area was filled with 10 kg of soil.

3.7.2 Seed treatment

The seeds were treated with seed dressing chemical Apron star (20% w/w thimethoxan, 20% w/w metalaxyl-m and 2% w/w difenoconazole) at the rate of 10 g per 5 kg of seed against fungicides and insecticides.

3.7.3 Sowing

Three seeds were sown per hole at intra row spacing of 40 cm on ridges. The seedlings were thinned to two plants per stand at two weeks after sowing (WAS) in the field trial, and to three stands per pot in the pot trial.

3.7.4 Manuring

Poultry manure was applied 3 days before planting in both trials, by incorporating it into the soil along the ridges by making shallow groves about 5 cm as per varied treatments in the field trial. For the pot trial manure was incorporated into the pots as per the varied treatments.

3.7.5 Fertilizer Application

NPK fertilizer was applied by side dressing at 2 WAS as per treatments (0, 50 and 100 kg ha^{-1}) in both trials.

3.7.6 Weed control

Glyphosate at 1.4 kg ai ha^{-1} was used prior to land preparation to kill the emerged weeds before planting. Hoe weeding was carried out at 3 and 5 WAS in the field trial while for the pot trial, weeds were hand pulled on a regular basis.

3.7.7 Pest and disease control

The okra plants were sprayed against beetles and caterpillars, by applying (Cyper force) which has a systemic and contact action, at the rate of 0.5 litres per hectare (30 mls per 15 litres of water) four times during plant growth, at four days intervals. Spraying starts from 3 weeks after seedling emergence, and stopped before the plant starts fruiting,

3.8 Meteoological data

The rainfall, temperature and relative humidity were obtained from the IAR meteorological station Samaru, Zaria throughout the trials.

3.9 Observations and Data Collection

3.9.1 Growth and yield components

Five plants were randomly sampled from each plot in the field, and all the three plants in the pot trial were tagged for observation on growth and yield at 3, 5 and 7 WAS.

3.9.2 Plant height

This was carried out by measuring the heights of the tagged plants with a meter rule from the top soil level to the tip of the terminal buds and the average recorded for each of the treatment.

3.9.3 Number of leaves per plant

This was taken by counting all fully expanded leaves on each of the tagged plants and the average value was recorded for each of the treatment.

3.9.4 Number of primary branches per plant

This was determined by counting all the developed primary lateral branches on each tagged plants and the mean value was recorded for each of the treatment.

3.9.5 Fresh shoot weight

Plants from the discard of each plot for the field trial were uprooted and shoots were separated from the roots and measured using Salter scale and the mean was recorded for each of the treatment.

3.9.6 Dry shoot weight

The fresh shoot in 3.9.4 above was placed in an envelope labelled and oven dried at temperature of 70^0 C until it reaches a constant weight, there after weighed and the mean recorded for each of the treatment.

3.9.7 Days to 50% flowering

This was recorded from daily visible observation covering the period of flower emergence up to 50% of the plants population in both the field and pots. Values obtained were recorded for each treatment.

3.9.8 Number of fruits per plant

Fresh fruits harvested from the tagged plants in the net plot and from the pots in the orchard at four days interval and were counted and recorded on per plant basis. Values were thereafter summed up from first to last harvest and recorded as per treatment.

3.9.9 Fruit length

The lengths of five fruits were taken from the net plot and from the pots, these were measured using meter rule and the average was recorded for each treatment.

3.9.10 Fruit diameter

Five fruits from the tagged plants in the net plot and the pots were taken and their diameters measured, from, with Vernier caliper and the average was recorded for each treatment.

3.9.11 Fresh fruit weight per plot

Fresh fruits harvested from the tagged plants in the net plot and from the pots were weighed using metoler balance and the average recorded for each treatment.

3.9.12 Fruit yield (kg ha^{-1})

This was the sum of weights of four harvests of fruits per plots and pots, thereafter by converted to kilogram per hectare (kg ha^{-1}).

3.9.13 Number of seeds per pod

This was determined from the tagged plants randomly selected within each plot and pot. The seeds were collected and counted from five randomly selected dry pods from the harvest of the tagged plants and the average was recorded for each treatment.

3.9.14 100-seed weight

100 seeds from pods of the five tagged plants dried in the field and pots were randomly sampled, counted, weighted in grams and recorded for each treatment.

3.10 Data Analysis

The data collected was subjected to statistical analysis of variance to test the significance of treatments effect using the F-test (Snedecor and Cochram, 1967). The means were separated using Duncan Multiple Range Test (Duncan, 1955). Correlation analysis was also carried out to find the magnitude and nature of association between the growth and yield parameters (Little and Hills, 1978). Regression analysis was also done to find out the optimum NPK fertilizer and poultry manure rates for maximum yield as suggested by Garg and Bansal (1972) and Reddy *et al*. (1987).

CHAPTER FOUR

4 RESULTS

4.1 Soil and manure Analysis

Physical and chemical properties of soil at the experimental site at 0-30 cm depth (for 2012 rainy season) and some chemical properties of poultry manure used are presented in Tables 4.1 and 4.2 respectively. The results of the soil physical analysis showed that the textural class of the soil used for the field trial was clay loam while that for the pot trial was sandy clay loam. The analysis indicated that the soils used for both the field and pot trials were slightly acidic (5.4 and 6.4), low in organic carbon (0.10 and 0.30) and high in total nitrogen. Available phosphorous was moderate. Exchangeable bases in the the field trial were high than those in the pot, with Ca, Mg and CEC appeared moderate while K and Na were low. Chemical properties of the poultry manure used showed a moderate level of K, Ca, total P and Na, while Mg was low. The nitrogen content was high.

4.2 Plant Height

The effects of NPK fertilizer and poultry manure on plant height of okra varieties for both the field and pot trials during 2012 rainy season at Samaru are shown in Table 4.3. The result shows that, Clemson spineless significantly produced taller plants than Ex-Samaru-4 at all sampling periods in both trials. Application of NPK fertilizer had no significant influence on plant height throughout the sampling periods in both trials. Increase in application of poultry manure from 0 to 2 t ha^{-1} significantly increased the

Table 4.1 Physical and chemical properties of experimental site soil at 0-30 cm depth

Physical properties	Field	Pot
Sand %	32	49
Silt %	36	27
Clay %	32	24
Textural class	Clay loam	Sandy clay loam
Chemical composition		
pH in H_2O (1:2:5)	5.54	6.40
pH in $CaCl_2$ (1:2:5)	5.29	4.51
Organic carbon%	0.10	0.30
Total nitrogen%	1.17	1.64
Available phosphorous mg/kg	6.83	9.80
Exchangeable bases (Cmol /kg/)		
Ca	4.00	2.80
Mg	3.26	1.85
K	0.33	0.35
Na	0.50	0.30
CEC	8.20	7.50

Table 4.2 Elemental composition of poultry manure used for the experiment during 2012 rainy season Samaru

Nutrients	Amount %
Total K	1.33
Total C	1.35
Total Mg	0.77
Total Na	1.35
Total N	3.07
Total P	1.80

Table 4.3 Effects of NPK fertilizer and poultry manure on plant height (cm) of okra varieties during 2012 rainy season in field and pot trials at Samaru

	Plant height (cm)					
	Field			Pot		
Treatment	3WAS	5WAS	7WAS	3WAS	5WAS	7WAS
Variety(V)						
Clemson spineless	14.81a	21.83a	34.98a	13.34a	24.03a	45.39a
Ex-Samaru-4	12.44b	18.23b	29.93b	11.73b	19.91b	36.86b
SE±	0.478	0.535	0.991	0.347	0.843	1.586
NPK rate (kg ha^{-1})						
0	13.23	18.92	30.79	12.43	20.96	38.37
50	13.84	20.63	33.33	12.04	22.52	42.73
100	13.78	20.53	33.25	13.13	22.13	42.29
SE±	0.586	0.655	1.215	0.424	1.033	1.943
Poulty manure t ha^{-1}						
0	11.44b	16.26b	26.34b	09.46c	17.83c	35.41b
2	14.67a	21.67a	34.92a	12.79b	21.90b	40.76b
4	14.74a	22.16a	36.11a	15.36a	25.87a	47.22a
SE±	0.586	0.655	1.215	0.424	1.033	1.943
Interaction						
V*F	NS	NS	NS	NS	NS	NS
V*P	NS	NS	NS	NS	NS	NS
F*P	NS	NS	NS	NS	NS	NS
V*F*P	NS	NS	NS	NS	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant.

Plant height except at 7 WAS for the pot experiment; further increase to 4 t ha^{-1} did not affect plant height in the field experiment. However in the pot trial, further increase to 4 t ha^{-1} resulted to increase in plant height. None of the treatment interactions on plant height were significant at all the sampling period

4.3 Number of Leaves per Plant

The effects of NPK fertilizer and poultry manure on number of leaves per plant of okra varieties during 2012 rainy season in field and pot trials are shown in Table 4.4. The result shows that number of leaves per plant was not significantly influenced by varietal difference throughout the sampling periods in both field and pot trials.

Applying 50 kg NPK ha^{-1} at 5 WAS in both trials significantly produced higher number of (7.0) leaves per plant than the control, but was statistically comparable with 100 kg NPK ha^{-1}. Likewise number of leaves produced by 100 kg ha^{-1} was at par with the control only for field trial. At 7 WAS, for the field trial, application of 100 and 50 kg NPK ha^{-1} produced statistically similar number of leaves per plant but higher than the control. There was no significant difference in number of leaves per plant at 3 WAS for the field trial and 7 WAS for the pot trial when NPK was applied.

Application of poultry manure in the field and pot trial did not influenced number of leaves per plant at 3 and 7 WAS, respectively. At 5 and 7 WAS, for the field trial and 5 WAS for the pot trial higher number of leaves per plant were obtained by applying 2 and 4 t ha^{-1} manure which were statistically comparable, but higher than the control.

Table 4.4 Effects of NPK fertilizer and poultry manure on number of leaves per plant of okra varieties during 2012 rainy season in field and pot trials

	Number of leaves per plant					
	Field			Pot		
Treatment	3WAS	5WAS	7WAS	3WAS	5WAS	7WAS
Variety(V)						
Clemson spineless	4.0	6.0	8.0	4.0	5.0	7.0
Ex-Samaru-4	4.0	6.0	7.0	4.0	5.0	7.0
SE±	0.07	0.12	0.25	0.08	0.17	0.13
NPK rate (kg ha^{-1})						
0	4.0	6.0b	7.0b	4.0	5.0b	7.0
50	5.0	7.0a	7.0b	5.0	6.0a	7.0
100	4.0	6.0ab	9.0a	4.0	6.0a	7.0
SE±	0.08	0.15	0.32	0.09	0.21	0.16
Poultry manure (t ha^{-1})						
0	4.0	6.0b	6.0b	4.0b	5.0b	7.0
2	4.0	8.0a	8.0a	4.0b	6.0a	7.0
4	5.0	8.0a	8.0a	5.0a	6.0a	7.0
SE±	0.08	0.15	0.32	0.09	0.21	0.16
Interaction						
V*F	NS	NS	NS	NS	NS	NS
V*P	NS	**	**	NS	NS	NS
F*P	NS	NS	NS	NS	NS	NS
V*F*P	NS	NS	NS	NS	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant **=highly significant at 5% level.

In the pot trial, application of 4 t ha^{-1} poultry manure at 3 WAS significantly produced higher number of leaves per plant than 2 t ha^{-1} and the control which were at par. Highly Significant interactions on number of leaves per plant were observed between variety and poultry manure at 5 and 7 WAS in the field trial.

