MANAGEMENT SYSTEMS FOR SUSTAINABLE PRODUCTIVITY OF PLANTAIN RATOON CROPS INTERCROPPING SYSTEMS IN THE TROPICAL ULTISOL OF IMO STATE, NIGERIA.

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JULY, 2021.

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CERTIFICATION

We certify that this work was carried out by Iwuanyanwu, Uzoma Prince (20114832538) of the Department of Crop Science and Technology, School of Agriculture and Agricultural Technology Federal University of Technology Owerri.

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DEDICATION

This work is dedicated to all men of goodwill; to the Almighty God for His grace and strength to carry out this work and to my wife, Dr. (Mrs.) Chioma and my children for their immeasurable love for me.

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ABSTRACT

Two field experiments were conducted at Umuagwo, Imo State in 2013 and 2014 cropping seasons to investigate management systems for sustainable productivity of plantain ratoon crops intercropping systems in the tropical ultisol of Imo State, Nigeria. Experiment one was the evaluation of the effect of four organic manure sources on the growth and yield of plantain ratoon crops under different cassava densities and to evaluate weed suppressibility at varying population of plantain ratoon crops / cassava mixture. Experiment two was the evaluation of the residual effects of the organic manure sources and ash on the plantain ratoon/ cassava mixture. The organic manure sources were zero, poultry manure at 10 tons/ha, pig dung at 10 tons/ha and cow dung at 10 tons/ha. The ash was a blanket application each applied at 5 tons/ha as organic amendment. The cassava densities were 100.0 x 50.0 cm (20,000 plants/ha), 100 x 100.0 cm (10,0000 plants/ha) at 100.0 x 200.0 cm (5,000 plants/ha). Experiment one and two were all 3 x 4 factorial experiments arranged in randomized complete block design (RCBD) with 12 treatments replicated three times. Plant height (cm), number of functional leaves, stem girth (cm), leaf area (cm^2), days to 50 % flowering (months), number of hands/bunch, number of suckers/plant, bunch weight (tons/ha), cassava plant height (cm), number of branches, plant canopy cover(m^2), stem yield (bundles/100 stems), weed dry weight (kg/ha), cassava tuber weight (tons/ha) were the evaluated parameters. The result from experiment one showed that organic manure sources had significant effect on the growth and yield of plantain ratoon crops /cassava mixture. Poultry manure at 10 tons/ha performed significantly better in both growth and yield parameters and suppressed weeds when compared with pig dung at 10 tons/ha and cow dung at 10 tons/ha. Experiment two showed that poultry manure at 10 tons/ha + ash at 5 tons/ha performed significantly better in both growth and yield parameters and when compared with pig dung at 10 tons/ha + ash at 5 tons/ha and cow dung at 10 tons/ha + ash at 5 tons/ha. Cassava densities produced significant ($P \geq 0.05$) increase in both growth and yield parameters assessed in the order of 100.0 x 100.0 cm (10,000 plants/ha) > 100.0 x 50.0 cm (20,000 plants/ha) > 100.0 x 200.0 cm (5,000 plants/ha). Poultry manure at 10 tons/ha, + ash at 5 tons/ha + 100.0 x 100.0 cm (10,000 plants/ha) cassava densities were more associated with bunch weight and tuber weight of cassava with 9.47 tons/ha for plantain and 10.52 tons/ha and 18.92 tons/ha and 19.98 tons/ha for cassava root yield both in 2013 and 2014 cropping seasons and in other yield components and may serve as a yardstick for selection of organic manure source, ash and densities. The physical and chemical analysis of the soil in both cropping seasons had that the nutrients persisted in the soil indicating that poultry manure, ash with 10,000 plants/ha cassava density had the best result in 2014 cropping seasons. For maximum production of plantain ratoon crops / cassava mixture, poultry manure at10 tons/ha + ash at 5 tons/ha with cassava density 100.0 x 100.0 cm (10,000 plants/ha) should be adopted.

Keywords: Organic manure sources, ash, plantain ratoon crops/cassava intercropping, sustainability, ultisol.

