Response of Tomato (Lycopersicon esculentum) and Okra (Abelmoschus esculentus) to Integrated Rates of Mineral and Organic Manure Application in the Guinea savanna Agro-ecological Z...

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Report on

Response of Tomato (*Lycopersicon esculentum*) and Okra (*Abelmoschus esculentus*) to Integrated Rates of Mineral and Organic Manure Application in the Guinea savanna Agro-ecological Zone of Nigeria

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DEDICATION

This work is dedicated to the spirit of the peasant farmers, without which this nation would have starved. To time and season that ensures their crops come to harvest, and to their human spirit that triumph against all obstacles to ensure the availability of food.

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ABSTRACT

The experiment was conducted at the Kogi State University Research and Demonstration Farm (latitude 7^0 30^1 and longitude 7^0 09^1E), Anyigba in the Southern Guinea savanna agro ecological zone of Nigeria. The study evaluated the effect of different nutrient sources (inorganic (MF), poultry manure (PM), oil palm residue (OPR), MF + PM, MF + OPR), and rates on the growth and yield of tomato and okra in the Guinea savanna agro-ecological zone in Nigeria. The aim of the research was to apply three rates of N: 0, 150 and 300 kg N ha^{-1} using inorganic and organic sources. Laboratory analysis of the organic sources for percentage N composition was carried out before application of the experimental rates. In respect of the tomato crop, data analysis revealed soil amelioration with either organic or inorganic nutrient forms significantly ($p \leq 0.05$) boosted total number of harvested tomato fruits and weight of harvested tomato fruits ha^{-1} with the highest yield obtained with integrated application of 150 kg N PM ha^{-1} + 150 kg N MF ha^{-1}. Also, in the okra crop, data analysis showed growth and yield parameters also responded positively to increase in nutrient rates over the control. While increasing poultry manure rate from 150 kg N ha^{-1} to 300 kg N ha^{-1} led to an increase in total number of harvested tomato and tomato yield ha^{-1}, increasing mineral fertilizer rate from 150 kg N ha^{-1} to 300 kg N ha^{-1} actually depressed tomato yield and number of tomato harvested per plot. Application of inorganic nutrient at the rate of 150 and 300 kg N ha^{-1} increased yield over the control by 88.15% and 74.68%, respectively, while application of organic nutrient at the rate of 150 and 300 kg N ha^{-1} gave yield increases of 81.93 and 85.98%, respectively over the control treatment. Integrated nutrient applications performed better than individual application for all the nutrient sources, with the best performance obtained in MF + PM combinations. Based on the research outcome, it is recommended that if tomato or okra is to be grown on inorganic fertilizer, application of N at the rate of 150 kg ha^{-1} is appropriate for the experimental area, while application of organic fertilizer at the rate of 300 kg N ha^{-1} is recommended for both crops. However, integrated application of N at the rate of 150 kg PM ha^{-1} + 150 kg MF ha^{-1} is recommended for higher tomato and okra yield.

Keywords: Height, plant gilt, growth, development and yield

CHAPTER ONE

INTRODUCTION

Preamble

Consumers' fears, caused by increasing potential for agricultural products to carry diseases or contain harmful additives, coupled with the economic premiums, for certified organic grains in most developed countries: United States of America and Europe have been driving many transition decisions relating to organic farming (Delate and Camberdella, 2004). The concept of organic farming is based on the assumption that soil with sufficient organic matter content, good soil structure, rich and variegated living organisms can provide a base for healthy crops.

Generally, soil productivity maintenance is a major constraint in tropical agriculture. Without the use of fertilizers, crops are moved between fields to utilize only fertile soils for some years, which may not meet the yearning for global food security. Thus, the efficient use of nutrients within crop production systems has been the focus of research for several decades. This experiment is set, therefore to determine the appropriate nutrient that will give best yield returns.

High cost of inorganic fertilizers in Nigeria coupled with the problem of product availability (Oyewole and Mera, 2010) justifies an investigation into alternative source of nutrients, this time, organic manure (poultry manure and oil palm residue), which is more readily available and cheaper; more so, it has been found that most farmers engaged in incorrect nutrient application due to inadequate technical knowledge and understanding of fertilizer best practice (Saliu and Obasi, 2011). More importantly, with regard to organic fertilizers, increasing awareness and availability of information on man's dietary habits has led to strong steady growth in the sale and consumption of organic foods. Therefore, organic farming has become the most highly valued method of sustainable production in agriculture and food trade (Bavec and Bavec, 2007).

It should be noted that while manure needs to be applied in large amounts to meet crop nutrient needs, nutrient composition of most mineral fertilizers is often high, with pronounced crop response with little application, in addition to ease of application, among other advantages of mineral nutrients. In any case, mineral fertilizers do not improve soil physical structure or enhance soil biological activity (McGuiness, 1993). They must therefore be used in conjunction with strategies that are designed to manage and maintain soil organic matter. One of such strategy is the use of organic manure. The enhancement of soil fertility factors by using organic fertilizers causes an immediate improvement in the utilization of mineral fertilizers. There is growing interest in the use of organic manures due to soil fertility depletion in most African soils coupled with scarcity and cost of mineral fertilizers, as earlier observed.

Introduction

Crop outputs in Nigeria is often severely constraint by complex interacting factors such as soil fertility; farmers' resources (which will directly impact on all farming operations, including ability to purchase conventional fertilizers), pests, diseases, crop management and crop related factors (Kumar *et al*., 1986; Dike, 1987; Selim *et al*., 1993; Alofe *et al.*, 1996; Smaling *et al*., 1996; Sinclair *et al.*, 1997 and Tian *et al.*, 2000). The alternating wet and dry seasons in the Nigerian savanna characterized by intense heat leads to rapid decomposition of soil organic matter (Adams, *et al*., 1998). In addition, indiscriminate burning of fallow and crop residues by farmers also reduces the accumulation of organic matter in the soil. Thus, soils rapidly lose their fertility and productivity under cultivation, necessitating a form of nutrient replenishing. Because soil organic matter is low, native soil N is also low coupled with wide spread P and S deficiencies in most soils of the savanna (FMARD, 2002). The ultimate aim of nutrient addition is to improve the productivity of the soil, thus impacting on the overall crop growth and consequently increases yield in crops (Adeyemi *et. al.*, 2001) and monetary returns that accrue to farmers.