Interactions between variety and poultry manure on number of leaves per plant at 5 and 7 WAS in the field trial is presented on Table 4.5. The result shows that at 5 WAS there was a corresponding increase in number of leaves per plant of variety Clemson spineless when manure rates were varied from 0 to 2 and 4 t ha^{-1}. However variety Ex-Samaru-4 gave higher number of (7.0) leaves per plant at 2 and 4 t ha^{-1} poultry manure, which were at par but higher than the control. When varieties were considered, at local control and 2 t ha^{-1} manure rates, Ex-Samaru-4 gave higher number of (7.0) leaves per plant than variety Clemson spineless. But at 4 t ha^{-1} poultry manure, no significant difference in the number of leaves per plant was observed between the varieties. However at 7 WAS both variety Clemson spineless and Ex-Samaru-4 gave the highest number of (8.0 and 9.0) leaves per plant at 4 t ha^{-1} poultry manure, and the least number of (6.0 and 7.0) were obtained at the control. When the two varieties were considered, at each poultry manure rate from 0 to 4 t ha^{-1} shows no significant difference between the varieties.

Table 4.5 Interaction between varieties and poultry manure on number of leaves at 5 and 7 WAS during 2012 rainy season field trial at Samaru

	Poultry manure t ha^{-1}		
Treatment	**0**	**2**	**4**
	5WAS		
Clemson spineless	5.0c	6.0b	7.0a
Ex-Samaru-4	6.0b	7.0a	7.0a
SE±0.124			
	7WAS		
Clemson spineless	6.0c	7.0bc	8.0ab
Ex-Samaru-4	7.0bc	7.0bc	9.0a
SE±0.438			

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

4.4 Number of Primary Branches per Plant

The effects of NPK fertilizer and poultry manure on number of primary branches per plant of okra varieties during 2012 rainy season field and pot trials at Samaru are shown in Table 4.6. The result shows that there was no significant difference in number of primary branches per plant between the varieties in both field and pot trials, except at 7 WAS in pot trial where Ex-Samaru-4 significantly produced higher number of (5.0) primary branches per plant than Clemson spineless. Applications of 50 kg NPK ha^{-1} significantly produced higher number of (5.0) primary branches per plant than the rest of the treatments which were statistically comparable at both sampling periods and trials.

Application of poultry manure had no significant influence on number of primary branches per plant at 5 WAS in both trials. However, at 7 WAS, application of 4 t ha^{-1} gave higher number of (6.0) primary branches per plant than other rates which were

Table 4 6 Number of primary branches per plant of okra varieties as influenced by NPK fertilizer and poultry manure during 2012 rainy season field and pot trials at Samaru

	Field		Pot	
Treatment	5WAS	7WAS	5WAS	7WAS
Variety(V)				
Clemson spineless	3.0	4.0b	3.0	4.0
Ex-Samaru-4	3.0	5.0a	3.0	4.0
SE±	0.13	0.24	0.16	0.14
NPK fertilizer kg/ha				
0	3.0b	4.0b	3.0b	4.0b
50	4.0a	5.0a	4.0a	5.0a
100	3.0b	4.0b	3.0b	4.0b
SE±	0.16	0.29	0.19	0.17
Poulty manure t ha^{-1}				
0	3.0	4.0b	3.00	4.0b
2	3.0	4.0b	3.00	4.0b
4	3.0	6.0a	3.00	6.0a
SE±	0.16	0.29	0.19	0.17
Interaction				
V*F	NS	NS	NS	NS
V*P	NS	NS	NS	NS
F*P	**	NS	NS	NS
V*F*P	NS	NS	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT.
NS = Not significant **=highly significant.

statistically similar in both trials. There was a highly significant interaction between NPK fertilizer and poultry manure at 5 WAS in field trial.

The interactions between fertilizer and poultry manure on number of primary branches per plant at 5 WAS in both field and pot trials are shown in Table 4.7. Equal number of primary branches per plant were recorded from the control and 50 kg ha^{-1} NPK fertilizer, and increasing poultry manure from 0 to 2 t ha^{-1} did not significantly affect number of primary branches per plant. Further increase to 4 t ha^{-1} increased the number of primary branches per plant. At 100 kg ha^{-1} NPK fertilizer, increasing poultry manure from 0 to 2 t ha^{-1} increased the number of primary branches per plant from 2 to 3, further increase to 4 t ha^{-1} resulted in statistically similar number of branches per plant. However, when poultry manure was held constant at different NPK level it was observed that at control and 4 t ha^{-1} manure, increasing NPK fertilizer from 0 to 50 kg ha^{-1} increased the number of primary branches per plant. Further increase in NPK from 50 to 100 kg ha^{-1} resulted to decrease in number of primary branches per plant.

At 2 t ha^{-1} increasing NPK from 0 to 50 kg ha^{-1} increased numbers of primary branches from 2 to 3 per plant, but further increase to 100 kg ha^{-1} resulted in statistically equal number of 3 primary branches per plant.

Table 4.7 Interaction between fertilizer and poultry manure on number of primary branches per plant at 5 WAS during 2012 rainy season field trial at Samaru

	Poultry manure (t ha-^{1})		
Treatment	**0**	**2**	**4**
0	2.0c	2.0c	3.0b
50	3.0b	3.0b	4.0a
100	2.0c	3.0b	3.0b
SE±0.283			

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

4.5 Fresh Shoot Weight per Plant

Effects of NPK fertilizer and poultry manure on shoot fresh weight (g) per plant of okra varieties during 2012 rainy season in Samaru is shown in Table 4.8. The result shows no significant difference on shoot fresh weight between the varieties throughout the sampling periods. NPK fertilizer had no significant influence on shoot fresh weight at 3 WAS. However, at 5 and 7 WAS, the control significantly gave lower shoot fresh weight than 50 and 100 kg NPK ha^{-1} which were statistically at par. The Control manure treatment produced lower shoot fresh weight than 2 and 4 t ha^{-1} which were statistically comparable throughout the sampling periods. None of the treatments interactions were significant on shoot fresh weight per plant.

Table 4.8 Effects of NPK fertilizer and poultry manure on shoot fresh weight (g) of okra varieties during 2012 rainy season field trial at Samaru

	Shoot fresh weight (g)		
Treatment	**3 WAS**	**5 WAS**	**7 WAS**
Variety(V)			
Clemson spineless	17.46	30.92	39.86
Ex-Samaru-4	13.63	34.39	41.00
SE±	1.459	1.889	2.238
NPK rates(kg ha^{-1})			
0	13.46	26.89b	32.35b
50	17.84	34.76a	44.06a
100	15.33	36.32a	44.88a
SE±	1.787	2.314	2.741
Poultry manure (t ha^{-1})			
2	17.73a	34.42a	43.25a
4	21.24a	39.39a	48.11a
SE±	1.787	2.314	2.741
Interaction			
V*F	NS	NS	NS
V*P	NS	NS	NS
F*P	NS	NS	NS
V*F*P	NS	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT.
NS = Not significant.

4.6 Dry Shoot Weight per Plant

Effects of NPK fertilizer and poultry manure on shoot dry weight (g) per plant of okra varieties during 2012 rainy season in Samaru is shown in Table 4.9. The result shows that shoot fresh weight was not significantly influenced by varietal difference and variation in NPK fertilizer rates throughout the sampling periods. Application of poultry manure at 2 and 4 t ha^{-1} gave shoot fresh weights that were at par, but higher than the control throughout the sampling periods. There was a highly significant interaction between variety and poultry manure at 3 WAS and a significant interaction between variety and NPK at 5 WAS respectively.

The Interaction between varieties and poultry manure on shoot dry weight per plant at 3 WAS (g) during 2012 rainy season in Samaru is shown in Table 4.10. The result shows that Clemson spineless had a lower shoot dry weight at the control than 2 and 4 t ha^{-1} manure which were at par. In Ex-Samaru-4, no significant difference was observed when manure was increased from 0-2 t ha^{-1} but further increase to 4 t ha-^{1} gave higher shoot dry weight of (3.23 g) than the control but were statistically comparable to 2 t ha-^{1}.

With respect to varieties, increase in poultry manure from 0 to 4 t ha^{-1} did not show any significant difference on shoot dry weight.

The Interaction between varieties and NPK fertilizer on shoot dry weight per plant at 5 WAS (g) during 2012 rainy season at Samaru is presented in Table 4.11. The results shows that all the treatment levels gave statistically similar response on shoot dry weight in Ex-Samaru-4. However, in Clemson spineless, increasing NPK from 0 to 50 kg ha^{-1} did not have any significant difference on shoot dry weight. Further increase to 100 kg NPK ha^{-1}

Table 4.9 Effects of NPK fertilizer and poultry manure onDry shoot weight (g) of okra at 2012 rainy season Samaru

	Dry shoot weight (g)		
Treatment	**3 WAS**	**5 WAS**	**7 WAS**
Variety(V)			
Clemson spineless	3.02	5.57	7.45
Ex-Samaru-4	2.34	6.64	7.48
SE±	0.353	0.437	0.618
NPK rate (kg ha^{-1})			
0	2.63	5.44	7.39
50	2.62	6.14	7.24
100	2.80	6.75	7.71
SE±	0.432	0.536	0.757
Poultry manure (t ha^{-1})			
0	1.24b	4.31b	5.37b
2	2.84a	6.54a	8.47a
4	3.96a	7.46a	8.50a
SE±	0.432	0.536	0.757
Interaction			
V*F	NS	*	NS
V*P	**	NS	NS
F*P	NS	NS	NS
V*F*P	NS	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT.
NS = Not significant
*=significant **=highly significant.

Table 4.10 Interaction table between varieties and poultry manure ondry shoot weight at 3WAS (g) during 2012 rainy season in Samaru

	Poultry manure (t ha^{-1})		
Treatment	**0**	**2**	**4**
Clemson spineless	1.23c	3.13ab	4.69a
Ex-Samaru-4	1.24c	2.56bc	3.23ab
SE±0.611			

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

Table 4.11 Interaction table between varieties and NPK fertilizer ondry shoot weight at 5WAS (g) during 2012 rainy season field at Samaru.

	NPK fertilizer (kg ha^{-1})		
Treatment	**0**	**50**	**100**
Clemson spineless	4.96b	6.55ab	8.30a
Ex-Samaru-4	5.91b	5.73b	5.20b
SE±0.757			

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

Significantly produced higher shoot dry weight and was statistically comparable with 50 kg NPK ha-^{1}.

When variety was considered, there was no significant difference between the varieties in terms of shoot dry weight at the control and 50 kg NPK ha-1, but the highest shoot dry weight was obtained in Clemson spineless when NPK was increased to 100 kg ha$^{-1.}$

4.7 Number of Fruits per Plant

The effects of NPK fertilizer and poultry manure on number of fruits per plant of okra varieties during 2012 rainy season in both field and pot trials in Samaru are shown in Table 4.12. Both results in the field and pot trial showed no significant difference in fruits number between the varieties evaluated.

In the field experiment, application of 100 kg ha^{-1} NPK fertilizer produced higher number of (5.0) fruits per plant than the control. The application of 50 kg NPK ha^{-1} and the control had similar number of fruits per plant. There was a significant interaction between variety and poultry manure in the field trial, while in the pot trial the result shows that the treatments had no significant effect on number of fruits per plant.