CHAPTER I

1.0 INTRODUCTION

1.1 Background Information

Plantain (*Musa AAB* group), a giant ratooning perennial plant of family *Musaceae* is an important staple food crop in the humid tropics of sub-Saharan Africa including high rainfall areas of southeastern Nigeria (Emma-Okafor, Obiefuna, Ibeawuchi, Peter-Onoh, Okoli and Keyagha, 2015). Plantain provides more than 25% carbohydrate and 10% of calorie intake of approximately 70 million people to that effect making the crop one of the most important sources of food energy in the region. (Nweke, 1996; Vuyisleke, 2011).

Small holder commercial cultivation of plantain in Nigeria is rapidly expanding to meet the continuously increasing demand for crops especially in the expanding urban centres (Obiefuna, 1986). Nevertheless, several soils supporting plantain in West Africa including those in Nigeria are of low productivity (Woomer and Muchena, 1993 and Swennen, 1990) and consist of about 70% of the tropical soils on which plantain is grown (Echezona, Baiyeri and Alingligh, 2011 and Baruwa, Masuku and Alimi, 2011).

The low yield of plantain and the characteristic rapid yield decline under field condition was usually attributed to soil fertility constraints (Irizarry, Green and Hernandez, 1989; Swennen, 1990; and IITA, 1995). Appropriate agronomic practices such as fertilizer application especially organic and inorganic fertilizer, mulching of plantains with organic materials have enhanced the productivity of the crop. Nitrogen and potassium may be added to the soil through the return of crop residues and ash or through inorganic fertilizers and organic manures (Obiefuna, 1990). According to Swennen (1990), Robinson (1996) Frison (1997), Nkendah and Akyempong (2003), FDA (1999) and Faturoti, Madukwe, Tenkouano and Agwu (2007), plantain and banana are among the most important staple food crops in the humid forest zone of west and central Africa (Ebiowei, 2013).

Traditionally, plantains from compound production systems produce heavy bunch and remain productive for many years (Ndubuizu, 1979). The dumping of house hold refuse around plantain mats as a steady source of organic matter is likely to be one reason for sustained productivity of such compound plantain production (Nweke and Njoku, 1985).

Commercial production of plantain is expanding at a fast rate in Nigeria. The number of commercial orchards has more than doubled in the recent past as a result of national awareness of plantain in production as a cheap but economic agricultural investment compared to other starchy carbohydrate of the low land humid tropics (Obiefuna, 1980).

In addition, research investigation in several areas such as propagules (Obiefuna and Ndubuizu, 1982), agronomy and farming systems (Devos and Wilson, 1978; Wilson 1976), crop protection and fertilizer (Obiefuna, Majumder and Uchegwu, 1981) have furnished the much needed minikit package on plantain production.

Plantain (*Musa spp)* is an important food crop in Sub-Saharan Africa providing more than 25% of the carbohydrate and 10% of the calorie for approximately 70 million people in the region (Swennen, 1990). Plantain is cultivated along the coast of West and Central Africa stretching from Guinea to the Democratic Republic of Congo and Central African Republic (Swennen, 1990). The major producing countries with an annual output exceeding one million tons including Nigeria, Ghana, Cote de' Ivoire and Cameroon. Food and Agricultural Organization, FAO (1997) reports that Nigeria is one of the major producers of plantain in West and Central Africa, but the per capita consumption for Nigeria is the lowest in the region implying the existence of the market potential for increased production in the country. The importance of plantain cannot be over emphasized. Benjamin, Dadzie and Wainwright (1995) showed that both rural and urban populace consume food prepared from plantain in many different forms in Ghana and also in Nigeria.