Soil fertility refers to the inherent capacity of a soil to supply essential nutrient elements to crops in adequate amount and in the right proportion for their optimum growth. The essential nutrient elements comprise the key component of soil fertility (ICAR, 2009). These elements can be supplied to the soil either in organic or inorganic forms or both. Organic manures contain high nitrogen, phosphorus, potassium and other essential nutrients (Oyewole and Oyewole, 2011). In contrast to chemical fertilizer, it adds organic matter to soil which improves soil structures, nutrient retention, aeration, soil moisture holding capacity and water infiltration (Deksissa *et al*., 2008). Specifically, poultry manure more readily supplies P to plants than other organic manure sources (Garg and Bahla, 2008). Although, poultry manure is an excellent nutrient source for plants, supplementing soil nutrients, require sound soil fertility management practices to prevent nutrient imbalances and associated animal health risks as well as surface - water and ground water contamination (Blay *et al*., 2002; Phan *et al*., 2002). In the absence of other constraints, nutrient uptake and yield are closely related (Hedge, 1997).

Organic fertilizers: farmyard manure (FYM), sheep manure (SM), poultry manure (PM), compost, among others have been used for crop production for centuries. The use of these forms of fertilizers certainly pre-date chemical (mineral) fertilizers, which is of more recent development in comparison with organic fertilizers. Organic fertilizers are more environmentally friendly, since they are of organic sources. Contrary, observations show that continuous use of mineral fertilizers create potential polluting effect on the environment (Oad *et al*., 2004), in addition to the fact that synthesis of this fertilizer form consumes large amount of energy with often huge financial implications. Although organic fertilizers exist in readily available forms; cheap and easy to assess, they need to be applied in large amounts to meet the nutrient requirements of crops (Prabu *et al*., 2003). Where large hectares are involved, this single fact play important role in the cost of organic fertilizer application; as it pushes up transportation cost. This salient factor thus introduces management component into an otherwise abundant nutrient source. Thus, a combination of organic and mineral nutrients has been advocated (Prabu *et al*., 2003). As the integration of organic sources and synthetic sources of nutrients not only supply essential nutrients but also have some positive interaction with chemical fertilizers to increase their efficiency and thereby reduce environmental hazards (Bocchi and Tano, 1994). Therefore, the broad objective of the study is to determine the response of tomato and okra to different levels of organic manure (poultry source and oil palm refuse), mineral NPK and the combined treatment in the study area.

The trial thus:

1) Investigated the response of tomato and okra to different rates of N in OM and inorganic fertilizer.

2) Determine the optimum rates of N for sustainable production of the study crops in the study area.

3) Find out the response of tomato and okra to combined effect of OM and inorganic fertilizer in the study area.

4) Investigate weed infestation in response to nutrient application.

5) Compute the gross margin and cost - benefit ratios for the nutrient treatments

CHAPTER TWO

LITERATURE REVIEW

2.1 Fertilizers

A fertilizer is any material: organic or inorganic, natural or synthetic, that supplies plants with the necessary nutrients for plant growth and optimum yield. Organic fertilizers are natural materials of either plant or animal origin, including livestock manure, green manures, crop residues, household waste, compost, and woodland litters. Inorganic (or mineral) fertilizers are fertilizers mined from mineral deposits with little processing, typically: lime, potash, or phosphate rock, or industrially manufactured through chemical processes, for example urea. Inorganic fertilizers vary in appearance depending on the process of manufacture. The particles can be of many different sizes and shapes (crystals, pellets, granules, or dust) and the fertilizer grades can include straight fertilizers (containing one nutrient element only), compound fertilizers (containing two or more nutrients usually combined in a homogeneous mixture by chemical interaction) and fertilizer blends (formed by physically blending mineral fertilizers to obtain desired nutrient ratios) (IRRI, 2009).

Mineral fertilizers need to be applied to crop at least two times within a growing season (split application), either basally at planting or top-dressed during vegetative growth. The amount of inorganic fertilizer used in most smallholder farming systems falls far below standard extension recommendations, due to poor purchasing power, risk aversion due to poor and unreliable rainfall, and lack of significant returns. When available, fertilizer use is not overly labor intensive, thus allowing time for other tasks (or for earning income elsewhere) (IRRI, 2009).

2.2 Organic Fertilizers

Organic fertilizers are materials added to the soil to enhance plant growth, development and optimum productivity (IRRI, 2009). These are mainly wastes or residues of plants or animal life. The best known organic manure is the waste from mixed arable and livestock farming called farmyard manure. Common amongst the farmyard manure are poultry droppings, cow dung, goat dung and sheep dung. Organic fertilizer materials are cheap and easy to come by as most of the organic fertilizer materials are wastes or bi-products of other agricultural crops and animal which could be use to augment the nutrient status, the biological and physical condition of the soil.

Organic nutrient sources are highly heterogeneous and vary in quality and quantity. The quality aspect is important in determining the nutrient release potential of the organic fertilizer (IRRI, 2009). Microorganisms that decompose organic fertilizers use the carbon in such materials as an energy source for growth. Required in even bigger quantities by microorganisms for growth and reproduction is nitrogen (N). Commonly available materials are often particularly low in N content. For organic fertilizers with low N contents (such as cereal straw and most smallholder farmyard manures), microorganisms themselves will consume much of the available N for their own growth. Consequently, insignificant amounts of N will be released for the crop. Thus, on their own, poor quality materials have limited potential to enhance productivity. The effectiveness of such materials can be improved by combining them with mineral N fertilizers such as ammonium-nitrate or urea. Mineral fertilizers may be used more efficiently by crops growing on soils with adequate amounts of soil organic matter supplied by organic fertilizers (IRRI, 2009).

Soil fertility on smallholder farms is almost entirely dependent on locally available resources (IRRI, 2009). Cattle manure, cereal and legume stover, and woodland litters are the commonly used organic fertilizers, but these are rarely applied in sufficient quantities to impact on crop yields. The use of high quality organic fertilizers is rarely practiced, although through research and extension activities in Africa, some farmers now include legume green manures or legume-based fallows in crop sequences. The main advantage of using organic fertilizers is that, compared to mineral fertilizers, they are usually available on or near the farm at very little or no cost other than labor costs of handling, transportation, or opportunity costs of land used for their production (IRRI, 2009).