The Interaction between varieties and poultry manure on number of fruits per plantof okra varieties during 2012 rainy season in field and pot trials at Samaru is presented in Table 4.13. The result shows that varying poultry manure rates had no significant influence on number of fruits in Clemson spineless. However, Ex-Samaru-4 shows a corresponding increase in the number of fruits as the levels of applied poultry manure was increased.

When varieties were considered at 0 t ha^{-1} poultry manure, variety Clemson spineless produced higher number of (4.0) fruits than Ex-Samaru-4, however, when poultry manure

Table 4.12 Effects of NPK fertilizer and poultry manure on number of fruits of okra varieties during 2012 rainy season field and pot trials at Samaru

	Number of fruits per plant	
Treatment	Field	Pot
Variety(V)		
Clemson spineless	4.0	5.0
Ex-samaru4	4.0	5.0
SE±	0.71	0.31
NPK rate (kgha^{-1})		
0	3.0b	4.0
50	4.0ab	5.0
100	5.0a	5.0
SE±	0.27	0.38
Poultry manure tha^{-1}		
0	4.0	4.0
2	4.0	5.0
4	4.0	5.0
SE±	0.27	0.38
Interaction		
V*F	NS	NS
V*P	*	NS
F*P	NS	NS
V*F*P	NS	NS

Means followed by the same letter (s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant *=significant

Table 4.13 Interaction between varieties and poultry manure on number of fruits of okra varieties during 2012 rainy season field trial at Samaru

	Poultry manure (t ha^{-1})		
Treatment	**0**	**2**	**4**
Clemson spineless	4.0b	4.0b	4.0b
Ex-Samaru-4	3.0c	4.0b	5.0a
SE±0.375			

Means followed by unlike letter are significantly different at 5% level of probability using DMRT

Was increased from 0 to 2 t ha^{-1} there was no significant difference in number of fruits between the varieties, but at 4 t ha^{-1-} poultry manureEx – Samaru-4 significantly gave higher number of fruits per plant than Clemson spineless.

4.8 Fruit Length

The effects of NPK fertilizer and poultry manure on fruit length of okra varieties during 2012 rainy season in field and pot trials at Samaru is shown in Table 4.14. The result shows that Clemson spineless significantly produced longer fruits than Ex-Samaru-4 in both field and pot trials. Neither NPK fertilizer nor poultry manure significantly influenced fruit length. None of the treatment interactions were significant on fruit length in both field and pot trials

Table 4.14 Effects of NPK fertilizer and poultry manure on fruit length of okra varieties during 2012 rainy season in field and pot trials at Samaru

	Fruit length (cm)	
Treatment	Field	Pot
Variety(V)		
Clemson spineless	12.03a	10.72a
Ex-Samaru-4	9.48b	7.14b
SE±	0.512	0.385
NPK rate (kg ha^{-1})		
0	10.54	7.60
50	10.21	7.56
100	11.52	8.62
SE±	0.051	0.471
Poultry manure (t ha^{-1})		
0	10.80	8.01
2	10.80	7.67
4	10.67	8.11
SE±	0.051	0.471
Interaction		
V*F	NS	NS
V*P	NS	NS
F*P	NS	NS
V*F*P	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant.

4.9 Fruit Diameter

The effects of NPK fertilizer and poultry manure on fruit diameter of okra varieties during 2012 rainy season in field and pot trials at Samaru is shown in Table 4.15. The result shows that the treatments had no significant influence on fruit diameter in both field and pot trials. None of the treatment interactions were significant on fruit diameter.

4.10 Number of Seeds per Pod

The effects of NPK fertilizer and poultry manure on number of seeds per pod of okra varieties during 2012 rainy season field and pot trials at Samaru is presented in Table 4.16. The result shows that in the field experiment, neither of the treatments significantly affected number of seed per pod.

In the pot trial, there was also no significant difference in number of seeds per pod between the the varieties and varying poultry manure rates. However, when NPK fertilizer rates were varied, the control had the least number of seeds than 50 and 100 kg NPK ha^{-1} which were statistically comparable. The treatment interactions were not significant statistically in both field and pot trials.

Table 4.15 Effects of NPK fertilizer and poultry manure on fruit diameter of okra varieties during 2012 rainy season field and pot trials at Samaru

	Fruit diameter (cm)	
Treatment	Field	Pot
Variety(V)		
Clemson spineless	2.08	1.85
Ex-Samaru-4	2.12	2.06
SE±	0.051	0.073
NPK rate (kg ha^{-1})		
0	2.06	1.84
50	2.04	1.97
100	2.17	2.05
SE±	0.062	0.089
Poultry manure (t ha^{-1})		
0	2.05	1.96
2	2.15	1.97
4	2.08	1.93
SE±	0.062	0.089
Interaction		
V*F	NS	NS
V*P	NS	NS
F*P	NS	NS
V*F*P	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant

Figure 4.16 Effects of NPK fertilizer and poultry manure on number of seeds per pod of okra varieties during 2012 rainy season field and pot trials at Samaru

	Number of seeds per pod	
Treatment	Field	Pot
Variety(V)		
Clemson spineless	78.0	80.0
Ex-Samaru-4	79.0	78.0
SE±	1.64	2.07
NPK rates (kg ha^{-1})		
0	76.0	65.0b
50	81.0	81.0a
100	78.0	80.0a
SE±	2.03	3.06
Poultry manure (t ha^{-1})		
0	78.0	78.0
2	79.0	81.0
4	79.0	80.0
SE±	2.03	3.06
Interaction		
V*F	NS	NS
V*P	NS	NS
F*P	NS	NS
V*F*P	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant

4.11 100 -Seeds Weight

The effects of NPK fertilizer and poultry manure on 100-seeds weight of okra varieties during 2012 rainy season in field and pot trials at Samaru is presented in Table 4.17. The result in the field shows no significant difference in 100-seeds weight between the varieties evaluated. However in the pot trial Clemson spineless gave lower weight of 100-seeds than Ex-Samaru-4. Neither NPK fertilizer nor poultry manure significantly influenced 100-seed weight in both trials. No significant treatment interactions on 100-seed weight observed in both trials.

4.12 Fruit Weight per Plant

The effects of NPK fertilizer and poultry manure on fruit weight per plant of okra varieties during 2012 rainy season in field and pot trials at Samaru is shown in Table 12. The results in both trials showed that varying poultry manure had no significant influence on fruits weight. Increase in NPK fertilizer from the control to 50 kg NPK ha^{-1} significantly increased fruit weight per plant, further increase to 100 kg NPK ha^{-1} gave fruit weight that were statistically similar in both trials. The interactions between the various treatments were not significant.

Table 4.17 Effects of NPK fertilizer and poultry on 100-seeds weight of okra varieties during 2012 rainy season field and pot trials at Samaru

	100-seeds weight (g)	
Treatment	Field	Pot
Variety(V)		
Clemson spineless	4.83	4.18b
Ex-Samaru-4	5.08	5.00a
SE±	0.209	0.153
NPK rates (kg ha^{-1})		
0	5.04	4.50
50	4.93	4.64
100	4.89	4.63
SE±	0.256	0.187
Poultry manure (t ha^{-1})		
0	5.08	4.46
2	5.07	4.66
4	4.76	4.66
SE±	0.256	0.187
Interaction		
V*F	NS	NS
V*P	NS	NS
F*P	NS	NS
V*F*P	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant.

Table 4.18 Effects of NPK fertilizer and poultry manure on fruit weight of okra varieties during 2012 rainy season in Samaru field and pot trials at Samaru

	Fresh fruit weight (g)	
Treatments	Field	Pot
Variety(V)		
Clemson spineless	14.82	15.00
Ex-Samaru-4	13.87	14.86
SE±	0.828	0.837
NPK rates (kg ha^{-1})		
0	11.08b	11.56b
50	15.01a	15.45a
100	16.94a	17.01a
SE±	1.004	1.025
Poultry manure (t ha^{-1})		
0	13.63	13.98
2	13.37	14.08.
4	16.02	16.07
SE±	1.004	1.025
Interaction		
V*F	NS	NS
V*P	NS	NS
F*P	NS	NS
V*F*P	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant.

4.13 Days to 50% Flowering

The effects of NPK fertilizer and poultry manure on days to 50% flowering of okra varieties during 2012 rainy season in both field and pot trials at Samaru is presented in Table 4.19. Result shows that Ex-Samaru-4 took longer days to attain 50% flowering in the pot trial. There was no significant difference on days to 50% flowering when NPK fertilizer was applied in both trials. Increasing poultry manure from control to 2 t ha-^{1} gave lower days (43) to attained 50% flowering. Further increase to 4 t ha^{-1} was not significant.None of the treatment interactions were significant on days to 50% flowering for both trials.

4.14 Fresh fruit Yield (Kg ha-^{1})

Table 4.20 shows the effects of NPK fertilizer and poultry manure on fresh fruit yield (kg ha^{-1}) of okra varieties during 2012 rainy season both in the field and pot trial at Samaru. The result shows that there was no significant difference in fruit yield between the varieties in both trials. Each increase in NPK fertilizer from 0 to 100 kg NPK ha$_{-}^{1}$ led to a corresponding increase in total yield of okra varieties in the field trial, with the highest fresh yield of (5283.6 kg ha^{-1}) obtained at 100 kg NPK ha^{-1}. In the pot trial however control gave lower fruit yield of (2892.3 kg ha^{-1})than 50 and 100 kg NPK ha^{-1} which were statistically at par. Varying poultry manure rates did not significantly affect the fresh fruit yield (kg ha^{-1}) in both trials.There were no significant treatments interactions on fresh fruit yield (kg ha^{-1}).

-

Table 4.19 Effects of NPK fertilizer and poultry manure on days to 50% flowering of okra varieties during 2012 rainy season field and pot trials Samaru

	Days to 50% flowering	
Treatment	Field	Pot
Variety(V)		
Clemson spineless	43.0	43.0b
Ex-Samaru-4	44.0	45.0a
SE±	0.32	0.65
NPK rates (kg ha^{-1})		
0	44.0	44.0
50	43.0	44.0
100	43.0	43.0
SE±	0.39	0.80
Poultry manure (t ha^{-1})		
0	45.0a	45.0a
2	43.0b	43.0b
4	42.0b	43.0b
SE±	0.39	0.80
Interaction		
V*F	NS	NS
V*P	NS	NS
F*P	NS	NS
V*F*P	NS	NS

Means followed by the same letter (s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant.

Table 4.20 Effects of NPK fertilizer and poultry manure on fresh fruit yield of okra pot and field trial at Samaru during 2012 rainy season

	Fresh fruit yield (kg ha^{-1})	
Treatment	Field	Pot
Variety(V)		
Clemson spineless	4110.6	4292.8
Ex-Samaru-4	3937.2	3983.7
SE±	342.222	387.226
NPK rates (kg ha^{-1})		
0	2728.0c	2892.3b
50	4060.1b	4337.8a
100	5283.6a	5184.6a
SE±	419.186	473.311
Poultry manure (t ha^{-1})		
0	3677.8	3480.9b
2	3699.1	3792.0ab
4	4694.8	5141.8a
SE±	419.186	473.311
Interaction		
V*F	NS	NS
V*P	NS	NS
F*P	NS	NS
V*F*P	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant.

4.15 Correlation studies

Correlation between fresh fruit yield (kg ha^{-1}) and growth parameters are shown in Table 4.21 and 4.22. Highly and positive correlation was observed in the field trial on okra fresh fruit yield (kg $ha-^{1}$), number of fruits per plant, fruit length and fruit weight. There was a negative correlation between okra fresh fruit yield (kg ha^{-1}) and fruit diameter. However, non positive correlation was obtained between fresh fruit yield (kg ha^{-1}) in plant height, number of leaves per plant and number of primary branches per plant.

