UNIVERSITY OF CAPE COAST

# EFFECT OF COMPOST AS SOIL AMENDMENT ON GROWTH, YIELD AND QUALITY OF OKRA (*Abelmoschus esculentus* L. Moench)

RANSFORD AMISSAH

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BY

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Thesis submitted to the Department of Soil Science of the School of Agriculture, College of Agriculture and Natural Sciences, University of Cape Coast in partial fulfilment of the requirements for award of Master of Philosophy Degree in Land Use and Environmental Science

MAY, 2015

## DECLARATION

### Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this University or elsewhere.

Candidate's Name: Ransford Amissah

Signature: ……. Date: ……...

### Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

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Co-Supervisor's Name: Prof. Daniel Okae-Anti

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## ABSTRACT

Organic nutrient sources such as compost could be used to improve the low fertility of tropical soils as it has the potential to enhance soil physical, chemical and biological properties and improve growth, yield and quality of crops. Pot and field experiments were conducted to investigate the effect of compost on growth, yield and nutritional quality of okra, *Abelmoschus esculentus* (L.) Moench. The pot experiment was done using the Completely Randomized design while field trial was done in Split-Plot Design (SPD). In all the pot and field experiments, compost was incorporated at rates of 0 kg N $ha^{-1}$ (control), 100 kg N $ha^{-1}$ and 200 kg N $ha^{-1}$ with three replicates. *Asontem* and *Enidaso* okra varieties were used as test crops.

Results from the study indicated that the addition of compost at 100 kg N $ha^{-1}$ in the pot experiment showed significantly greater plant height, number of leaves, leaf area, dry matter content and nutrient content in stem, leaf, petiole and root of harvested okra plants. The results for field work showed that the *Enidaso* variety responded better to compost application in that this variety recorded the highest plant height, had less incidence of okra mosaic disease and had higher dry matter. Using the Duncan's Multiple Range Test (DMRT), no significant difference was found between compost application rates of 100 kg N $ha^{-1}$ and 200 kg N $ha^{-1}$ in terms of soil organic carbon, soil total nitrogen, available phosphorus, pH, ECEC, moisture content, exchangeable $Ca^{2+}$ and $Mg^{2+}$ contents. Proximate analysis for moisture and protein contents as well as nutrients (magnesium, potassium, phosphorus and sodium) composition of edible pods of okra was also not significant. For economic reasons, an application rate of 100 kg N $ha^{-1}$ was recommended.

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## DEDICATION

I dedicate this work to my mother Mrs. Grace Woode and elder sister Gifty Sam.

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# CHAPTER ONE

## BACKGROUND INFORMATION

Vegetables production in the tropics is very important since they supply minerals, vitamins and proteins to augment the shortages of these nutrients in the chiefly starchy diets of the people (Bakhru, 2003). Vegetables also contain valuable antioxidants that protect the body by neutralizing free radicals or unstable oxygen molecules that damage cells and result in poor health. Vegetables are valuable in preserving alkaline reserve in the body (Kumar et al., 2010). They are also important as sources of vitamins A, C, and folate (folic acid and folacin).

Vegetables are important protective foods that promote good health and prevent diseases. They contain valuable food ingredients which build up and repair the body (Bakhru, 2003; Edet and Etim, 2007). In most developing countries of the world, producing vegetable as a staple food item has continued to increase (Udoh et al., 2005). According to Kebede and Gan (1999), the main sources of farm income for small-scale and inadequately resourced farmers are arable crop production and vegetable crops. The importance of vegetables has gained recognition around the globe (Brandt and Kidmose, 2003).

A report by the Asian Vegetable Research Development Centre (AVRDC) for Africa in 2004 revealed that vegetables are the cheapest sources of micronutrients. Vegetable cultivation serves as a means for rural development through generation of foreign exchange for Africa. The value of okra is the eatable green seedpods (Adewole and Ilesanmi, 2011). Fruits are harvested when immature and eaten as a vegetable. Examples of exotic okra cultivars include

Emerald, Jade, Burmese Okra, Louisiana Short, Alabama Red, Silver Queen Okra, and Star of David. The local cultivars found in Ghana include Asontem, Torkor, Saloni, Enidaso whiles Spineless, Jokoso, LD 88, V-35 and Ex Borno are Nigerian cultivars. Okra varieties differ by height, size of fruit, colour of fruit, early or late maturing (Udoh et al., 2005).

Okra is one of the most important vegetable crops and a source of calorie (4550k cal $kg^{-1}$) for human consumption. According to Babatunde et al. (2007), okra is the most commonly grown vegetable crop in the tropics. The immature pods contain 86% water, 2.2% protein, 10% carbohydrate, 0.2% fat and vitamins A, B and C (Norman, 1992). Benefits gained from eating and the money-making opportunity it offers to peasant farmers make okra a popular vegetable in every market in tropical Africa (Tindall, 1992).

**Statement of the problem**

Owing to their low nutrient status, crop yields are low in most tropical soils. To replenish the fertility of their soils to improve crop yield, some farmers use synthetic fertilizers (Tisdale et al., 1990). These mineral fertilizers have resulted in increase in food production to meet the demand of the population (FAO, 2002). However, the use of these mineral fertilizers has suffered severe drawbacks due to their high costs, highly variable nature of tropical soils and inherent low nutrient conversion efficiency (AGRA, 2008). Further, some farmers in sub-Saharan Africa who use synthetic fertilizers do not carry out sufficient soil testing before applying these mineral fertilizers. This could promote soil acidification which reduces soil fertility resulting in reduced yield (FAO/IFA/IFDC, 2003).

Moreover, accumulation of nutrients, particularly N and P in surface water bodies from agricultural run-off from farmlands due to over-application of synthetic N and P fertilizers creates algal blooms and red tides (eutrophication) which destroy the aesthetic values of these water bodies (FAO, 2003). There is therefore an increased global interest in the use of organic nutrient inputs as alternative source for increased crop production.

**Justification**

Synthetic fertilizer acquisition and use is a challenge for most smallholder farmers who are engaged in vegetable crop production. Okra is an important source of minerals and antioxidants which promote good health. However, the nutrient poor sub-Saharan soils are often unable to support sustainable production of this important vegetable crop. Since most smallholder farmers are unable to rely on the synthetic nutrient sources for okra production, it is therefore important to consider the use of organic nutrient inputs such as compost to produce this important vegetable crop to meet the demand of the populace (Adewole and Ilesanmi, 2011). Organic nutrient sources such as compost are readily accessible as they can be produced easily within the local environment to promote growth and yield of okra. Apart from the supply of required nutrients, regular application of compost has long term positive impact on soil physical properties (Eghball, 2001). The use of compost in vegetable production could also enhance the livelihood of the inadequately resourced peri-urban farmer since compost materials are easily accessible and inexpensive (Akanbi et al., 2004). Furthermore, compost releases nutrients in their right proportions thereby preventing leaching while ensuring synchrony between nutrient supply and crop uptake (Badejo and Togun, 1998).

Recent studies have shown that the use of compost could result in quality food and also help preserve soil fertility (Basu et al., 2011). Further, compost when incorporated into the soil improves microbial activity. Compost supplies the soil with enough organic matter which increases soil organic carbon content (Porter, 2004). Organic matter improves soil stability, improves cation exchange capacity by holding nutrients and water which improves plant growth (Terry, 2002**).**

According to Gruhn et al. (2000), incorporation of compost rehabilitates croplands caused by intensive crop production and improper soil management practices when used as soil amendment (FAO, 2008).

**Hypotheses**

The hypotheses underlying the study are presented below:

**$H_o$:** Compost application improves soil physico-chemical properties

**$H_a$:** Compost application does not improve soil physico-chemical properties of soil.

**$H_o$:** Compost application improves growth rate, total dry matter content and nutrient content of okra.

**$H_a$:** Compost application does not improve growth rate, total dry matter content and nutrient content of okra.

**$H_o$:** Compost application improves the nutritional quality and tolerance of okra to pests and diseases.

**$H_a$:** Compost application does not improve the nutritional quality and tolerance of okra to pests and diseases.

**$H_o$:** Different varieties of okra respond differently to different levels of compost application

**$H_a$:** Different varieties of okra do not respond differently to different levels of compost application

**General objective**

The main objective of the study was to examine the effect of compost as soil amendment on some selected soil physico-chemical properties, growth, yield and nutritional quality of okra, *Abelmoschus esculentus* (L.) Moench.

**Specific objectives**

The specific objectives of the study were to:

a) Examine how compost improves soil pH, total N, available P, exchangeable $Ca^{2+}$, $Mg^{2+}$, $K^{+}$ and $Na^{+}$, total organic carbon, effective cation exchange capacity, exchangeable acidity, moisture content, particle size distribution and bulk density.

b) Investigate the effect of compost on growth rate, total dry matter yield and nutrient content in two okra varieties.

c) Investigate the effect of compost on nutritional quality and the tolerance of two cultivars of okra to pests and diseases.

# CHAPTER TWO

# LITERATURE REVIEW

## Introduction

Soils in tropical Africa cover several hundred million hectares and most often support agriculture marginally because of their natural low fertility (Amberger, 2006). The presence of high iron and aluminum contents, low activity clay, and low organic matter limit the fertility of some highly acidic tropical soils (Hartemink, 2003). High temperatures, high humidity and frequent heavy rains cause rapid decomposition of organic matter. These result in low nutrient content of these soils. According to White (2006), heavy rains especially monsoon rains could lead to rapid nutrient leaching and chemical weathering of most soils.

A study conducted by Wild (1993) on sub-Saharan soils revealed that the soils were uniformly low in nutrients and were easily lost on cultivation. These light coloured soils low in organic matter content hinder productivity. Most tropical soils would irreversibly change to ironstone on cultivation. The study also showed that soils with low pH (below 5.0) allow formation of high aluminium and iron content, pseudosilts and clay balls as well as low-levels of organic matter, clay, base saturation and high phosphate-fixing capacity. The impoverished nature of these soils affects the economic development of most African countries that depend on agriculture (Scherr, 1999).

## Factors that contribute to low fertility of tropical soils

Anthropogenic and physico-climatic factors are considered among the principal factors that affect soil fertility potential of most soils in tropical Africa. Omotayo and Chukwuka (2009) cited indiscriminate human activities like

continuous cropping, haphazard logging, vegetation removal and uncontrolled bush burning as practices that affect soil fertility in tropical Africa.

According to Juo et al.(1995), continuous cropping on Alfisols, Oxisols and Ultisols in the tropics have resulted in rapid nutrient decline of soil organic matter of most surface soils during the first year of cultivation. Also, continuous cropping has been observed to cause significant decline in soil pH and exchangeable calcium and magnesium levels (Hossner and Juo, 1999). Decline in crop yields under continuous cultivation has been attributed to acidification, soil compaction and loss of organic matter. According to Woomer et al. (1994), tillage practices associated with continuous cropping results in initial decline in soil organic matter which then stabilizes at low levels (Sanchez and Buol, 1975).

Further, uncontrolled and repeated burning activities by some smallholder farmers have negative impact on soil microenvironment. Acceleration of erosion and destruction of beneficial organisms like earthworms and termites are some examples of the negative impacts. Bush burning which commonly occurs as soil management system in sub-Saharan Africa could also contribute to soil fertility depletion of most soils (Swift and Palm, 2000).

According to Ayoola and Adeniyan (2006), high population pressure in tropical Africa has made bush fallowing system unsustainable. Intensive cropping on available croplands has resulted in changes in the natural physical and chemical properties of most soils. These limitations together with changes in biotic components of soil microenvironment have worsened the overall reduction in soil fertility status (Woomer and Swift, 1994).

Uncontrolled removal and cutting down of natural vegetation have negative effect on soil systems in sub-Saharan Africa. Deterioration of soil physical structure and conditions through crusting and surface sealing, compaction and formation of restrictive layers in the soil profile hinders soil productivity. Such soils are more vulnerable to wind and water erosion which unattended could lead to large-scale degradation of soils (FAO, 2003).

The natural physical and chemical features of soils in relation to weather/climatic patterns also contribute immensely to the observed trend in soil fertility decline of countries in Sub-Saharan Africa. Loss of nitrogen (N) and phosphorus (P) through wind and water erosion are some of the main factors that contribute to soil nutrient depletion through physico-climatic processes. According to Amede (2003) as cited by Henao and Baanante (2006), leaching of N and K has also been reported as a contributing factor to nutrient depletion that results in low fertility.

High intensity, short duration and large year to year variations in annual precipitations could also contribute to soil fertility decline in semi-arid countries of Sub-Saharan Africa (Sivakumar et al., 1992). Moreover, sunshine intensity is high in these semi-arid areas with high velocity winds as regular environmental phenomenon. As a result, sandy Entisols and Alfisols which are major soil types in this region have weak structures with low organic matter content and low water holding capacity. These features make these soils more susceptible to wind and water erosion (Sivakumar et al., 1992; Deckers, 1993).

**Strategies for soil fertility management**

Decline in fertility of tropical soils remains a challenge in improving agricultural production (Sanchez, 1976). Nutrient depletion has resulted in shortage of food as tropical soils are susceptible to erosion. Methods of improving soil fertility in sub-Saharan Africa are available but the political will to decide the acceptability of these improved measures however remains a serious threat (Hartemink, 2003). The two main ways of improving the fertility of these poorly buffered soils include the use of synthetic (inorganic) and organic nutrient sources.

**Inorganic nutrient sources**

The potential use of synthetic fertilizer has remained one of the possible ways of improving soil fertility in many African countries. These mineral fertilizers help to restore lost nutrients (White, 2006). However, cost of importing, manufacturing as well as distributing these fertilizers has made these fertilizers expensive. Even when these mineral fertilizers are available, lack of expertise on the side of some farmers in most part of sub-Saharan Africa could make their use harmful. This is because indiscriminate use without further soil testing could result in nutrient imbalance. Continual use of these mineral fertilizers on these poorly buffered soils is not helpful as they encourage soil acidification and promote decline of soil fertility resulting in reduced yield (Hartemink, 2003).

The negative environmental impacts associated with the use of these synthetic fertilizers are eminent. In the search to improve yield, most of these fertilizers are either misapplied or over-applied with harmful effect on both surface and ground water bodies (White, 2006). Eutrophication (excessive enrichment of surface water bodies by nutrients of N and P fertilizers) carried by runoffs severely affects the

aesthetic values of surface water bodies. According to Olaniyi and Odedere (2009), nitrate leaching from soils resulting from over application of mineral fertilizers could cause serious health hazard (blue baby syndrome). Destruction of the ozone layer by nitrous oxide resulting from denitrification could also result in other products that could cause further damage to the ozone layer. Disadvantages associated with the use of mineral fertilizers far exceed the advantages. This puts human and environment under threat. The use of organic nutrient source in improving the fertility of these impoverished tropical soils is ecologically important since it prevents nutrient pollution.

**Organic nutrient sources**

Soil fertility replenishment using organic nutrient sources is sustainable and environmentally friendly. These organic nutrient sources supply nutrients to plants when incorporated into the soil by slow release. Plant nutrients supplied include nitrogen, phosphorus, potassium and other trace elements like copper, manganese, iron and sulphur in available forms which eventually improves plant growth. Studies have shown that incorporating organic nutrients into the soil improves soil's water retention capacity, decreases bulk density, improves soil stability and reduces erosion (Edet and Etim, 2010). Some of these organic nutrient sources include green manure, farmyard manure, legumes, crop residues and compost. Applying these organic nutrient sources as soil amendments give residual effects on growth and yield of subsequent plants.

The use of organic nutrient sources could improve the organic matter, N, P, K, Ca and Mg levels in the soil. The work of Akanni and Ojeniyi (2008) revealed that application of poultry manure to the soil improved soil nutrient status. They

recorded significant increase in N, P, K, Ca and Mg levels in manured soil compared to unmanured soil (control).

**Green Manure**

Green manure is an organic material from plants. These plants are planted for short period of time, harvested and then incorporated into the soil for improving soil physical property and eventually the fertility of the soil. Addition of green manure to the soil increases the percentage of organic matter in the soil which eventually stimulates microbial activity (Doran and Parkin, 1996). Green manure is an excellent practice of adding notable quantities of nitrogen, phosphorus, sulphur and potassium to the soil.

**Farmyard Manure**

These are litter from cattle, poultry, pigs and other farm animals mixed with urine. Composition of farmyard manure could vary as it may contain low levels of micronutrients. Farmyard manure is an important source of N, P and K. Adding farmyard manure to the soil increases available phosphorus and exchangeable K, Ca and Mg contents (Magdoff, 1998). Poultry manure for example has high nutrient composition. The quantity of N, P and K in one ton of dry poultry manure is about twice the content in a ton of dry sheep, goat or cattle manure.

According to Kenyan Agricultural Research Institute (KARI, 2000), nitrogen level in poultry manure is about 30 kg $ton^{-1}$, phosphorus about 4 kg $ton^{-1}$ and potassium is about 24 kg $ton^{-1}$. This makes poultry manure a widely used soil conditioner in raising the pH as well as the exchangeable bases of soils.

According to Michael et al. (2012), application of animal manure could lead to improved structural stability and reduction in soil bulk density. Increasing both the organic unit of the soil and preserving a balance between fine and coarse pores improve soil physical and chemical properties. Farmyard manure improves moisture retention, water infiltration rate and the hydraulic conductivity of the soil (Tisdale et al., 1990).

Increasing soil fertility by adding animal waste strengthens soil tilt and aeration, improves water retention capacity. It also stimulates microbial activity that makes nutrients readily available for plant use (Ladd et al., 1996). Proper use of farmyard manure promotes sustainable crop production by immobilizing soil nutrients that are prone to leaching. Farmyard manure encourages the flourishing of soil fauna mostly earthworms and other microorganisms that live in the soil rhizosphere (White, 2006).

**Legumes**

Legumes are plants or crops that have the ability to fix nitrogen from the air with the help of root nodule bacteria. Adding these organic nutrient sources to the soil helps in preserving soil nitrogen concentration for ideal use by plants or crops. For proper soil fertility improvement in most parts of Africa, farmers use *Leucaena leucocephala* as substitute for natural fertilizer (Ofosu-Anim et al., 2006). Adding *Leucaena leucocephala* with moderate fertilizer improves crop response to nutrients especially cereals. Legumes have high levels of biomass production, N fixation, N in the leaves and great amount of phosphorus, potassium and calcium in the leaves (Eghball, 2001).

**Crop or plant residues**

They are leftovers of crops or plants after harvest. These plants decay and return nutrients to the soil. Depending on their nature and amount, crop or plant residue improves soil fertility through soil micro fauna activities. Plant or crop remains are rich in nitrogen but low in lignin and polyphenols. They undergo rapid decomposition to release plant nutrients in short period of time. However, the low quality plant remains have low nitrogen content but high in lignin and polyphenols. This characteristic makes the low quality plant residues to have a prolonged period of decomposition which eventually affects the release of plant nutrients. There is total protection of nutrients released against leaching until they are mineralized (Topliantz and Bollof, 2005). However, their bulky quantities make composting the best alternative.

**Compost**

Composting is partial decaying of diverse organic materials by a mixed microbial population in a moist, warm and oxygen present environment (Raabe, 2001). During composting, the microorganisms consume oxygen while feeding on organic materials. Active composting produces much heat, large quantities of carbon dioxide and water vapor into the air. The carbon dioxide and water loss can amount to half the weight of the starting materials, reducing the volume and mass of the final product.

Organic materials are mixed, piled and stored under conditions that are conducive to aerobic decomposition and nutrient conservation to give humus like organic materials. Applying the finished product which is compost, as mulching

material, an organic soil conditioner or as slow release organic fertilizer has added benefits on soil and plant (Raabe, 2001).

Most people usually regard compost as the most important form of organic matter. Compost improves soil structure by improving soil tilt and water-holding capacity. Compost, with other organic matter, improves the capacity of soil to hold nutrients through a complex called cation exchange capacity.

Adding vermicompost to the soil indirectly provides nutrients for plant use by adding earthworms and other organisms. These organisms digest organic matter producing nutrient-rich castings, or excrement (Eghball, 2001).These products are significantly richer in nutrients than the surrounding soil and in a form which is readily available to plant roots. Besides soil improvement and the economic benefits of using compost, composting can provide other benefits. Compost helps fight soil- borne pathogens that cause plant diseases when neem leaves are used as component of the compost materials.

There are several methods used in preparing compost. Examples include the thermophilic method, vermicomposting, Bangalore method, Indore method, Berkeley's rapid method and cage method.

**Thermophilic method**

This is the most commonly used method where intensive decomposition occurs within large and well aerated piles or heaps. It is thermophilic because the large mass of rapidly decaying organic materials combined with the insulating features of the pile or heap results in a notable buildup of heat. Thermophilic composting usually undergoes three-stage decomposition. First, early mesophilic

stage occurs, with rapid metabolism of sugars and readily available microbial food sources. This eventually raises the surrounding temperature in the compost pile or heap to over 40 $^{o}$C.

Second, a thermophilic stage occurs during the next few weeks or months. Temperature in the compost pile or heap rises from 50 $^{o}$C to 75 $^{o}$C while aerobic thermophilic organisms break up cellulose and other more resistant materials. Frequent mixing of compost materials at this stage is important in the maintenance of oxygen supply as well as uniform heating of all compost materials. Afterwards, the easily decayed organic compounds are used up and humus like compound forms (Raabe, 2001). The last stage involves a second mesophilic or curing stage. The temperature in the compost pile or heap begins to fall to the temperature of the surrounding environment. There is recapture of organic materials by mesophilic organisms including useful micro-organisms that produce plant-growth stimulating compounds or are hostile to animals that cause plant diseases.

**Vermicomposting**

Involves introduction of certain litter-dwelling (epigeic) worms into the compost pile. These litter dwelling worms aid in transforming organic materials. The most commonly used worms include red wigglers, white worms, and other earthworms which consume the raw organic materials in moist, aerated piles. Keeping the piles shallow usually prevent heat buildup that could kill these worms. The final product, vermicast contains low levels of harmful substances and higher saturation of organic nutrients. Vermicompost is rich in microbes which convert nutrients already available in the soil into available forms for plants. Unlike other

composts, worm casting also contain worm mucus which holds soil nutrients in place.

Vermicompost improves soil physical structure, enriches soil with microorganisms by adding enzymes such as phosphatase and cellulase. Adding vermicompost to the soil attracts deep-burrowing earthworms already present in the soil. On plants, vermicompost improves germination, growth as well as crop yield, improves root growth and structure and enriches soil with plant hormones like auxins and gibberellins (Quilty and Cattle, 2010).

**Bangalore method**

This method of composting works aerobically during the first two weeks and then undergoes anaerobic decomposition at slow rate during the later stage of decomposition. Laying of organic materials is in opposite form after filling, before covering the pit with 15-20 cm thick layer of soil or mud. Without turning and watering, organic materials are allowed to remain in the pit for three months. The volume of organic materials reduces because of the insulating nature of the mud that prevents loss of moisture. Some of the advantages associated with the use of this method include protection of pile or heap from adverse weather, retention of nutrients, easy turning of compost pile or heap and prevention of fly nuisance. However, the duration involved in producing matured compost is much longer.

**Indore method**

The Indore composting method is an ideal way of making compost with slight adverse effects. This method places compost items in a pile or heap layers using lattice of old branches 10-20 cm to allow drainage and air circulation. Divide transversely the base of the compost heap into six equal sections using five and

one left vacant. An added advantage includes adding old compost which could speed up the decomposition.

**Berkeley rapid method**

The Berkeley rapid method corrects some of the problems previously associated with the use of both the Bangalore and Indore methods. The Berkeley method produces compost within three to four weeks. Proper use of this method depends on several causes which are important in getting matured compost within the shortest possible time. The causes include the size and nature of compost materials. Organic materials should be between 1.3 to 3.8 cm and be soft or succulent (Raabe, 2001). For good compost, the organic materials should have a carbon to nitrogen ratio of 30:1. Mixing equal quantity of green plant materials with equal quantity of naturally dry plant materials gives this ratio. Advantages of the rapid composting method include the easy turning of compost heap, prevention of fly nuisance. Adding such compost to the soil could kill disease causing organisms that affect plants.