Cassava, *Manihot esculenta (Crantz)* is a perennial woody shrub with an edible root which grows in tropical and sub-tropical areas of the world (Onwueme and Sinha, 1991). It is the second most important staple food after rice in sub-Saharan Africa as it is tolerant to poor soils and flourishes on well drained friable, loamy soil (Akinsanmi, 1998). As an important staple food crops in sub-Saharan Africa, cassava accounts for more than 100 calories per day in diet of individuals and community (IITA, 1988). The crop can be processed and eaten in various forms. Roots are processed into a wide variety of granules, paste, flour etc or consumed freshly boiled. Also, raw cassava root meals are used as maize substitute for compounding livestock feed (Onwueme and Sinha, 1991).

Cassava is a food crop of great importance. Cassava is a staple food for over 500 million people in the tropical world. In Central Africa, cassava is estimated to provide over 1000 k cal. per day to 30 million people (Cock, 1985). Current trends indicated that the consumption of cassava is on the increase and that the growing of cassava is expanding in semi-arid areas where cassava has not been cultivated for over 20 years ago (IITA, 1979). Thus, FAO (1991) believed that the adoption of disease and pest resistant varieties released by IITA has increased cassava production in many African countries to such an extent that Nigeria has since 1989 become the largest cassava producer in the world. Approximately, 90% of the cassava produced in Africa and Asia is used for human consumption with exception of Thailand where a large proportion of the cassava produced is exported to the European community and used in animal feed formulation (Cock, 1985).

Cassava has comparatively high biological production because of rapid and prolonged crop growth and produces 2.2 times more calories per hectare than maize (FAO, 1986), with a lower resource cost (Hahn, Terry, Leuchner , Akobundu, Okoli and Lal, 1979 and Onwueme and Sinha, 1991). The crop has thus been rapidly adopted by farmers and integrated well into the traditional farming and food system in Africa. Cassava has become one of the most important staple food crops in tropical Africa, because of its efficient production of cheap energy, all year round availability, tolerance to extreme ecological stress condition and suitability to the prevailing farming and food systems in the continent (Hahn, *et al.*, 1979). Cassava is used industrially for production of alcohol, adhesives and starch (Onwueme and Sinha, 1991). However, cassava is considered an inferior food source by many eaters and non-eaters of cassava simply because of its low protein content, although cassava leaves (as vegetables) contain 26.1% quantity of protein on dry weight basis (Hahn, 1983).

1.2 Problem Statement

The productivity of plantain in southeastern Nigeria is marred by poor fruit yield as a result of low fertlity of the soil, on the other hand, cassava has constraints growing with plants such as plantain with broad leaves with heavy broad canopy, besides, weeds are serious problem in crop production. Weeds can reduce crop yield up to between 40 and 60%. Therefore, the research was aimed at development of a management system for improved productivity of plantain ratoon crops intercropped with cassava using different organic manure sources.

1.3 Objectives of the Study

The specific objectives of the investigations were to:

i. determine the effect of organic manures and ash on the growth and yield of plantain ratoon crops under different cassava densities.

ii. ascertain weed suppressibility (suppression efficiency) at varying population of plantain ratoon crop /cassava mixture.

iii. determine the response of plantain ratoon crops in combination with cassava.

iv. ascertain the effects of organic manures and ash on the growth and yield patterns of plantain/cassava mixture.

v. determine the residual effects of organic manure and ash on the plantain ratoon crops.

vi. determine the optimum organic manure source on the growth and yield of plantain / cassava mixture.

vii. assess the residual effect of organic manures on soil physico-chemical properties.

1.4 Justification of the Study

Owing to the bulky nature of organic manures, the cost of transportation and handling constitute a constraint to its use, by peasant farmers; notwithstanding, organic manures can sustain cropping systems through better nutrient recycling and improvement of soil physical attributes (El-Shakweer, El-Sayed and Ewees, 1998). The use of inorganic fertilizers has not been helpful under intensive agriculture because of its high cost and it is often associated with reduced crop yield, soil degradation, nutrient imbalance and acidity (Kang and Balasubramanian, 1990; Obi and Ebo, 1995).

Furthermore, even though the convenience and potency of inorganic fertilizer in terms of easy transportation as well as precision of application both in quantity and location appealed strongly to farmers generally, in the humid tropics (Wiken, 1987); soil exhaustion and nutritional imbalances arising from increased and indiscriminate use of inorganic fertilizer have necessitated need for research on the use of organic manure and ash to produce plantain and cassava mixture.