In the pot trial, there was a highly and positive correlation between okra fresh fruit yield and plant height, number of leaves per plant, number of fruits per plant, fruit weight and fruit length in which a positive correlation was observed between okra yield kg $ha-^{1}$ and fruit weight. Correlation between fresh fruit yield, numbers of primary branches per plant and fruit diameter were not significant.

Table 4.21 Correlation matrix of yield and growth parameters of okra as influenced by different levels of NPK fertilizer and poultry manure in 2012 rainy season field trial Samaru

S/N	1	2	3	4	5	6	7	8
1	1.00							
2	0.402**	1.00						
3	0.045	0.084	1.00					
4	0.126	0.039	0.078	1.00				
5	0.235	-0.172	0.052	0.388**	1.00			
6	0.009	0.063	0.063	0.067	0.079	1.00		
7	0.061	0.244	0.3190**	0.435**	0.206	-0.116	1.00	
8	0.091	0.093	0.220	0.189**	0.390**	-0.007	0.846**	1.00

Key

1 plant height (cm)

2 number of leaves per plant

3 number of primary branches per plant

4 number of fruits per plant

5 fruit length (cm)

6 fruit diameter (cm)

7 fresh fruit weight (g)

8 fresh fruit yield kg ha^{-1}

**Significant at 1% level

Table 4.22 Correlation matrix of yield and growth parameters of okra as influenced by different levels of NPK fertilizer and poultry manure in 2012 rainy season pot trial Samaru

S/N	1	2	3	4	5	6	7	8
1	1.00							
2	0.650**	1.00						
3	0244	0.601	1.00					
4	0.396**	0.307**	0.183	1.00				
5	0.297*	0.158	-0.116	0.240	1.00			
6	-0.109	0.054	0.192	-0.122	-0.128	1.00		
7	0.221	0.346**	0.105	0.140	0.383**	0.551**	1.00	
8	0.466**	0.505**	0.176	0.778**	0.385**	0.205	0.316*	1.00

KEY

1 plant height (cm)

2 number of leaves per plant

3 number of primary branches per plant

4 number of fruits per plant

5 fruit length (cm)

6 fruit diameter (cm)

7 fresh fruit weight (g)

8 fresh fruit yield kg ha^{-1}

*Significant at 5% level
**Significant at 1% level

4.16 Regression analysis

The regression analysis between okra fresh fruit yield (kg ha^{-1}) against poultry manure and NPK fertilizer in field and pot trials are shown in figures 4.1, 4.2, 4.3 and 4.4 respectively. The regression equations for poultry manure against fresh fruit yield (kg ha^{-1})were both quadratic, such that the optimum yields of Clemson spineless variety were 5167 kg ha^{-1} at 3.5 t ha^{-1}, while Ex-Samaru-4 was 5205 kg ha-^{1} at 4 t ha^{-1} in the field trial. The highest yield and optimum rate of poultry manure in the pot trial was 5084 kg ha^{-1} at 3.4 t ha^{-1} for Clemson spineless and 5026 kg ha^{-1} at 4 t ha^{-1} for Ex-Samaru-4 respectively.

Similarly the regression analysis between okra fresh fruit yield (kg ha^{-1}) against NPK fertilizer in field and pot trials were linear in both cases. The result further suggests that the optimum NPK rates were not achieved.

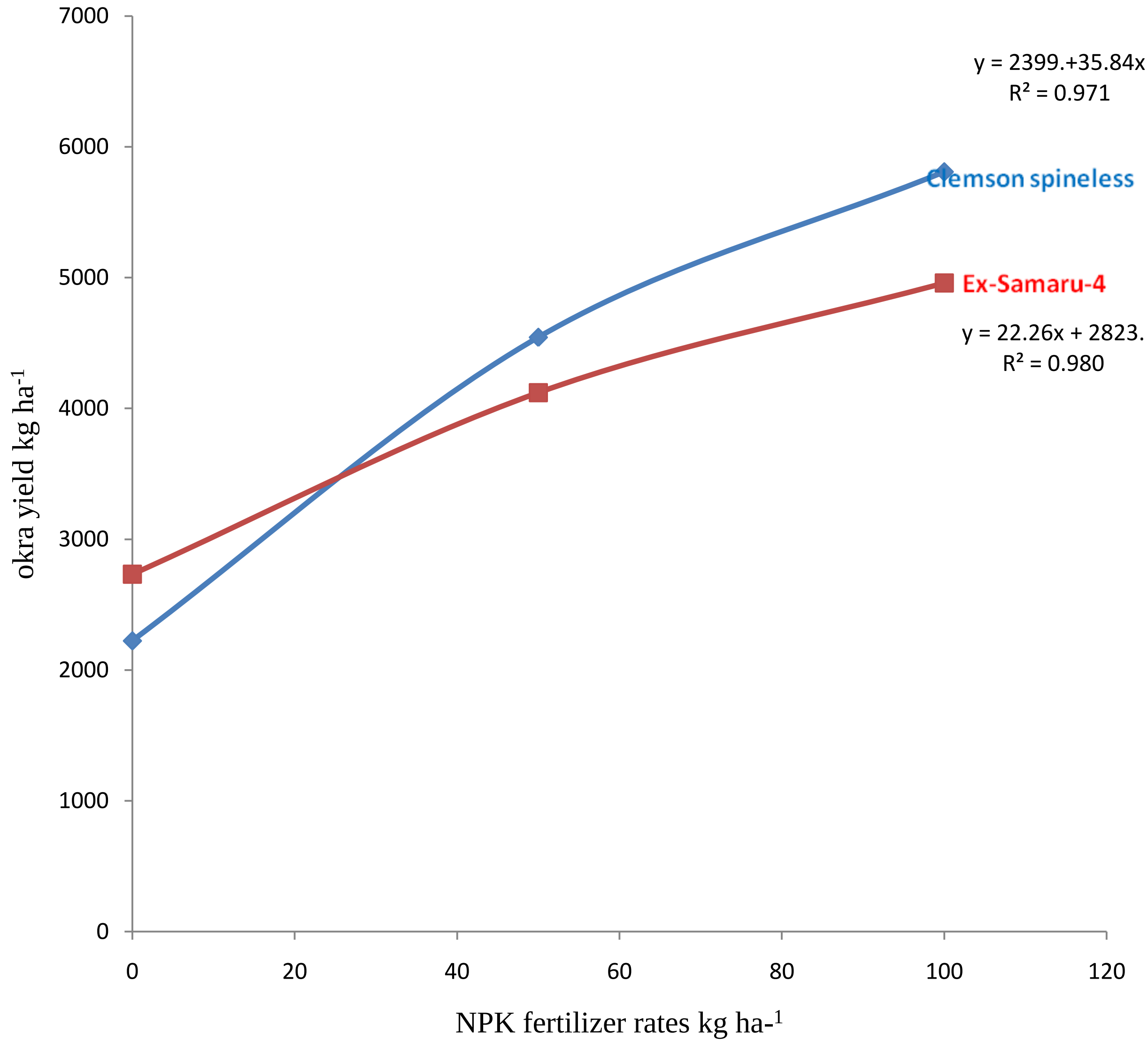

Figure 4. 1 Regression of okra fruit yield against NPK fertilizer kg ha-1 in pot trial.

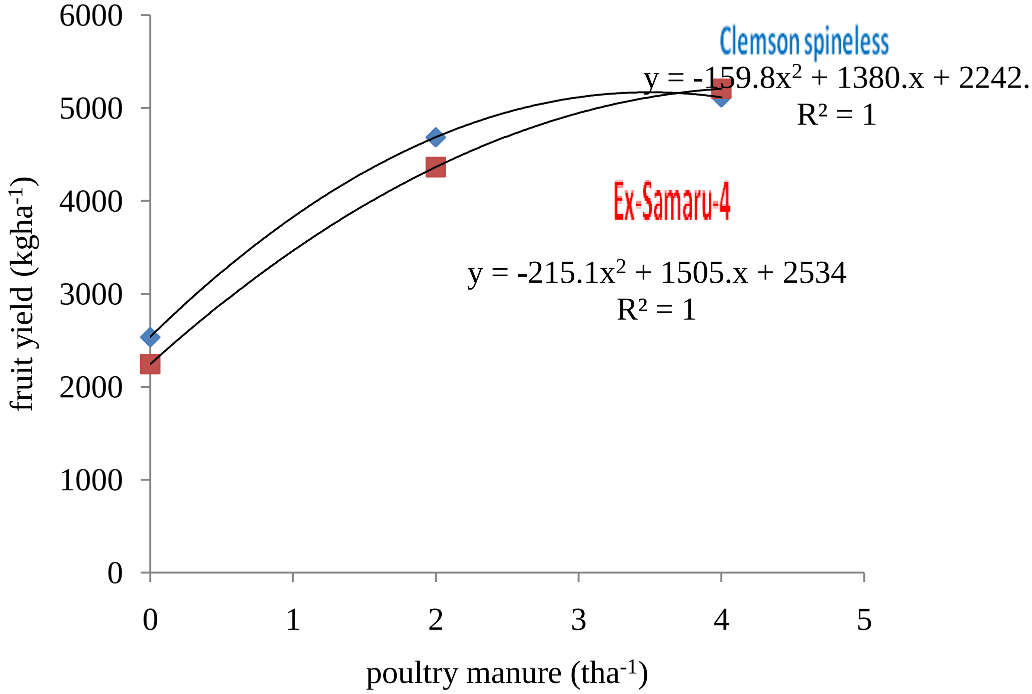

Figure 4.2 Regression of fruit yield kg ha-1 against poultry manure in the field trial.

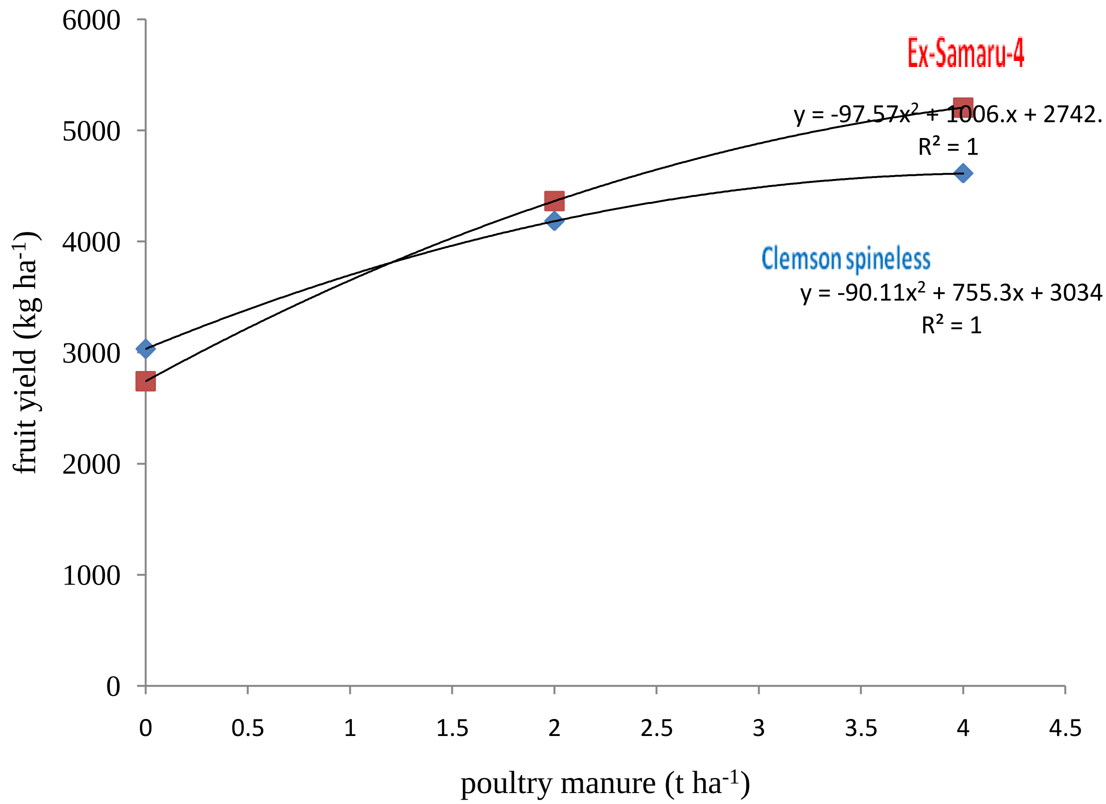

Figure 4.3 Regression of fruit yield kg ha-1 against poultry manure in the pot trial.