**Effect of compost on soil physical properties**

Compost releases nutrients at slow rate which prevents nutrient pollution. Good quality compost is a valuable soil conditioner. It improves soil quality by adding organic matter, nutrients and useful microorganisms. Compost improves soil physical structure. In clay and clay loam soils, adding compost reduces bulk density, improves workability and porosity and increases gas and water permeability which reduces erosion (Michael et al., 2012). When applied in enough quantities, compost has both immediate and long-term positive impact on soil. It resists compaction in fine-textures soils and improves water holding

capacity as well as soil stability in coarse-textured (sandy) soils. The humus content in compost enables it to bind soil particles. Humus is a stable residue that results from high degree of organic matter decomposition. The adhesive nature of the humus holds the soil particles together making them more resistant to erosion thereby improving the soil's ability to hold water (Xiaoyu et al., 2012).

Recent studies also suggest that adding compost to sandy soils could promote moisture dispersion by allowing more water to move laterally from the point of application (Boutler et al., 2000). Compost enhances easy penetration of plant's roots to absorb nutrients in the soil (Wilier and Yussefi, 2004). For instance in sandy soils, humus enhance soil aggregate stability and prolong water holding capacity. In clay soils, the humus surrounds the clay particles creating more spaces in the soil. This ensures easy absorption of water as well as plant nutrients. The spongy and jelly-like nature of the humus provides the compost with this unique feature which makes compost a slow releaser of nutrients for plant use throughout the growing season (Gruhn et al, 2000).

Also, Ojeniyi (2000) confirmed that the use of organic nutrient sources could have significant influence on soil physical properties which enhance nutrient availability. His work showed that goat manure addition led to improved soil stability and a reduction in soil bulk density. This confirmed the assertion by Tisdale et al. (1990) that compost improves moisture retention, water infiltration rate and the hydraulic conductivity of the soil.

**Influence of compost on soil chemical properties**

On soil chemical properties, adding compost helps to improve the calcium content in the soil by regulating soil pathogens or acidity. Adding compost to the

soil may adjust the pH of the soil. Depending on the pH of the compost and the native soil, compost addition may raise or lower the soil/compost blend's pH. Therefore, adding neutral or slightly alkaline compost to an acidic soil will increase the soil pH if added in enough quantities.

Specifically, compost can affect soil pH even when applied at low quantities (10 – 20 ton $acre^{-1}$). Adding compost also has the capacity to buffer or stabilize soil pH, making the soil resistant to changes in pH. Compost incorporation improves the cation exchange capacity of soils. An important factor that influences cation exchange capacity of soils is organic matter and this is a constituent of compost.

According to White (2006), increasing soil organic matter through compost addition also increases the soil's cation exchange capacity. The stable organic matter in the compost releases nutrients at slow rate keeping nutrients for long period of time allowing plants to effectively use these nutrients. This prevents nutrient loss through leaching. Incorporating compost in sandy soils improves the cation exchange capacity by holding plant nutrients in the root zones. Adding compost to soils improves the low-level of organic matter in tropical soils since it has high organic matter content (Hossner and Juo, 1999). This reduces erosion by promoting infiltration and reducing surface water runoff. The important plant nutrients supplied by compost in a balanced proportion further lessens environmental pollution because of the stability of organic matter which help release nutrients at a slow rate (Topliantz and Bollof, 2005).

Though compost is a good source of N, P and K, it may also contain micronutrients essential for plant growth. On greater scale, depending on the materials used, compost has low levels of nutrients compared to most commercial synthetic fertilizers. However, applying at greater rates show significant cumulative effect on nutrient availability.

**Influence of compost on soil biological properties**

Adding compost to the soil provides the soil with varying forms of microorganisms. These soil microorganisms are essential in productive soils and for plant health. The organic carbon present in compost largely stimulates microbial growth by providing energy. Compost contains large number of different useful species of micro-arthropods which improve the fertility of exhausted soils by breaking down organic matter (Lalande et al., 1998). Essentially, compost encourages the flourishing of soil fauna most especially earthworms and other microorganisms that occupy the soil rhizosphere (White, 2006).

**Effect of compost on soil fertility**

Proper soil management without harming the health of the soil is a pre-requisite for achieving high productivity from any agricultural land (Lal and Sanchez, 1992). Studies show that the use of organic nutrient sources such as compost promises to be one of the best options in improving soil fertility in tropical Africa (Edet and Etim, 2007). The use of good compost on exhausted soils restores most of the lost necessary macro- and micro-nutrients. A research by Edet and Etim (2010) revealed that compost addition to the soil enhances soil's water retention capacity and other soil physical properties. According to Awe et al. (2011), the importance of organic matter in improving soil fertility by using

compost in providing plant nutrients is important. Compost varies widely in composition and its addition to the soil helps in preserving soil fertility. The use of composted animal and plant wastes provides plants with useful nutrients for proper development and yield.

According to Masarirambi et al. (2012), applying cattle manure at different rates resulted in increase in all the growth features measured using *Corchorus olitorius* L (wild okra) as a test crop. Application rate of 60 ton $ha^{-1}$ recorded the highest plant height whiles incorporation of the manure also improved the soil structure.

According to Ayoola and Adeniyan (2006) compost offers a means of ensuring long-term soil fertility without the need for mineral fertilizers. Further, unlike other fertilizers, compost does not have only a short-term effect but also medium to long term positive impact on soil. This according to FAO (2008) improves the long-term productivity capacity of the soil.

According to Johnston (1989), the benefits of increased soil organic matter content through compost use to increase crop yield and nutrient uptake was observed by conducting long-term experiments at Rothamsted. Further, McConnell et al.(1993) reviewed a literature which reported that applying compost between 18 to 146 ton $ha^{-1}$ could result in 6 to 163% increment in soil organic matter content. Also, a study conducted by Zebarth et al. (1999) over a three year period showed an increase in soil organic matter from five different organic sources which included food waste and composted pig manure.

**Effect of compost on vegetable crop production**

The addition of organic nutrient sources like compost to the soil enhances soil fertility and crop production through improved nutrient use efficiency (Singh, 2000). This is due to increased nutrient availability resulting from improved soil structure, improved moisture and CEC of the compost amended soil (Ndaeyo et al., 2007). The types of materials used in the preparation of compost are known to influence the rate of decomposition as well as nutrient release for plant /crop use (Christo and Onuh, 2005). The addition of low carbon sources reduces the amount carbon which generates energy for microbial activity. Vermicompost is very important because it adds variety of microorganisms to the soil which speed up rate of nutrient mineralization making them readily available for plant use (Okwuagwu et al., 2003).

**Influence of compost on growth of okra**

Compost influences plant growth and health indirectly through the growing medium by providing nutrients, mostly micro nutrients and by improving soil conditions and water retention capacity (Lampkin and Measures, 2001). Okra needs nutrients such as nitrogen, phosphorus, potassium and calcium for growth and photosynthesis. The right amount of these nutrients play specialized roles in plants (Njoku and Ebeniro, 2009). For instance, phosphorus has the greatest effect on the average nutrients needed for ideal yield of okra. It is responsive to nitrogen for plant growth whiles potassium improves fruit quality. Studies have shown that adding compost to soils improves plant growth (Tiamiyu et al., 2012). The improvement in plant growth is because of the increased organic matter content in the soil and other helpful microbes (Dick, 1994).

According to Akanbi et al. (2010), addition of compost to the soil could result in increased plant growth. This was obvious in their study using four rates of compost (0, 2, 3 and 4.0 kg $ha^{-1}$) and NHAe 47- 4 (okra) as test plant. The addition of compost led to significant increase in stem height, stem girth during the fourth week of planting and leaf area on the tenth week after planting. The study revealed that plants sampled from the 0 kg $ha^{-1}$ compost plot had significantly shorter stem height compared to plants sampled from plots of the other three rates.

However, there were no significant differences in plant height among the three compost rates. Treatment two (2 kg $ha^{-1}$) of compost recorded the most robust stem which was 2.13cm in girth during the tenth week.

**Influence of compost on yield of okra**

Adding quality compost could have positive impacts on plant yield after harvest. Compost addition supplies plants with the essential nutrients needed for growth and fruiting. The work of Ofosu-Anim et al. (2006) showed an increase in the yield of okra plant sampled from plots incorporated with different types of organic manure including compost. Using compost prepared from elephant grass, lawn clippings, *Leucaena leucocephala*, top-soil and cow dung with *Asontem* white as test crop, the study revealed a significant increase in pod length, girth and fresh pod weight of plants sampled from plots incorporated with manure compared to plots with no manure. Treatment used in the study caused varying differences in soil structure and fertility. According to (Agarwala et al., 1981; Tisdale, 1990), the increase in the soil's ability to keep water and available nutrients in the manured plots might have given added support to the plants.

Further work by Effiong et al. (2009) also showed adding compost to soil could also result in potential improvement in yield and nutrient uptake of organic crops. The work of Uwah et al. (2010) using *LD 88*(okra variety)as a test crop revealed that okra needs an ideal amount of 80 kg N $ha^{-1}$ for good yield.

However, other research works reported that recording good yield depends mostly on the cultivar used, moisture content, soil type and the nature of compost (Bisht and Bhat, 2006).

**Effect of compost on quality of okra**

There are serious concerns about food quality on the international market. Decline in food quality is often from the use of agrochemicals to increase food production to meet the demand of the population (FAO, 2003). A survey carried out by Dr. Liza Oates at RMIT University revealed that urine of people who consumed organic produce for one week had low levels of dialkylphosphates (DAP) compared to the urine of people who consumed the same conventional produce for a week (Isaacs, 2014). This buttress the findings of the work of Xiaoyu et al. (2012) which also revealed that organic produce are of good quality compared to produce from conventional farms.

Good quality compost is a valuable soil conditioner which supplies the soil with organic matter and helpful soil microbes. The supply of readily available nutrients occurs at a slow rate thus preventing the washing away of nutrients (Cook, 2001). A survey carried out by the United States Soil Science Association in 2000 showed that organic produce had higher dry matter contents than conventional produce. A further comprehensive review of food quality by United

States National Organic Standard Board (NOSB) (2009) showed that organic foods had higher mineral and vitamin contents compared to conventional produce.

**Effect of compost on tolerance of okra to pests and diseases**

Composted manures offer promise as valuable soil amendments for vegetable crop producers. Current studies show that composted manures could increase vegetable yield, influence crop diseases, and bring about changes in soil microbial life. According to Zebarth et al. (1999), compost influences plant development by improved soil structure and increased humus content. Specifically, the ability of compost to provide plants with disease resistance depends on how it directly influences plant-pathogen interaction.

According to Abbasi et al. (2002), composts have the potential to activate and stabilize soil microflora. Suppressing of plant disease by test crops was attributed to nature and maturity of the compost. Using turnip, radish, beet and carrot as test crops, Johnston et al. (1989) noticed a drastic decrease in disease incidence when he applied composted manures to the soil. Plots treated with compost had less incidence of disease. The compost amended plots recorded lower incidence of root lesions compared to plots without compost. With Cercospora leaf spot disease, plots with dairy cow and goat composts recorded less incidence of the disease. The significant disease suppression recorded in the study was likely to have contributed to greater plant productivity.

According to Jacques and Mohammed (2004), adding compost could result in reduction of disease incidence in steamed soil. They infected steamed soil with inoculum of *Pythium ultimum* and found out there was a clear decline in death of cucumber sown in steamed soil amended with compost. The steamed soil without

compost had high-level of disease even with small inoculum quantities of *Pythium ultimum*. This work further confirms assertion made by (Tuitert et al., 1998). They confirmed that the ability of compost to suppress plant diseases depends on compost ingredients, management of oxygen and maturity.

**Other factors that affect plant growth**

There are other factors that play important roles in plant growth. These are light, temperature, humidity, crop stress decline and watering regime.

**Light**

Light is an essential factor in preserving quality plants. The rate of growth and time that a plant remains active is dependent on the light it receives. Plant use light energy in photosynthesis and other metabolism. Sunlight intensity, quality (wavelength) and day length (sunlight hours) affect plant growth, yield and quality. Most field grown plants grow best under high light intensity. Light intensity needed for the maximum rate of photosynthesis is diverse depending on plant cultivar and prevailing conditions. Low intensity of light disables photosynthesis. This gives low synthesis of photo assimilates which sternly influences plant growth, development, and yield. Plants grown under low intensity are spindly with light green leaves. A similar plant grown in bright light are shorter with better branches, and have larger, dark green leaves.

Classification of plants depends on light needs, such as high, medium and low. Increasing the period in which plants get light can help to compensate for low light intensity as long as the plant's flowering cycle is not sensitive to day length. Increased light duration allows plants to make enough food to survive and grow.

However, plants need darkness to develop and exposure to light is not more than 16 hours a day.

On the field, providing shade, use of cover crops with row covers, and selecting planting dates provide the most desirable intensity. For instance, crops such as watermelon, cantaloupe and honeydew melons need high light intensity and warm temperatures to produce good growth and high sugar content in their fruit.

**Temperature**

Most plants tolerate normal temperature variations. Foliage plants need 21 $^{o}$C and 27 $^{o}$C and 16$^{o}$C to 20 $^{o}$C at night. Most flowering plants prefer the same daytime temperature range, but grow best when temperatures at night range from 13 $^{o}$C to 16 $^{o}$C. Lower temperatures at night help plants to recover from moisture loss, intensify flower color and prolong flower life. Excessively low or high temperatures could result in plant stress, inhibit growth, or promote a spindly appearance and foliage damage or drop. Cool temperatures at night are more desirable for plant growth compared to high temperatures.

**Crop stress**

Crop stress is another factor that affects the growth, yield and quality of plants. This results from effect of any environmental factor causing plants to deviate from their ideal growth and rate of development. Dealing with the effects of crop stress because of unstable weather has been the most difficult challenge that confronts arable crop growers. Adopting good cultural practices such as regular weeding and thinning out of overcrowded plants are ways of reducing the effect of stressful conditions.

**Watering regime**

Plants need enough quality water throughout their developmental stages to fruiting. Increasing water use efficiency is one of the major goals of farmers. For instance, vegetable crops need more total water and more frequent irrigation than most agronomic crops. Vegetable water needs vary from 543,000 to 1,086,000 gallons $acre^{-1}$ for each growing season, depending on the type of vegetable, production location and environmental conditions. Reducing water needs of any given vegetable has little effect because plant water use is genetically controlled. However, delivery and cultural practices influence total volume of water supplied to meet crop needs.

Today, drip or trickle systems are most efficient for high value vegetable crops. Under drip or trickle systems, water waste is less in the delivery process. However, the ability of trickle or drip irrigation to place precise quantity of water in the exact place where needed remains a challenge.

It was observed from the literature review that quite a number of studies have been carried out on vegetable crop production using organic nutrient sources due to the high cost, unavailability and environmental effects associated with the use of mineral fertilizers. The literature review showed that optimal use of compost for optimal results varies with agro-ecological zone, soil type and the type of test crop used. It is therefore worth carrying out this study to ascertain these assertions about compost as soil amendment.

# CHAPTER THREE

# MATERIALS AND METHODS

## Compost preparation

The compost was prepared using Berkeley rapid method. The superiority of this method lies in its ability to produce mature odourless compost within four weeks (Raabe, 2001). The table below summarizes the materials that were used in preparing the compost and their weights.

**Table 1: Materials used in preparing compost and their respective weights**

| Compost | Weight (kg) |
|---|---|
| Poultry manure | 44.0 |
| Cow dung | 60.9 |
| Household ash | 6.9 |
| Dry leaves of *Tectonia grandis* | 2.18 |
| Fresh leaves of *Azadirachta indica* | 2.64 |
| Fresh leaves of *Leucaena leucocephala* | 3.64 |
| Dry maize husks | 0.02 |
| Moist soil | 17.1 |

## Characterization of compost

### Determination of compost pH

Ten (10) g of compost were weighed in duplicate into a 50 ml centrifuge tube. Twenty-five ml of distilled water was added to each sample to obtain compost-water solution of ratio 1:2.5. The centrifuge tubes were placed on a

mechanical shaker for 15 minutes to thoroughly mix the compost. The pH of the resultant solutions was determined using the Jenway 3510 pH meter (Page et al., 1982).

**Determination of total organic carbon**

Total organic carbon content of the compost was determined using standard laboratory method by Walkley-Black (Stewart et al., 1974). 0.2 g of 2 mm sieved compost was weighed in duplicate and then transferred into 500 ml Erlenmeyer flask. Ten ml of potassium dichromate ($K_2Cr_2O_7$) solution was added and the flasks were gently swirled for 30 seconds. After swirling, 20 ml of concentrated sulphuric acid ($H_2SO_4$) was added and swirled for one minute. The flasks were allowed to stand for thirty minutes. The content of each flask was diluted with 200 ml of distilled water. Ten ml of orthophosphoric acid was added to the solution in the flask followed by 1ml of diphenylamine sulphonate indicator. The excess $Cr_2O_7$ was then back titrated with 0.5 M ferrous solution until a green endpoint was reached. A blank titration was also carried out in a similar way. The percentage organic carbon in the compost was calculated using the formula:

$$\text{O.C (\%)} = \frac{(B-S)x Molarity of \text{Fe}(II)\ x\ 0.003}{weight of compost\ (g)}\ x\ \frac{100}{77}\ x\ 100 \quad \ldots\ldots\ldots\ldots\ (1)$$

S= Sample titre value

B= Blank titre value

0.003 = 12/4000 = milliequivalaent weight of carbon

100/77 = the factor which converts the carbon actually oxidized to total carbon

100 = the factor to change from decimal to percent.

**Determination of total nitrogen**

Total nitrogen content of the compost was determined using the Micro-Kjeldahl method as described by Page et al. (1982). About 0.2 g of compost was weighed in triplicate into separate Kjeldahl digestion flasks. Approximately 1.1g of catalyst mixture was added followed by 3 ml of concentrated $H_2SO_4$. The flasks were placed on a digester and heated for 2 hours at 360 °C. The flasks were removed after a clear digest was obtained and were allowed to cool. The digest was transferred into a 50 ml conical flask by washing with distilled water and then topped up to the 50 ml mark. Twenty ml aliquot of the digest was pipetted into the distillation unit followed by 10 ml of NaOH. A 100 ml conical flask containing 5 ml boric acid ($H_3BO_3$) indicator was placed under the funnel of the distillation unit to collect 50 ml of the distillate. The distillate was titrated against 1/140 M HCl solution to obtain wine colour. The nitrogen content of the compost was calculated using the formula below:

$$N\ (\%) = \frac{(S-B)\ x solution volume}{100\ x volume of aliquot x weight of compost} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

S= Sample titre value (ml)

B= Blank titre value (ml)

**Determination of total phosphorus**

Two (2) milliliters aliquot of the digest was pipetted into 25 ml flat-bottom test tubes. Four ml of colour forming reagent (reagent B) was added. The resultant solution was topped up with distilled water to the 25 ml mark. The test tubes were allowed to stand for 15 minutes for colour development and their absorbance determined using spectrophotometer (CE 1000 series) at 882 nm.

From a stock solution of 5µg P $ml^{-1}$ was prepared as working solutions containing 0.0, 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0 µg P $ml^{-1}$. The absorbances of the working solutions were determined using the spectrophotometer (CE 1000 series) at 882nm after development of the blue colour after 15 minutes. The concentration of P in the compost was deduced from the standard calibration curve.

Total potassium in the compost digest was determined using the flame photometer.

**Determination of available cations ($Ca^{2+}$, $Mg^{2+}$ and $Na^{+}$)**

Extraction of the $Ca^{2+}$, $Mg^{2+}$ and $Na^{+}$ was done by weighing approximately 0.5 g of the sieved compost into 50 ml centrifuge tubes. Twenty ml of ammonium acetate ($NH_4OAc$) solution was added, shaken for 1 hour and allowed to stand overnight. The suspension was transferred into 100 ml conical flasks fitted with Whatman filter paper. The compost residue trapped on the filter paper was successively leached with 20 ml of the $NH_4OAc$solution until 100 ml of the filtrate was obtained. Filtrate was used for the determination of$Ca^{2+}$, $Mg^{2+}$ and $Na^{+}$. Calcium and magnesium were determined using EDTA titrimetry whiles Na was determined with the flame photometer.

$$cmol_c\ K^{+}\ kg^{-1}\ compost = \frac{C\ x\ 0.256}{weight\ of\ compost\ (g)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$cmol_c\ Na^{+}\ kg^{-1}\ compost = \frac{C\ x\ 0.44}{weight\ of\ compost\ (g)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$cmol_c\ Ca^{2+}kg^{-1}\ compost = \frac{4\ x\ T}{weight\ of\ compost\ (g)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$cmol_c\ Mg^{2+}kg^{-1}$ compost = $\frac{4\ x\ T}{weight\ of\ compost\ (g)}$ .....(6)

where;

C = concentration from calibration curve

T = titre value

**Determination of calcium and magnesium by EDTA titrimetry**

Twenty-five ml aliquot of the filtrate was pipetted into a 250 ml Erlenmeyer flask. The solution was diluted with distilled water to the 150 ml mark followed by addition of 15 ml buffer solution. One ml each of KCN, $NH_2OH.HCl$, $K_4Fe\ (CN)_6$ and 1 ml of TEA were added to the solution. The resultant solution was allowed to stand for 5 minutes and 10 drops of EBT indicator was added and titrated against 0.005 M EDTA disodium solution.

**Determination of only calcium by titrimetry**

Twenty-five ml aliquot of the filtrate was pipetted into a 250 ml Erlenmeyer flask and diluted with distilled water to the 150 ml mark. One ml each of KCN, $NH_2OH.HCl$ and TEA (triethanolamine) were added to the compost extract followed by 20 ml of 10% NaOH. Ten drops of calcon indicator was added and titrated from red to blue endpoint with 0.005 M EDTA solution.

Total K and available Na in compost were determined by aspirating the sample using flame photometry (Page et al., 1982).

**Nature of experiment**

The study was carried out under two different environments. The first experiment was conducted in pots to investigate the effect of the compost prepared on nutrient composition in okra plant. This experiment lasted for seven weeks in which test crops did not attain fruiting stage. So, a field experiment was carried out to further determine the ability of the compost on nutritional quality of okra fruits (edible pods) and on pests (*Podagrica uniformis*) and disease (okra mosaic). Standard laboratory procedures used are described below with a brief description of the study area.

**Description of study site**

The research was carried out on the Teaching and Research Farm of the School of Agriculture of the University of Cape Coast. The study area is located at an altitude of 22 m mean sea level, latitude $5^{o}$ 07' 40" N and longitude $1^{o}$ 18' 24" W in the Central Region of Ghana (Ghana Geological Survey, 1960).

According to Asamoa (1973), the soil at the school farm belongs to the Udu series and it is classified as lixisol (World Reference Base for Soil Resource, 2006).

**Experimental design for field work**

The experiment consisted of nine raised beds measuring 2 m x 5 m with 1 m interval between them. Each bed was further divided into two subplots of size 2 m x 2 m with the remaining 1 m serving as a boundary between the subplots. There were three rates of compost application that is: 0 kg N $ha^{-1}$ (control), 100 kg N $ha^{-1}$ and 200 kg N $ha^{-1}$with three replicates. The experimental design used was a split-plot design (SPD) with two local okra varieties (*Asontem* and *Enidaso*) as test

crops. Using a planting distance of 60 cm x 60 cm, four seeds were sown per hole and then thinned to one plant per stand when they were well established.