2.3 Method and Time of Application

The method and timing of fertilizer application is an essential component of good farming. For organic materials, decomposition rate and timing of application influence the release of nutrients to the crop (IRRI, 2009). Organic fertilizer application methods include broadcasting, banding, and spot application (or side-dressing). Broadcasting requires less labor and helps to evenly cover the field surface before incorporation into soil through plowing or hand-hoeing. Incorporation generally increases the fertility status of the whole plow layer. If the quantity of organic fertilizer is limited, it may be banded along furrows or spot applied, but the seed needs to be placed away from the fertilizer. Side-dressed organic fertilizers are not likely to have much immediate effect due to delayed nutrient release. Mineral fertilizers can be applied by hand or with application equipment. When hand applied, it is essential to distribute the fertilizers uniformly and at the recommended rates to avoid over- or under-fertilization (IRRI, 2009). Application equipment needs proper adjustment to ensure uniform spreading. Broadcast fertilizer should be incorporated after application to enhance effectiveness or to avoid evaporation losses of N. With banding or spot application, take care that no fertilizer is placed too close to either the seed or the germinating plant, to avoid damage to the seedling or roots (IRRI, 2009).

2.4 Effectiveness of Fertilizer

Continued use of organic fertilizers results in increased soil organic matter, reduced erosion, better water infiltration and aeration, higher soil biological activity as the materials decompose in soil, and increased yields after the year of application (residual effects). Proper handling of organic fertilizers enhances their quality and effectiveness. For example, with the exception of green manures, there is significant crop response if organic fertilizers are combined with N-based mineral fertilizers or other N-rich organic materials. Mineral fertilizers on the other hand immediately supply nutrients needed by crops. Basal fertilizers contain elements required for good crop establishment and early growth while top-dressing can be done through split applications depending on visible hunger signs and/or moisture availability. In risky environments, spot application of small amounts of N fertilizers improves fertilizer effectiveness. The best response to fertilizer use is obtained if the soil has a high inherent fertility level (high organic matter status). Building inherent fertility requires practices such as retaining crop residues on the field (IRRI, 2009).

2.5 Effect of Organic Manure on Growth

IRRI (2009) highlighted the role of organic matter in sustaining the fertility of soil for good production of vegetables by binding the soil, but observed that best performance is obtained on well drained, fertile soil with adequate content of organic fertilizers and reserve of major elements, which are generally suitable for growth. Organic fertilizers are very active and important component of soil. It is a nitrogen reservoir, furnishing large portion of soil phosphorus and sulphur and protects soil against erosion. It supplies the cementing substance for desirable aggregate soil formation and loosens the soil. In Nigeria, various studies have been conducted on nutrients requirements of okra with inorganic fertilizers (Adelana, 1985; Majanba *et al*., 1986; Akin - Taylor, 1986) while very little have been reported on sole use of organic manure or in combination with inorganic fertilizer.

Beneficial effects of organic matter in crop production have been emphasized. Although a lot of researches have been carried out to determine the effect of organic materials on growth and yield of crops (Adelana, 1985; Majanba *et al*., 1986; Akin - Taylor, 1986), it is important to observe that the nutrient value of different organic manure are not the same. Komolafe (1980) reported that the richest manure is poultry droppings, followed by cattle dung, goat dung, pig dung, and horse dung. Accordingly, FAO (1984) indicated that poultry manure can be use on most crops but because of its high nitrogen content, it is important to adjust nitrogen fertilizer use to avoid excessive application of N. Its potassium content, is however, relatively low. Also, Simpson (1986) reported that the application of organic manure significantly increased the growth parameter and yield of okra, which may be attributed to the high level of N supplied by the organic manure, an essential plant nutrient for growth. Iremiren (1984) reported that the enhanced growth observed in okra may be due to increase oxygenation and water movement in the soil as a result of nutrient addition; a steady release of nutrients in all life of the crop through organic manure decomposition.

2.6 Effect of Organic Manure on Yield

The Chinese obtain high level of soil fertilizer through the use of organic wastes as far back as the 16th century (Oyewole, and Oyewole, 2011). The effect of organic fertilizers in crop production particularly in okra production cannot be over-emphasized (Oyewole, 2011). Organic fertilizers have beneficial effect on soil nutrient composition, structural aggregation, infiltration rate, microbial and other biological activities of the soil; these and with a host of others will subsequently improve okra productivity, particularly in the tropics (Oyewole and Mera, 2010; Oyewole and Oyewole, 2011; Oyewole, 2011; Oyewole, *et al*., 2012). The use of cheap and locally available sources of plant nutrient which can ameliorate the problem of soil acidity, low nutrient status has been the recent focus in topical soil management. However, it is well known that when crop residue is returned to farm land a meaningful contribution of nutrient to subsequent crops is observed particularly if the residues could furnish nutrients in available form (Omueti *et al*., 2000). Organic matter plays a prominent role in sustained productivity of soils.

Simpson (1986) reported that animal manure contain more concentrate nutrients than plant manure. However 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. Soils with high organic matters are more productive than those low in organic matter. With a given soil type, the darker the soil, the more productive it should be. Although, the organic manures contain plant nutrients in small quantities as compared to the inorganic fertilizers, the presence of growth promoting factors like enzymes and hormones, besides plant nutrients make them essential for improvement of soil fertility and crop productivity (Oyewole and Mera, 2010; Oyewole and Oyewole, 2011; Oyewole, 2011; Oyewole, *et al*., 2012).

Agricultural sustainability refers to the capacity to remain productive while maintaining the soil fertility and increasing biodiversity. The use of manure and biologically active preparations of animal and plant origin is most commonly used by those farmers who aim for sustainable crop production (Abou El-Magd *et al*., 2006). Though nutrients contained in manures are released more slowly, they are stored for a longer time in the soil ensuring longer residual effects, improved root development and higher crop yields (Abou El Magd *et al*., 2006). Organic manures improve soil fertility by activating soil microbial biomass, which in turn leads to development in corps (Ayuso *et al*., 1996). While El-Shakweer *et al*. (1998) observed that application of manures sustains cropping system through better nutrient recycling, with manures providing a source of all necessary macro-and micro-nutrients in available forms, thereby improving the physical and biological properties of the soil (Abou El - Magd *et al*., 2006).