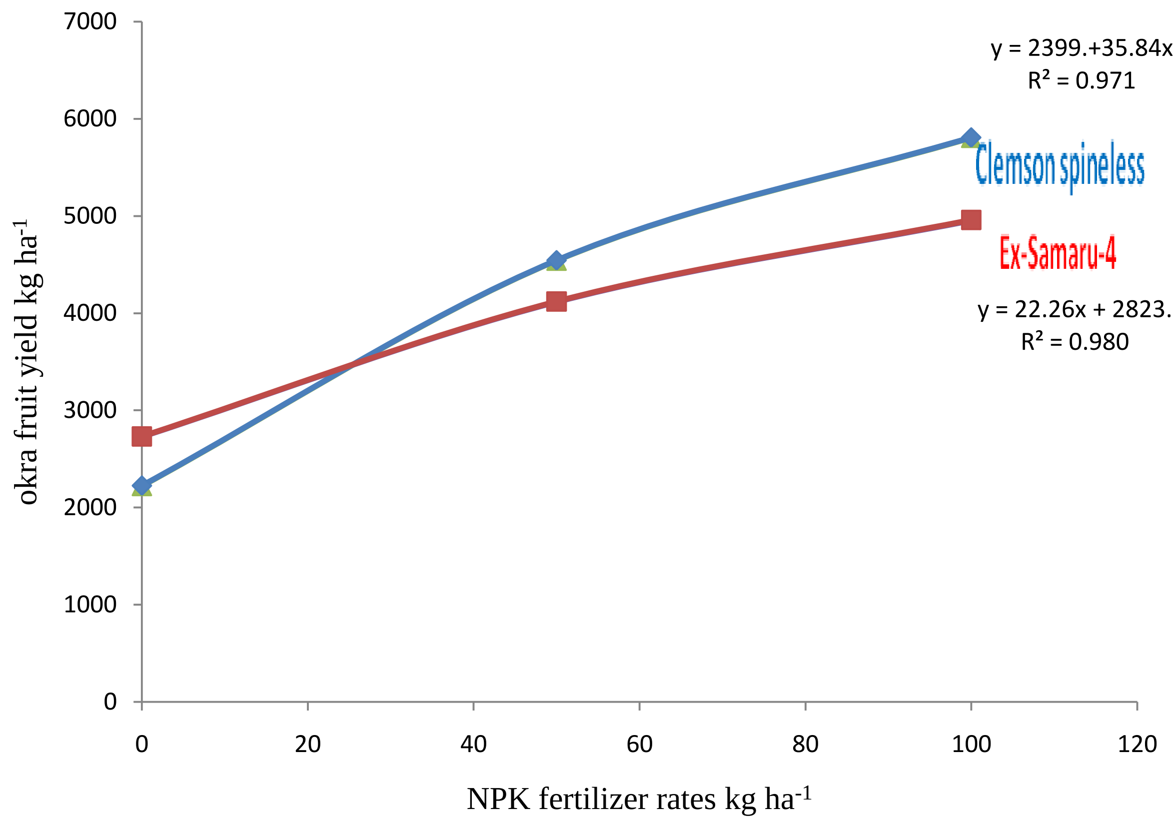

Figure 4.4 Regression of okra fruit yield against NPK fertilizer kg ha-1 in field trial.

CHAPTER FIVE

5 DISCUSSION

The crop growth and yield recorded in the two trials could be attributed to the high amount and well distributed rainfall received. The rainfall was adequate for both vegetative and reproductive stages of the crop. Apart from the high rainfall, the good performance of the crop was probably due to the relative higher total nitrogen content and available phosphorus in the soils of the experimental sites. Under low fertility the plants will be unable to obtain nutrients in adequate amounts for good growth and development thereby affecting crop yield. This is in line with the study of Adeosun. (2000) in rice, in which he stressed that low yield of rice was obtained due to low levels of soil nutrient, pH, organic matter, available P and total nitrogen which made the crops unable to maximally utilize them for carbohydrate synthesis, the consequence of which was ultimately growth and yield reduction.

5.1 Varietal response

The significant difference recorded between the two okra varieties on plant height, fruit length, number of days to 50% flowering, number of primary branches per plant and 100-seeds weight could be explained by the fact that these characteristics are genetically controlled and can be influenced by environmental factors. This could also be due to the differences in the rates of nutrient absorption and utilization between the two varieties, which could lead to production of more assimilates in the okra plants as well as increase in growth and yield attributes. Thus, variety Clemson spineless was observed to be taller and has longer pods as well as flowered earlier than Ex-Samaru-4. Plant height of plants is genetically determined (IAR 1985). The height of okra plant is perhaps more of genetic than and environmental trait. Saijin *et al*. (2002) also reported that growth parameters such as plant height, number of branches are enhanced by genetic factor, the varieties differ significantly from one another. Variety Ex-Samaru-4 has broad leaves which have the ability to intercept more solar radiation that can result in the supply of assimilates during the ripening period, and this may be the reason for more seeds development than in Clemson spineless. Ibrahim *et al.* (2002) reported that differences in growth indices of okra is normally attributed to their genetic makeup, this is in line with the work of Emebiri *et al.* (1992) who reported cultivar differences among okra in terms of growth. Akinfasoye *et al.* (1997) also reported that different in yield of crops has been attributed to the cultivars grown and their genetic makeup.

5.2 Response to NPK fertilizer

Okra plants required NPK nutrients of about 40-60 N, 20-40 P and 20-40 K (kg ha^{-1}) for optimum growth and yield development (Anon., 2004), however, where these nutrients are insufficient or inadequate, application of the deficient elements through fertilization should be required or recommended under different agromatic conditions which can be manipulated to maximized production from a unit land area. Application of 250 kg NPK ha^{-1} proved effective in ensuring better performance in terms of growth in okra Babatola and Olaniyi (1997).

The significant response of growth components such as number of leaves per plant, number of primary branches per plant and shoot fresh weight in both trials could be attributed to the role of applied NPK to the plants during the trials, which were essential in plant growth and development. This is supported by the findings of Smith *et al.* (2001) who reported that the use of NPK under good environmental conditions significantly influenced the growth and fruit yield of okra. The crop requires adequate supply of nutrients particularly nitrogen, phosphorus and potassium for optimum growth and yield. This also agrees with the findings of Adediran and Banjoko. (2003) which showed that application of these nutrients (N, P and K) is important for enhanced fruit number and yield of okra. Another study have shown that the application of N and or NPK led to significant increase in the growth and yield of okra (Katung *et al*.,1996). Growth characters such as plant height, shoot fresh weight, number of leaves per plant, number of primary branches per plants are maximised either at 60 or 90 kg N ha^{-1} at early stage of growth. The crops needs up to 60 kg N ha^{-1} to show any significant response on growth parameters like plant height and days to 50 % flowering in okra.

The significant response recorded by okra on yield components such as number of fruits per plant and fruit yield (kg ha^{-1}) to the application of NPK fertilizer up to 100 kg ha^{-1}, in which fruit weight showed a significant response by the application of 50 kg ha^{-1} could be attributed to the significant role play by NPK in the improvement of soil fertility, nutrient uptake and enhancement of crop yields. NPK fertilizer have been reported to cause a significant effects on fruit weight, fruit number and yield ok okra (Jan *et al*., 2002). This is in contrary with the findings of Obi *et al.* (2005) who reported no significant increase in fruit yield and fruit weight of okra plants with NPK fertilization.

Akintunde *et al.* (2000) reported least yield components without the application of NPK fertilizer in okra. This proved that application of NPK fertilizer is so vital and important for enhanced crop yield and development.

The non significant response in number of fruits per plant to NPK fertilizer in the pot trial could be as a result of the soil chemical composition (Table 1) and the homogeneity of the environment in which a little increase in the application of NPK fertilizer may not show any significant effect on number of fruits per plant. However, any additional increase in fertilizer could only promote luxury consumption by the plants. The plants might have already obtained the required nutrients required for fruiting from the little amount initially in the soil. Soil analysis (Table 1) showed that the soils from the two locations were high in nitrogen and moderate in P and K making the soils fertile, hence the non significant response of such yield components to NPK fertilizer observed. In contrary to this, the field trial experienced washing away of nutrients by leaching which may go beyond the root zone and not been used and utilized by the plant due to high rainfall experienced during the months of the trial (Appendix 1), in which a slight increased in NPK fertilizer in this case may show a significant effect on yield attributes.

Other yield components such as fruit length, fruit diameter, number of seeds per pod and 100- Seeds weight were not significantly influenced by application of NPK fertilizer in both trials. This may be due to the differences in the plants response to the environment which may or may not permit genetic expression of each component (Westerman and Crothers., 1977). Akinfasoye *et al.* (1997) reported that differential in yield of okra has been attributed to the varieties grown and their genetic makeup, which are responsible to show any significant response to the treatments received.

5.3 Response to Poultry Manure

The significant increase in plant height, number of leaves per plant, number of primary branches per plant, shoot fresh and dry weight as a result of the application of poultry manure in both trials may be attributed to the beneficial role of manure in enhancing soil nitrogen, phosphorus, potassium and other essential nutrients which in turn improved growth and development of the plants during the trials (Table 2). The positive effect of poultry manure on these growth attributes could also be due to the contribution made by the manure to fertility status of the soils, as the soils were low in organic carbon content. Manure when decomposed, increased both macro and micro-nutrients as well as enhances physico-chemical properties of the soil. This could have led to its high vegetative growth. (Akanbi *et al*., 2000), poultry manure has been reported to contain a relative high nitrogen content that supported more of vegetative growth in crops. Dademel *et al*. (2004) reported that the nitrogen content in both organic fertilizers has been known to enhance leaf production, flowering, seed formation and root formation, this will lead to higher metabolic activities and consequently higher fresh fruit yield in okra. Okra growing on poultry manure performed better in terms of plant height, number of leaves, number of branches as well as shoot weight. This shows that poultry manure were readily available and in the best form for easy absorption by the plant roots, hence there is a boost in the morphological growth of the plant. This is supported with the findings of Ajari e*t al*. (2003) in okra production in which they reported that, organic manure especially poultry manure could increase plant height and branches of crops. Increase in the poultry manure rate has a significant effect on the vegetative growth of the plant.The increased application of poultry manure which contains appreciable quantities of magnesium might have helped in chlorophyll synthesis which in turn increased the rate of photosynthesis.