**Field soil sampling for initial analyses**

Using the random sampling technique, soil samples were collected from a depth of 0 – 15 cm from four different spots on each main plot with auger before dividing them into subplots. Composite soils were obtained after thorough and careful mixing of sampled soils. These composite soils were placed in a labeled polythene bags and taken to the laboratory. These samples were air-dried, crushed and sieved through a 2 mm mesh to obtain fine fractions. The sieved soil samples were used in the determination of soil physico-chemical properties such as pH, particle size distribution, total organic carbon, total nitrogen, available phosphorus, exchangeable bases ($Ca^{2+}$, $Mg^{2+}$, $K^{+}$ and $Na^{+}$), ECEC and exchangeable acidity ($H^{+}$ and $Al^{3+}$). Fresh soil samples were used for moisture content and bulk density determination.

**Soil sampling and experimental design for pot work**

Systematic random sampling was used to collect soil samples (0 – 15 cm) depth from the Teaching and Research Farm of the School of Agriculture. Composite soil samples were obtained by thorough mixing. Composite samples were air-dried, crushed and sieved through 2 mm mesh. The experiment consisted of eighteen pots containing 800 g of 2 mm air-dried soil. Experimental design used was completely randomized design (CRD) with three replications. Compost was incorporated at rates of 0 kg N $ha^{-1}$, 100 kg N $ha^{-1}$ and 200 kg N $ha^{-1}$ using *Asontem* (early maturing okra variety) and *Enidaso* (late maturing okra variety) as test crops. Four seeds were sown per pot and then thinned to one plant after one

week of establishment. Soil moisture content was maintained at 60% water filled pore spaces (WFPS) and maintained throughout the study period by weighing.

**Laboratory analyses of soil samples**

**Determination of soil bulk density**

Using core samplers, soil samples were collected from two main plots in each replicate. After collection, the core samplers were taken to the laboratory to determine the fresh weight of soil samples. After weighing, the core samplers and their contents were placed in the oven at a temperature of 105 $^{o}$ C for 48 hours. The samplers were removed from the oven and allowed to cool in a desiccator for 30 minutes and weighed to determine the weight of the dry soil samples. The bulk density of the soil was calculated using the formula below:

Bulk density (g cm$^{-3}$) = $\frac{weightofoven-drysoil}{volumeofbulksoil}$ ..... (7)

**Determination of soil moisture content**

Ten (10) g of fresh soil samples were weighed into cleaned beakers. The soil samples were oven-dried at a temperature of 105 $^{o}$ C for 48 hours. The samples were removed from the oven and put in a desiccator to cool for 30 minutes. The dry weights of the soil samples were determined after cooling. The percentage moisture content of the soil samples was determined using the formula below.

Moisture content (%) = $\frac{weight\ of\ fresh\ soil-weight\ of\ oven-dry\ soil\ (g)}{weight\ of\ oven-dry\ soil\ (g)}\ x\ 100$...(8)

**Soil pH determination**

Ten (10) g of air-dried 2mm sieved soil samples were in weighed in duplicate into 50 ml centrifuge tubes. Twenty-five ml of distilled water was added. The centrifuge tubes were tightly covered and placed on a mechanical shaker for

fifteen minutes to homogeneously mix the soil samples. The tubes were removed and the pH of the soil samples was determined using the pH meter.

**Particle size distribution**

Particle size distribution for soil textural class was carried out using pipette method according to Rowel (1994). Ten (10) g of 2 mm sieved air-dried soil samples were weighed into separate beakers followed by the addition of 50 ml distilled water. Ten ml of hydrogen peroxide ($H_2O_2$) was added to the resulting solution to destroy the organic matter. The peroxide treated soil samples were quantitatively transferred into 500 ml plastic bottles. Ten ml of sodium hexametaphosphate $(NaPO_3)_6$ was added to each soil solution. The bottles containing the soil solutions were placed on a mechanical shaker and left overnight. The samples were removed from the mechanical shaker and were quantitatively transferred into 500 ml measuring cylinders. Each sample solution was topped up to the 500 ml mark with distilled water.

**Separation of silt and clay fractions**

Silt and clay fraction was determined using a calibrated retort stand fixed with 25 ml pipette. The tip of the pipette was allowed to touch the surface of the soil solution in the measuring cylinder and the value was recorded (d/cm). The cylinder was thoroughly shaken for 5 minutes to dislodge all soil materials at the bottom of the cylinder. The pipette was dipped (d + 10 cm) deep into the soil solution to pick 25 ml of the soil solution into a beaker after 40 seconds. The procedure was applied to the rest of soil solutions in the measuring cylinders. The soil solutions in the measuring cylinders were allowed to stand for 5 hours before determining the clay fraction.

**Separation of only clay fraction**

Soil particles left in suspension after 5 hours were the clay fractions. The pipette was gently lowered until the tip touched the surface of the soil solution. The value was noted and recorded as d in cm as indicated in the clay and silt determination. Twenty five ml of the soil solution was pipetted in different sets of beaker.

**Separation of sand fraction**

After taking the clay fraction, the remaining was sand with little silt and clay fractions that had settled at the bottom of the measuring cylinder. The supernatant liquid was gently poured away and the sediment was quantitatively transferred into a beaker. Water was added to the sediment and then allowed to settle for 30 seconds. After 30 seconds, the water was carefully decanted while the supernatant containing the sediment was retained in the beaker. This procedure was repeated until the supernatant was clear. At this point, all the silt and clay fractions were washed out of the sand. The sand was then transferred into a different beaker.

The beakers containing the silt and clay fractions, only clay fraction and sand fraction were placed in the oven at a temperature of 105 $^{o}$C for 72 hours. The beakers were removed from the oven, cooled in a desiccator and weighed.

**Determination of soil total organic carbon**

Soil total organic carbon was determined using standard laboratory method by Walkley-Black (1934). 0.5 g of 2 mm sieved soil samples were weighed in duplicate and then transferred into 500 ml Erlenmeyer flasks. Ten ml of potassium dichromate ($K_2Cr_2O_7$) solution was added and the flasks were gently swirled for

30 seconds. After swirling, 20 ml of concentrated sulphuric acid ($H_2SO_4$) was added and swirled for one minute. The flasks were allowed to stand for thirty minutes. The content of each flask was diluted with 200 ml of distilled water and swirled to ensure thorough mixing. Ten ml of orthophosphoric acid was added to the soil solution in the flask followed by 1 ml of diphenylamine sulphonate indicator. The excess $Cr_2O_7$ was then back titrated with 0.5 M ferrous solution until a green endpoint was reached. A blank titration was also carried out in the same way. The percentage organic carbon in the soil was calculated using formula one (1) above.

**Soil total nitrogen determination**

Total nitrogen in the soil samples was determined using Micro-Kjeldahl method according to Page et al. (1982). 0.5 g of the air-dried soil samples (2mm) were weighed into different micro-Kjeldahl digestion flasks. 0.2 g of 1.1 g $K_2SO_4$ (catalyst mixture) was added to soil samples after which 3 ml of concentrated $H_2SO_4$ was also added. The flasks were cautiously heated on a digestion stand for 2 hours at 360$^{o}$C. After complete digestion, the flasks were allowed to cool after which 20 ml of distilled water was added. The Kjeldahl flasks were swirled to bring any insoluble material into suspension and carefully transferred into 100 ml conical flasks retaining all the sand particles in the original digestion flask. Five ml of boric acid ($H_3BO_3$) indicator was pipetted into separate conical flasks and placed under the condenser of the distillation apparatus.

Twenty ml aliquot of the sample was pipetted into the distillation apparatus followed by the addition of ten 10 ml of 10 N NaOH through the funnel of the apparatus, and the NaOH was allowed slowly into the distillation chamber by

opening the stopcock of the funnel. When the distillate in the 50 ml Erlenmeyer flask got to the 50 ml mark, the distillation process was halted. The $NH_4^+$ - N in the distillate was determined by titrating with 1/140 M HCl which changed from green to wine red. Percentage N in soil was calculated using formula two (2) for determination of % N in compost.

**Soil available phosphorus**

Available phosphorus in the soil samples was determined using Bray No. 1 method outlined in Page et al., (1982). One (1) g of the air-dry soil sample was weighed into 50 ml centrifuge tube followed by the addition of 10 ml of extracting solution. The tubes were placed on a mechanical shaker for 5 minutes and quantitatively transferred into a 50 ml conical flask fitted with Whatman filter paper to leach the soil solution. One ml aliquot of the filtrate was pipetted into a 25 ml round bottom test tube followed by addition of 4 ml colour forming reagent (reagent B). The resultant solution was then topped up with distilled water to the 25 ml mark and allowed to stand for 15 minutes for colour development. The absorbance of the solution was read using the spectrophotometer (CE 1000 series) at 882 nm.

Standard working solutions of P (0, 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0 µg $ml^{-1}$) were prepared from 5 µg P $ml^{-1}$ of the stock solution using the same procedure described above. The standard solutions were allowed to stand for 15 minutes for the colour to develop and their absorbances read using the spectrophotometer at 882 nm. A calibration curve was obtained by plotting absorbance against concentration for the standard solution. Concentration of P in soil sample aliquot was calculated using the calibration curve from the formula below:

$$\mu g\ P\ g^{-1}\ soil = \frac{C\ x\ Dilution\ factor}{weight\ of\ soil\ (g)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

where:

C = concentration of P obtained from calibration curve (µg $ml^{-1}$)

**Determination of exchangeable cations ($Ca^{2+}$, $Mg^{2+}$, $K^{+}$, and $Na^{+}$)**

Extraction of the $Ca^{2+}$, $Mg^{2+}$, $Na^{+}$ and $K^{+}$ was done by weighing 5 g of the sieved soil sample into 50 ml centrifuge tubes (Rowel, 1994). Twenty ml of ammonium acetate solution was added, shaked for 1 hour and allowed to stand overnight. The suspension was transferred into 100 ml conical flasks fitted with Whatman filter paper. The soil trapped on the filter paper was successively leached with 20 ml of the $NH_4OAc$solution until 100 ml of the filtrate was obtained. The collected filtrate was used for the determination of$Ca^{2+}$, $Mg^{2+}$, $Na^{+}$ and $K^{+}$.

Calcium and magnesium were determined using EDTA titrimetry whiles Na and K were determined using the flame photometer. Exchangeable $K^{+}$ was determined using formula 3, exchangeable $Na^{+}$ content was estimated using formula 4, exchangeable $Ca^{2+}$ and $Mg^{2+}$ were determined using formulae 5 and 6 respectively.

**Determination of calcium and magnesium by EDTA titrimetry**

Twenty-five ml aliquot of the filtrate was pipetted into a 250 ml Erlenmeyer flask. The solution was diluted with distilled water to the 150 ml mark followed by 15 ml of buffer solution. One ml each of KCN, $NH_2OH.HCl$, $K_4Fe(CN)_6$ and 1 ml of TEA were added to the solution. The resultant solution was allowed to stand for 5 minutes and 10 drops of EBT indicator was added and titrated against 0.005 M EDTA disodium solution.

**Determination of only calcium by EDTA titrimetry**

Twenty-five ml aliquot of the filtrate was pipetted into a 250 ml Erlenmeyer flask and diluted with distilled water to the 150 ml mark. One ml each of KCN, $NH_2OH.HCl$ and 1 ml of TEA were to the soil extract followed by 20 ml of 10% NaOH to raise the pH. Ten drops of calcon indicator was added and titrated from red to blue endpoint with 0.005 EDTA solution.

**Determination of exchangeable acidity ($H^+$ and $Al^{3+}$)**

Exchangeable acidity was determined using standard laboratory method as outlined by (Rowel, 1994). Ten grams of 2 mm sieved soil was weighed into 50 ml centrifuge tubes followed by 20 ml of 1 M KCl solution. The soil samples were placed on a mechanical shaker for one (1) hour. The soil samples were leached successively with 10 ml volumes of the KCl solution. The filtrate was topped up to 100 ml with some of the KCl solution. Fifty ml of the aliquot was pipetted into 100 ml conical flask and five drops of phenolphthalein indicator was added. The resultant solution was titrated from colourless to pink with 0.01M NaOH solution. This measures the exchangeable $H^+$ and $Al^{3+}$.

$$\text{cmol}_c\ H^+ \text{ and } Al^{3+}kg^{-1} \text{ soil} = {0.2\ x(S-B)x\ 10}\Big/{weight of soil\ (g)} \quad \ldots\ldots\ldots\ldots (10)$$

where:

S = Sample titre value

B = Blank titre value

**Collection of potted plant growth data**

Data on plant height, number of leaves, leaf length and leaf width were collected during $2^{nd}$, $3^{rd}$, $4^{th}$, $5^{th}$, $6^{th}$ and $7^{th}$ week after sowing (WAS).

**Sampling of potted plants**

At the end of the seventh week, each okra plant was carefully uprooted from each pot. The plants were washed with distilled water and then separated into leaves, stem, petiole and root and their fresh weights taken. These parts were placed in the oven at 60 $^{o}$ C for dry matter determination.

**Analysis of compost amended soil after harvest**

Air-dried soil samples were analyzed for pH, organic carbon, total nitrogen and available phosphorus. Also, exchangeable $Ca^{2+}$, $Mg^{2+}$, $K^{+}$ and $Na^{+}$, exchangeable acidity and effective cation exchange capacity were also determined.

**Potted plants nutrient analysis**

Oven-dried plant parts were milled separately using Glenson milling machine. Nutrient contents (N, Ca, Mg, K and P) were determined in leaf, stem, petiole and root of the two varieties.

Percentage nitrogen was by Micro-Kjeldahl method, percentage calcium and magnesium were determined using EDTA titrimetry. Percentage potassium was by flame photometry while percentage phosphorus content was determined using plant digest.

$$\text{Ca (\%)} = \frac{Molarity\ of\ EDTA\ x\ Titre\ value\ x\ Mwt\ of\ Ca\ x\ Solution\ vol}{Sample\ wt\ (g)\ x\ Vol\ of\ aliquot\ x\ 10} \quad \ldots\ldots\ldots(11)$$

$$\text{Mg (\%)} = \frac{Molarity\ of\ EDTA\ x\ Titre\ value\ x\ Mwt\ of\ Mg\ x\ Solution\ vol}{Sample\ wt\ (g)\ x\ Vol\ of\ aliquot\ x\ 10} \quad \ldots\ldots\ldots(12)$$

$$N\ (\%) = \frac{(T-B)\ x\ Molarity\ of\ HCl\ x\ 14.007\ x\ 100}{Sample\ wt\ (mg)}\ x\ 5 \quad \text{.....(13)}$$

$$K\ (\%) = \frac{Concentration\ x\ 100}{10000\ x\ sample\ wt(g)} \quad \text{.....(14)}$$

$$P\ (\%) = \frac{Concentration\ x\ Solution\ vol\ x\ Final\ vol}{sample\ wt\ (g)\ x\ Aliquot\ vol}\ x\ 10000 \quad \text{.....(15)}$$

**Collection of field data**

Data on plant height and number of leaves were collected during the 4th, 6th and 8th WAP. Data on population of *Podagrica uniformis* was collected on weeks 4, 5, 6, 7, 8 and 9 by manual counting of pests found underneath of leaves.

Data on total number of plants infested with leaf okra mosaic were counted manually in each subplot at week 11. The severity of the disease was scored using rating system by Yayeh (1994) in an experiment to assess disease severity in hot pepper indicated below:

**Table 2: Scoring of severity of okra mosaic in two different varieties of okra using Yayeh rating system**

| Disease score | Description |
|---|---|
| 0 | Healthy asymptomatic plants |
| 1 | Mild mosaic, mottle or chlorosis of leaves |
| 2 | Moderate chlorosis, mottle or mosaic without significant leaf distortion |
| 3 | Score 1 or 2 plus leaf malformation |
| 4 | Severe chlorosis, mottle or mosaic plus stunting or dwarfing of whole plant |
| 5 | Score 4 plus leaf drop or dying |

**Harvesting and drying of edible pods**

Harvesting of immature edible pods was done manually from 8 – 13 WAP. Harvested fruits (edible pods) were weighed and their fresh weights recorded. The pods were oven-dried at 60 $^{o}$C for 72 hours.

**Edible pods quality analysis**

Proximate analysis of edible pods was carried out according to standard laboratory procedures outlined by AOAC (1990). The parameters analyzed were moisture, ash, protein (or Kjeldahl protein), fat, fibre and soluble carbohydrates.

**Moisture content**

Moisture content of the harvested fruits was determined using the fresh and dry weights. The harvested fruits were oven-dried at 60$^{o}$C until constant weights were obtained. The percentage moisture content of the fruits was calculated using the formula indicated below:

Moisture content (%) = $\frac{(P-A)}{P}\ x\ 100$ …… (16)

where:

P = fresh weight of harvested fruits (g)

A = dry weight of harvested fruits (g)

**Ash content**

Approximately 0.2 g of the milled sample was weighed into a pre-weighed empty crucible. The crucibles containing the sample were placed in the oven at 100$^{o}$C for 24 hours. The crucibles were removed from the oven and then transferred to a furnace where the temperature was raised to 550 $^{o}$C. The temperature was maintained for 8 hours until a white ash was obtained. The

crucible was then removed from the furnace to a desiccator and allowed to cool for 30 minutes and weighed. The percentage ash content of the sample was calculated using the formula below:

Ash content (%) = $\frac{Ash\ weight}{Oven-dry\ weight}\ x\ 100$ ..... (17)

**Protein content (Kjeldahl protein)**

Protein content was determined by weighing 0.2 g of the milled sampled was weighed into different digestion flasks followed by the addition of 4.5 ml of digestion mixture. The samples in the flasks were digested for two hours on a digestor. After digestion, the flasks were removed and allowed to cool. Each flask was washed with distilled water and the solution poured into a100 ml conical flask. The solution was then made to the mark with distilled water. Twenty ml aliquot of the solution was pipetted into the distillation apparatus followed by 10 ml of NaOH solution. Five ml of boric acid was also pipetted into 50 ml conical flasks. Each conical flask containing the boric acid was successively placed under the funnel of the unit to collect 50 ml of the distillate. The distillate was then titrated from green to wine red endpoint using 1/140 M HCl. The percentage nitrogen in the edible pods was calculated using the formula below:

% N = $\frac{(S-B)\ x\ M\ x\ 14.007}{weight of sample\ (mg)} x\ 100\ x100/20$ ..... (18)

where:

S = sample titre (ml)

B = blank titre (ml)

M = molarity of HCl

The protein content in the edible pods was calculated using the formula:

% protein = % N x 6.25**,** where 6.25 is the protein-nitrogen conversion factor.

**Fat content**

Approximately 4 g of the milled sample was weighed into a 50 x 10 mm Soxhlet extraction thimble. The sample was then transferred into a 50 ml capacity Soxhlet extractor. A clean, dry 250 ml round-bottom flask containing was placed under the soxhlet extraction unit. Fifty (50) millilitres of petroleum ether was measured and poured into the soxhlet extraction thimble that contained the sample and extracted for 6 hours using a heating mantle. The round-bottom flask was later removed and placed in an oven. The sample was left in the oven at 60 $^{o}$C for 3 hours. The sample was removed and put into a desiccator to cool and then weighed. The fat content of the sample was calculated as follows:

Fat content (%) = $(W\ x\ 100)\ /\ (weight\ of\ oven - dry\ sample)$..... (19)

where:

W = weight of ether extract (g)

**Fibre content**

Fibre content was determined by weighing approximately 0.4 g of the milled samples was weighed into separate predried crucibles. The crucibles were inserted in the fibretec Hot Extraction Unit. Hundred ml of concentrated $H_2SO_4$ (1.25%) solution was added to the sample and allowed to boil for thirty minutes exactly from the onset of boiling. After boiling, the samples in the crucibles were washed with hot distilled water followed by addition of 100 ml 1.25% NaOH and then boiled for another 30 minutes. The crucibles were transferred to the fibretec Cold Extraction Unit and then washed with methanol. The crucibles were later

removed and dried at 105 $^{o}$C overnight and weighed after cooling. The samples in the crucibles were ashed for about 3 hours at 500 $^{o}$C, cooled in the desiccator and weighed. The percentage fibre content in the fruits was calculated using the formula below:

Fibre content (%) = $\frac{weightlossthroughashing}{weightofoven-drysample} x\ 100$ …….. (20)

**Determination of soluble carbohydrates**

Soluble carbohydrate content in edible pods was determined using standard laboratory procedure according to Brown et al. (1957) as outlined in Stewart et al., (1974). Step one involved the extraction of fruit materials whiles step two involved colour development.

**Extraction of materials**

Approximately 0.01 g of the milled sample was weighed into different 50 ml conical flasks and 30 ml of distilled water then added. A glass bubble was placed in the neck region of the flasks and then simmered gently on a hotplate for two hours. The conical flasks were periodically topped up to the 30 ml mark with distilled water. The samples were allowed to cool and the solution poured into 50 ml volumetric flasks fitted with No. 44 Whatman filter paper. The solution was diluted to the 50 ml mark with distilled water. Blank solution was also prepared using distilled water.

**Colour development**

Two ml each of standard solution was pipetted into different sets of boiling tubes. Two ml of the extract was also pipetted into another set of boiling tubes. Ten (10) ml of anthrone reagent was added to the boiling tubes containing the

sample solutions and the blank and then mixed thoroughly in an ice bath. The tubes were then placed in a beaker of boiling water and kept in dark cupboard and boiled for 10 minutes. The tubes were removed from the boiling water and transferred into cold water in the dark. The optical density of the samples and the blank were measured at 625 nm using the spectrophotometer (CE 1000 series). A calibration graph was obtained by plotting absorbance against concentration for the standard solution. The glucose content (mg) in the milled fruits was determined using the formula:

$$\text{Soluble carbohydrates (\%)} = \frac{C\ (mg) x\ extract\ volume}{10\ x\ aliquot\ volume\ x\ sample\ weight} \quad \ldots\ldots\ldots\ldots (21)$$

where:

C = concentration of glucose obtained from graph (mg).

**Mineral elements analysis of oven-dry pods**

Principal elements analyzed included calcium, magnesium, sodium, potassium and phosphorus after milled samples were digested using 4.5 ml of digestion mixture.

**Magnesium content in pods using EDTA titrimetry**

Magnesium content in the edible pods was determined using 10 ml aliquot of the pod digest. The percentage magnesium in edible pods was calculated using the formula below:

$$\text{Mg (\%)} = \frac{Molarity\ of\ EDTA\ x\ T\ x\ Atomic\ mass\ of\ Mg\ x\ Vs}{Sample\ weight\ x\ 10\ x\ aliquot\ volume} \quad \ldots\ldots\ldots\ldots\ldots (22)$$

where;

T = titre value (ml);

Vs = solution volume (ml)

Atomic mass of Magnesium = 24.31

Molarity of EDTA = 0.005 M

**Calcium content in pods by EDTA titrimetry**

Ten milliliters aliquot of the digest was pipetted into a 250 ml Erlenmeyer flask and diluted with distilled water. One ml each of KCN, $NH_2OH.HCl$ and1 ml of TEA were added to the resultant solution followed by addition of 20 ml of 10% NaOH to raise the pH. Ten drops of calcon indicator was added and titrated from red to blue endpoint with 0.005 EDTA solution. The percentage calcium was calculated using the formula below:

$$\text{Ca (\%)} = \frac{Molarity\ of\ EDTA\ x\ T\ x\ Atomic\ mass\ of\ Ca\ x\ Vs}{Sample\ weight\ x\ 10\ x\ aliquot\ volume} \quad \ldots\ldots\ldots\ldots\ldots\ldots (23)$$

where;

T = titre value (ml)

Vs = solution volume (ml)

Atomic mass of calcium = 40.08

Molarity of EDTA = 0.005 M

**Potassium and sodium contents by flame photometry**

Potassium and sodium contents in the edible pods were determined by aspirating the digest with the flame photometer. Potassium and sodium contents were calculated as follows:

$$\text{K (\%)} = (C\ x\ Vs)/(10{,}000\ x\ sample\ weight) \quad \ldots\ldots\ldots\ldots\ldots\ldots (24)$$

$$\text{Na (\%)} = (C\ x\ Vs)/(10{,}000\ x\ sample\ weight) \quad \ldots\ldots\ldots\ldots\ldots\ldots (25)$$

where:

C = respective concentrations of K and Na from standard graph

Vs = solution volume (ml)

**Determination of phosphorus content in pods**

Phosphorus content in the edible pods was determined using the edible pod digest obtained after digestion of milled pods. One ml aliquot of the digest was pipetted into a 25 ml flat bottom test tube followed by addition of 4 ml of colour forming reagent (reagent B). The resultant solution was then topped up with distilled water to the 25 ml mark and allowed to stand for 15 minutes for colour development. The absorbance of the solution was read using the spectrophotometer (CE 1000 series) at 882 nm.