1.5 Scope of the Study

The objective of the experiment was to determine management systems for surtainable productivity of plantain ratoon crops intercropping systems in the tropical ultisol of Imo State, Nigeria. Four organic manuare soruces and three cassava densilities will be evaluated. The experiment will cover two cropping seasons. Experiment one and two will be 3 x 4 factional experiment arranged in a randomized complete block design (RCBD). The study will not cover the pests and diseases control of the crops to be studied. The two experiments will run concurrently.

CHAPTER II

2.0 LITERATURE REVIEW

2.1 Plantain production in the tropics

It has become imperative in our tropical soils that improved management practices especially through the use of external inputs from different organic and inorganic sources is necessary to enable our crops to be productive. Bationo and Mokwunye (1991) reported that most soils of West Africa, semi arid tropics are derived from acidic parent materials which are poor in clay and nutrients. Besides that, 43% of the tropical soils belong to the acidic low fertility group (Sanchez and Logan, 1992) and 36% of the soil is dominated by soils with low nutrient reserves and low Cation Exchange Capacity (CEC). The predominantly low yield of plantain and the characteristic rapid yield decline under field condition has been attributed to soil fertility constraints (Irizarry, *et al.,* 1989; Swennen, 1990 and IITA, 1995). Appropriate agronomic practices such as application and mulching plantain with organic materials have enhanced production of the crop (Swennen, 1990). Nevertheless, Nitrogen and Potassium which are major elements required by plantain are often the most limiting elements in many tropical soils (Yayock, and Awoniyi 1988) especially in the plantain zones particularly due to luxury or excessive uptake of nutrients by the crop. Nitrogen may be added to the soil through addition of organic manures, while potassium may be added to the soil through the return of crop residues and ash or through inorganic fertilizers and organic manures.

Fertilization is a common cultural practice which the farmers carry out to maximize yield of crops. It is becoming increasingly mandatory with intensive use of land if satisfactory yields are expected. Thus, as a result of high energy cost, inorganic fertilizers have become very costly and also scare (Swennen, 1990; Spore, 2009) especially in the developing countries. Consequently, fertilizer use in most African countries is very low and the use of organic manure is gaining prominence, being readily cheap and comparable with inorganic fertilizer in yield improvement. The soils in the humid tropics for instance, the ultisols and ferralitic soils in Nigeria are known to be low in organic matter and in cation exchange and buffer capacity and are therefore low in soil nutrients (Sanchez and Logan; 1992).

Currently, plantain is grown in 52 countries with world production of 33 million metric tons (FAO, 2004). Production of plantain in Nigeria between 1990 and 2004 indicated a downward trend in terms of yield per hectare, while price per ton has steadily increased within the period. Nevertheless, only eight African countries were named among the top ten world producers of plantain with Nigeria ranking as the fifth highest producer of plantain (FAO, 2004; Shaibu, *et al.*, 2012).

In terms of total production, the banana ranks after oranges, grapes and apples, but when plantain production is added, it becomes the world's number one fruit crop.

Incidentally, most plantains are produced by small scale farmers who often do not have the financial resources for sustained production by means of application of chemical fertilizers, fungicides and pesticides. Farmers attached little premium to the foregoing, and thus apply less, with the belief the plantain can always produce for itself with little organic manure derived from kitchen and animal remains.

On the other hand, black Sigatoka, diseases (a leaf spot of plantain / banana disease) has reduced production resulting in acute scarcity of the crop with the resultant high cost of fruit yield loss of up to 50 % and more were recorded making the disease a major threat to the farm economy in West and Central Africa (Jeger, Eden-Green, Turesh, Johnson and Waller Brown, 1995). Notwithstanding, it is known that profitability is an important concept because it relates to the financial feasibility of expansion of the efficiency of the technical and managerial process.