Yield components such as number of fruits per plant, fruit diameter, number of seeds per pod, fruit weight and 100-seeds weight were not significantly influenced by the application of poultry manure. This could be attributed to the fact that vegetative growth had been favoured more if poultry manure was applied at higher dosage. Coupled with the high N content in the soils that could favour vegetative growth at the expense of reproductive growth, thus lead to the non significant response in the yield components. It could either be there were some nutrients already present in the soil or the plant need were satisfied with that quantity of nutrients present in the soil. This would have apportioned more of the plant photosynthete to more of growth and less for yield characters as well as pod development. This is peculiar to high nitrogen application present in the poultry manure which might bring nutrient in-balance and antagonism that could result in the lower yield observed in the present investigation. Application of high rate of manure or manure with high N content has been reported to cause reduction in fruits yield (Adekiya and Agbede , 2009). A significant response in fruit yield (kg ha^{-1})to poultry manure was observed only in the pot trial, and this could be attributed to the fact that the environment in the pot trial was homogenous and there was an evenly distribution of water at the later stage of the trial by irrigation. The result is in agreement with the findings of Nehra *et al.* (2001) and Sanwal *et al*. (2007) that higher yield response due to organic manure is ascribed to the movement in physical and biological properties of soil resulted in better supply of nutrients that led to good crop yield. The reason for increased in yield could also be attributed to the solubilization effect of the major essential nutrients with addition of poultry manure thereby resulting to increased uptake of N P and K (Sendurkunaran *et al*., 1998).

The non significant response in fruit yield (kg ha^{-1}) to poultry manure experienced in the field experiment could be as a result of water logging experienced in some of the plots during the trial due to the soil topography, physical and biological properties which made it difficult for the plants to respire and utilise the nutrient available in the soil for its growth and development, thus caused reduction in yield. This could also be as a result of leaching, which made difficulty in the absorption and utilization of the nutrients that can be used for good yield and development, which may go beyond the root zone of the okra plant. Rajashree (2005) also reported that higher yield response of crops due to organic manure application could be attributed to improved physical and biological properties of soil resulting in better supply of nutrients to the plant.

5.4 Interactions

The interactions between varieties and poultry manure was significant on number of leaves per plant, dry shoot weight and number of fruits per plant. Ex-Samaru-4 gave higher number of fruits per plant as well as higher number of leaves per plant than Clemson spineless due to the genetic composition of the individual variety and their ability to adapt to the environmental conditions. The higher shoot dry weight obtained in Clemson spineless may also be as a result of the morphology of the variety which was taller than variety Ex-Samaru-4 and this contributes to the weight of the plant.

Interactions between NPK fertilizer and poultry manure recorded a significant increase on number of primary branches per plant. High number of primary branches was obtained when 50 kg NPK ha^{-1} was applied in combination with 2 t ha-^{1} poultry manure thgan the rest of the treatments. This is in agreement with the findings of a research in which application of 50% NPK +50 % poultry manure proved most effective in ensuring good performance in terms of growth and fresh yield of ladies finger in valley soils of Chittangon, Bangladesh, and also reported that nutrients seemed more available to okra plants with mixes than the organic material alone (Akande *et al*., 2003). The nutrient use efficiency of crops tends to be better with mix of manure and inorganic fertilizers. Nutrients seemed more available to okra plant with the mixes than the organic materials alone, a similar trend of response had been earlier observed with other crops such as maize (Makinde *et al*., 2001) and with sorghum bichlor L (Bayu *et al*., 2006).

Interaction between varieties and NPK fertilizer was significant on dry shoot weight, Clemson spineless gave higher shoot dry weight than Ex-Samaru-4 when 100 kg ha^{-1} NPK fertilizer was applied this could be attributed to the genetic characters of the variety and its ability to utilize nutrients supplied to it during growth phase.

5.5 Correlation studies

The positive and significant correlations observed between fruit yield (kg ha^{-1})and growth attributes such as plant height, number of leaves per plant, number of primary branches per plant, and yield characters such as number of fruits per plant, fruit length as well as fruit weight revealed theses as important to yield and critical determinants of fruit yield (kg ha^{-1}). It was observed that significant increased in each of these parameters leads to an increased in the total okra fruit yield (kg ha^{-1}). This is in agreement with the findings of Raji (2002) which shows the relationship between growth, yield and yield components of some okra varieties.

5.6 Regression analysis

The regression analysis showed a quadratic response of poultry manure against fruit yield in both trials which indicates that the optimum poultry manure requirement for the okra plant was attained at 3.5 t ha^{-1}. This is contrary to the findings of Aalsiri *et al*. (1999) who reported an optimum yield of okra with the application of 10 t ha^{-1} poultry manure. The reasons for the difference in yield could be attributed to the fact that each okra variety responded differently to the treatments, and could also be as a result of the high of nutrient concentration in the poultry manure used during these trials, in which a less quantity could lead to a significant increase in the yield of okra. While a linear response was observed on NPK fertilizer levels, indicating that the optimum level was not obtained in both trials. Omotosa and Shittu (2007) also reported that the optimum yield in okra plant was obtained with the application of 150 kg ha^{-1} NPK fertilizer

CHAPTER SIX

6 SUMMARY AND CONCLUSIONS

Field and pot trials were conducted during the 2012 rainy season at the research farm of the Institute for Agricultural Research Samaru (11^0 11^I N, 07^0 38^0 E and 686m above sea level) and in the orchard of the Department of Agronomy Ahmadu Bello University, Zaria to test the effects of NPK fertilizer and poultry manure on common okra varieties (Clemson spineless and Ex-Samaru-4), three levels of NPK fertilizer (0, 50 and 100 kg NPK ha-^{1}) and three levels of poultry manure (0, 2 and 4 t ha-^{1}) making a total of 18 treatments. The treatments in the field were laid in randomized complete block design (RCBD), and complete randomized design (CRD) in the pot trial replicated three times in all possible factorial combinations. The data collected during the trials include growth components such as plant height, number of leaves per plant, number of primary branches per plant, shoot fresh weight, dry shoot weight and days to 50% flowering, yield and yield components such as number of fruits per plant, number of seeds per pod, fruit length, fruit diameter, fruit weight and 100-seeds weight were also taken.

A corresponding increase in okra fruit yield kg ha^{-1} was obtained in the field trial, by each increase in the application of NPK fertilizer. 100 kg NPK ha^{-1} gave the highest fruit yield of (5283 kg ha^{-1}). Statistically similar fruit yields of (5184 and 5437 kg ha^{-1}) were obtained in the pot trial at 50 and 100 kg NPK ha^{-1}. A significant increase in number of primary branches per plant by the application of 50 kg NPK fertilizer ha^{-1} gave the highest number of (5.0) primary branches per plant of in both trials. However higher number of (9.0 and 7.0) leaves per plant were observed in the field and pot trials by the application of 100 kg NPK ha^{-1}. Other attributes such as fresh shoot weight and number of fruit, showed a significant response to NPK fertilizer only in the field trial. With the higher fresh shoot weight of (44 g) obtained at 50 and 100 kg NPK ha^{-1} at 7 WAS. Highest number of (5) fruits were obtained at 100 kg NPK ha^{-1}. However the highest fruit yield of (5141 kg ha^{-1}) was obtained at 4 t ha^{-1} poultry manure in the pot trial. Variety Clemson spineless gave taller plants of (34 and 45 cm) and longer fruits of (12 and 10 cm) than variety Ex-Samaru-4 in both the field and pot trials. However fewer days of (43) to attained 50% flowering was observed in variety Clemson spineless in the pot trial. Higher 100-seeds weight of (5.0 g) was also obtained in variety Ex-Samaru-4.

Highly and positive correlation between yield (kg ha^{-1}), number of fruits per plant, fruit length and fruit weight were obtained in both trials, but highly positive correlation between yield (kg ha^{-1}), plant height and number of leaves per plant was obtained only in the pot experiment.

Regression analysis showed that optimum yields of 5167 kg ha^{-1} at 3.5 t ha^{-1} and 5084 kg ha^{-1} at 3.4 t ha^{-1} poultry manure were obtained in variety Clemson spineless in field and pot trials, while 5205 kg ha^{-1} at 4 t ha^{-1} and 5026 kg ha^{-1} at 4 t ha^{-1} poultry manure in variety Ex-Samaru-4 also in the field and pot trial respectively. When NPK fertilizer was applied even up to 100 kg ha^{-1} the optimum yields were not attained in both trials.

From the results obtained application of 3.5 t ha-^{1} poultry manure using variety Clemson spineless and 4 t ha-^{1} in Ex-Samaru-4 should be recommended for okra production at Samaru. While in order to attain optimum yield in the two varieties there is need for application of NPK fertilizer beyond 100 kg ha^{-1}.

REFERENCES

Abou El-Magd, M.A. El-Bassiony, M. and Fawzy, Z.F. 2006. Effect of organic manure with or without chemical fertilizer on growth, yield and quality of some varieties of Broccoli plants. J. of Applied Science Res., 2 (10):791-798.

Adediran, J.A., L.B. Taiwo, M.O. Akande and R.A. Soluble, 1999. Comparative effect of organic – based fertilizer and mineral fertilizer in the dig matter yield of maize. Bioscience Research communications, 11(4):17-24.

Adediran, J.A, and V.A Banjoko, 2003. Comparative effectiveness of some compost fertilizer formulations for maize in Nigeria. *Nigerian Journal of soil science, 13: 24-49.*

Adekiya A.O, Agbede TM, 2009. Growth and yield of Tomato (Lycopersicon Esculentus Mill) as influenced by poultry manure and NPK fertilizer. *Journal of food.Agriculrure 21 (1): 10-20*

Adenawoola, AR. Residual Effects Of Poultry Manure And NPK Fertilizer Residues On Soil Nutrient And Performance Of Jute (*Corchorus olitorous* L.). Nigeria Journal ofSoil Science. 2005; 15: 133-135.

Adeosun J.O. (2000) Response of upland rice varieties (*Oryza sativa* L.) Varieties to nitrogen, period of weed interference and chemical weed control. Unpublished Ph.D. Dissertation submitted to the Postgraduate School Ahmadu Bello University, Zaria 143 pp.

Adejonwo, K.O (1987). Effect of variety, Nitrogen, Level and period of Weed interference on growth and yield of okra (Abelmoschus esculentus L. moench). Agronomy seminar, department of Agronomy,IAR ABU.50pp

Adepetu,J . A and S. A. Corey. 1975. Organic phosphorus predictor of plant available Phosphorus in soils of southern Nigeria. Soil science, 122(3): 22-38

Akinfasoye JA, Olufolaji AO, Tauru FM, Adenowoola RA (1997), Effect of different phosphorus levels on the yield of four tomato cultivars (Lycopersicon esculentus) Peoccedings of the 15th Annual Conference of Horticultural Society of Nigeria. Pp 56-68

Agbede 2008. Effect of poultry manure Soil physical and chemical properties, growth and grain yield of sorghum in southwest Nigeria. *American- Eurasian journal of sustainable Agriculture 2 (1) : 72-77.*

Ahmadu, M.A Ahmed, M.K and Ogunlela. V.B (2000) effect of Nitrogen, sowing date, population and variety on growth parameters and yield of okra (*Abelmoschus esculentus* L. Moench). *Paper presented at the 18th Annual Conference of Horticultultural Societyof Nigeria held on 28th May-1st June, 2000 at the Institute for Agricultural Research*
A.B.U Zari, PP 32-34

Alasiri, K.O. and O.O. Ogunkeye. 1999. Effect of different levels of poultry manure on seed yield of Okra. Proceedings 25th Annual conference of Soil Science Society of Nigeria, 21st – 25th November, 1999. Benin, Nigeria.