Standard working solutions of P (0, 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0 µg $ml^{-1}$) were prepared from 5 µg P $ml^{-1}$ of the stock solution using the same procedure described above. The standard solutions were allowed to stand for 15 minutes for the colour to develop and the absorbance read using the spectrophotometer at 882 nm. A calibration curve was obtained by plotting absorbance against concentration for the standard solution (Page et al., 1982). The concentration of P in the milled fruit aliquot was calculated using the calibration curve from the formula below:

P (%) = $C\ x\ Vs\ x\ final\ volume/sample\ weight\ x\ aliquot\ vol.\ x\ 10000$….(26)

where:

C = concentration of P in aliquot obtained from calibration curve

Vs = solution volume (ml)

**Statistical analysis**

All data collected were subjected to analysis of variance (ANOVA) using GENSTAT statistical package ($4^{th}$ Edition). Significant differences among means were separated using Duncan's Multiple Range Test (DMRT) at 0.05 probability level.

# CHAPTER FOUR

# RESULTS

## EXPERIMENT 1: EFFECT OF COMPOST ONGROWTH, DRY MATTER AND NUTRIENT COMPOSITION IN OKRA

Tables 3 and 4 summarize the chemical composition of compost and physico-chemical properties of the soil used for the pot experiment before sowing.

**Table 3: Chemical composition of compost used in the study**

| Parameter | Value |
|---|---|
| pH | 8.93 |
| Organic carbon (%) | 14.0 |
| Total nitrogen (%) | 1.20 |
| Total phosphorus (%) | 0.90 |
| Total potassium (%) | 28.80 |
| **Available cations (%)** | |
| $Ca^{2+}$ | 76.00 |
| $Mg^{2+}$ | 9.80 |
| $Na^{+}$ | 18.40 |

The table above shows that N, P, K, Ca, Mg and Na contents of the compost prepared and used in the study were quite high indicating that the compost was of good quality. The carbon-nitrogen (C: N) ratio of 12:1 was less than C: N ratio reported by Rynk et al. (1992) for cattle manure which was 19:1.

**Table 4: Physico-chemical composition of soil (0 – 15) cm before sowing**

| Parameter | Value |
|---|---|
| Moisture content (%) | 10.0 |
| Bulk density (g $cm^{-3}$) | 1.38 |
| pH | 6.30 |
| Organic carbon (%) | 0.87 |
| Total nitrogen (%) | 0.07 |
| Available phosphorus (µg $g^{-1}$) | 6.56 |
| **Exchangeable cations ($cmol_c$ $kg^{-1}$)** | |
| $Ca^{2+}$ | 1.12 |
| $Mg^{2+}$ | 1.03 |
| $K^{+}$ | 0.10 |
| $Na^{+}$ | 0.04 |
| Exchangeable acidity ($cmol_c$ $kg^{-1}$) | 0.07 |
| ECEC ($cmol_c$ $kg^{-1}$) | 2.36 |
| Sand (%) | 71.35 |
| Silt (%) | 9.22 |
| Clay (%) | 19.43 |
| Textural class | Sandy loam |

Analysis of soil samples collected before sowing showed that the soil is slightly acidic with pH of 6.3 and bulk density of 1.38 g $cm^{-3}$. Also, the soil had low levels of organic carbon, total nitrogen, available phosphorus and exchangeable cations. The soil is sandy loam with sand (71.35 %), clay (19.43 %) and silt (9.22 %). The effective cation exchange capacity (ECEC) was 2.36 $cmol_c$ $kg^{-1}$.

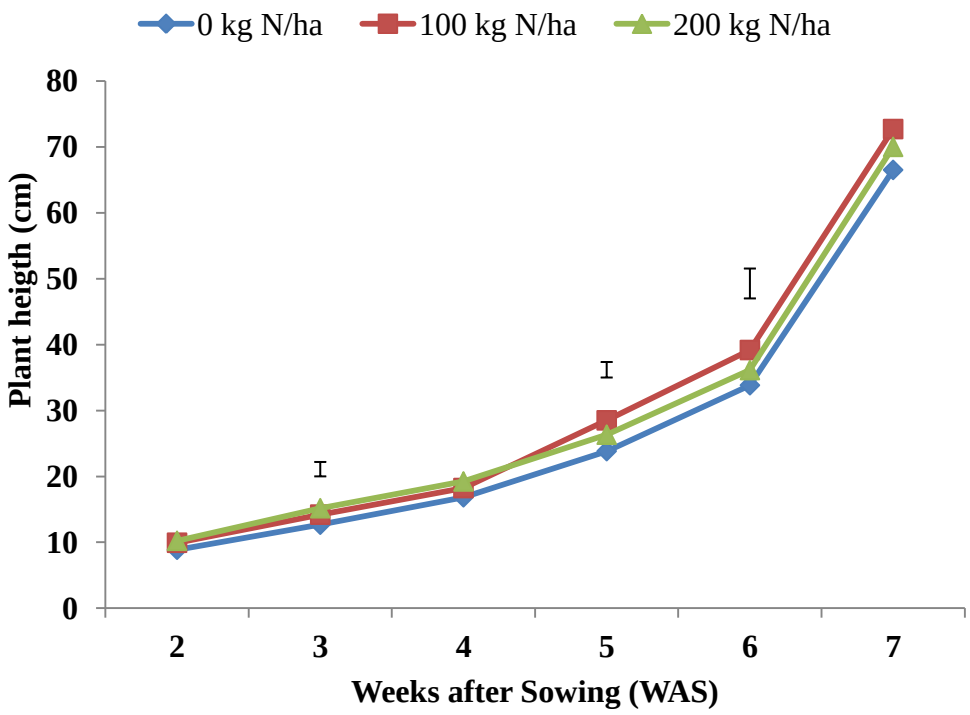


**Figure 1: Height response of *Asontem* to three levels of compost at 2 – 7 WAS for pot experiment.**

The figure above shows how the height of an early maturing variety of okra responded to the compost applied to the experimental soil. Application rate of 200 kg N $ha^{-1}$ showed significant increase in height of the *Asontem* variety followed by 100 kg N $ha^{-1}$ while the control recorded the least height.

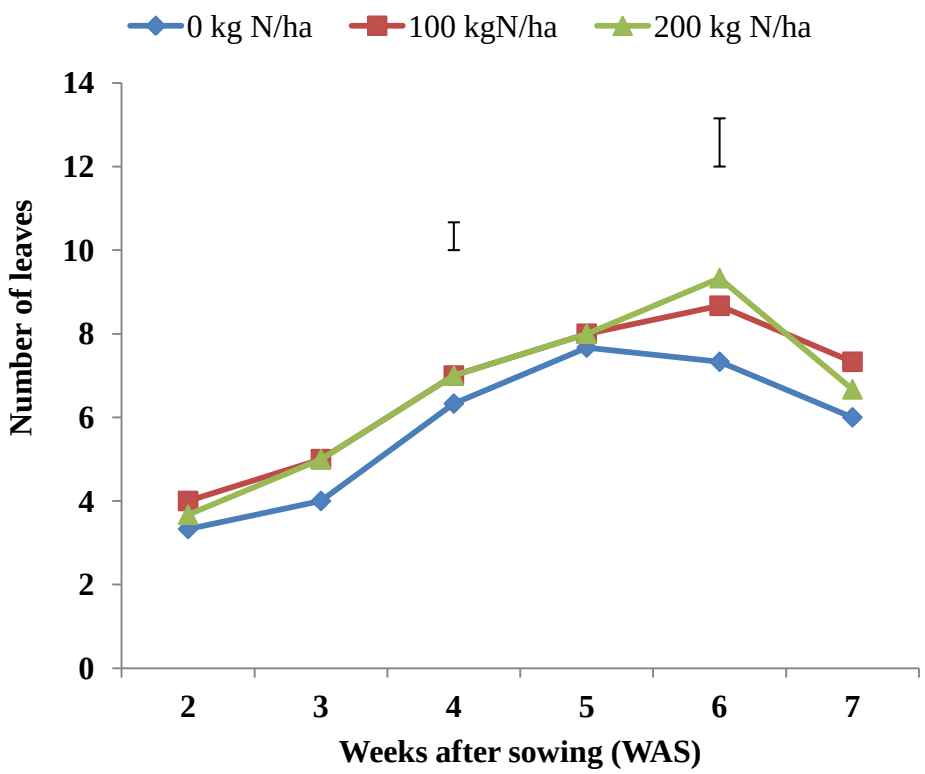


**Figure 2: Effect of compost on leaf number of *Asontem* at 2 – 7 WAS during pot trial.**

Figure 2 shows leaf number response of *Asontem* to the three rates of compost application. There was significant increase in mean number of leaves with the application rate of 200 kg N $ha^{-1}$ recording the highest number of leaves followed by 100 kg N $ha^{-1}$ while 0 kg N $ha^{-1}$ recorded the least number.

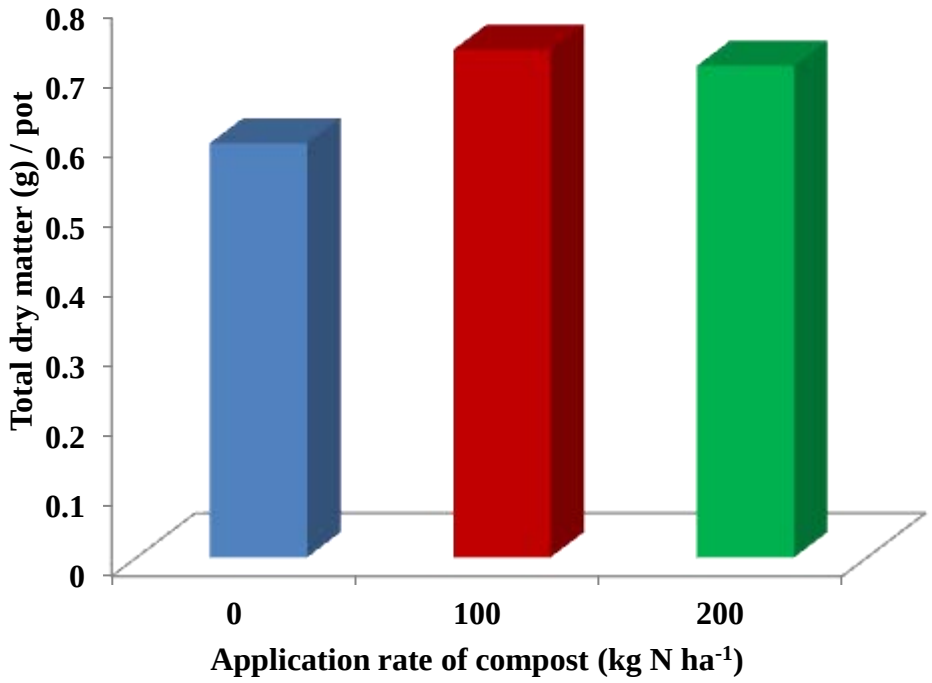


**Figure 3: Effect of compost on dry matter yield of *Asontem* after harvest during pot experiment.**

The figure above shows the effect of compost on the dry matter yield of the early maturing variety (*Asontem*) after harvest. Total dry matter yield recorded for the three rates of compost application that is: 0 kg N $ha^{-1}$, 100 kg N $ha^{-1}$ and 200 kg N $ha^{-1}$ were 0.59 g, 0.73 g and 0.71 g respectively.

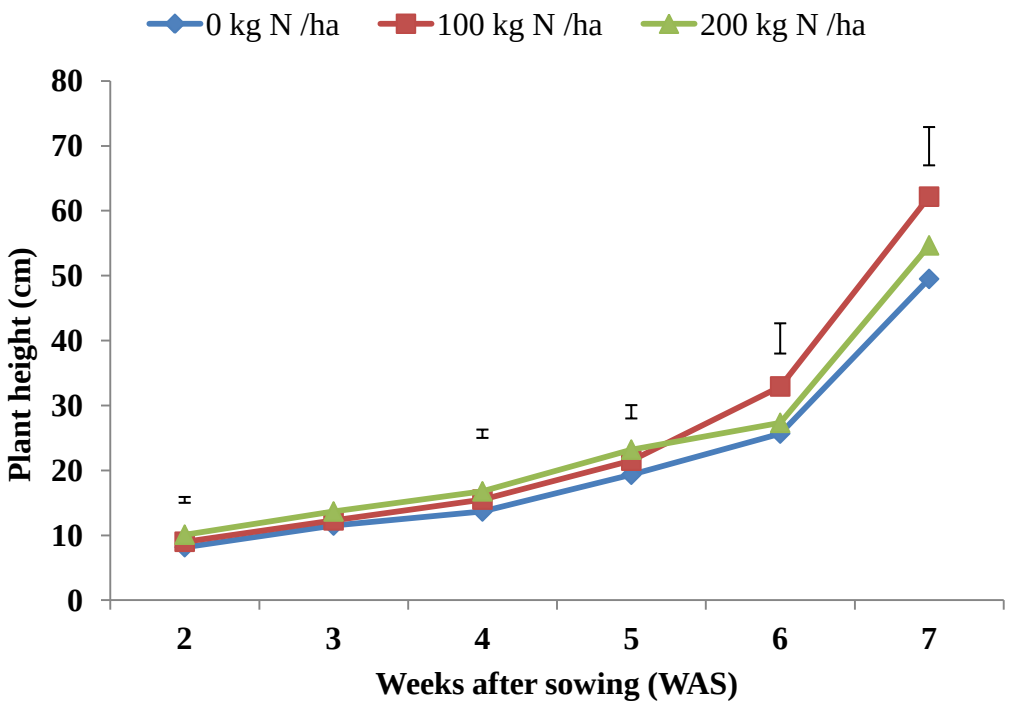


**Figure 4: Effect of compost on height of the *Enidaso* variety at 2 – 7 WAS during pot trial.**

Figure 4 shows the effect of compost on height response of the *Enidaso* variety. The figure shows that there was significant increase in height with application rate of 100 kg N $ha^{-1}$ recording the highest height followed by 200 kg N $ha^{-1}$ and then the control (0 kg N $ha^{-1}$).

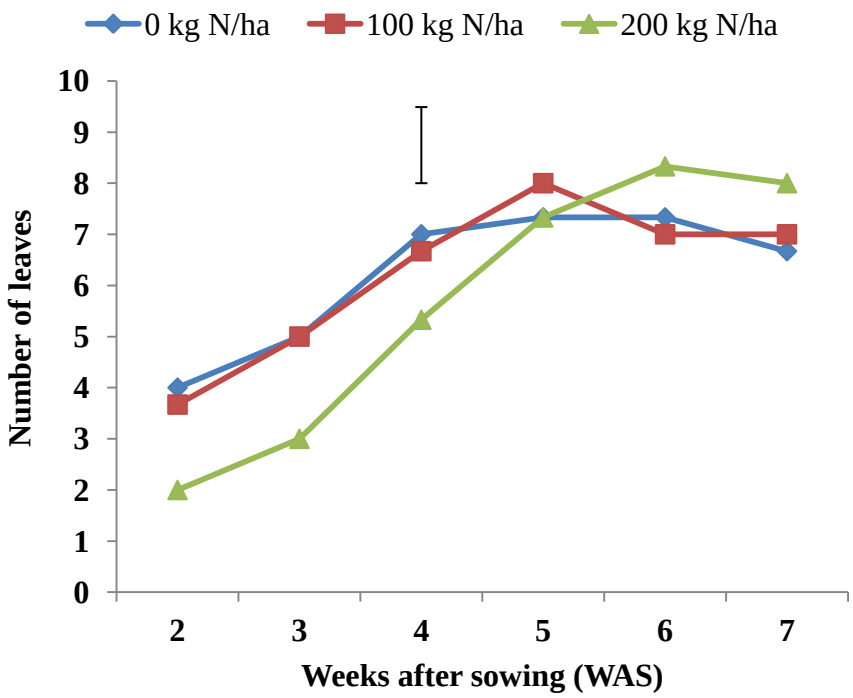


**Figure 5: Effect of compost on leaf number of the *Enidaso* variety at 2 – 7 WAS during pot experiment.**

Figure 5 above shows the effect of compost on mean leaf number of *Enidaso* during pot experiment. The graph shows that application rate of 100 kg N $ha^{-1}$ had the highest ($p < 0.05$) mean number of leaves.

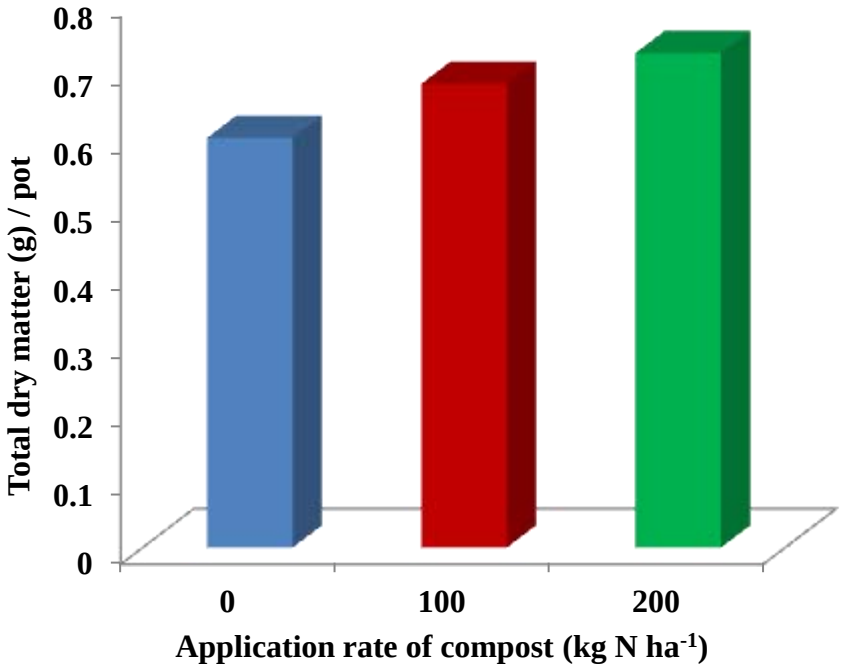


**Figure 6: Dry matter yield of *Enidaso* as affected by compost at harvest during pot experiment.**

The figure shows that there was no significant difference in total dry weight. The respective total dry matter recorded for the three levels of compost application were 0.60 g, 0.68 g and 0.72 g for 0 kg N $ha^{-1}$, 100 kg N $ha^{-1}$ and 200 kg N $ha^{-1}$.

**Table 5: Effect of compost on exchangeable cations content of soil used in pot experiment**

| | Exchangeable cations ($cmol_c\ kg^{-1}$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $Ca^{2+}$ | | $Mg^{2+}$ | | $K^{+}$ | | $Na^{+}$ | |
| **Compost** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** |
| 0 kg N $ha^{-1}$ | 7.7 | 8.8 | 0.61 | 0.64 | 0.15 | 0.17 | 0.37 | 0.34 |
| 100 kg N $ha^{-1}$ | 9.89 | 10.29 | 0.73 | 1.13 | 0.83 | 0.83 | 0.93 | 0.93 |
| 200 kg N $ha^{-1}$ | 12.08 | 11.7 | 1.89 | 1.71 | 1.37 | 1.32 | 1.42 | 1.36 |
| Mean value | 9.89 | 10.26 | 1.08 | 1.16 | 0.78 | 0.77 | 0.91 | 0.88 |
| $Lsd_{0.05}$ (compost) | 0.901 | | ns | | 0.0987 | | 0.1246 | |
| $Lsd_{0.05}$ (variety) | ns | | ns | | ns | | ns | |

ns = Not significant at 0.05 probability level

Table 5 presents results on the exchangeable cations of the experimental soil after compost amendment. The table shows that there was significant increase in exchangeable $Ca^{2+}$, $Mg^{2+}$ and $K^{+}$ contents. Application rate of 200 kg N $ha^{-1}$ recorded the highest value in terms of exchangeable $Ca^{2+}$, $Mg^{2+}$ and $K^{+}$ followed by 100 kg N $ha^{-1}$ while the control (0 kg N $ha^{-1}$) had the least value.

**Table 6: Effect of compost on moisture content, total nitrogen, organic carbon, available phosphorus, pH and ECEC of soil for pot trial**

| | Soil property | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MC (%) | | TN (%) | | OC (%) | | AP (µg $g^{-1}$) | | pH | | ECEC (cmolc $kg^{-1}$) | |
| **Compost** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** |
| 0 kg N $ha^{-1}$ | 13.7 | 13.7 | 0.12 | 0.14 | 1.54 | 1.67 | 12.39 | 9.15 | 6.2 | 6.2 | 11.3 | 11.4 |
| 100 kg N $ha^{-1}$ | 20.4 | 20.6 | 0.14 | 0.14 | 1.72 | 1.86 | 33.72 | 34.73 | 6.7 | 6.7 | 12.6 | 13.4 |
| 200 kg N $ha^{-1}$ | 15.7 | 16.3 | 0.15 | 0.14 | 1.99 | 1.88 | 98.85 | 77.29 | 6.9 | 6.9 | 14.1 | 15.9 |
| Mean value | 16.6 | 16.9 | 0.14 | 0.14 | 1.75 | 1.80 | 48.32 | 40.39 | 6.6 | 6.6 | 12.7 | 13.6 |
| Lsd $_{0.05}$ (compost) | 0.925 | | ns | | ns | | 32.149 | | ns | | ns | |
| Lsd $_{0.05}$ (variety) | ns | | ns | | ns | | ns | | ns | | ns | |

MC = moisture content, TN = total nitrogen, OC = organic carbon, AP = available phosphorus and ECEC = effective cation exchange capacity

Result on some selected physico-chemical properties of the compost-amended soil is presented in Table 6. From the table, application rate of 100 kg N $ha^{-1}$ recorded an increase in moisture content which was significant. For soil available phosphorus, application rate of 200 kg N $ha^{-1}$ had the highest value followed by 100 kg N $ha^{-1}$ while the unamended soil recorded the least value. Apart from soil moisture content in which the highest value (with p value of < 0.001) was recorded at 100 kg N $ha^{-1}$, total nitrogen, organic carbon, pH and ECEC recorded the highest value at application rate of 200 kg N $ha^{-1}$.