In developing countries, yield from okra and other vegetables are much lower than those obtained by farmers in developed countries where considerable farm inputs are used (Akemo *et al*., 2000). Intensive land use has reduced productivity and environmental quality, while low cost and low input production methods are needed to maintain and if possible improve soil productivity and crop yield. Optimum production of okra requires intensive practice that provides nutrients and water needed for sustaining okra productivity. The use of organic manure especially poultry dropping and ruminant dung for crop production has helped to improved agricultural practice in West African Countries. Organic manure helps to improve the physical condition of soil and provide adequate amount of necessary nutrients for soil productivity. Organic fertilizer play vital role as a major contributor of plant nutrients. It also acts as a store house for cation exchange capacity and as a buffering agent against undesirable pH fluctuation (Adepetu and Corey, 1987). Organic manure improves cohesiveness of soil, increases its water retention capacity and promotes a stable structure of the soil which brings increase in crop yield (Abou El - Magd *et al*., 2006). Organic manures are rich in nutrient composition and could be easily ploughed back into fields to enhance better performance. Oyewole and Oyewole (2011) observed that organic manures are good sources of nitrogen, potassium, calcium, phosphorus which are essential nutrients that increase the growth and yield of crops. However nutrients in organic manure vary within wide limits according to the demand of the animal and their feeding.

2.7 Effect of Inorganic Fertilizers on Crop Production

The use of inorganic fertilizer is a must since land is becoming limited due to competitive demands. Nigerian soils are largely deficient in major essential nutrients (Amhakhian, 2010). Nutrient elements have specific function in crop growth and development but no single nutrient can produce any meaningful plant growth on its own. The addition of artificial fertilizers is efficient, due to its nutrient concentration and relative ease of transportation and application. In Nigeria, straight fertilizers such as urea, single supper-phosphate and muriate of potash (potassium chloride) were the first set of fertilizer sources widely imported or produced.

Nigerian agriculture is faced with the challenge of increasing efficiency in agricultural productivity. This will involve adequate supply of essential crop nutrients, which will be a critical link between productions of food to meet today's need and long-term agricultural sustainability. Fertilizer has been recommended for okra fruit production (Fatokun and Cheda, 1983). However, the current price of fertilizer calls for its economic utilization to meet specific requirements of crops. Crop quality is also improved by adequate use of fertilizer provided they are applied in accordance with the latest concept and knowledge.

One of the factor limiting okra production is soil nutrient content especially nitrogen. Nitrogen fertilizer makes up to 50% of all the nutrients input, and its availability play an important role in determining farmer's crop yield. This has been attributed to the fact that its role in the plant cannot be easily subsided (FAO, 1998). Application of NPK especially N has been reported to significantly improve okra growth, dry matter partitioning (Akanbi *et al*., 2005) and fruit yield (Fatokun and Cheda, 1983).

2.8 Effect of Inorganic Fertilizers on Okra Yield

Inorganic fertilizers are synthetic, chemical, artificial material added to the soil that supplies one or more required nutrients for plants. 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 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 (Adelana, 1985). 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 fertilizer is reported to be responsible for over 50% yield increase in crops (Ayodele, 1993).

Okra requires nutrients such as nitrogen (N), phosphorus (P), potassium (K), 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 those nutrients result in poor performance of crop with growth been affected resulting to low yield. A judicious application of phosphorus and potassium fertilizer is relevant in enhancing good yield and enabling the farmers to make profit (Ayodele, 1993). Fatokun and Cheda (1983) reported that application of 25 kg P/ha in the forest zone gave optimum yield of okra while NIHORT (1985) reported increase in okra fruit yield with application of up to 30 kg P/ha. The plant height, leaf number, number of primary branches, leaf steam and total dry weight were all reported to be increased by phosphorus application up to 26 kg P/ha (Majanba *et al.*, 1982).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental area

The experiment was conducted in 2012 and 2013 cropping seasons at the Kogi State University Research and Demonstration Farm (latitude 7^0 30^1 and longitude 7^0 09^1E), Anyigba in the Southern Guinea savanna agro ecological zone of Nigeria to determine the effect of organic and inorganic fertilizers and their combination on the growth, development and yield of tomato and okra. The study area which is Kogi State, lies between latitude 5^0 15^1 to 7^0 45^1 N and longitude 5^0 45^1 and 8^0 45^1 East of the equator. The mean annual rainfall ranges from 1,560 mm at Kabba in the West to 1,808 mm at Anyigba in the East. The dry season generally extends from November to March. During this period, rainfall drops drastically to less than 12.0 mm in any of the months. Temperatures show some variations throughout the years, with average monthly temperature varying between 17 ^{0}C and 36.2 ^{0}C. The state has two main vegetations: the forest savanna mosaic zone and the southern guinea zone. It also has two main geological formations, they are: the Basement complex rocks to the west while the other half is on Cretaceous sediments, to the north of the confluence and east of River Niger (Amhakhian, *et al*., 2010). The soils like most soils in north central agricultural zone of Nigeria have high erodibility, structurally weak, coarse textured with low organic matter status (Amhakhian, *et al*., 2010).

3.2 Soil analysis

Soil samples were randomly collected from ten points at two depths: 0 – 15 cm and 15 – 30 cm, on the experimental plot thoroughly mixed together to form two composite samples. The samples collected were air dried, crushed with the aid of wooden roller and sieved through 2 mm sieve.

The samples were then subjected to physical and chemical analysis as described by Chang and Jackson (1958) (Appendix I).

3.3 Treatment combination and experimental design

The treatment consisted of rates of inorganic and organic fertilizers supplying various rates of nitrogen as shown on fig. 1 below.

3.4 Organic manure analysis

To calculate the required amounts of organic manure that will supply the needed experimental rates of N ha^{-1}, sample of organic manure to be used was analyzed for its total nitrogen, phosphorus and potassium, with emphasis on N content. The N contents in a unit of poultry manure (PM) and oil palm residue (OPR) were then used to calculate the required N rates.

3.5 Seed bed preparation

Conventional tillage operations: plough and harrowing, coupled with seed bed preparation were carried out before seed were sown on the flat fortified by high ridges to keep applied nutrients from being washed into other plots. Main plot was divided into sub plots of size 2 x 1.5 m separated by 1m leeway.