It is a well-known fact that application of organic manure would go a long way towards helping in the management of soils in the tropics. Even though farmers have adopted the use of inorganic fertilizers, the intensive use of inorganic fertilizers over a long time contributes to soil depletion (Pierri, 1992).

The availability of nutrients on soils is an essential factor for proper growth and development of plants. To obtain high yield, fertilizers are needed to supply the crop with the nutrients they are lacking in the soil (FAO, 2000). Therefore, the use of organic manure in maintaining soil fertility and raising the productivity of crop is an agreeable agricultural practice, in many parts of the world. Organic manure is a major source of Nitrogen, Phosphorus, Potassium and Sulphur in many tropical soils (Olatunji, 2005) and has the potential of improving soil infiltration capacity as well as raising the pH of the soil in acid soils (Olanikan, 2006). The general influence of organic manure on the physico-chemical properties of soils have gained prominence in recent times, thereby attracting renewed interest in its use; organic manure has been known to stabilize soil aggregates and impart beneficial effects in the soil structure (Adeoye, 2005).

It has been reported that over the years a lot of problems tend to militate against the production of this crop especially in the tropics. Some of these problems are weeds. Robinson (1996) reported that weeds are a major constraint in the production of the crop for subsistence farmers. In West Africa, weed growth is very prolific and lack of effective weed control is a major factor that reduces yield and this has led to overall yield decline, currently, most researchers are particularly concerned with identifying management techniques that could reduce weeds without paying attention to the economics of such identified techniques. Anderson (1996) reported that weeds in plantain can be controlled through mulching, use of herbicides and manually.

According to Obiefuna (1989), it is also feasible to control weeds in plantain biologically using Egusi melon (*Colocynthis citrullus).*

2.1.1 Tropical farming system (multiple cropping)

Multiple cropping, the growing of two or more crops on the same field in the same year, is a common form of cropping system in the tropics. For centuries farmers, have taken advantage of all year round favourable temperature and solar radiation, when water is available to produce a number of crops simultaneously on the same piece of land. This form of agriculture in which a mixture of crops is grown in a seemingly random arrangement has been termed and condemned by some agricultural scientists as a ‘primitive’ and ‘disorderly’ method of farming (Andrews and Kassam, 1976). These scientists had predicted that this system of cropping would eventually give way to sole cropping as a natural and inevitable consequence of agricultural development (Grime, 1963).

As a result of increasing interest in multiple cropping researches, especially in the tropical and sub-tropical regions, several workers, (Ruthenberg, 1971; AAASA 1975; Andrews and Kassam, (1976) have attempted to classify and define the various components of multiple cropping. Within the concept of multiple cropping, there are several possibilities of crop arrangements in space and time dimensions. Of importance under discussion is intercropping. Intercropping is the growing of two or more crops simultaneously on the same land in different but proximate stands. This system is the most dominant cropping system in most parts of the tropics including Nigeria. Under this system, planting spaces are usually increased so as to reduce inter-specific competition. Okigbo and Greenland (1976) observed that in West Africa, traditional farmers who practice intercropping usually make mounds or ridges. In Costa Rica, Hart (1975) obtained a Relative Yield Total (RYT) of 1.37 for yields and 1.30 for net income in cassava/maize/beans mixed cropping system.

Row-intercropping is common under conventional tillage conditions and, as was suggested by Sanchez (1976), is perhaps the central concept of intercropping. Several investigations on row intercropping have given relative yield totals (RYTS) ranging from 1.2 to 1.6 (Andrews and Kassam, 1976), while values as high as 2.4 have been obtained in some experimental stations (Sanchez, 1976). Trenbath (1974) showed that crop competition for light under row intercropping systems is minimized when the intercrops have different canopy arrangements. However, Dalal (1974) observed no significant differences in yields between crops grown in rows and those grown under mixed cropping.

2.1.2 Intercropping

Intercropping is usually the growing of two or more crop species on the same piece of land under the same management practices (Norman, 1974). This cropping system has been known as the most widely agricultural practice used in the humid and sub-humid regions and is likely to continue, so far at least to the foreseeable future (Okigbo and Greenland, 1976).