**Table 7: Effect of compost on percentage nitrogen (% N) in leaf, stem, petiole and root of two okra varieties**

| | Plant parts | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Leaf | | Stem | | Petiole | | Root | |
| **Compost** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** |
| 0 kg N $ha^{-1}$ | 2.61 | 2.73 | 0.75 | 0.83 | 1.30 | 1.31 | 0.59 | 0.87 |
| 100 kg N $ha^{-1}$ | 3.28 | 2.79 | 0.95 | 1.20 | 1.82 | 1.85 | 1.05 | 1.22 |
| 200 kg N $ha^{-1}$ | 3.25 | 2.82 | 0.96 | 1.12 | 1.43 | 1.63 | 1.05 | 1.01 |
| Mean of variety | 3.05 | 2.78 | 0.89 | 1.05 | 1.52 | 1.60 | 0.90 | 1.03 |
| $Lsd_{0.05}$ (compost) | 0.093 | | 0.078 | | 0.169 | | 0.118 | |
| $Lsd_{0.05}$ (variety) | 0.066 | | 0.056 | | ns | | 0.083 | |

V1 = *Asontem* (Early maturing okra variety)

V2 = *Enidaso* (Late maturing variety)

Effect of compost on percentage nitrogen (% N) content in leaf, stem, petiole and root of the two okra varieties are presented in Table 7. The results indicate that nitrogen content in the leaf was higher as compared to stem, petiole and root. With lsd value of 0.066, mean % N content in the two varieties was significant. *Asontem* as a variety recorded higher nitrogen of 3.05 % while *Enidaso* had 2.78 % of nitrogen in the leaves. Petiole recorded the second higher content of nitrogen. The mean percentage nitrogen content in the petiole of *Asontem* was found to be 1.52 % while *Enidaso* had 1.60 %. With lsd value of 0.13, mean nitrogen content in the roots of *Asontem* and *Enidaso* was also significant. From the table, application rate of 200 kg N $ha^{-1}$ recorded the highest nitrogen content in leaf, stem, petiole and root of the two okra varieties.

**Table 8: Effect of compost on percentage phosphorus (% P) in leaf, stem, petiole and root of two okra varieties**

| | Plant parts | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Leaf | | Stem | | Petiole | | Root | |
| **Compost** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** |
| 0 kg N $ha^{-1}$ | 0.39 | 0.34 | 0.28 | 0.28 | 0.39 | 0.39 | 0.23 | 0.26 |
| 100 kg N $ha^{-1}$ | 0.52 | 0.48 | 0.34 | 0.36 | 0.62 | 0.46 | 0.31 | 0.31 |
| 200 kg N $ha^{-1}$ | 0.48 | 0.43 | 0.36 | 0.37 | 0.45 | 0.47 | 0.31 | 0.30 |
| Mean of variety | 0.46 | 0.42 | 0.33 | 0.34 | 0.49 | 0.44 | 0.28 | 0.29 |
| $Lsd_{0.05}$ (compost) | 0.025 | | 0.010 | | 0.019 | | 0.031 | |
| $Lsd_{0.05}$ (variety) | 0.017 | | 0.007 | | 0.014 | | 0.022 | |

Phosphorus content in leaf, stem, petiole and root is presented in Table 8. Mean phosphorus content in the leaves of the two varieties was significant. Petiole also recorded the second highest phosphorus content. With p value of < 0.01, mean percentage phosphorus content in the petiole of the two okra varieties was significant. The interaction between compost and variety was also significant. Application rate of 100 kg N $ha^{-1}$ recorded higher percentage phosphorus in leaf, stem, petiole and root of the two varieties of okra.

**Table 9: Effect of compost on percentage potassium (% K) in leaf, stem, petiole and root of two okra varieties**

| | Plant parts | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Leaf | | Stem | | Petiole | | Root | |
| **Compost** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** |
| 0 kg N $ha^{-1}$ | 1.42 | 1.34 | 1.30 | 1.40 | 1.55 | 1.33 | 0.97 | 1.39 |
| 100 kg N $ha^{-1}$ | 1.86 | 1.77 | 2.04 | 1.73 | 2.88 | 2.40 | 1.69 | 1.89 |
| 200 kg N $ha^{-1}$ | 1.93 | 1.91 | 2.07 | 2.10 | 3.19 | 2.91 | 1.80 | 1.91 |
| Mean of variety | 1.74 | 1.67 | 1.80 | 1.74 | 2.54 | 2.09 | 1.49 | 1.73 |
| $Lsd_{0.05}$ (compost) | 0.094 | | 0.036 | | 0.204 | | 0.080 | |
| $Lsd_{0.05}$ (variety) | ns | | 0.025 | | 0.145 | | 0.057 | |

Table 9 shows the results on the effect of compost on potassium content in leaf, stem, petiole and root of the two okra varieties (*Asontem* and *Enidaso*). The table shows that application rate of 200 kg N $ha^{-1}$ compost had higher potassium content in the leaf, stem, petiole and root of the two okra varieties. Application rate of 100 kg N $ha^{-1}$ recorded the second highest value while the unamended soil (0 kg N $ha^{-1}$) had the least value.

**Table 10: Effect of compost on percentage calcium (% Ca) in leaf, stem, petiole and root of two okra varieties**

| | Plant parts | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Leaf | | Stem | | Petiole | | Root | |
| **Compost** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** |
| 0 kg N $ha^{-1}$ | 1.99 | 1.65 | 0.94 | 0.68 | 1.35 | 1.20 | 0.50 | 0.55 |
| 100 kg N $ha^{-1}$ | 2.19 | 2.38 | 1.09 | 0.92 | 2.39 | 2.18 | 0.69 | 0.64 |
| 200 kg N $ha^{-1}$ | 3.20 | 3.11 | 1.17 | 1.22 | 2.58 | 2.43 | 1.04 | 0.85 |
| Mean of variety | 2.46 | 2.38 | 1.07 | 0.94 | 2.11 | 1.94 | 0.74 | 0.68 |
| $Lsd_{0.05}$ (compost) | 0.272 | | 0.143 | | 0.202 | | 0.089 | |
| $Lsd_{0.05}$ (variety) | 0.192 | | 0.104 | | 0.143 | | ns | |

Table 10 presents results on percentage calcium (% Ca) in the leaf, stem, petiole and root of the test crops. The table shows that calcium content was high in the leaf and petiole of the test crops. With the leaf, there was significant difference at compost, variety and compost-variety interaction levels (Table 17; Appendix A). Application rate of 0 kg N $ha^{-1}$ had the least value of 1.99 % and 1.65 % for *Asontem* and *Enidaso* respectively. Percentage calcium obtained at 200 kg N $ha^{-1}$ for *Asontem* was almost twice the value at 0 kg N $ha^{-1}$. From table 9, it was deduced that the addition of the compost enhanced the calcium content in various parts of the two okra plants. From the table, application rate of 200 kg N $ha^{-1}$ of compost recorded the highest calcium content in the leaf, stem, petiole and root of the two test crops.

**Table 11: Effect of compost on percentage magnesium (% Mg) in leaf, stem, petiole and root of two cultivars of okra**

| | Plant parts | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Leaf | | Stem | | Petiole | | Root | |
| **Compost** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** |
| 0 kg N $ha^{-1}$ | 0.12 | 0.70 | 0.57 | 1.09 | 0.33 | 0.96 | 0.21 | 0.79 |
| 100 kg N $ha^{-1}$ | 0.79 | 1.03 | 0.89 | 1.47 | 0.60 | 1.44 | 1.11 | 1.45 |
| 200 kg N $ha^{-1}$ | 0.94 | 1.41 | 1.29 | 2.54 | 0.66 | 1.54 | 1.76 | 1.86 |
| Mean of variety | 0.62 | 1.05 | 0.92 | 1.70 | 0.53 | 1.31 | 1.03 | 1.37 |
| $Lsd_{0.05}$ (compost) | 0.23 | | 0.32 | | 0.07 | | 0.35 | |
| $Lsd_{0.05}$ (variety) | 0.16 | | 0.22 | | 0.05 | | 0.25 | |

Table 11 also presents results on percentage magnesium (% Mg) content in leaf, stem, petiole and root of test crops. From the table, it was observed that an increase in rate of compost application resulted in increase in magnesium content in leaf, stem, petiole and root of the two test crops used in the study. The root of the test crops was found to have higher magnesium content. With lsd value of 0.34, magnesium content in the root of *Asontem* was greater than that of *Enidaso*. Magnesium content in the root of *Asontem* at 200 kg N $ha^{-1}$ (1.76 %) was eight (8) times greater than 0.21 % obtained at 0 kg N $ha^{-1}$. The root of the *Enidaso* variety recorded % Mg content of 1.86 at 200 kg N $ha^{-1}$ which was twice the value obtained at 0 kg N $ha^{-1}$. The table shows that compost application at 200 kg N $ha^{-1}$ had higher % Mg content followed by 100 kg N $ha^{-1}$. The unamended soil recorded the least magnesium content in leaf, stem, petiole and root of the test crops.

**Table 12: Effect of compost on leaf area of two okra varieties at 2 – 7 WAS during pot trial**

| | Leaf Area ($cm^2$) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Week 2 | | Week 3 | | Week 4 | | Week 5 | | Week 6 | | Week 7 | |
| **Compost** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** |
| 0 kg N $ha^{-1}$ | 3.4 | 2.4 | 7.6 | 5.4 | 9.1 | 9.5 | 9.4 | 10.3 | 9.9 | 10.7 | 10.3 | 11.1 |
| 100 kg N $ha^{-1}$ | 4.7 | 5.3 | 8.5 | 9.3 | 10.9 | 10.5 | 11.2 | 10.7 | 11.7 | 11.2 | 12.1 | 11.7 |
| 200 kg N $ha^{-1}$ | 5.9 | 5.8 | 10.3 | 9.7 | 11.5 | 11.7 | 11.8 | 13.3 | 12.2 | 13.8 | 12.6 | 14.3 |
| Mean of variety | 4.7 | 4.5 | 8.8 | 8.1 | 10.5 | 10.6 | 10.8 | 11.4 | 11.3 | 11.9 | 11.7 | 12.4 |
| Lsd $_{0.05}$ (compost) | 1.2 | | 2.4 | | ns | | 2.6 | | 2.7 | | 2.7 | |

Table 12 shows the effect of compost application on leaf area of the test crops from the 2 – 7 WAS (weeks after sowing). From the table, it was observed that leaf area of the test crops increased throughout the growing period. Application rate of 200 kg N $ha^{-1}$ recorded the highest leaf area followed by 100 kg N $ha^{-1}$ with the least value occurring at 0 kg N $ha^{-1}$ of compost application.

## EXPERIMENT TWO: EFFECT OF COMPOST AS SOIL AMENDMENT TO A LIXISOL ON NUTRIENT COMPOSITION AND NUTRITIONAL QUALITY OF OKRA

**Table 13: Effect of compost on nutritional quality of edible pods of two okra varieties after harvest**

| | Proximate analysis (%) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MC | | PC | | AC | | FiC | | FC | | SC | |
| **Compost** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** |
| 0 kg N $ha^{-1}$ | 87.6 | 87.5 | 20.0 | 15.1 | 9.4 | 7.6 | 9.3 | 9.1 | 1.3 | 1.3 | 23.5 | 23.0 |
| 100 kg N $ha^{-1}$ | 88.0 | 87.8 | 20.8 | 18.0 | 10.3 | 8.9 | 9.7 | 9.7 | 2.1 | 1.6 | 25.7 | 24.6 |
| 200 kg N $ha^{-1}$ | 88.2 | 87.7 | 20.2 | 18.3 | 11.2 | 9.1 | 10.7 | 10.2 | 2.0 | 2.0 | 25.9 | 26.9 |
| Mean of variety | 87.9 | 87.6 | 20.3 | 17.2 | 10.3 | 8.6 | 9.9 | 9.7 | 1.8 | 1.7 | 25.0 | 24.8 |
| $Lsd_{0.05}$ (compost) | ns | | ns | | 0.85 | | 0.06 | | 0.44 | | 0.54 | |
| $Lsd_{0.05}$ (variety) | ns | | ns | | 0.51 | | 0.03 | | ns | | ns | |

MC = moisture content, PC = protein content, AC = ash content, FiC = fibre content, FC = fat content and SC = soluble carbohydrates content

Table 13 presents results on nutritional quality of edible okra pods. From the table, ash, fibre, fat and soluble carbohydrates contents were significantly influenced by the compost. Mean moisture and protein contents of edible pods were not significantly different. Their contents were however improved by the compost. Moisture content of edible pods of the two varieties of okra was between 87.5 % - 88.2 %. Protein content in *Asontem* was higher compared to the *Enidaso* variety which were 20.3 % and 17.2 % respectively. With least significant difference (lsd) value of 1.7, the two varieties were found to have significant amount of ash. *Asontem* recorded mean ash content of 10.3 % while the *Enidaso* variety recorded an ash content of 8.6 %. Fibre content of the test crops was also significantly different. With lsd value of 0.2, *Asontem* variety had mean fibre content of 9.9 % while the *Enidaso* variety recorded mean fibre content of 9.7 %. Interaction was also significant.

**Table 14: Effect of compost on mineral composition of edible pods of two okra varieties**

| | Mineral composition (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ca | | Mg | | K | | Na | | P | |
| | V1 | V2 | V1 | V2 | V1 | V2 | V1 | V2 | V1 | V2 |
| 0 kg N $ha^{-1}$ | 0.77 | 0.69 | 0.34 | 0.31 | 1.76 | 1.72 | 1.05 | 1.05 | 0.48 | 0.48 |
| 100 kg N $ha^{-1}$ | 0.79 | 0.72 | 0.41 | 0.32 | 1.82 | 1.82 | 1.10 | 1.06 | 0.53 | 0.54 |
| 200 kg N $ha^{-1}$ | 0.77 | 0.75 | 0.43 | 0.33 | 1.82 | 1.85 | 1.11 | 1.10 | 0.59 | 0.54 |
| Mean of variety | 0.78 | 0.72 | 0.39 | 0.32 | 1.80 | 1.80 | 1.09 | 1.07 | 0.53 | 0.52 |
| $Lsd_{0.05}$ (compost) | 0.017 | | ns | | ns | | ns | | ns | |
| $Lsd_{0.05}$ (variety) | 0.025 | | ns | | ns | | ns | | 0.016 | |

Ca = calcium, Mg = magnesium, K = potassium, P = phosphorus and Na = sodium

Table 14 presents data on some principal mineral elements in the edible pods of okra. From the table, it could be observed that the mean values of potassium, magnesium, sodium and phosphorus contents of edible pods were not significantly different. There was significant difference in the mean value of calcium content of the edible pods of the two okra varieties.

**EXPERIMENT 3: INFLUENCE OF COMPOST ON GROWTH, DRY MATTER YIELD, PESTS AND DISEASETOLERANCE OF OKRA**

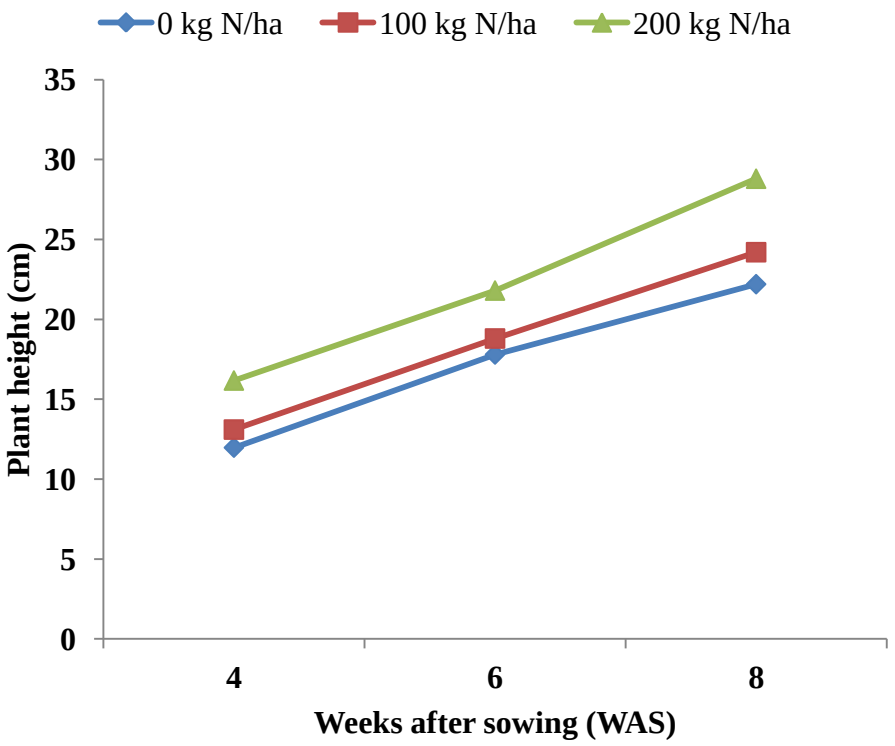


**Figure 7: Mean height of *Asontem* as affected by compost at 4 - 8 WAS for field work.**

Mean height of the early maturing variety is presented in Figure 7. It shows that incorporation of compost enhanced growth of test crop. The figure shows that growth rate was higher at 200 kg N $ha^{-1}$ followed by 100 kg N $ha^{-1}$. Growth rate was slow at 0 kg N $ha^{-1}$ (control).

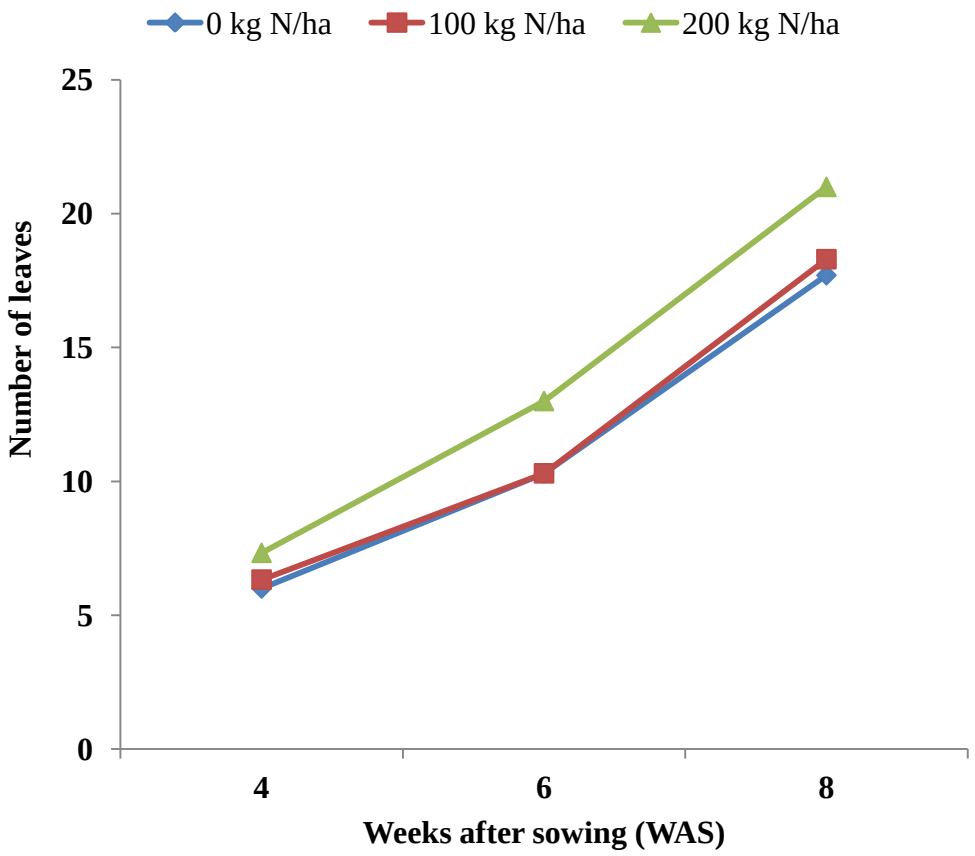


**Figure 8: Mean number of leaves recorded on *Asontem* at 4 - 8 WAS for field experiment.**

Figure 8 presents results on the effect of compost on mean number of leaves that were recorded on the *Asontem* variety. The figure shows that mean number of leaves was not significantly different. Application rate of 200 kg N $ha^{-1}$ recorded higher leaf number.

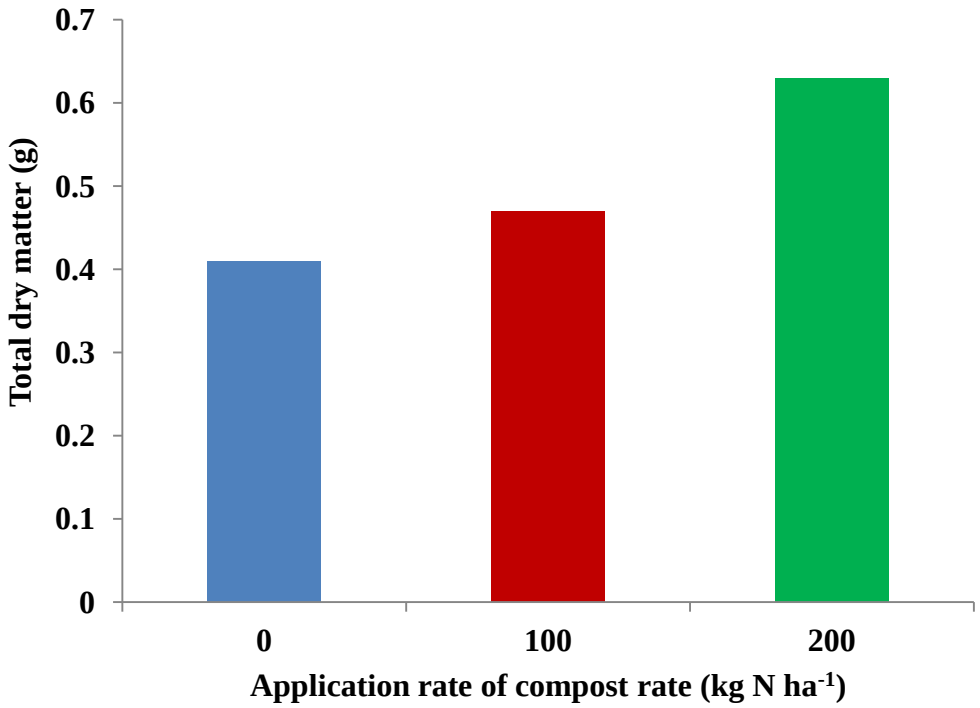


**Figure 9: Mean dry matter of edible pods of *Asontem* as affected by compost during field experiment.**

Mean dry matter of *Asontem* after harvest is presented in Figure 9. The figure shows that mean dry matter was higher at 200 kg N $ha^{-1}$ followed by 100 kg N $ha^{-1}$ while the unamended soil had the least dry matter.

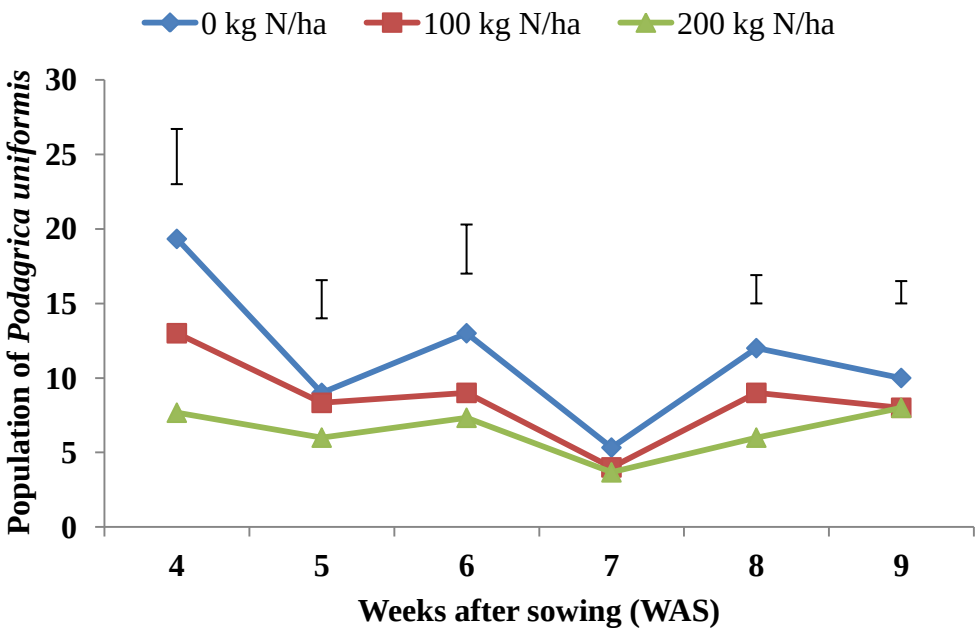


**Figure 10: Effect of compost on mean population of *Podagrica uniformis* counted on *Asontem* at 4 – 9 WAS during field experiment.**

Result on mean population of *Podagrica uniformis* sampled on *Asontem* is presented in Figure 10. The figure indicates that application rate of 200 kg N $ha^{-1}$ of compost recorded the least ($p < 0.05$) population of *Podagrica uniformis*. Mean population of pests was also found to be less at 100 kg N $ha^{-1}$ compared to the control (0 kg N $ha^{-1}$).