Study crop	Plant nutrient application
Tomato	**Control**
	Inorganic Nutrient
	150 kg N/ha
	300 kg N/ha
	Poultry Manure
	150 kg N/ha
	300 kg N/ha
	Oil Palm Residue
	150 kg N/ha
	300 kg N/ha
	Poultry Manure + Inorganic Nutrient
	75 kg PM/ha + 75 kg MF/ha
	150 kg PM/ha + 150 kg MF/ha
	Oil Palm Residue + Inorganic Nutrient
	75 kg PM/ha + 75 kg MF/ha
	150 kg PM/ha + 150 kg MF/ha
Okra	**Control**
	Inorganic Nutrient
	150 kg N/ha
	300 kg N/ha
	Poultry Manure
	150 kg N/ha
	300 kg N/ha
	Oil Palm Residue
	150 kg N/ha
	300 kg N/ha
	Poultry Manure + Inorganic Nutrient
	75 kg PM/ha + 75 kg MF/ha
	150 kg PM/ha + 150 kg MF/ha
	Oil Palm Residue + Inorganic Nutrient
	75 kg PM/ha + 75 kg MF/ha
	150 kg PM/ha + 150 kg MF/ha

Fig. 1: Treatment combinations

3.6 Study Crops

3.6.1 Tomato

3.6.2 Nursery operations and seedling transplant (Tomato)

Tomato seedlings were raised in nursery boxes, for four weeks before being transplanted onto experimental plots. In the nursery, the seedlings were shaded against direct impact of solar radiation. The boxes were kept weed free and watered every other day. Prior to seedling transplant into the field, the soil was heavily watered to enhance seedling removal. Vigorous seedlings were then transplanted onto the experimental plot at 4 weeks old after a heavy rain fall spaced 50 cm x 50 cm.

3.6.3 Okra sowing

The okra seeds were sown at a depth of 3 cm at the rate of two (2) seeds per hole and at a spacing of 30 cm x 50 cm. The emerged plant stands were later thinned to one (1) plant per stand after two weeks of sowing.

3.6.4 Weed control

Routine cultural operation such as hoe weeding at two weekly were carried out. Before weeding, weed count was determined using average of three quadrant throws (30 x 30 cm).

3.6.5 Nutrient management

Fertilizer and manure application were applied as in the treatment. For plots that were to receive organic manure (PM or OPR), the nutrient sources were incorporated a week to seed sowing (for okra) or seedling transplant (for tomato), while for those plots to be treated with NPK fertilizer, this was applied immediately after seed sowing or seedling transplant, respectively for okra and tomato crop. For those that were to receive combined nutrient application, the OM component were incorporated as in other sole manure treatments (a week prior to okra seed sowing or tomato transplanting), while the NPK components were came with either seed sowing (for okra) or tomato seedling transplant.

3.6.6 Data collection

On data collection, at two weekly data on plant height, stem gilt and number of leaves were determined per plot as means of four randomly sampled plants. Height was measured using a meter rule, stem diameter using Vanier calipers, while numbers of leaves were visibly counted. Individual treatment yields were computed on fresh weight basis as sum of all harvests from individual net plots (kg) extrapolated to one hectare. Other parameters taken include days to first flowering, pod length and pod diameter for okra. The growth and yield parameters collected were subjected to analysis of variance (ANOVA) (Statistical Analysis System (SAS) 1998) to evaluate the effect of organic and inorganic manures on okra growth, development and yield parameters. Significantly different means ($p \leq 0.05$) were separated using the Fisher Least Significant Difference (F-L S D) Test.

3.6.6.1 Weed population

Data on weed population as influenced by nutrient application were determined at two weeks intervals prior to weeding operations. Data on weed population were transformed (Gomez and Gomez, 1984) using the square root transformation before been subjected to statistical analysis.

Significantly different means ($p \leq 0.05$) were separated using the Fisher Least Significant Difference (F-L S D) Test.

3.6.6.2 Gross margin / cost – benefit ratios

Gross margin was computed based on inputs applied against output as in the formula below.

$$GM = TR - TVC$$

Where GM = gross margin

TR = total revenue in naira

TVC = total variable cost in naira

CHAPTER FOUR

RESULTS AND DISCUSSION

Soil in the experimental site was predominately sandy (75.00 per cent) with 17.00 per cent clay and 8.00 per cent silt. Evidently, the organic content was low: 2.41 g kg^{-1}, observing that the critical level of organic matter required for optimum crop production is 30 g kg^{-1} (Agboola and Corey, 1972). The soil contains 0.07 g kg^{-1} total N (1.50 g kg^{-1} being critical level for optimum production of maize in Nigeria (Agboola and Corey, 1972), 1.102 cmol kg^{-1} value for K while available P was 14.29 ppm. The soil analysis is an indication that the soil of the experimental site is critically limited by various macro nutrients: N, P and K, based on the critical levels of these elements required for optimum crop production in Nigeria. While discussing the soil properties of Anyigba, Kogi State, Nigeria, Amhakhian (2010) observed that the sandy nature of the soils in this area could imply low organic matter content. The sandy texture of the soil would also encourage rapid leaching of cations into the subsoil from the surface soil (Amhakhian, 2010). While Guzel and Ibrika (1994) observed that the low P content of some tropical soils have been attributed to low apatite content of the soil forming minerals. The author also added that the low P content of most savanna soils may also be attributed to their level of maturity.

Results of analysis of poultry manure show average N was 4.52 per cent, while mean P and K were 2.64 and 1.19 per cent, respectively. Oyewole and Oyewole (2011) observed that poultry manure production occurs as a result of the normal everyday processes of the poultry industry. Svotwa, *et al*. (2007) earlier reported that, if one were looking strictly at the fate of the nutrient inputs, the major product of any animal feeding system is manure, not animal protein. Often manures are considered waste materials and a place to dispose of them has to be found. However, if the manure is considered a by-product of the industry, a possible use for it in a market economy can be found – soil enrichment (Svotwa, *et al*., 2007). Similarly, Oyewole and Oyewole (2011) reported that laboratory analysis of sampled poultry manure reveals varying levels of N, P and K. These components (N, P and K), they observed, are important plant nutrients required for plant growth and yield formation. They added that, it should therefore be expected that the fertility status of the soil would benefit from poultry manure application since manure is known to improve soil organic matter, as well as macro and micro-nutrient status of the soil (Maerere, *et al*., 2001; Adeniyan and Ojeniyi, 2003; Adediran, *et al*., 2003; Akande and Adediran, 2004). Adesodun, *et al.* (2005) had found that application of poultry manure to soil increased soil organic matter, N, P, soil physical properties and soil moisture. While Aluko and Oyedele (2005) attributed this improved soil moisture to the mulching effect of organic matter and improved moisture retention, in addition to water acceptance as a result of improved soil structure and macro porosity.

4.1 Tomato crop

4.1.1 Effect of plant nutrient on plant growth and yield parameters

Analyzed data revealed that final plant heights, stem gilt, number of harvested fruits/ha, and fruit weight/ha showed significant ($p \leq 0.05$) influence of nutrient application on these parameters of growth and yield (Table 1). In respect of individual nutrient application, poultry manure source gave the best growth and yield responses, followed by in-organic fertilizer and finally, oil palm residue. In respect of integrated nutrient application, combining poultry manure with in-organic fertilizer gave the best growth and yield responses, with the best overall responses obtained with the application of 150 kg PM/ha + 150 kg MF/ha.