Alasiri KO. Effect of combined use of poultry manure and NPK fertilizer on seed yield of okra. Horticultural Society of Nigeria. 20th Annual Conference/Silver Jubilee, Held at National Horticultural research Institute, Ibadan. 2002;9.

Anburani A. and Manivannan K. 2002. Effect of integrated nutrient management on growth in brinjal (*Solanum melongena* L.) cv. Annamalai. South Indian Horticulture. 50(4-6): 377-386.

A. O. Ano., J. A. Agwu, Effect of animal manure on selected soil properties 11. Nitrogen, potassium and phosphorus. Nigerian Journal of soil science 16 (2006) 145-150.

O. Ajari., L. E. K. Tsado., J. A. Oladiran., E. A. Salako, Plant height and fruit yield of okra as affected by field application of fertilizer and organic matter in Bida, Nigeria. The Nigerian Agricultural Journal, 34 (2003) 74-80.

Akanbi, W.B., J.A. Adediran, A.O Togun and R.A Soul, 2000 effect of organic-base Fertilizer on the growth, yield and storage life of Tomato (lycopersicon esculentum) Bioscience Research Communication, 12 (24) : 14-18.

Akanbi, W.B., Akande, M.O. and Adediran J.A. 2005. Suitability of composted maize straw and mineral nitrogen fertilizer for tomato production J. of Veg. Science, 11 (1): 57-65.

Akande, M. O., Oluwatoyinbo, F. I., Adediran, J. A., Buari, K. W. and Yusuf, I. O. 2003. Soil amendments affect the release of P from rock phosphate and the Development and yield of okra. *Journal of Vegetable Crop Production,9 (2):3–9*

Akande, M. O., Oluwatoyinbo, F. I., Adediran, J. A., Buari, K. W. and Yusuf, I. O. 2003. Soil amendments affect the release of P from Rock phosphate and the development and yield of okra. *Journal of Vegetable Crop Production,* 8(3):6–13.

Akande M.U, J.A. Adediran, and F.I Oluwatoyin (2005) Effect of rock Phosphate amended with poultry manure on soil available Phosphate and yield of maize, and cowpea. *AfricanjournalBiotechnology, 4:444-448.*

Alasiri, K.O. and O.O. Ogunkeye. 1999. Effect of different levels of poultry manure on Seed yield of Okra. Proceedings 25th Annual conference of Soil Science Society of Nigeria, 21st – 25th November, 1999. Benin, Nigeria.

Aliyu, L. (2000): Effect of organic and mineral fertilizer on growth, yield and composition of pepper (*capsicum annum*) Bio 1. Agric Hort.18:29-36.

Anonymous (2004). Africa recovery, Vol 1.17 pp10, www.africarecovery.org

Anonymous, (2001) proposal for vietnamwse assistance withj Rice production in Nigeria, CU Annual crop production figures, 2001. Abuja, Nigeria, project coordinating unit. Federal ministry of Agriculture and Rural Development. Pp 11-19

Awe, O.A., Abdulsalam, R.A., Ogunlela, O.A. 2006. Effect of NPK 20-10-10 fertilizer on the pod and root growth of okra in humid tropics. In: proceeding of the 31st Annual conference of the soil science society of Nigeria, Ahmadu Bello University, Samaru Zaria pp: 33-38.

Ayodele O.J and Olaniyan F.O, (1982). Egusi-melon agronomy fertilizer Studies. In: VegetableProgramme. NIHORT Annual Response of Okra to Organic and Inorganic Fertilization, pp 31-46.

Ayodele and Adelena (1993), Response of Okra (Abelmoschus esculentus) to nitrogen fertilizer. *Nigerian Agricultural journal Vol. 34, pp 58.*

Babatola, L. A and Olaniyi, J.O 1999. Effect of N P K 15:15:15 level and plant spacing on performance and shelf-life of okra. Annal of Agricultural Sciences,(1): 24-29.

Babatola LA, Ojo DO, Adewoyin OB (2002). Effect of NPK 20:10:10 fertilizer levels on the yield of okra-sweetcorn intercrop and post harvest quality of okra. *Proceedings. Horticultural Society ofNigeria. Conference*. pp 74-78.

Babatola, L.A., 2006. Effects of NPK 15:15:15 fertilizer on the performance and storage of okra (Abelmoschus escuklentus). Proceedings of the Horticultural Society of Nigeria Conference. Pp: 125-128.

Babatola IA, Olaniyi, MA (1997). Effect of NPK fertilizer levels and plant spacing on performance and shelf life of okra (Abelmoschus esculentus)

Babatunde, R.O., Omotesho, O.A, and Sholoton, S.o (2007). Socio-Economic characteristics and Food Security Status of farming Household in Kwara State, North Central Nigeria. *Pakistan Journal of Nutrition Vol-6 No.1 P16*

Bayu, W., Rethman, N.F.G., Hammers, P.S. and Alemu, G. 2006. Effects of farmyard manure and inorganic fertilizers on sorghum growth, yield and Nitrogen use in a semi arid area of Ethiopia. *Journal of plant Nutrition, 29:391-407.*

Blennerhassett RM, El-Zaftawi BM (1986). Productivity and growth of six okra cultivars. *Australian J. Agric*. 26:625-629.

C. A. Onwu., S. A. Ayuba., A. Ali, The effect of organic manure on the growth and yield of castor plant (Ricinus Cumunis). J. Of Sustainable Development in Agriculture and Environment 3 (2) (2008) 64-70.

C. A Palm, J. K. Myer and S. M. Nandwa, Combined use of organic and inorganic nutrient sources for soil fertility maintenance and replenishment (Soil Science Society of America Special Publication 51, 1997)

Central Bank of Nigeria (CBN) 1996 Annual Report and Statement of Account Nigeria pp 23.

Chauhan, D. V. S. 1972. Vegetable production in India (3rd edition). Ram Prasad and Sons, Agra.

V. O. Chude, Perspectives on fertilizer use in the 21st country. Book of abstracts, soil science society of Nigeria Benin, 1999 25th Annual Conf. Held at Precious Palm Royal Hotel from 21st -25th November 1999.

Dademal AA, Dangale JH, Mhaskar NV (2004). Effect of manures and fertilizers content and uptake of nutrients by okra on laterilic soil of konkan. J. soils and crops. 14 (2): 262-268.

Dauda, S. N., L. Aliyu., U. F. Chiezey, Effect of seedling age at transplant and poultry manure on fruit yield and nutrients of garden egg (S. gilo L) Varieties. *J. Trop. Sci. 5 (2005) 38-48.*

Daniel-Kalko, N.N. (1982). Yield and stability of okra varieties from northern Nigeria grown under river state dry season. Ministry of Agriculture. Port Harcourt, Nigeria pp.18.

Duncan, D.B (1955). Multiple Range and Multiple (F) Test. Biometric 11:1-42

Dupriez, H. and De. Leaner, P. (1989) African Gardens and orchards: Growing vegetables and fruits 1st edition. The Macmillan press Ltd, New York, 333P.

Economic Commission of Africa, 2001. State of the Environment in Africa. Economic Commission of Africa, P.O.Box 3001, Addis Ababa, Ethiopia ECA/FSSDD/01/06.

Eke, K.A., Essien, B.A. and Ogbu. J,U. (2008) : Determination of optimum planting time of okra (Abelmoschus esculentus) Cultivars in the Derived Savannah Proceedings of the 42nd Annual Conference of Agricultural Society of Nigeria (ASN) October 19th to 23rd at Ebonyi State University.

Emeberi LC, Obiefuna JC, Abaniyi MSC and Ikpor MN (1992). Growth, yield and yield components response of three okra cultivars (Abelmoschus esculentus) to nitrogen fertilization in humid tropics Acta Horticultural. 30(11):47-58

Farinde A.O. and Owalarefe L.B. (2007) Nigeria fertilizer sector, present situation and Future prospects IFDC. Technical Bulletin 12(1) P.18.

Fatokun, C.A., Chedda, H.R.1983. The effects of nitrogen and phosphorus on yield and chemical composition of Okra (Abelmoschus esculentus). Acta. Horticulture 123, 283-290

FAO, 2006. World reference base for soil resources. World Soil Resources Report 84 Food and Agriculture Organization of the United Nation, Rome. pp.88

Fayemi P.O. Nigerian vegetables, Heinemann Education Books Nigeria Plc 1999: 13-17

Federal Fertilizer Department (2002). Fertilizer use management practices for crops in Nigeria. Produced by Federal Fertilizer Department, Federal Ministry of Agriculture and Rural Development Abuja P 188

Garg , J.S. and Bansal, M.G. (1972). Optimum dose of nitrogen for high yielding dwarf wheat. *Fertilizer News* 17 (10): 53:55.

G. A. Thomas, Toxicity identification of poultry litter aqueous leachate, Soil Fertilizer, 8(1), 1997, 251-252.

Grubben, G. J. H. and Denton, O. A 2004. Plant resources of Tropical Africa 2. vegetables. PROTA Foundation, Wageningen, Netherlands/ Backhuys Publishers, Leiden, Netherlands / C T A Wageningen, Netherlands.

Ibrahim L, Amau A and Abubakar IU (2002). Gowth indices and yield of tomato (Lycopersicon esculentus) Varieties as influenced by crop spacing at Samaru. Proccedings of the 8th Annual Conference of Horticultural Society of Nigeria. Pp 40-47

IAR (1985). *Annual Reports*. Institute of Agric. Research Samaru, ABU, Zaria.

Iken, J.E., Amusa, N.A. 2004 maize research and production in Nigeria, *African journal Bio-tech. 3, 302-307.*

Iyagba AG, Onuegbu BA, Ibe AE (2012). Growth and yield response of okra (*Abelmoschus esculentus* (L.) Moench) varieties to weed interference in South - Eastern Nigeria. Global J. Sci. Frontier Res. 12:8(1)23-31.

Jan ND, Igbal M, Ghafoor A, Waseem K, Jillani MS (2000). Effect of NPK fertilizers and spacing on the yield of Bottle guord (*Legenariasiceratia* M.). *Pakistan J. Biol. Sci.* 3(3): 448-449

J.A Raji (2002) Ghana journal of agriculture ans science 35, 3-10.

John L.W, Jainer DB, Samuel LT and Warmer LW., Soil fertility and fertilizers and introduction to nutrient management (Person Edu. India, 2004)

Katung, M.D., J.D. Olanrewaju, U.S. Gupta and I. Kureh, 1996. Fruit and Seed yields of okra as influenced by Farm yard manure and Nitrogen fertilizer. In:Proc. 14th HORTSON Conf; Ago-Iwoye, 1 -4 April, 1996.

KARI (Kenya Agricultural Research Institute) (2000) Soil Fertility Management Handbook for extension, staff and farmers. Technical Notes Series No. 5.

Khan FA, Din, JU, Ghaffoor A, Khan KW (2002). Evaluation of different cultivars of okra (*Abelmoschus esculentus* L.) under the Agroclimatic conditions of Dera Ismail Khan. *Asian J. Plant Sci*. 1(6):663- 664.

Kochhar, S.L. 1986. Tropical Crops: A Textbook of Economic Botany. 1st Edition,MacMillan Publishers,London, UK, 256 p.