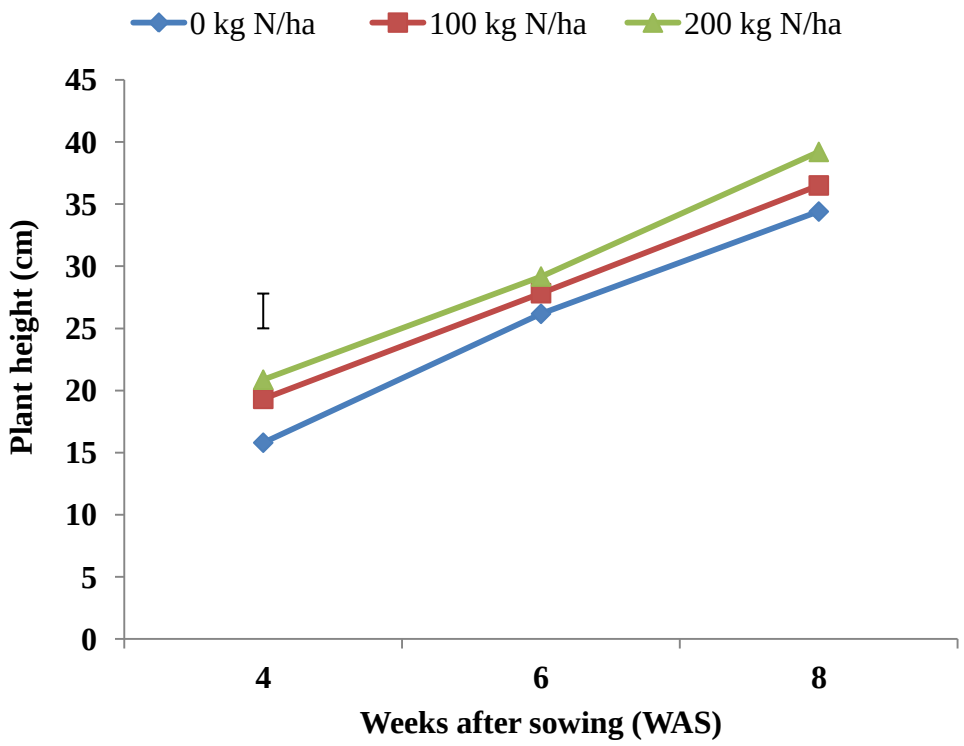


**Figure 11: Mean height of *Enidaso* as affected by compost at 4 - 8 WAS for field work.**

Figure 11 shows the effect of the compost applied on mean height of the late maturing variety (*Enidaso*) of the test crops. The figure shows that application rate of 200 kg N $ha^{-1}$ recorded higher plant height followed by 100 kg N $ha^{-1}$. The unamended soil (0 kg N $ha^{-1}$) had the least plant height.

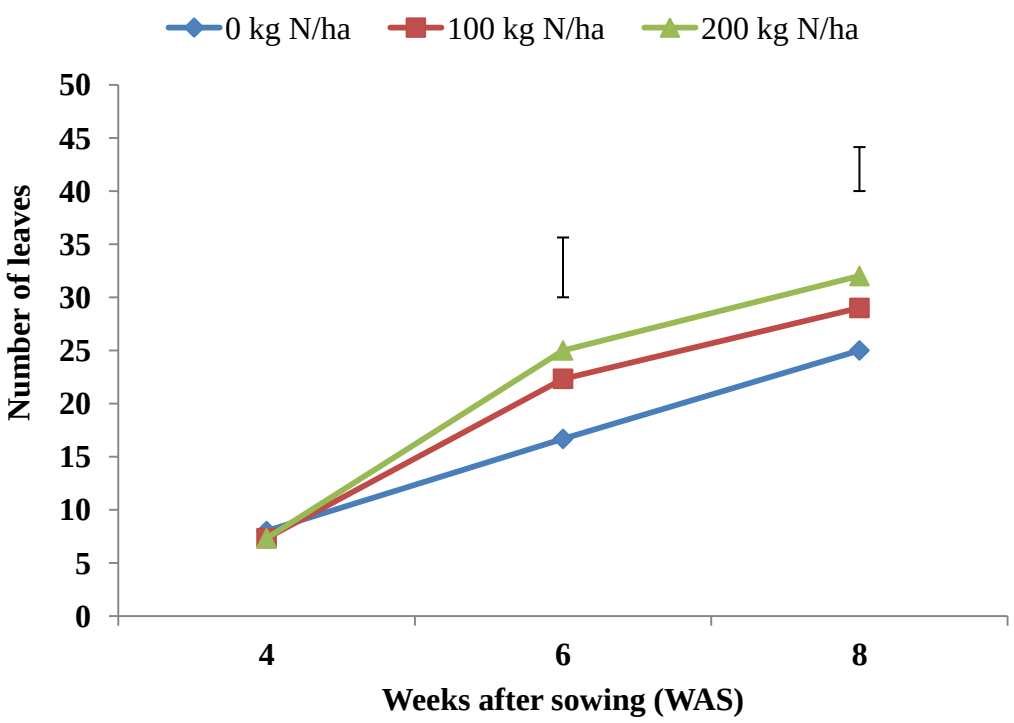


**Figure 12: Mean number of leaves on *Enidaso* as affected by compost at 4 - 8 WAS during field work.**

Mean number of leaves sampled from *Enidaso* is presented in Figure 12. The incorporation of compost resulted in significant increase in mean number of leaves. It was observed that mean number of leaves was higher at application rate of 200 kg N $ha^{-1}$ and at 100 kg N $ha^{-1}$. The control soil had less number of leaves.

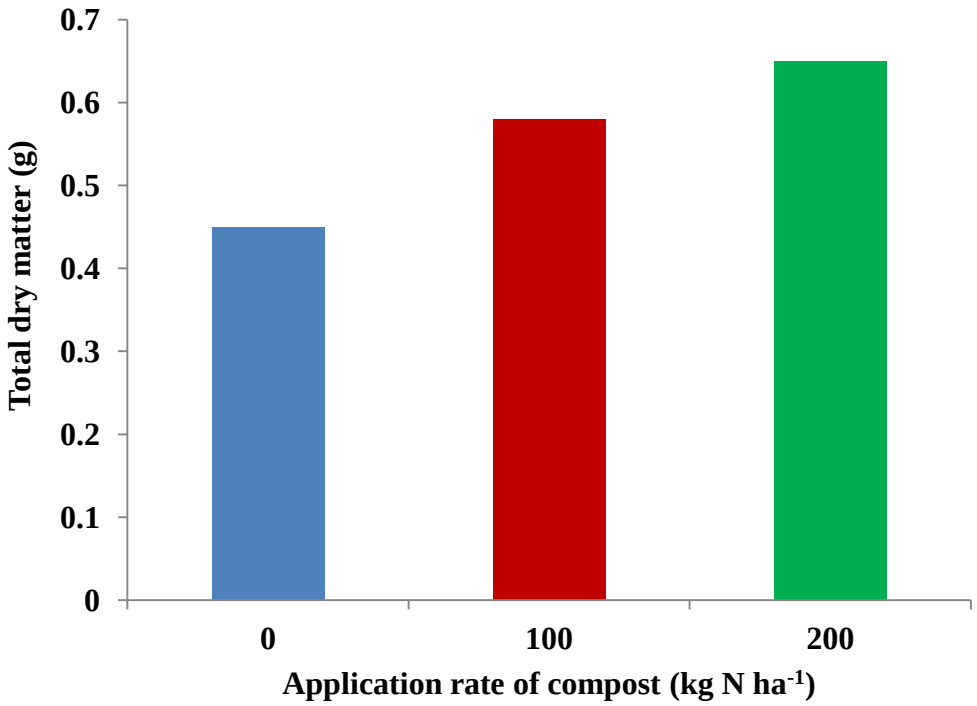


**Figure 13: Effect of compost on mean dry matter of edible pods of *Enidaso* during field trial.**

Mean total dry matter of edible pods of *Enidaso* is presented in Figure 13. Mean total dry matter was higher at 200 kg N $ha^{-1}$ and at 100 kg N $ha^{-1}$. The control (0 kg N $ha^{-1}$) recorded the least dry matter yield. There was no significant difference in mean dry matter of the edible pods.

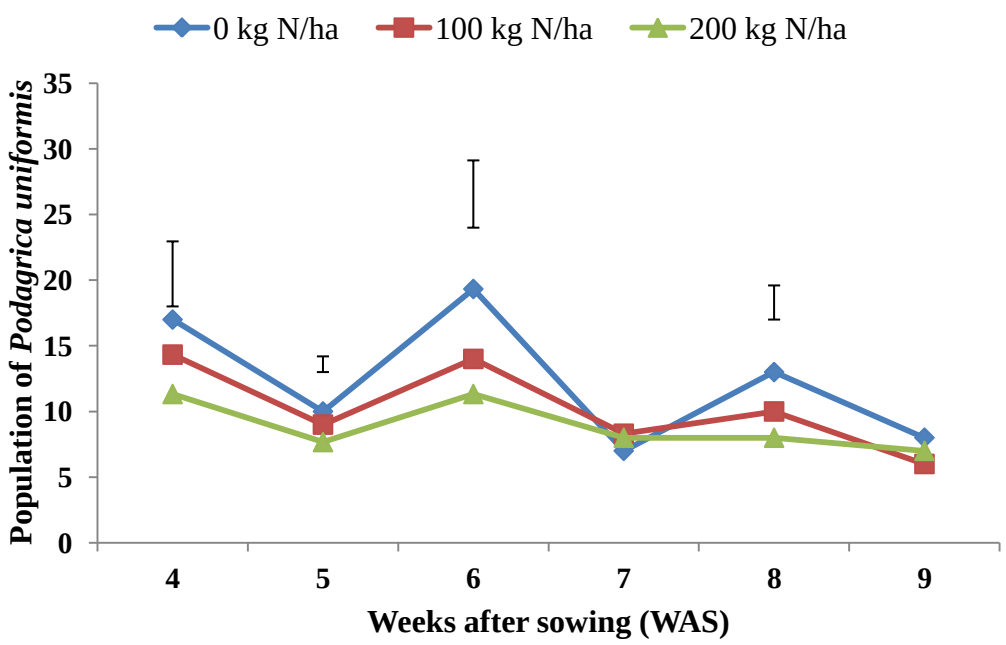


**Figure 14: Effect of compost on mean population of *Podagrica uniformis* counted on the *Enidaso* variety at 4 – 9 WAS during field experiment.**

Mean population of *Podagrica uniformis* recorded on *Enidaso* is presented in Figure 14. The figure shows that application rate of 200 kg N $ha^{-1}$ of compost recorded the least number of pest followed by 100 kg N $ha^{-1}$. The unamended soil (0 kg N $ha^{-1}$) had higher number of pests.

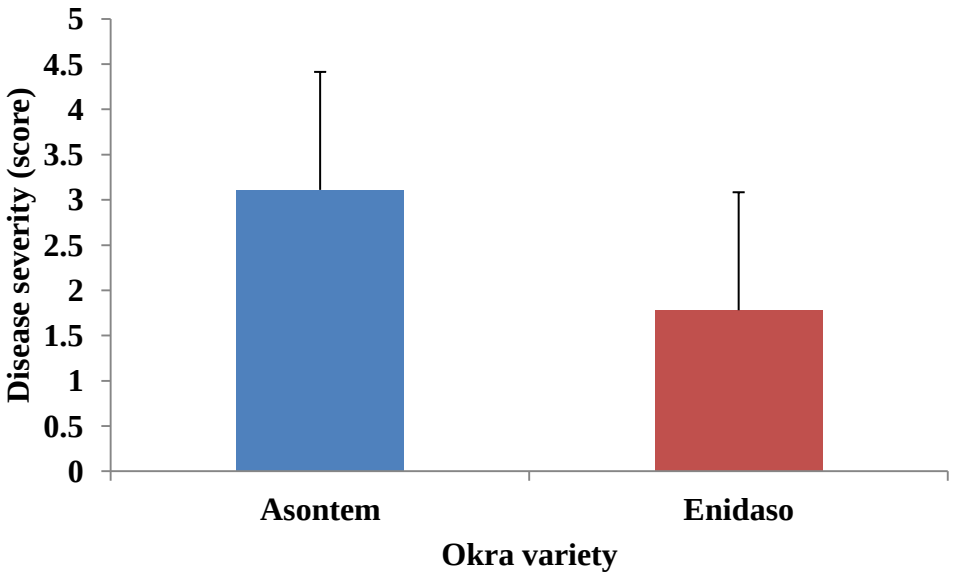


**Figure 15: Effect of compost on severity of okra mosaic disease in two okra varieties during field trial.**

Figure 15 shows the severity of okra mosaic disease in the two okra varieties used in the study. The figure shows that prevalence rate of okra mosaic was higher in *Asontem* compared to the *Enidaso* variety.

**Table 15: Effect of compost on exchangeable cations content of soil used for field experiment**

| | Exchangeable cations ($cmol_c\ kg^{-1}$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $Ca^{2+}$ | | $Mg^{2+}$ | | $K^{+}$ | | $Na^{+}$ | |
| **Compost** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** |
| 0 kg N $ha^{-1}$ | 8.24 | 8.19 | 0.72 | 0.93 | 0.35 | 0.34 | 0.34 | 0.37 |
| 100 kg N $ha^{-1}$ | 8.40 | 8.37 | 0.77 | 1.12 | 0.46 | 0.54 | 0.40 | 0.46 |
| 200 kg N $ha^{-1}$ | 8.45 | 8.61 | 1.41 | 1.55 | 0.53 | 0.54 | 0.56 | 0.56 |
| Mean value | 8.36 | 8.39 | 0.97 | 1.20 | 0.47 | 0.47 | 0.43 | 0.46 |

Data on exchangeable $Ca^{2+}$, $Mg^{2+}$, $K^{+}$ and $Na^{+}$ contents of soil used in field trial after compost amendment is presented in Table 15. The table shows that the application of compost at 200 kg N $ha^{-1}$ recorded the highest exchangeable cations content followed by 100 kg N $ha^{-1}$. The least values were recorded at 0 kg N $ha^{-1}$ (unamended soil).

**Table 16: Effect of compost on organic carbon, total nitrogen, available P, pH, ECEC and bulk density of soil used in field experiment**

| | Soil property | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | O.C (%) | | T.N (%) | | A.P (µg $g^{-1}$) | | pH | | ECEC ($cmol_c$ $kg^{-1}$) | | B.D (g $cm^{-3}$) | |
| **Compost** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** | **V1** | **V2** |
| 0 kg N $ha^{-1}$ | 1.21 | 1.30 | 0.14 | 0.13 | 29.1 | 29.6 | 6.5 | 6.5 | 11.4 | 10.4 | 1.37 | 1.37 |
| 100 kg N $ha^{-1}$ | 1.29 | 1.37 | 0.15 | 0.14 | 43.5 | 60.6 | 6.5 | 6.6 | 12.4 | 11.6 | 1.36 | 1.35 |
| 200 kg N $ha^{-1}$ | 1.43 | 1.41 | 0.16 | 0.17 | 78.7 | 60.6 | 6.6 | 6.6 | 13.3 | 13.4 | 1.33 | 1.34 |
| Mean value | 1.31 | 1.36 | 0.15 | 0.15 | 50.4 | 50.3 | 6.6 | 6.6 | 12.9 | 11.8 | 1.35 | 1.35 |

Table 16 presents data on some physico-chemical properties of experimental soil after compost amendment during field trial. The results indicate that there was improvement in soil organic carbon, total nitrogen, available phosphorus, pH, effective cation exchange capacity (ECEC) and bulk density. The highest values were recorded at application rate of 200 kg N $ha^{-1}$ followed by 100 kg N $ha^{-1}$ while the unamended soil (0 kg N $ha^{-1}$) had the least values.

**A**

**B**

**C**

**D**

**Plate 1:** Pictures of potted okra plants; A shows okra plant at 2 days after sowing (DAS), B shows okra plant at 3 weeks after sowing (WAS), C is a picture of okra plant at 4 WAS and D is a picture of ground neem seed extract used as biocide.

**A**

**B**

**C**

**D**

**E**

**Plate 2:** Pictures of field work; A gives a layout of experimental plot; B shows okra plant with flower bud; C is a picture of okra plant at 3 WAS with wood ash to control *Podagrica uniformis*; D shows okra plant at 5 WAS with flower and E shows okra plant with immature edible pod.

# CHAPTER FIVE

# DISCUSSION

This chapter discusses the results of the study. The findings were compared to other studies carried out by researchers who have conducted similar study using similar or different varieties of test crops, similar or different soil amendments on different soils. The chemical composition of the compost prepared and used in the study is presented in Table 3. The compost used in this study was found to contain relatively higher amounts of N, P, K, Ca, Mg and Na compared to those reported by Rynk et al. (1992).

## Effect of addition of compost on soil fertility

The soil was found to be slightly acidic with pH value of 6.3 and bulk density of 1.38 g $cm^{-3}$. The soil was low in nitrogen (0.07 %), available phosphorus (6.56 µg $g^{-1}$), exchangeable calcium (1.12 $cmol_c$ $kg^{-1}$), $Mg^{2+}$ (1.03 $cmol_c$ $kg^{-1}$), potassium (0.10 $cmol_c$ $kg^{-1}$) and sodium (0.04 $cmol_c$ $kg^{-1}$). Moreover, the soil had low level of organic carbon (0.87 %). According to Verloo and Demeyer (1997), soil with exchangeable $Ca^{2+}$ of 2.49 $cmol_c$ $kg^{-1}$, $Mg^{2+}$ content of 2.45$cmol_c$ $kg^{-1}$and $K^+$ content of 0.2 $cmol_c$ $kg^{-1}$is considered normal. Initial soil analysis showed that the soil was fairly deficient in nutrients. The low pH could be attributed to heavy rainfall that leaches soil available nutrients as they are easily replaced by Al and Fe in some acidic soils. The low levels of organic carbon could also be linked to rapid decomposition of organic matter as result of high temperatures, high humidity and intensive sunshine (Amberger, 2006).

Phosphorus availability in the soil is influenced by soil reaction, clay mineralogy and the management of fertilizer (Tisdale et al., 1990). Table 4 shows

that the soil analysed before compost incorporation had low phosphorus content. The above-mentioned factors could have played a role in the availability of phosphorus. In acid soils, $Al^{3+}$ easily precipitates at pH of 5.2. When this occurs, $Ca^{2+}$ becomes abundant where phosphorus is reduced by reacting with suitable cation. This reaction further reduces the availability of phosphorus in the soil. The soil was sandy loam in texture with high percentage of sand (71.35 %) followed by clay (19.43 %) and silt (9.22 %). Effective cation exchange capacity of the soil was also low (Table 4).

Analysis of soil samples collected before sowing showed that the soil had low moisture content (Table 4). The application of compost significantly influenced the moisture content of the soil at 100 kg N $ha^{-1}$ (Table 6). This could be attributed to the improvement of soil aggregates by the compost. The gel-like humic substance in organic matter has the ability enhance soil aggregate stability. This physical property of soil enhances water retention capacity. According to Ofosu-Anim et al. (2006), incorporation of compost has significant effect in improving soil physical properties such as moisture content. Adding compost to soil could result in the formation of stable aggregate which enhances water infiltration rate. Further, Amanullah et al. (2010) reported that poultry manure which constituted the second largest composition of the compost contains about 3 – 5 % N, 1.5 – 3.5 % P and 1.5 – 3.0 % K. Poultry manure also has high organic matter which enhances soil water holding capacity and nutrient retention (KARI, 2000). Total nitrogen content of the soil also increased when it was amended with compost (Table 6). Even though the mean values were not significantly different

from each other, the improvement could be linked to the sufficient quantity of nitrogen from *Leucaena leucocephala* included as compost material (Table 1). Studies have shown that *Leucaena leucocephala* has the ability to add nitrogen to the soil when used as soil amendment (Nwachukwu et al., 2014). Soil pH was significantly increased by the application of compost. The significant improvement could be linked to the alkaline nature of the compost pH (8.93). Studies have shown that the addition of compost have beneficial impact on soil pH depending on the pH of the compost. Also, according to Ogbomo (2013), an improvement in pH of compost amended soil could be attributed to the possible enrichment of the soil with calcium from the compost. The alkaline nature of the compost pH could be attributed to the addition of poultry manure since it has the potential to raise pH of soil or compost (KARI, 2000).

The incorporation of compost resulted in significant increase in exchangeable bases ($Ca^{2+}$, $K^{+}$ and $Na^{+}$). The significant increase could be attributed to the relatively higher levels available cations in the compost. Studies have shown that low pH (5.2) could impede calcium availability while high pH (between 7.5 and 8.5) could result in the formation of Ca-$PO_4$ complex reducing it availability (Stevenson, 1986). The type of clay minerals present could also influence exchangeable cations availability. For example, 2:1 clay minerals require greater saturation of CEC compared to 1:1 clay minerals which supply adequate calcium. The significant increase could also be attributed to the creation of supplementary exchange sites by the compost. This facilitates easy and rapid replacement of same or similar cations (Ofosu-Anim et al., 2006). The increase in

available nutrients could also be attributed to nutrient mineralization and gradual release of nutrients which are essential for plant use (Olaniyi and Odedere, 2009). Increase in the rate of compost application resulted in increased exchangeable cations. Studies have shown that the use of compost as soil amendment has the potential to enhance the exchangeable cations of soil through improved cation exchange capacity (CEC) (van Wambeke, 1992). The significant difference could also be due to the inclusion of poultry manure, household ash and maize husk in the preparation of compost since they are important sources of nutrients. Data on soil pH (Table 6) also show that the pH of the compost amended soil was within range (6.3 – 6.9) which favoured nutrient availability.

Total organic carbon content in compost amended soil also improved. The improvement could be attributed to the organic carbon content of the compost (Table 3). Compost is rich in organic carbon and when incorporated into the soil enhances the soil carbon content. This confirms the work of Michael et al. (2012) which used kraal compost as treatment. They attributed the significant increase in soil organic carbon to the kraal compost that was added to the soil.

The application of compost also resulted in significant increase in soil available phosphorus attributable to the relatively higher total phosphorus content in the compost (Table 3). Stevenson (1986) reported that soil moisture, aeration (oxygen abundance), and salinity are examples of the factors that affect the rate of phosphorus mineralization from organic matter decomposition. It could also be that the pH of the soil after it had been amended with compost enhanced phosphorus availability (Table 6). Soil pH between 6.0 and 7.5 is ideal for

phosphorus availability. The highest pH value obtained was 6.9 at 200 kg N $ha^{-1}$. This value was quite favourable for phosphorus availability. Also, organic matter maintenance plays an important role in controlling phosphorus availability (Schlecht et al., 2006). The significant increase in soil available phosphorus could be linked to an ideal pH range and organic matter content of compost used in the study.