Generally, previous observations have shown beneficial effects of fertilizers (organic or inorganic) on soil nutrient composition, structural aggregates, infiltration rate, microbial and other biological activities of the soil (Omueti *et al*., 2000), which must have improve tomato growth over the control, cumulating in better plant performance with nutrient application. Simpson (1986) reported that the application of organic manure significantly increased crop growth parameters and yield, and attributed it to the high level of N supplied by the organic manure, an essential plant nutrient for growth. Organic manures have been said to improve soil fertility by activating soil microbial biomass, which in turn leads to development in corps (Ayuso *et al*., 1996).

4.1.2 Economics of nutrient application

Application of in-organic nutrient at the rate of 150 kg N/ha yielded 88.15% return over the control (Table 2), while applying 300 kg N/ha in-organic nutrient yielded only 74.68% return over the control. Application of organic nutrient at the rate of 150 and 300 kg N/ha yielded 81.93 and 85.98 percent returns, respectively over the control treatment. The highest return on fertilizer investment was obtained with the application of 150 kg PM/ha + 150 kg MF/ha (90.17%) over the control, which was followed by application of 150 kg N OPR/ha + 150 kg N MF/ha (89.84%) over the control.

4.2.1 Okra crop

4.2.2 Effect of plant nutrient on plant growth and yield parameters

Analyzed data revealed that final plant heights, stem gilt, number of harvested pods/ha, and pod weight/ha showed significant ($p \leq 0.05$) influence of nutrient application on these parameters of growth and yield in okra (Table 3). In respect of individual nutrient application, poultry manure source gave the best growth and yield responses, followed by oil palm residue and finally, in-organic fertilizer. In respect of integrated nutrient application, combining poultry manure with in-organic fertilizer gave the best growth and yield responses, with the best overall responses obtained with the application of 150 kg PM/ha + 150 kg MF/ha.

As observed in respect of the tomato component, previous observations have shown beneficial effects of fertilizers (organic or inorganic) on soil nutrient composition, structural aggregates, infiltration rate, microbial and other biological activities of the soil (Omueti *et al*., 2000), which must have improve tomato growth over the control, cumulating in better plant performance with nutrient application. Simpson (1986) reported that the application of organic manure significantly increased crop growth parameters and yield, and attributed it to the high level of N supplied by the organic manure, an essential plant nutrient for growth. Organic manures have been said to improve soil fertility by activating soil microbial biomass, which in turn leads to development in corps (Ayuso *et al*., 1996).

Table 1: Effect of nutrient source and rates on tomato growth and yield in the Guinea Savanna Agro-ecological Zone in Nigeria

Plant nutrient application	Height (cm)	Mean stem gilt (cm)	Fruit number per ha	Fruit weight (t ha^{-1})
Control	5.95	0.63	109,871	1.5
Inorganic Nutrient (MF)				
150 kg N/ha	10.84	1.69	447,213	12.7
300 kg N/ha	12.91	1.82	414,399	6.0
Mean	**11.88**	**1.76**	**430,806**	**9.4**
Poultry Manure (PM)				
150 kg N/ha	20.21	1.88	501,666	8.3
300 kg N/ha	19.98	2.11	671,796	10.7
Mean	**20.10**	**2.00**	**586,731**	**9.5**
Oil Palm Residue (OPR)				
150 kg N/ha	9.95	1.53	321,876	7.3
300 kg N/ha	11.67	1.71	337,965	10.3
Mean	**10.81**	**1.62**	**329,921**	**8.8**
Poultry Manure + Inorganic Nutrient				
75 kg PM/ha + 75 kg MF/ha	15.58	2.75	735,435	14.2
150 kg PM/ha + 150 kg MF/ha	16.46	2.71	827,371	15.3
Mean	**16.02**	**2.73**	**781,403**	**14.8**
Oil Palm Residue + Inorganic Nutrient				
75 kg OPR/ha + 75 kg MF/ha	11.84	1.69	417,163	12.3
150 kg OPR /ha + 150 kg MF/ha	13.29	1.78	424,939	14.8
Mean	**12.57**	**1.74**	**421,051**	**13.6**
$LSD_{0.05}$	0.346*	0.826*	1311.65*	0.80*

* Statistically significant ($p \leq 0.05$)

Table 2: Effect of nutrient source and rates on economics of nutrient application in tomato in the Guinea Savanna Agro-ecological Zone in Nigeria

Plant nutrient application	Mean of two years (t/ha)	Total return on enterprise	Input cost (₦)	Net return on enterprise (₦)	Per cent returns (%)
Control	1.5	300,000	-	300,000	-
Inorganic Nutrient (MF)					
150 kg N/ha	12.7	2,540,000	7,500	2,532,500	88.15
300 kg N/ha	6.0	1,200,000	15,000	1,185,000	74.68
Poultry Manure (PM)					
150 kg N/ha	8.3	1,660,000	150	1,659,850	81.93
300 kg N/ha	10.7	2,140,000	300	2,139,700	85.98
Oil Palm Residue (OPR)					
150 kg N/ha	7.3	1460000	150	1,459,850	79.45
300 kg N/ha	10.3	2060000	300	2,059,700	85,43
Poultry Manure + Inorganic Nutrient					
75 kg N PM/ha + 75 kg N MF/ha	14.2	2,840,000	3825	2,836,175	89.42
150 kg N PM/ha + 150 kg N MF/ha	15.3	3,060,000	7650	3,052,350	90.17
Oil Palm Residue + Inorganic Nutrient					
75 kg N OPR/ha + 75 kg N MF/ha	12.3	2,460,000	3825	2,456,175	87,79
150 kg N OPR/ha + 150 kg N MF/ha	14.8	2,960,000	7650	2,952,350	89.84

Table 3: Effect of nutrient source and rates on okra growth and yield in the Guinea Savanna Agro-ecological Zone in Nigeria