Kolawole GO, Olapede AO, Alade CR, Olaniyi JO (2008). Response of okra (Abelmoschus esculentus) varieties to NPK fertilizer in the South Guinea Savanna of Nigeria. Niger. J. Horticult. Sci. 13: 99-108.

L. Van-Camp, B. Bujarrabal, A. R. Gentile, R.J.A. Jones, L. Montanarella, C. Olazabal, S. K. Selvaradjou, Organic matter and biodiversity - Volume III . Reports of the Technical Working Groups established under the Thematic Strategy for Soil Protection, EUR 21319 EN/3, (Luxembourg, Official Publications of the European Communities, 2004)

Little, T.M. and Hills, F.J. (1978). Agricultural Experimentation Design Analysis, John Willey and Sons. Ins. New York 350.

Lombin, J, A. Adepeju and K.A. Ayotade, 1991. Complementary use of organic and in organic fertilizers in Arable crop production. In the Nigerian Agriculture. Kaduna, Nigeria. March 26 -27, 1991.

Majanbu, I.S., Ogunlela, V.B., Ahmed, M.K. and Olanrewaju. J.D (1985). Response of two okra varieties (*Abelmoschus esculentus* L. Moench) to fertilizer yield and yield components as influenced by nitrogen and phosphorous application. Fertilizer Research 6:527-567.

Makinde, E.A and A. A. Ayoola, 2008. Residual influence of early season Crop fertilization and cropping system on growth and yield of Cassava. *American Journal of Agric. and Biological Science. 3(4): 712- 715.*

Makinde , E.A., A.A. Agboola and F.I. Oluwatoyinbo. 2001. The effects of organic and inorganic fertilizers on the growth and yield of maize in maize / melon intercrop. *Moor journal of Agricultural Research 2:15-20*

Maerere A.P., Kimbi G. G. and Nonga D. L. M. 2001. Comparative effectiveness of animal manures on soil chemical properties, yield and root growth of Amaranthus (*Amaranthus cruentus* L.) AJST. 1(4).

Mario Amati, Erik Deeken, Tens Varlingen, Elise pinners and san chine A. Tarn.1989. First Edition AGRONOMISA. Post brs 41, 6700 A.A Wageningen, the Netherlands. Pp 6-60.

Moyin-Jesu, E. I. 2007. Use of plant residues for improving Soil fertility, pod nutrients, root growth And pod weight of okra (*Abelmoschus esculentus* L.). Bioresource Technology 98(11), 2057-2064.

M. Premsekhar., V. Rajashree, Influence of organic manure on growth, yield and quality of okra. American Eurasian Journal of Sustainable Agriculture, 3 (1) (2009) 6-8.

Nath, P (1976) Vegetable for tropical region ICAR , New Delhi 97pp.

National Research Council (NRC). Okra, lost crop of Africa: Vegetables. 2006:2.

Nehra A.S., Hooda I.S. and Singh K.P. 2001. Effect of integrated nutrient management On growth and yield of wheat (*Triticurn aestivum* L.) *Indian Journal of Agronomy 45: 112117.*

NIHORT, 1985. Effect of spacing and different rates of nitrogen fertilizer on seed yield of okra (Avelmoschus esculentus). NIHORT Vegetable programme Annual Report, pp: 45-47.

Odeleye FO and Odeleye OMO (2001). Evaluation of morphological characteristics of two Exotic and two Adapted Varieties of tomato (Lycopersicon esculentus) in south west, Nigeria. Peoccedings of the 19th Annual Conference of Horticultural Society of Nigeria. Pp 28-30.

Olarewaju JU and Showemino FA (2002). Response of pepper to nitrogen and phosphorus fertilization in northern Nigeria .In Peoccedings of the 21st Annual Conference of Horticultural Society of Nigeria. P 28

Ogunlana JO. Effect of neem plant extract on insect pest control on performance of okra. Unpublished Project of submitted to the Department of Crop Production, Olabisi Onabanjo University. 1995.

O. N. Adeniyan., S. O. Ojeniyi, Comparative effectiveness of different levels of poultry manure with NPK fertilizer on residual soil fertility, nutrient uptake and yield of maize. Moor Journal of Agricultural Research 2 (2003) 191 -197.

Olaniyi,J.O;Ogunrinde,J.O,Olabode,O.S; Akanbi,W.B. 2005. Effect of organic mineral fertilizer Application on growth, yield and nutrient uptake of Maize. Journal of Applied Agricultural and Apicultural Research, 2(1):10-19.

Oladatun, A.O 2002 Managing manure as a fertilizer, Saskactchewani, Agriculture, food and Rural Revitalization. 5 pp.

Omotoso, S. O., and Shittu, O. S, (2007). Effect of NPK fertilizer rates and method of application on growth and yield ok Okra (*Abelmoschus esculentus* L. Moench). *Research Journal of Agronomy, 1: 84-87.*

Omotoso, S. O., and Shittu, O. S, (2008). Soil properties, leaf nutrient composition and yield of okra [*Abelmoschusesculentus* (L.) Moench] as affected by Broiler litter and NPK 15:15:15 fertilizers in Ekiti State,
Nigerian International Journal of Agric Research. 3, 140-147.

Philips TA (1997). An Agricultural Note Book/ with special Reference to Nigeria/ London Group Ltd London P 76.

Reddy, K.C. Soffes, A.R. and Prince, G.M.(1975). Tropical legumes for green manure Nitrogen production and the effect on succeeding crop yields. *Agronomy Journal 78:1-4*

Reddy T.Y Reddi G.H. (1995) *Principles of Agronomy, 2nd Edition Kalyani Publishers, New Delhi 110002 Pp.223.*

Rice, R.P. Rice, L.W and Tridall, H,D, (1987) Fruits and vegetable Production In Africa Macmillan publishers, Limited London pp.277- 278.

S. O. Ojeniyi O. N. Folorunso., Comparative effectiveness of different levels of poultry manure with NPK fertilizer on residual soil fertility, nutrient uptake and yield of maize. Moor Journal of Agricultural Research 2 (2003) 191 -197.

Sam-Aggrey, W.G. and Takie, Y. (1989). Horticultural crop production: Vegetable crops.Agritex, Ministry of lands and Agriculture, Harare, Zimbabwe.

Sanwal S.K., Lakminarayana K., Yadav R.K., Rai N., Yadav D.S. and Mousumi B. (2007). Effect of organic manures on soil fertility, growth, physiology, yield and quality of turmeric. *Indian Journal of Horticulture. 64(4): 444-449*

Schippers, R.R. (2000) African indigenous Vegetables An overview of the Cultivated species.DFID, CTA 118 pp. National Resources Institute (NRIU) University of Greenwich London, United Kingdom 214pp.

Schippers, R.R.2000: African Indigenous Vegetables. Netherlands PP 103-118.

Sendurkumaran S., Natarajan S. and Thamburaj S. 1998. Effect of organic and inorganic fertilizers on growth, yield and quality of tomato. South Indian Hortic. 46(3 and 4): 203-205.

Sharma, A.R. and B. N. Mittra, 1991. Effect of different rates of application of organic and c. *Journal of Agricultural Science (Cambridge)* 117: 313-318.

Shukla, V.and L. B. Nalk. 1993. Agro-Technique for Malvaceae Vegetables, In: Ifovance in horticulture vol 5. Malhotra publishing house, New Delhi, India, PP 399-425.

Singh IP 1995. Effect of various doses of nitrogen on seed yield and quality of okra. Ann. Agril. Res. **16**(2): 227-229.

Singh TR, Singh SK, Singh MP, Srivastava BK. Effect of Integrated Nutrient Management on Crop Nutrient Uptake and Yield under Okra-Pea-Tomato Cropping System in a Mollisol. Indian Journal of Horticulture. 2004;61(4):312-314.

Smith , M.A.K T.P Tolorun and 0.S. Aneji,2001. Effect of combine mulch and fertilizer on weed growth and okra (*Abelmoschus esculentus* L. Moench) yield in the humid tropical environment, Proceedings of the 35th annual conference of the Agricultural society of Nigeria, University of Agriculture Abeokuta, Sep. 16-20, 2001, PP 43-50.

Smil V. 2000 phosphorous in the Environment National flows and Human interferences. Annual Review of Energy and Environment. 25: 53:88.

Snedecor, G.W and G.W. Cochran (1967) Statistical methods, 6th edition.l0wa state University Press.Ames USA. 456 PP

Sonkuwar RH, Mahakal KH and Lale BB (1997). Effect of different levels of nitrogen on Growth and Yield in Okra varieties. PKV. Research journal 21 (2): 202-204.

Splittstoessor W.E. (1990). Vegetable growing handbook. New York: Van Nostrand Reinhold. Pp 248-250.

Steiner KG. Overcoming Soil Fertility Constraints to Crop Production in West Africa: Impact of Traditional and Improved Cropping Systems on Soil Fertility. 1991.

Sunassee, S.(2001), Use of Litter for Vegetable Production. AMAS 2001. Food and Agricultural Research Council, Reduit, Mauritius, pp.225- 263.

Taiwo, L. B., Adediran, J. A., Ashaye, O. A., Odofin, O. F., Oyadoyin, A. J. 2002. Organic okra *(Abelmoschus esculentus* L.): its growth, yield And organoleptic Properties. Nutrition and Food Science 32(5), 180-183.

Tindall, H.D., Rice, R.P. and rice L.W. (1986). Fruit and vegetable Production in Africa.Macmillan press.

Tindall, H. D. 1983. Vegetables in the Tropics. Macmillan Education Limited. Houndmills Hampshire, 533 p.

Thompson, H.C. 1949. Vegetable crops, Me Gram Hill Book Company, Inc. New York, Toronto, London, 1919-1949. 611Pp

T. Y. Reddy., G. H. S Reddi, Principal of Agronomy (1st ed. Pp 190). Kalyani Publishers, Calcutta India 1992.

Udoh, D.J., Ndon, B.A., Asaquo, P.E and Ndueyo, N.U (2005): Crop production technigues for the Tropics. Concept Publisher, Lagos, Nigeria.Pp 223-247.

Wevil.V.C. (2002). Quality of Horticultural Products. Better Worth and Co. publication. Ltd.London.

Westerman, D.T and S.E Crothers (1977) plant population effects on seed yield components of beans .crop science 17:493-6.

Windham SL (1966). Fertilizer study shows rates for okra production. Miss. Farm Res . 29(3): 5-6.

Wolford, R, and Banks, D. (2006). Okra (http://www.urbanext.uivc/veggies/okra 1.htm)

Zodape, S. T., Kawarkhe, V. J., Patolia, J. S., Warade A. D. 2008. Effect of liquid seaweed fertilizer on yield and quality of okra *(Abelmoschus esculentus*L.*). Journal of Scientific & Industrial Research*67, 1115-1117.

Appendix 1: Meteorological weather report for 2012 rainy season Samaru

		Temp °c				
Month	R/H %	Max	Min	Sunshine/hr	Rainfall/mm	Wind km/hr
April	51	39	23	7.20	7.3	186.29
May	68	34	21	5.94	263.4	178.30
June	76	32	22	6.70	120.7	176.50
July	83	30	20	5.23	165.3	160.01
August	82	29	19	4.50	426.7	135.16
September	77	30	20	5.02	270.3	93.94
October	70	34	21	7.32	79.6	95.60
Mean	72.42	32.57	20.85	5.98	190.47	146.54

Source: IAR Meteorological Station