**Effect of addition of compost on growth and yield of okra**

The incorporation of compost significantly increased the mean height of the *Asontem* variety (Figure 1). This could be as a result of nutrient mineralization and their availability for plant use. Compost contains vital nutrients like N, P and K that are needed by plants for good yield. The significant increase in height could also be attributed to genetic trait since okra height is genetically influenced (Amanullah et al., 2010). The growth rate of the late maturing variety (*Enidaso*) was also significantly influenced by compost. The improvement in soil nutrient status as well as improved moisture, ECEC, enhanced organic matter could have resulted in the significant growth of these okra varieties. According to Gruhn et al. (2000), the use of compost as soil amendment offers numerous benefits which include improvement in soil aggregate stability by humus. The humic substance binds and retains nutrients for plant use. Mean number of leaves sampled on *Asontem* showed significant difference. From Figure 2, mean number of leaf increased and reached a highest level during the $6^{th}$ week. Leaf number however declined which could be caused by detachment of leaves from the stem of test crop. Mean number of leaves counted on the *Enidaso* variety was also significant.

Results on mean total dry matter for the two varieties of okra (*Asontem* and *Enidaso*) were found to be insignificant (Figures 3 and 6) respectively. Application rate of 100 kg N $ha^{-1}$was found to have highest dry matter yield for *Asontem* (Figure 3) while application rate of 200 kg N $ha^{-1}$ have the highest dry matter for *Enidaso*. The incorporation of compost had significant effect on mean nutrient (N, P, K, Ca and Mg) contents in the leaf, stem, petiole and root of the two test crops (Tables 7, 8, 9,10 and 11) respectively. The significant differences recorded could be attributed to factors such as relatively higher nutrient content (N, P, K, Ca and Mg) in compost, ideal moisture content and soil pH (Stevenson, 1986). Further, improvement in ECEC could have also enhanced nutrient availability for plant uptake. Genetic factors might have also played significant role in the nutrient contents in the individual parts of the test crops because plant nutrients uptake is genetically controlled (Adetuyi et al., 2011). The results on nutrient content in the leaf, stem, petiole and root of the two test crops were high compared those reported by Effiong et al. (2009). According to KARI (2000), organic nutrient sources such as manure and compost are some of the best ways of improving crop yield. The use of compost for instance helps in the maintenance of soil organic matter content which improves plant growth and nutrient uptake through microbial activity (Porter, 2004). The application of compost had significant influence on leaf area. Application rate of 100 kg N $ha^{-1}$ recorded the highest leaf area throughout the study period. Plants with high leaf area tend to have greater photosynthetic activity which is needed for growth and nutrient assimilation (Oworu et al., 2010).

For the field experiment, results indicated that the application of compost showed an increase in height for *Asontem*. However, mean plant height was not significantly different (Figure 7). Compared to the *Asontem* variety, mean height of *Enidaso* was significant (Figure 11). The significant difference in height could be attributed to the efficient utilization of available nutrients supplied by the compost which is needed for growth. There was no significant difference in mean number of leaves for *Asontem*. However, mean number of leaves for *Enidaso* was significant (Figure 12). Analysis of total dry matter was found to be not significant for both varieties (Figures 9 and 13) respectively.

**Effect of addition of compost on nutritional quality of okra**

Results on nutritional quality of edible pods showed that there was no significant difference in moisture and protein contents. The result obtained for mean moisture for *Asontem* and *Enidaso* were 87.9 % and 87.6 % respectively (Table 13).This was in accordance with the findings of Effiong et al. (2009) as well as Norman (1992) who reported that okra pods have high moisture content (around 88 %). It is believed that the high moisture content makes okra an easily perishable vegetable crop and also easily digestible.

Protein content for *Asontem* and *Enidaso* was found to be 20.3 and 17.2% fibre was 9.9% and 9.7 %, fat was 1.8 % and 1.7 %, ash was found to be 10.3 % and 8.6 % while soluble carbohydrates was 25 % and 24.8 %respectively. Comparing these results to those reported by Adetuyi et al. (2011) showed that the test crops used in study had high nutritional value. The work of Adetuyi et al. (2011) reported protein content between 13.61 and 16.27 %, fibre content was between

10.15 and 11.63 %, fat (9.03 and 10.57 %) and ash (7.19 and 9.63 %) using *Benin, Auchi, Ikaro, Akure, Okene* and *Lokoja* varieties of okra as test crops. It could be observed that the test crops (*Asontem* and *Enidaso*) used in the study had low fibre and fat contents compared to those used by Adetuyi et al. (2011). Also comparing these results to those reported by Nwachukwu et al. (2014) using Malaysian okra variety as test crop showed that the test crops used in the study had high nutritive value. Proximate analysis of their test crop gave the following results 4.81 %, 2.44 %, 2.44 % and 11.7 % for protein, ash, fibre and carbohydrate respectively. Also the results when compared to those reported by Adewole and Ilesanmi (2011) showed the two varieties of okra used in the study had high nutritive value.

According Zodape et al. (2008), the application of organic fertilizers like liquid seaweed and compost have the ability to influence the nutritional quality of okra. Other studies however, have also reported that nutritional quality of okra depends on the type of cultivar, soil type and cultural practices (Bhist and Bhat, 2006).

**Influence of compost on mineral element contents of edible pods of okra**

Analysis of calcium content of edible pods did show significant difference at compost, variety and interaction levels. It was found out that an increase in application rate gave a corresponding increase in calcium content in edible pods (Table 14). The significant difference in % Ca content could be due to the genetic constituent of each variety. According to Stevenson (1986), Ca uptake by plants is genetically controlled. The significant difference could also be attributed to the

total calcium supplied by the compost since it was rich in calcium (Table 3). Also, the ratio of calcium compared to other cations in solution might have contributed to the significant difference in % Ca in the edible okra pods. Soil pH which was within optimal range might have also played an important role.

Magnesium content in edible pods was not significant. This was same for potassium and sodium. Phosphorus whose primary role is to store energy and transfer this energy for growth and reproductive activities was significant at variety and interaction levels. The significant difference could be attributed to total phosphorus content of compost. The results obtained were high as compared to result of Effiong et al. (2009).

**Effect of compost on pests and diseases control in okra**

Results on the use of compost in controlling pests and diseases showed that the *Asontem* was less resistant to pest and disease. Population of *Podagrica uniformis* recorded on the *Asontem* variety was found to be higher compared to the number sampled on the *Enidaso* variety (Figures 10 and 14). The difference in mean population of pest was significant. The reduction in pest population could be attributed to the inclusion of neem leaves in the preparation of compost. Okutu (2010) reported that neem leaves which contain azadiractin as its active ingredient has insecticidal compounds that deter and control pests and diseases. According to Sambo and Okutu (2010), when neem leaves were included as compost material, they observed significant reduction in grasshopper, various chewing beetles and whitefly population. The work of Spridhar et al. (2002) revealed that neem leaves could be used to control whiteflies, thrips, aphids and grasshoppers in tomato

production when diluted neem leaf extract in soapy water. Further work by Sing and Singh (2000) successfully reported how they used neem seed powder mixed in soapy water to control aphids, whiteflies and diamond black moths. Neem leaf and seed extract has been shown to effectively control insect pests. This buttressed early assertion made by Jacques and Mohamed (2004) that incorporation of compost with neem as added ingredient could suppress pest and disease infestation. They attributed the decline in pest population to the microbiological activity of the compost. They believed that physiochemical and biological properties of the compost could have influenced the suppression capacity. In their study, they reported that the maturity and composition of the compost influenced plant disease suppression. Further work by Akanbi et al. (2004) revealed that compost has the ability to promote the development of healthy root zones which suppress fungal diseases. The addition of compost to the soil does not only suppress soil borne diseases but also reduces foliar pathogens (Boutler et al., 2000). Also, plant ability to develop resistance to pest infestation and diseases is a genetic trait. Studies have shown that compost has the ability to strengthen and increase plant resistance to pests and diseases (Hoitink et al., 1997). The significant difference in resistance and ability of the *Enidaso* variety to tolerate pest and disease could be attributed to the quality and maturity compost that was used in the study.

Analysis of physico-chemical properties of soil used for the field trial showed an improvement with application rate of 200 kg N $ha^{-1}$ recording high values followed by 100 kg N $ha^{-1}$. The unamended soil recorded the least values.

Studies have shown that incorporation of compost leads to improved aggregate stability which reduces compaction and enhance root penetration (Akanbi et al., 2010).Analysis of soil total organic carbon showed an improvement in total organic carbon of the soil as rate of compost application was increased (Table 16). This could be due to the sufficient supply of organic matter which led to increase in soil organic carbon content. There was improvement in exchangeable cations of compost amended soil. Addition of compost could lead to increase in exchangeable cations ($Ca^{2+}$, $Mg^{2+}$ and $K^{+}$). The improved exchangeable bases could be due to the creation of supplementary exchangeable sites which facilitates easy exchange of these cations (KARI, 2000) which were provided by the available cations of the compost. The increase in effective cation exchange capacity (ECEC) could be due to the presence of different functional groups on the surface of organic matter component of the compost which are easily exchanged or replaced with similar or same cation on the soil colloid.

Comparing mean differences between application rates of 100 kg N $ha^{-1}$ and 200 kg N $ha^{-1}$of compost for both pot and field experiments using Duncan's Multiple Range Test (DMRT) showed that there was significant difference among the mean values of N, P, K, Ca and Mg contents analyzed in the stem, leaf, petiole and root of two okra varieties used in the study. Also, there was no significant difference in the mean height of the two test crops, no significant difference in exchangeable $Ca^{2+}$, $K^{+}$, $Na^{+}$, available phosphorus and pH of the compost amended soil. Proximate analysis of edible pods of the two okra varieties showed no significant difference in fibre, fat, ash and soluble carbohydrates contents for

application rates of 100 kg N $ha^{-1}$ and 200 kg N $ha^{-1}$. For economic purposes, an application rate of 100 kg N $ha^{-1}$ was recommended for the experiment.

# CHAPTER SIX

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

An assessment of the value of compost as a soil amendment was carried out. Initial soil analyses showed that the soil was deficient in nutrients. The compost was characterized for pH, total N, P, K and available cations ($Ca^{2+}$, $Mg^{2+}$ and $Na^{+}$). To assess the potential of the compost produced as soil amendment, growth parameters such as plant height, number of leaves and leaf area of two okra varieties were taken at weeks 2, 3, 4, 5, 6 and 7 during pot trial.

Compost for pot experiment was incorporated at rates of 0 kg N $ha^{-1}$, 100 kg N $ha^{-1}$and 200 kg N $ha^{-1}$ representing 0 g, 24.2 g, 48.3 g of compost on weight basis (Appendix E). The experimental design used was a Completely Randomized Design (CRD) with three replicates. Total dry matter of test crops was determined after harvest. Major nutrients analysed in stem, leaf, petiole and root of test crops included nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg).

Field experiment had compost incorporated at rates of 100 kg N $ha^{-1}$and 200 kg N $ha^{-1}$ with 0 kg N $ha^{-1}$as control. This represents 3.33 kg and 6.67 kg and 0 kg of compost on weight basis respectively (Appendix E). Data on plant height and number of leaves of test crops were taken at weeks 4, 6 and 8. Data on population of *Podagrica uniformis* was taken at $4^{th}$, $5^{th}$, $6^{th}$, $7^{th}$, $8^{th}$ and $9^{th}$ week after sowing (WAS). Total fresh weight and total dry matter of edible pods of the two okra varieties were determined after harvest. Selected soil physico-chemical properties examined were pH, bulk density, moisture content, total organic

carbon, total nitrogen, available phosphorus, exchangeable bases ($Ca^{2+}$, $Mg^{2+}$ , $K^{+}$ and $Na^{+}$), exchangeable acidity, effective cation exchange capacity (ECEC) and particle size distribution for textural class.

Specific objectives of the study included an evaluation of the effect of compost on growth rate and dry matter yield of okra, evaluation of nutrient composition and nutritional quality of test crops, an examination of the tolerance of okra to pests and diseases and also an investigation of the effect of compost on some selected soil physico-chemical properties.

Result on nutrient composition for potted okra plants was found to be significant. A favourable pH, ideal moisture content and enhanced ECEC could have influenced the release of readily available nutrients for plant use. The *Enidaso* variety used in the field experiment recorded significant difference in height and leaf number. Mean population of *Podagrica uniformis* was significant with application rate of 200 kg N $ha^{-1}$ of compost recording the least number of pests.

Proximate analysis of harvested edible pods showed that the okra varieties used in the study had high nutritional value. Protein content for *Asontem* and *Enidaso* was found to be 20.3 % and 17.2 %. These values were relatively higher compared to proximate analysis of four local varieties used by Adetuyi et al. (2011). Also, the okra varieties were low in fat and fibre. Analysis of nutrient composition that is; Ca, Mg, K, Na and P contents being the principal elements in the pods were also enhanced.

The study revealed that the use of compost as soil amendment improved soil physical and chemical properties. Soil physico-chemical properties that recorded significant improvement were moisture content, exchangeable $Ca^{2+}$, $K^{+}$ and $Na^{+}$. Others were soil available phosphorus and pH. Also, exchangeable magnesium content, total nitrogen, organic carbon and ECEC of the soil were also increased with a reduction in bulk density.

In summary, compost used in the study improved the low fertility status of the soil. It also enhanced growth, nutrient composition and nutritional quality of okra when used as soil amendment. Okra mosaic disease was found to be severe in *Asontem* than in *Enidaso* making the *Enidaso* variety resistant to okra mosaic disease. The recommended rate of application for the experiment was 100 kg N $ha^{-1}$ due to economic reasons. The null hypothesis of the study was accepted.

Based on the results of the study, there would be the need to carry out series of experiments on the same experimental plot to investigate the residual effect of the compost used on subsequent crops. Future studies could target biochemical characterization of any compost that would be used in future research to determine lignin, polyphenols and other secondary metabolites present. This would enable researchers to recommend to farmers the appropriate organic nutrient sources to be used in preparing compost.

Also, the study could be enhanced by carrying out further investigations on the test crops (*Asontem* and *Enidaso*) as they exhibited varying behavioural responses.

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## APPENDICES

## APPENDIX A

## TABLES OF ANALYSIS OF VARIANCE OF NUTRIENT CONTENTS IN STEM, LEAF, PETIOLE AND ROOT OF OKRA PLANTS AT HARVEST FOR POT WORK

**Table 17: Anova on effect of compost on calcium content in leaves of okra at harvest**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 4.21338 | 1.40446 | 28.45 | <.001 |
| Variety | 1 | 0.70384 | 0.70384 | 14.26 | 0.002 |
| Compost.Variety | 2 | 1.34015 | 0.44672 | 9.05 | <.001 |
| Residual | 12 | 0.78993 | 0.04937 | | |
| Total | 17 | 7.04730 | | | |

**Coefficient of variation: 8.9 %**

**Table 18: Anova on effect of compost on calcium content in petiole of okra at harvest**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 5.36265 | 1.78755 | 65.50 | <.001 |
| Variety | 1 | 0.23010 | 0.23010 | 8.43 | 0.010 |
| Compost.Variety | 2 | 0.14158 | 0.04719 | 1.73 | 0.201 |
| Residual | 12 | 0.43667 | 0.02729 | | |
| Total | 17 | 6.17100 | | | |

**Coefficient of variation: 7.9 %**

**Table 19: Anova on effect of compost on calcium content in root of okra at harvest**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.488246 | 0.162749 | 30.14 | <.001 |
| Variety | 1 | 0.009204 | 0.009204 | 1.70 | 0.210 |
| Compost.Variety | 2 | 0.195712 | 0.065237 | 12.08 | <.001 |
| Residual | 12 | 0.086400 | 0.005400 | | |
| Total | 17 | 0.779562 | | | |

**Coefficient of variation: 10.3 %**

**Table 20: Anova on effect of compost on calcium content in stem of okra at harvest**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.43590 | 0.14530 | 10.59 | <.001 |
| Variety | 1 | 0.22042 | 0.22042 | 16.07 | 0.001 |
| Compost.Variety | 2 | 0.23235 | 0.07745 | 5.65 | 0.008 |
| Residual | 12 | 0.21947 | 0.01372 | | |
| Total | 17 | 1.10813 | | | |

**Coefficient of variation: 12.0 %**

**Table 21: Anova on effect of compost on potassium content in leaves of okra at harvest**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.911100 | 0.303700 | 50.51 | <.001 |
| Variety | 1 | 0.000417 | 0.000417 | 0.07 | 0.796 |
| Compost.Variety | 2 | 0.247683 | 0.082561 | 13.73 | <.001 |
| Residual | 12 | 0.096200 | 0.006013 | | |
| Total | 17 | 1.255400 | | | |

**Coefficient of variation: 4.6 %**

**Table 22: Anova on effect of compost on potassium content in petiole of okra at harvest**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 9.83188 | 3.27729 | 116.92 | <.001 |
| Variety | 1 | 0.21282 | 0.21282 | 7.59 | 0.014 |
| Compost.Variety | 2 | 0.59582 | 0.19861 | 7.09 | 0.003 |
| Residual | 12 | 0.44847 | 0.02803 | | |
| Total | 17 | 11.08898 | | | |

**Coefficient of variation: 7.5 %**

**Table 23: Anova on effect of compost on potassium content in root of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.279546 | 0.093182 | 21.65 | <.001 |
| Variety | 1 | 0.537004 | 0.537004 | 124.76 | <.001 |
| Compost.Variety | 2 | 1.648779 | 0.549593 | 127.69 | <.001 |
| Residual | 12 | 0.068867 | 0.004304 | | |
| Total | 17 | 2.534196 | | | |

**Coefficient of variation: 4.2 %**

**Table 24: Anova on effect of compost on potassium content in stem of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 2.1678125 | 0.7226042 | 825.83 | <.001 |
| Variety | 1 | 0.0051042 | 0.0051042 | 5.83 | 0.028 |
| Compost.Variety | 2 | 0.1648458 | 0.0549486 | 62.80 | <.001 |
| Residual | 12 | 0.0140000 | 0.0008750 | | |
| Total | 17 | 2.3517625 | | | |

**Coefficient of variation: 1.7 %**

**Table 25: Anova on effect of compost on magnesium content in leaves of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 1.32875 | 0.44292 | 11.74 | <.001 |
| Variety | 1 | 0.83627 | 0.83627 | 22.17 | <.001 |
| Compost.Variety | 2 | 0.58710 | 0.19570 | 5.19 | 0.011 |
| Residual | 12 | 0.60347 | 0.03772 | | |
| Total | 17 | 3.35558 | | | |

**Coefficient of variation: 23.8 %**

**Table 26: Anova on effect of compost on magnesium content in petiole of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.362746 | 0.120915 | 34.42 | <.001 |
| Variety | 1 | 3.642604 | 3.642604 | 1037.04 | <.001 |
| Compost.Variety | 2 | 0.424712 | 0.141571 | 40.30 | <.001 |
| Residual | 12 | 0.056200 | 0.003512 | | |
| Total | 17 | 4.486263 | | | |

**Coefficient of variation: 6.6 %**

**Table 27: Anova on effect of compost on magnesium content in root of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 4.54871 | 1.51624 | 17.88 | <.001 |
| Variety | 1 | 1.02920 | 1.02920 | 12.14 | 0.003 |
| Compost.Variety | 2 | 1.05191 | 0.35064 | 4.13 | 0.024 |
| Residual | 12 | 1.35687 | 0.08480 | | |
| Total | 17 | 7.98670 | | | |

**Coefficient of variation: 25.2 %**

**Table 28: Anova on effect of compost on magnesium content in stem of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 3.37548 | 1.12516 | 16.43 | <.001 |
| Variety | 1 | 4.79720 | 4.79720 | 70.05 | <.001 |
| Compost.Variety | 2 | 2.21278 | 0.73759 | 10.77 | <.001 |
| Residual | 12 | 1.09573 | 0.06848 | | |
| Total | 17 | 11.48120 | | | |

**Coefficient of variation: 22.2 %**

**Table 29: Anova on effect of compost on nitrogen content in root of okra plant**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.383383 | 0.127794 | 13.83 | <.001 |
| Variety | 1 | 0.081667 | 0.081667 | 8.84 | 0.009 |
| Compost.Variety | 2 | 0.273200 | 0.091067 | 9.86 | <.001 |
| Residual | 12 | 0.147800 | 0.009237 | | |
| Total | 17 | 0.886050 | | | |

**Coefficient of variation: 10.2 %**

**Table 30: Anova on effect of compost on nitrogen content in leaves of okra plant**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.537079 | 0.179026 | 30.98 | <.001 |
| Variety | 1 | 0.105338 | 0.105338 | 18.23 | <.001 |
| Compost.Variety | 2 | 0.564113 | 0.188038 | 32.54 | <.001 |
| Residual | 12 | 0.092467 | 0.005779 | | |
| Total | 17 | 1.298996 | | | |

**Coefficient of variation: 2.6 %**

**Table 31: Anova on effect of compost on nitrogen content in petiole of okra plant**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.88808 | 0.29603 | 15.61 | <.001 |
| Variety | 1 | 0.00015 | 0.00015 | 0.01 | 0.930 |
| Compost.Variety | 2 | 0.16108 | 0.05369 | 2.83 | 0.071 |
| Residual | 12 | 0.30347 | 0.01897 | | |
| Total | 17 | 1.35278 | | | |

**Coefficient of variation: 9.0 %**

**Table 32: Anova on effect of compost on nitrogen content in stem of okra plant**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.298513 | 0.099504 | 24.20 | <.001 |
| Variety | 1 | 0.100104 | 0.100104 | 24.34 | <.001 |
| Compost.Variety | 2 | 0.068546 | 0.022849 | 5.56 | 0.008 |
| Residual | 12 | 0.065800 | 0.004113 | | |
| Total | 17 | 0.532963 | | | |

**Coefficient of variation: 6.8 %**

**Table 33: Anova on effect of compost on phosphorus content in leaves of okra plant**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.0075125 | 0.0025042 | 5.95 | 0.006 |
| Variety | 1 | 0.0135375 | 0.0135375 | 32.17 | <.001 |
| Compost.Variety | 2 | 0.0502125 | 0.0167375 | 39.77 | <.001 |
| Residual | 12 | 0.0067333 | 0.0004208 | | |
| Total | 17 | 0.0779958 | | | |

**Coefficient of variation: 4.7 %**

**Table 34: Anova on effect of compost on phosphorus content in petiole of okra plant**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.0535333 | 0.0178444 | 67.98 | <.001 |
| Variety | 1 | 0.0104167 | 0.0104167 | 39.68 | <.001 |
| Compost.Variety | 2 | 0.0504500 | 0.0168167 | 64.06 | <.001 |
| Residual | 12 | 0.0042000 | 0.0002625 | | |
| Total | 17 | 0.1186000 | | | |

**Coefficient of variation: 3.6 %**

**Table 35: Anova on effect of compost on phosphorus content in root of okra plant**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.0115000 | 0.0038333 | 6.13 | 0.006 |
| Variety | 1 | 0.0037500 | 0.0037500 | 6.00 | 0.026 |
| Compost.Variety | 2 | 0.0095500 | 0.0031833 | 5.09 | 0.012 |
| Residual | 12 | 0.0100000 | 0.0006250 | | |
| Total | 17 | 0.0348000 | | | |

**Coefficient of variation: 8.8 %**

**Table 36: Anova on effect of compost on phosphorus content in stem of okra plant**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.02164583 | 0.00721528 | 101.86 | <.001 |
| Variety | 1 | 0.00050417 | 0.00050417 | 7.12 | 0.017 |
| Compost.Variety | 2 | 0.00291250 | 0.00097083 | 13.71 | <.001 |
| Residual | 12 | 0.00113333 | 0.00007083 | | |
| Total | 17 | 0.02619583 | | | |