Plant nutrient application	Height (cm)	Mean stem gilt (cm)	No of harvested pods per ha	Mean fruit weight (t/ha)
Control	16.7	1.0	241,667	1.4
Inorganic Nutrient (MF)				
150 kg N/ha	29.9	1.6	707,500	9.5
300 kg N/ha	57.6	1.5	706,667	9.4
Mean	**43.8**	**1.6**	**707,084**	**9.5**
Poultry Manure (PM)				
150 kg N/ha	43.7	1.1	815, 000	10.2
300 kg N/ha	67.5	1.8	933,334	13.2
Mean	**55.6**	**1.5**	**874,167**	**11.7**
Oil Palm Residue (OPR)				
150 kg N/ha	38.4	0.7	805,000	9.4
300 kg N/ha	43.1	0.8	823,333	10.3
Mean	**40.8**	**0.8**	**814,167**	**9.9**
Poultry Manure + Inorganic Nutrient				
75 kg N PM/ha + 75 kg N MF/ha	33.3	0.8	1,137,500	13.1
150 kg N PM/ha + 150 kg N MF/ha	41.2	0.8	1,151,667	14.1
Mean	**37.3**	**0.8**	**1,144584**	**13.6**
Oil Palm Residue + Inorganic Nutrient				
75 kg N OPR /ha + 75 kg N MF/ha	43.4	1.7	812,000	10.4
150 kg N OPR /ha + 150 kg N MF/ha	45.1	1.8	825,463	11.3
Mean	**44.3**	**1.8**	**818,732**	**10.9**
F-LSD ($p \leq 0.05$)	9.87*	0.48*	48,904*	0.975*

* Statistically significant ($p \leq 0.05$)

4.3 Effect of nutrient source and rates on weed population m-^{2} and weed dry matter

The data given on Tables 4 indicates significant ($p \leq 0.05$) increase in weed population with nutrients application over the control in both 2012 and 2013 cropping seasons**.** In addition, data given on Tables 5 indicates significant ($p \leq 0.05$) influence of nutrient application on weed dry weight in 2012 and 2013 cropping seasons. Integrating nutrient sources (organic and in-organic) consistently gave the highest weed dry matter in 2012 and 2013 cropping seasons with the least result observed in the control treatment.

Major *et al.* (2005) in a similar experiment conducted on weed composition and cover after three years of soil fertility management in the central Brazilian Amazon observed that weed population responded positively to improved soil fertility management. The authors reported that while application of both inorganic and organic fertilizers significantly increased weed ground cover, the number of species within plots also significantly increased following the addition of inorganic fertilizer. These increases were even greater with the addition of chicken manure and compost, they added. It should therefore be expected that improvements in the fertility of nutrient poor soils will increase weed pressure (Major *et al*., 2005). In addition, when organic manure is combined with in-organic nutrients, weed pressure is likely to be intensified, unless crop and weed emergence patterns are modified, such that they result in a competitive advantage for the crop (Major *et al*., 2005).

CONCLUSION

In many developing countries like Nigeria, farmers have limited financial resources and can rarely afford to purchase sufficient mineral fertilizer. The use of single super - phosphate and other synthetic fertilizers are usually beyond the reach of peasant farmers due to their high cost and scarcity. Crops have become so expensive to grow that nutrient deficiencies should not be allowed to limit their yields. With management practices such as continuous cropping and reduce fallow periods, the soil can hardly support cropping. The need therefore, arises for production practices that will ensure high yield. Therefore this experiment conducted during 2012 and 2013 cropping seasons investigated the effect of organic, inorganic fertilizers and their integration on the growth, development and yield of tomato and okra in Kogi state, Nigeria with the aim of recommending the most appropriate rates. Based on the research outcome, it is recommended that if tomato or okra is to be grown on inorganic fertilizer, application of N at the rate of 150 kg ha^{-1} is appropriate for the experimental area, while application of organic fertilizer at the rate of 300 kg N ha^{-1} is recommended for both crops. However, integrated application of N at the rate of 150 kg PM ha^{-1} + 150 kg MF ha^{-1} is recommended for higher tomato and okra yield.

Table 4: Weed population on experimental plots in Anyigba, Kogi State, Nigeria

Nutrient application	Weed population m-2					
	2012 cropping season			2013 cropping season		
	3WAT	5WAT	7WAT	3WAT	5WAT	7WAT
Control	09	06	11	09	11	27
Poultry manure (PM)						
200 kg N/ha organic	16	48	38	13	37	29
300 kg N/ha organic	18	54	53	13	41	38
Inorganic Nutrient (MF)						
200kg N/ha in-organic	11	30	34	9	23	32
300kg N/ha in-organic	14	31	36	13	25	36
Poultry manure + Inorganic Nutrient						
200kg N/ha (50% PM + 50% MF)	14	34	43	10	26	29
300 kg N/ha (50% PM + 50% MF)	15	46	54	14	35	45
Oil Palm Residue (OPR)						
200 kg N/ha organic	11	29	37	11	16	19
300 kg N/ha organic	12	41	51	12	25	35
Oil Palm Residue (OPR) + Inorganic Nutrient						
200kg N/ha (50% PM + 50% MF)	11	16	19	30	34	34
300 kg N/ha (50% PM + 50% MF)	18	19	27	48	37	38
F-LSD ($p \leq 0.05$)	**1.2***	**1.6***	**2.6***	**1.9***	**1.7***	**2.5***

* Statistically significant ($p \leq 0.05$)

Table 5: Effect of nutrient application on dry weight of weeds per net plot in Anyigba, Kogi state

Nutrient application	Weed dry weight (g) m^{-2}					
	2012 cropping season			2013 cropping season		
	3WAT	5WAT	7WAT	3WAT	5WAT	7WAT
Control	1.50	1.09	1.40	1.35	0.97	1.14
Poultry manure (PM)						
200 kg N/ha organic	4.18	2.64	2.24	3.78	2.18	2.07
300 kg N/ha organic	4.48	4.71	3.90	4.27	3.11	3.37
Inorganic Nutrient (MF)						
200kg N/ha in-organic	0.88	1.30	2.08	0.79	1.17	1.98
300kg N/ha in-organic	2.24	1.34	2.21	2.02	1.20	2.15
Poultry manure + Inorganic Nutrient						
200kg N/ha (50% PM + 50% MF)	3.04	2.49	4.08	2.74	2.23	3.88
300 kg N/ha (50% PM + 50% MF)	6.35	4.40	4.47	5.71	3.90	4.17
Oil Palm Residue (OPR)						
200 kg N/ha organic	1.13	1.36	1.24	2.28	1.11	1.37
300 kg N/ha organic	1.47	2.75	2.34	2.37	1.18	2.37
Oil Palm Residue (OPR) + Inorganic Nutrient						
200kg N/ha (50% PM + 50% MF)	1.49	1.96	1.96	1.34	1.77	1.67
300 kg N/ha (50% PM + 50% MF)	3.78	2.95	2.31	3.40	2.65	2.13
F-LSD (5%)	0.711*	0.237*	0.272*	0.171*	0.24*	0.712*