Furthermore, intercropping systems are based on the exact arrangement of crops as hereunder summarized:

They are as follows:-

- **Row intercropping:** when the various crops are grown in separate rows. (Onwueme and Sinha, 1991).
- **Patch intercropping:** when each of the various crops in the field is grown in several small patches interspersed with similar patches of other crops. (Onwueme and Sinha, 1991).
- **Mixed intercropping:** when the various crops are gown intermingled more or less at random with each other. (Onwueme and Sinha, 1991).
- **Relay intercropping:** when a second crop variety is sown between the stands of existing sole crop just before the first crop is harvested. In this situation, both the first and the second crops spend most of their field lives as sole crops

and grow together on the field for only a brief period. Relay intercropping is also seen as a case of overlapping crop rotation. (Onwueme and Sinha, 1991).

Intercropping offers farmers the opportunity to engage nature's principle of diversity on their limited farmlands. The practice ensures sustainable agriculture.

Sustainable agriculture seeks, at least in principle, to use nature as a model for designing agricultural systems, which reduces cost and increase profitability while at the same time sustain farmers' resource base. Intercropping is the growing of two or more crops in proximity to promote interaction between the crops (Willey, 1983). The system is commonly practiced by small-scale farmers in developing countries like Nigeria.

Sustainable agriculture simulates natures system as the model for designing agricultural system. Since nature consistently integrates plants and animals into a diverse landscape, a major principle of sustainable agriculture is to create and maintain diversity. Output from one organism becomes input for another. Intercropping is used to reduce cost and increase profitability, while at the same time sustaining land resource base (Grossman and William, 1993). Martin, Ralph, Don Smith and Harre Voldarg (1987) reported that when two or more crops are growing together, each must have adequate space to maximize co-operation and maximize competition between them.

2.1.3 Early Practice of Inter-cropping

Traditional farmers practice intercropping for several reasons. Probably the most important reason being that gross returns per unit area of land under intercropping are usually higher than under sole cropping (Crookston and Kent, 1976; Okigbo and Greenland, 1976). Also, this system offers them insurance against monocrop failures, helps control soil erosion, weeds infestation and enables a more even distribution of labour. It has been reported that intercropping however, does not always result in increased yield of each component crop in a mixture. A few investigators have reported a reduction in the yield of each component crop (Enyi, 1973b). In other instances, there has been an increased yield of one component and a reduced yield of the other (Agboola and Fayemi, 1974).

The overall effect of intercropping has, however, been an increased land productivity in terms of total returns, and land equivalent ratio (LER), but generally a decrease in the mixture yield of each component species (CATIE, 1977; IITA, 1974, 1976, 1979; CIAT, 1979). Other reports by various researchers (Andrews and Kassam, 1976) confirm that sweet potato can be grown and mixed with the following erect crops: - upland rice, guinea corn, soya beans, plantain, cocoyam and cassava. Purseglove (1968) had reported however, that sweet potato is shade tolerant. The effect of interference between roots of crops in a mixture (Baldwin, Nye and Tinker, 1973) reported that large reductions in uptake occur between the roots that are clumped rather than where the roots are randomly distributed. A related study (Andrews and Newman, 1970) noted that if the components of mixture have similar root properties, the mobile nutrients in the volume of the root systems are shared in proportion to the length of the roots present in the volume.

The practice of intercropping has been so interwoven into the socio-economic life of Nigeria peasant farmers that attempts to introduce systems foreign to their environment and tradition have met with little success (Nye and Greenland, 1960; Webster and Wilson, 1989). In addition, mechanized field operations are difficult to implement in intercropping system (Okigbo and Greenland, 1976).