**Coefficient of variation: 2.6 %**

## APPENDIX B

## TABLES OF ANALYSIS OF VARIANCE OFPHYSICO-CHEMICAL PROPERTIES OF COMPOST AMENDED SOIL FOR POT EXPERIMENT

**Table 37: Anova on effect of addition of compost on moisture content of post-treatment soil**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 157.3443 | 52.4481 | 91.78 | <.001 |
| Variety | 1 | 0.4088 | 0.4088 | 0.72 | 0.410 |
| Compost.Variety | 2 | 0.3602 | 0.1201 | 0.21 | 0.888 |
| Residual | 12 | 9.1435 | 0.5715 | | |
| Total | 17 | 167.2569 | | | |

**Coefficient of variation: 4.7 %**

**Table 38: Anova on effect of addition of compost on total nitrogen content of post-treatment soil**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.0005458 | 0.0001819 | 0.66 | 0.588 |
| Variety | 1 | 0.0002042 | 0.0002042 | 0.74 | 0.402 |
| Compost.Variety | 2 | 0.0009458 | 0.0003153 | 1.15 | 0.361 |
| Residual | 12 | 0.0044000 | 0.0002750 | | |
| Total | 17 | 0.0060958 | | | |

**Coefficient of variation: 12.1 %**

**Table 39: Anova on organic carbon content of compost amended soil**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 0.30410 | 0.10137 | 1.84 | 0.181 |
| Variety | 1 | 0.06000 | 0.06000 | 1.09 | 0.313 |
| Compost.Variety | 2 | 0.12723 | 0.04241 | 0.77 | 0.529 |
| Residual | 12 | 0.88380 | 0.05524 | | |
| Total | 17 | 1.37513 | | | |

**Coefficient of variation: 13.3 %**

**Table 40: Anova on exchangeable $Ca^{2+}$ content of compost amended soil**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 43.0400 | 14.3467 | 26.48 | <.001 |
| Variety | 1 | 1.0584 | 1.0584 | 1.95 | 0.181 |
| Compost.Variety | 2 | 2.3816 | 0.7939 | 1.47 | 0.261 |
| Residual | 12 | 8.6677 | 0.5417 | | |
| Total | 17 | 55.1477 | | | |

**Coefficient of variation: 7.5 %**

**Table 41: Anova on exchangeable $K^+$ content of compost amended soil**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 4.725300 | 1.575100 | 242.01 | <.001 |
| Variety | 1 | 0.000600 | 0.000600 | 0.09 | 0.765 |
| Compost.Variety | 2 | 0.005300 | 0.001767 | 0.27 | 0.845 |
| Residual | 12 | 0.104133 | 0.006508 | | |
| Total | 17 | 4.835333 | | | |

**Coefficient of variation: 11.7 %**

**Table 42: Anova on exchangeable $Mg^{2+}$ content of compost amended soil**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 4.5939 | 1.5313 | 2.08 | 0.143 |
| Variety | 1 | 0.0451 | 0.0451 | 0.06 | 0.808 |
| Compost.Variety | 2 | 1.0333 | 0.3444 | 0.47 | 0.709 |
| Residual | 12 | 11.7899 | 0.7369 | | |
| Total | 17 | 17.4621 | | | |

**Coefficient of variation: 71.3 %**

**Table 43: Anova on exchangeable $Na^+$ content of compost amended soil**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 3.60097 | 1.20032 | 115.79 | <.001 |
| Variety | 1 | 0.00540 | 0.00540 | 0.52 | 0.481 |
| Compost.Variety | 2 | 0.00270 | 0.00090 | 0.09 | 0.966 |
| Residual | 12 | 0.16587 | 0.01037 | | |
| Total | 17 | 3.77493 | | | |

**Coefficient of variation: 12.4 %**

**Table 44: Anova on effect of compost on available phosphorus content of soil**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 20789.5 | 6929.8 | 10.04 | <.001 |
| Variety | 1 | 183.7 | 183.7 | 0.27 | 0.613 |
| Compost.Variety | 2 | 535.0 | 178.3 | 0.26 | 0.854 |
| Residual | 12 | 11039.0 | 689.9 | | |
| Total | 17 | 32547.2 | | | |

**Coefficient of variation: 67.1%**

**Table 45: Anova on effect of compost on soil pH**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F - PROBABILITY |
|---|---|---|---|---|---|
| Compost | 2 | 1.976667 | 0.658889 | 105.42 | <.001 |
| Variety | 1 | 0.000000 | 0.000000 | 0.00 | 1.000 |
| Compost.Variety | 2 | 0.003333 | 0.001111 | 0.18 | 0.910 |
| Residual | 12 | 0.100000 | 0.006250 | | |
| Total | 17 | 2.080000 | | | |

**Coefficient of variation: 1.2 %**

## APPENDIX C

## TABLES OF ANALYSIS OF VARIANCE OF PROXIMATE AND MINERAL CONTENTS IN EDIBLE PODS

**Table 46: Anova on effect of compost on moisture content of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 1.7241 | 0.8620 | 1.42 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.0483 | 0.0242 | 0.04 | 0.961 |
| Residual | 4 | 2.4236 | 0.6059 | 2.74 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.5832 | 0.5832 | 2.64 | 0.155 |
| Compost.Variety | 2 | 0.3454 | 0.1727 | 0.78 | 0.499 |
| Residual | 6 | 1.3266 | 0.2211 | | |
| Total | 17 | 6.4512 | | | |

**Replicate CV: 0.4 %, Replicate.Compost CV: 0.6 %** and **Replicate.Compost.Variety CV: 0.5 %**

**Table 47: Anova on effect of compost on ash content of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.0069 | 0.0035 | 0.01 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 7.8691 | 3.9346 | 13.23 | 0.017 |
| Residual | 4 | 1.1895 | 0.2974 | 1.51 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 13.3128 | 13.3128 | 67.81 | <.001 |
| Compost.Variety | 2 | 0.7959 | 0.3980 | 2.03 | 0.213 |
| Residual | 6 | 1.1780 | 0.1963 | | |
| Total | 17 | 24.3522 | | | |

**Replicate CV: 0.3 %, Replicate.Compost CV: 4.1 %** and **Replicate.Compost.Variety CV: 4.7 %**

**Table 48: Anova on effect of compost on fat content of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.11668 | 0.05834 | 0.76 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 1.40801 | 0.70401 | 9.11 | 0.032 |
| Residual | 4 | 0.30906 | 0.07726 | 1.81 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.10125 | 0.10125 | 2.37 | 0.175 |
| Compost.Variety | 2 | 0.24570 | 0.12285 | 2.87 | 0.133 |
| Residual | 6 | 0.25660 | 0.04277 | | |
| Total | 17 | 2.43729 | | | |

**Replicate CV: 5.7 %, Replicate.Compost CV: 11.4 %** and **Replicate.Compost.Variety CV: 11.9 %**

**Table 49: Anova on effect of compost on fibre content of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.0588111 | 0.0294056 | 20.92 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.0835444 | 0.0417722 | 29.72 | 0.004 |
| Residual | 4 | 0.0056222 | 0.0014056 | 1.87 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.1200500 | 0.1200500 | 160.07 | <.001 |
| Compost.Variety | 2 | 4.9567000 | 2.4783500 | 3304.47 | <.001 |
| Residual | 6 | 0.0045000 | 0.0007500 | | |
| Total | 17 | 5.2292278 | | | |

**Replicate CV: 0.7 %, Replicate.Compost CV: 0.3 %** and **Replicate.Compost.Variety CV: 0.3 %**

**Table 50: Anova on effect of compost on protein content of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 42.21 | 21.10 | 1.09 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 10.35 | 5.18 | 0.27 | 0.778 |
| Residual | 4 | 77.25 | 19.31 | 0.95 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 44.84 | 44.84 | 2.21 | 0.188 |
| Compost.Variety | 2 | 9.43 | 4.71 | 0.23 | 0.800 |
| Residual | 6 | 121.85 | 20.31 | | |
| Total | 17 | 305.93 | | | |

**Replicate CV: 10.0 %, Replicate.Compost CV: 16.6 %** and **Replicate.Compost.Variety CV: 24.0 %**

**Table 51: Anova on effect of compost on soluble carbohydrates content of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 5.34653 | 2.67327 | 23.54 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 2.02063 | 1.01032 | 8.90 | 0.034 |
| Residual | 4 | 0.45423 | 0.11356 | 1.55 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.19636 | 0.19636 | 2.69 | 0.152 |
| Compost.Variety | 2 | 31.85201 | 15.92601 | 217.85 | <.001 |
| Residual | 6 | 0.43863 | 0.07311 | | |
| Total | 17 | 40.30840 | | | |

**Replicate CV: 2.7 %, Replicate.Compost CV: 1.0 %** and **Replicate.Compost.Variety CV: 1.1 %**

**Table 52: Anova on effect of compost on calcium content of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.0000111 | 0.0000056 | 0.05 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.0026778 | 0.0013389 | 11.76 | 0.021 |
| Residual | 4 | 0.0004556 | 0.0001139 | 0.24 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.0117556 | 0.0117556 | 25.19 | 0.002 |
| Compost.Variety | 2 | 0.0047444 | 0.0023722 | 5.08 | 0.051 |
| Residual | 6 | 0.0028000 | 0.0004667 | | |
| Total | 17 | 0.0224444 | | | |

**Replicate CV: 0.1 %, Replicate.Compost CV: 1.0 %** and **Replicate.Compost.Variety CV: 2.9 %**

**Table 53: Anova on effect of compost on potassium content of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.003678 | 0.001839 | 1.41 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.005811 | 0.002906 | 2.23 | 0.224 |
| Residual | 4 | 0.005222 | 0.001306 | 0.68 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.000050 | 0.000050 | 0.03 | 0.877 |
| Compost.Variety | 2 | 0.027100 | 0.013550 | 7.07 | 0.026 |
| Residual | 6 | 0.011500 | 0.001917 | | |
| Total | 17 | 0.053361 | | | |

**Replicate CV: 1.0 %, Replicate.Compost CV: 1.4 %** and **Replicate.Compost.Variety CV: 2.4 %**

**Table 54: Anova on effect of compost on sodium content of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.003878 | 0.001939 | 1.05 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.006411 | 0.003206 | 1.74 | 0.285 |
| Residual | 4 | 0.007356 | 0.001839 | 0.71 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.000450 | 0.000450 | 0.17 | 0.692 |
| Compost.Variety | 2 | 0.003033 | 0.001517 | 0.58 | 0.586 |
| Residual | 6 | 0.015567 | 0.002594 | | |
| Total | 17 | 0.036694 | | | |

**Replicate CV: 1.7 %, Replicate.Compost CV: 2.8 %** and **Replicate.Compost.Variety CV: 4.7 %**

**Table 55: Anova on effect of compost on phosphorus content of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.0001333 | 0.0000667 | 0.50 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.0002333 | 0.0001167 | 0.87 | 0.484 |
| Residual | 4 | 0.0005333 | 0.0001333 | 0.67 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.0249389 | 0.0249389 | 124.69 | <.001 |
| Compost.Variety | 2 | 0.0078111 | 0.0039056 | 19.53 | 0.002 |
| Residual | 6 | 0.0012000 | 0.0002000 | | |
| Total | 17 | 0.0348500 | | | |

**Replicate CV: 0.6 %, Replicate.Compost CV: 1.5 %** and **Replicate.Compost.Variety CV: 2.7 %**

**Table 56: Anova on effect of compost on magnesium content of okra**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.010233 | 0.005117 | 1.65 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.010133 | 0.005067 | 1.63 | 0.304 |
| Residual | 4 | 0.012433 | 0.003108 | 0.59 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.024200 | 0.024200 | 4.57 | 0.076 |
| Compost.Variety | 2 | 0.005200 | 0.002600 | 0.49 | 0.635 |
| Residual | 6 | 0.031800 | 0.005300 | | |
| Total | 17 | 0.094000 | | | |

**Replicate CV: 8.2 %, Replicate.Compost CV: 11.1 %** and **Replicate.Compost.Variety CV: 20.4 %**

## APPENDIX D

## TABLES OF ANALYSIS OF VARIANCE OF SOIL PHYSICO-CHEMICAL PROPERTIES OF COMPOST AMENDED SOIL FOR FIELD TRIAL

**Table 57: Anova on effect of compost on bulk density of experimental soil**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.015011 | 0.007506 | 1.23 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.031111 | 0.015556 | 2.55 | 0.193 |
| Residual | 4 | 0.024356 | 0.006089 | 0.85 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.000139 | 0.000139 | 0.02 | 0.894 |
| Compost.Variety | 2 | 0.001244 | 0.000622 | 0.09 | 0.918 |
| Residual | 6 | 0.042767 | 0.007128 | | |
| Total | 17 | 0.114628 | | | |

**Replicate CV: 2.4 %, Replicate.Compost CV: 3.7 %** and **Replicate.Compost.Variety CV: 5.7 %**

**Table 58: Anova on effect of compost on moisture content of soil used for field trial**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 8.5612 | 4.2806 | 1.60 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 2.0170 | 1.0085 | 0.38 | 0.708 |
| Residual | 4 | 10.7161 | 2.6790 | 3.06 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 1.5371 | 1.5371 | 1.76 | 0.233 |
| Compost.Variety | 2 | 2.2433 | 1.1217 | 1.28 | 0.344 |
| Residual | 6 | 5.2525 | 0.8754 | | |
| Total | 17 | 30.3272 | | | |

**Replicate CV: 8.0 %, Replicate.Compost CV: 10.9 %** and **Replicate.Compost.Variety CV: 8.8 %**

**Table 59: Anova on effect of compost on organic carbon content of experimental soil**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.03248 | 0.01624 | 1.09 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.06646 | 0.03323 | 2.23 | 0.223 |
| Residual | 4 | 0.05949 | 0.01487 | 0.74 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.01108 | 0.01108 | 0.55 | 0.487 |
| Compost.Variety | 2 | 0.02936 | 0.01468 | 0.73 | 0.522 |
| Residual | 6 | 0.12123 | 0.02020 | | |
| Total | 17 | 0.32010 | | | |

**Replicate CV: 3.9 %, Replicate.Compost CV: 6.5 %** and **Replicate.Compost.Variety CV: 10.6 %**

**Table 60: Anova on effect of compost on total nitrogen content of soil**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.0008333 | 0.0004167 | 1.79 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.0026333 | 0.0013167 | 5.64 | 0.068 |
| Residual | 4 | 0.0009333 | 0.0002333 | 1.02 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.0000222 | 0.0000222 | 0.10 | 0.765 |
| Compost.Variety | 2 | 0.0002111 | 0.0001056 | 0.46 | 0.650 |
| Residual | 6 | 0.0013667 | 0.0002278 | | |
| Total | 17 | 0.0060000 | | | |

**Replicate CV: 5.6 %, Replicate.Compost CV: 7.2 %** and **Replicate.Compost.Variety CV: 10.1 %**

**Table 61: Anova on effect of compost on available phosphorus content of soil**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 162. | 81. | 0.08 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 4899. | 2449. | 2.32 | 0.214 |
| Residual | 4 | 4217. | 1054. | 0.86 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0. | 0. | 0.00 | 0.993 |
| Compost.Variety | 2 | 927. | 464. | 0.38 | 0.700 |
| Residual | 6 | 7350. | 1225. | | |
| Total | 17 | 17554. | | | |

**Replicate CV: 7.3 %, Replicate.Compost CV: 45.6 %** and **Replicate.Compost.Variety CV: 69.5 %**

**Table 62: Anova on effect of compost on exchangeable calcium content of soil used for field trial**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 2.9748 | 1.4874 | 1.03 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.2681 | 0.1341 | 0.09 | 0.913 |
| Residual | 4 | 5.7699 | 1.4425 | 5.10 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.0027 | 0.0027 | 0.01 | 0.926 |
| Compost.Variety | 2 | 0.0811 | 0.0406 | 0.14 | 0.869 |
| Residual | 6 | 1.6972 | 0.2829 | | |
| Total | 17 | 10.7938 | | | |

**Replicate CV: 5.9 %, Replicate.Compost CV: 10.1 %** and **Replicate.Compost.Variety CV: 6.3 %**

**Table 63: Anova on exchangeable magnesium content of compost amended soil**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.5916 | 0.2958 | 0.64 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 1.4514 | 0.7257 | 1.58 | 0.312 |
| Residual | 4 | 1.8382 | 0.4596 | 1.21 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.2404 | 0.2404 | 0.63 | 0.456 |
| Compost.Variety | 2 | 0.0348 | 0.0174 | 0.05 | 0.955 |
| Residual | 6 | 2.2720 | 0.3787 | | |
| Total | 17 | 6.4284 | | | |

**Replicate CV: 20.5 %, Replicate.Compost CV: 44.2 %** and **Replicate.Compost.Variety CV: 56.7 %**

**Table 64: Anova on exchangeable potassium content of compost amended soil after harvest**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.036478 | 0.018239 | 6.42 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.121211 | 0.060606 | 21.35 | 0.007 |
| Residual | 4 | 0.011356 | 0.002839 | 1.62 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.002939 | 0.002939 | 1.68 | 0.243 |
| Compost.Variety | 2 | 0.005211 | 0.002606 | 1.49 | 0.299 |
| Residual | 6 | 0.010500 | 0.001750 | | |
| Total | 17 | 0.187694 | | | |

**Replicate CV: 12.0 %, Replicate.Compost CV: 8.2 %** and **Replicate.Compost.Variety CV: 9.1 %**

**Table 65: Anova on exchangeable sodium content of compost amended soil after harvest**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.011411 | 0.005706 | 7.55 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.126878 | 0.063439 | 83.96 | <.001 |
| Residual | 4 | 0.003022 | 0.000756 | 0.15 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.003756 | 0.003756 | 0.74 | 0.424 |
| Compost.Variety | 2 | 0.003011 | 0.001506 | 0.29 | 0.755 |
| Residual | 6 | 0.030633 | 0.005106 | | |
| Total | 17 | 0.178711 | | | |

**Replicate CV: 6.9 %, Replicate.Compost CV: 4.3 %** and **Replicate.Compost.Variety CV: 16.0 %**

**Table 66: Anova on effective cation exchange capacity of compost amended soil after harvest**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 8.3377 | 4.1688 | 1.09 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 7.4959 | 3.7480 | 0.98 | 0.452 |
| Residual | 4 | 15.3668 | 3.8417 | 5.10 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.7606 | 0.7606 | 1.01 | 0.354 |
| Compost.Variety | 2 | 0.0884 | 0.0442 | 0.06 | 0.944 |
| Residual | 6 | 4.5214 | 0.7536 | | |
| Total | 17 | 36.5708 | | | |

**Replicate CV: 7.9 %, Replicate.Compost CV: 13.2 %** and **Replicate.Compost.Variety CV: 8.3 %**

**Table 67: Anova on exchangeable acidity of compost amended soil after harvest**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.09101 | 0.04551 | 0.91 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.10388 | 0.05194 | 1.04 | 0.434 |
| Residual | 4 | 0.20059 | 0.05015 | 1.00 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.05445 | 0.05445 | 1.09 | 0.337 |
| Compost.Variety | 2 | 0.08143 | 0.04072 | 0.81 | 0.487 |
| Residual | 6 | 0.30007 | 0.05001 | | |
| Total | 17 | 0.83143 | | | |

**Replicate CV: 75.0 %, Replicate.Compost CV: 136.4 %** and **Replicate.Compost.Variety CV: 192.6 %**

**Table 68: Anova on effect of compost on pH of experimental soil**

| SOURCES OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN SUM OF SQUARES | VARIANCE RATIO | F-PROBABILITY |
|---|---|---|---|---|---|
| Replicate stratum | 2 | 0.007778 | 0.003889 | 0.13 | |
| Replicate.Compost stratum | | | | | |
| Compost | 2 | 0.021111 | 0.010556 | 0.35 | 0.727 |
| Residual | 4 | 0.122222 | 0.030556 | 11.00 | |
| Replicate.Compost.Variety stratum | | | | | |
| Variety | 1 | 0.000556 | 0.000556 | 0.20 | 0.670 |
| Compost.Variety | 2 | 0.007778 | 0.003889 | 1.40 | 0.317 |
| Residual | 6 | 0.016667 | 0.002778 | | |
| Total | 17 | 0.176111 | | | |

**Replicate CV: 0.4 %, Replicate.Compost CV: 1.9 %** and **Replicate.Compost.Variety CV: 0.8 %**

## APPENDIX E

## CALCULATIONS ON APPLICATION RATES OF COMPOST FOR POT AND FIELD EXPERIMENTS USING BULK DENSITY

### Pot experiment

Bulk density for pot experiment was determined in duplicate by weighing two different measuring cylinders of 100 ml capacity. The measuring cylinders were labeled A and A 1.

Weight of empty measuring cylinder A = 106.99 g, weight of cylinder A + fresh soil = 256.47 g

Weight of empty measuring cylinder A 1 = 108.87 g, weight of cylinder A 1 + fresh soil = 253.77 g

Weight f cylinder A + oven-dried soil = 246.54 g

Weight of cylinder A 1 + oven-dried soil = 244.04 g

| Measuring cylinder | Weight of fresh soil (g) | Weight of oven-dried soil (g) |
|---|---|---|
| A | 149.48 | 139.55 |
| A 1 | 144.9 | 135.17 |

Mass of oven-dried soil sample in cylinder A = 139.55g, volume of soil = 100 $cm^3$

Bulk density of soil in cylinder A (g $cm^{-3}$) = $\frac{Mass}{Volume} = \frac{139.55}{100}$

= 1.3955 = 1.4 g $cm^{-3}$

Bulk density of soil in cylinder A 1 (g $cm^{-3}$) = $\frac{Mass}{Volume} = \frac{135.17}{100}$

= 1.3517 = 1.35 g $cm^{-3}$

Average bulk density = $\frac{1.4+1.35}{2}$ = 1.38 g $cm^{-3}$

From bulk density, mass = bulk density x volume, where volume of soil in hectare of land = 0.2 x $10^6$

Mass of soil in hectare of land = 1.38 x 0.2 x $10^6$

= 280, 000 kg or 2.8 x $10^5$ kg

At 100 kg N $ha^{-1}$

280,000 kg soil = 100 kg N of compost

So, 0.8 kg soil = X kg N compost

By ratio and proportion, 0.8 kg (800 g) soil = 0.00029 kg N or 0.29 g N compost

Every 100 g of compost = 1.2 g N

Therefore, X g of compost = 0.29 g N

Using ratio and proportion, 0.29 g N will be contained in 24.2 g of compost

So, application rate of 100 kg N $ha^{-1}$ contains 24.2 g of compost

At 200 kg N $ha^{-1}$ which is twice 100 = 0.29 g N x 2 = 0.58 g N

If every 100 g of compost = 1.2 g N

Y g of compost = 0.58 g N

This means that 0.58 g N will be contained 48.3 g of compost

Application rate of 200 kg N $ha^{-1}$ contains 48.3 g of compost

**Field experiment**

Bulk density (g $cm^{-3}$) = $\frac{Mass}{Volume}$

Mass of soil in hectare of land = 1.38 x 0.2 x$10^6$

= 280,000 kg

1 hectare of land = 10,000 $m^2$

If 10,000 $m^2$ = 280,000 kg soil

Then, plot size of 4 $m^2$= X kg soil

By ratio and proportion, 4 $m^2$ of land contains 112 kg soil

At 100 kg N $ha^{-1}$

If 280,000 kg soil = 100 kg N compost

Then, 112 kg soil = X kg N of compost

This means 112 kg soil contains 0.04 kg N of compost

Every 100 kg of compost = 1.2 kg N

Therefore, Y kg of compost = 0.04 kg N

By ratio and proportion, application rate of 100 kg N $ha^{-1}$ contains 3.33 kg of compost

At 200 kg N $ha^{-1}$ which twice 100 = 0.04 kg N x 2 = 0.08 kg N

If every 100 kg of compost = 1.2 kg N

Then, Y kg of compost = 0.08 kg N

By ratio and proportion, application rate of 200 kg N $ha^{-1}$ contains 6.67 kg of compost