* Statistically significant ($p \leq 0.05$)

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APPENDICES

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09-12-13

The Deputy Vice Chancellor Admin
Kogi State University, Anyigba
P.M.B. 1008,
Anyigba
Kogi State

Through

The Dean
Faculty of Agriculture
Kogi State University, Anyigba

Through

The Head
Department of Crop Production
Faculty of Agriculture
Kogi State University, Anyigba

Sir,

REPORT ON APPROVED RESEARCH PROJECT INTERVENTION GRANT

I, Dr Oyewole, C.I. (SS 417) having applied and received a total sum of three hundred and forty thousand naira (N340, 000.00) being the approved amount in the 2009/2010/2011 TETfund Research Project Intervention [Batch 2 RP disbursement], thereby forward a compressive report of work done after due completion of the research.

I really do want to appreciate the Kogi State University, Anyigba for providing the enabling environment to attract such fund and also do acknowledge TETfund for the financial support to conduct this research.

Thank you sir
Yours faithfully,

Dr Oyewole, C.I.

Income:

Total amount approved and released for the trials: Three hundred and forty thousand naira only [₦340, 000.00] provided for in the 2009/2010/2011 TETfund Research Project Intervention [Batch 2 RP disbursement] covering for the activities as contained in Tables 1 and 2 below.

Table 1: Approved budget for the first trial

s/no	Work description	Estimated budget (N)
1	Pre planting soil collection at two depths	2,500
2	Soil analysis	40,000
3	Land preparation (bed preparation)	5,500
4	Tomato seed	1,000
5	Okra seed	500
6	Planting operations	3,000
7	Fertilizer	
8	NPK	2,500
	Urea	2,500
	SSP	2,500
	Organic manure (PM, OPR and CD)	5,000
9	Organic manure analysis	5,000
10	Post harvest soil analysis	40,000
11	Crop harvest	9,000
12	Data collection (all parameters)	17,000
13	Data analysis and interpretation	25,000
14	Miscellaneous	9,000
	Total	**170,000**

Table 2: Approved budget for the second trial

s/no	Work description	Estimated budget (N)
1	Pre planting soil collection at two depths	2,500
2	Soil analysis	40,000
3	Land preparation (bed preparation)	5,500
4	Tomato seed	1,000
5	Okra seed	500
6	Planting operations	3,000
7	Fertilizer	
8	NPK	2,500
	Urea	2,500
	SSP	2,500
	Organic manure (PM, OPR and CD)	5,000
9	Organic manure analysis	5,000
10	Post harvest soil analysis	40,000
11	Crop harvest	9,000
12	Data collection (all parameters)	17,000
13	Data analysis and interpretation	25,000
14	Combined analysis and interpretation of data	5,000
15	Miscellaneous	4,000
	Total	**170,000**

Expenditure:

Activities carried out as provided in the first and second trials: The team was able to raise two trials of tomato and okra in 2012 and 2013 cropping seasons and expended the released amount on the activities shown Tables 3 and 4 below.

Table 3: Activity and cost implication in the first trial

s/no	Activity carried out	Approved amount (₦)	Expenditure incurred (₦)
1	Pre planting soil collection at two depths (0 -15cm and 15 – 30 cm), one man day @ N2, 500/day	2,500	2,500
2	Soil analysis for major macro and micro nutrients	40,000	40,000
3	Land preparation (bed preparation)	5,500	9,000
4	Procurement of Tomato seed	1,000	1,000
5	Procurement of Okra seed	500	2,400
6	Planting operations	3,000	3,000
7	Procurement of Fertilizer		
8	Procurement of NPK	2,500	5,000
	Procurement of Urea	2,500	5,000
	Procurement of SSP	2,500	5,000
	Procurement of Organic manure (PM, OPR and CD)	5,000	5,000
9	Organic manure analysis	5,000	5,000
10	Data collection on the field (all parameters)	17,000	17,000
11	Crop harvest	9,000	9,000
12	Data collection on post field (yield and yield parameters)	-	6,000
13	Data analysis and interpretation (including printing work)	25,000	25,000
14	Post harvest soil collection at two depths (0 -15cm and 15 – 30 cm)	-	5,000
15	Post harvest soil analysis	40,000	40,000
16	Miscellaneous	9,000	
	i. Hoes (2 x 250 / hoe)		500
	ii. Boots		1,500
	iii. Poly bags for soil collection @ N10/ bag		150
	iv. Bags for harvest @ N50/ bag		2,500
	v. Transportation cost		3,000
	Total	**170,000**	**183,400**

Table 4: Activity and cost implication in the second trial

s/no	Activity carried out	Approved amount (₦)	Expenditure incurred (₦)
1	Pre planting soil collection at two depths (0 -15cm and 15 – 30 cm), one man day @ N2, 600/day	2,500	2,600
2	Soil analysis for major macro and micro nutrients	40,000	40,000
3	Land preparation (bed preparation)	5,500	18,000
4	Procurement of Tomato seed	1,000	1,000
5	Procurement of Okra seed	500	2,400
6	Planting operations	3,000	3,000
7	Procurement of Fertilizer		
8	Procurement of NPK	2,500	5,000
	Procurement of Urea	2,500	5,000
	Procurement of SSP	2,500	5,000
	Procurement of Organic manure (PM, OPR and CD)	5,000	5,000
9	Organic manure analysis	5,000	5,000
10	Data collection on the field (all parameters)	17,000	17,500
11	Crop harvest	9,000	9,100
12	Data collection on post field (yield and yield parameters)	-	6,200
13	Data analysis and interpretation (including printing work)	25,000	25,000
14	Combined data analysis interpretation (including printing work)		15,000
15	Post harvest soil collection at two depths (0 -15cm and 15 – 30 cm)	-	5,000
16	Post harvest soil analysis	40,000	40,000
17	Miscellaneous	9,000	
	vi. Hoes (4 x 250 / hoe)		1000
	vii. Boots		1,500
	viii. Poly bags for soil collection @ N10/ bag		160
	ix. Bags for harvest @ N50/ bag		2,500
	x. Transportation cost		2900
	xi. Typing and printing of the final report		N30,000
	Total	**170,000**	**229,710**
	Gross total	**340,000**	**413,100**

Dr Oyewole, C.I.
Team leader