2.2 Importance of plantain in Nigeria

Several researchers have shown that the demand for plantain within the country has increased with supply struggling to meet demand. This has hindered the status of plantain as a foreign exchange earner. It remains an important staple food both as raw material for preparing many products. It not only serves as a source of revenue for many people but also a raw material for industries producing value added products in many parts of Nigeria. Plantain occupies an important role in rapid food production, being a perennial ratoon crop with a short gestation period. The crop ranked third among starchy staples after cassava (*Manihot esculenta*) and yam (*Dioscorea spp*). It is a major source of carbohydrate for more than 50 million people. In Nigeria, all stages of the fruit (from inmature to overripe) are used as a source of food in one form or the other.

The immature fruits are peeled, sliced and fried with palm oil and served as snacks (dodo –ikire). Industrially plantain fruits serve as composite in the making of baby food ("Babena and "Soyanmusa), bread, biscuits and others (Ogazi, 1996;

Akyeampong, 1999). Even though the fruits are produced all year round, the major harvest comes in the dry season (November to February), when most other starchy staples are unavailable or difficult to harvest. The plantain plays a very important role in bridging the hunger gap (Wilson, 1986) as well as assisting farmers in having cash at hand through sales of plantain. In Nigeria, plantain peels are used as feed for livestock, while the dried peels are used for soap production. The directed leaves, sheath, and petioles are used as tying materials, sponges and roofing materials. Plantain leaves are also used for wrapping, packing, marketing and serving food.

In comparison with the situation in the past three decades where plantain was regarded as food for the elites in the cities or food for birds in some villages, plantain products (chips, flour) are now flooding the streets, even in the dry, non – plantain regions of Nigeria. Presently, quite unlike few years into a big business, both in major cities and small towns in Southern parts of Nigeria. There are over 2000 small scale plantain chips processing business and several medium scale producers in the Lagos metropolis alone. In the Southwestern Nigeria, many plantain flour processors are developing and the market seems to be expanding each day.

Plantain and their products are high in demand and this is reflected by the relatively high price of plantain compared with other starchy staple crops with the exception of yam in Nigeria. The production is relatively static despite the high demand mostly as a consequence of the increased incidence of black Sigatoka disease which has a strong influence on yield, and the green leaves and other diseases and pests (Ramsey, Daniel, and Anderson, 1990). Declining soil fertility has also been implicated (IITA, 1997) as a cause of low production of plantain thus making it imperative to look for alternative source of replenishing soil nutrient in plantain production. Normally, the production of food in Nigeria is mainly practiced by rural small holder farmers who produce mainly cassava, yam, cocoyam and plantain. Small holder farming systems as virtually practiced in the rain forest zone is dependent on fallow periods and this practice has progressively resulted in depletion of soil productivity. The situation has worsened with rapid population growth. As farm family holdings decreased, farmers are forced to practice continuous cultivation, cultivating the same farm year in year out usually without fertilizer application has become essential in food and cash crop production (Obiefuna, 1987).

Farmers over time have developed complex mixed cropping systems which have usually poly cultural and suited to certain agro – ecological environment (Obiefuna, 1987). Plantain based inter cropping system is predominant in the tropical rain forest zone (Karikari, 1971; Ruddle, 1974; Wilson, 1976) and it ranks first in Nigeria (Ndubuizu, 1979). Experimental reports in plantain intercropping with food crops such as cassava, cocoyam and maize etc., showed high productivity per unit area of inter – crop over sole cropping of either of the components, (Devos and Wilson, 1978 and Karikari, 1980).

Plantain production is expanding rapidly in West African sub-region including Nigeria, where the crop has become a priority carbohydrate staple food (FAOSTAT, 2010; Shaibu, Maji and Ogbonna, 2012). Some production problems have been in Nigeria to support the sustained productivity of the commercial orchards. These include propagules evaluation, weed competition and plantain inter-crop arrangement, economic fertilizer levels for optimum production (Obiefuna, 1980; Ndubuizu, Obiefuna and Manufor, 1981) and the frequency of fertilizer application (Ndubuizu, 1978). Furthermore, fertilizer is important for the growth and development of suckers during the first three months after planting to enhance hand and finger numbers, both of which determine the yield (Twyford and Walmsley, 1973), In plantain, however, the transition from vegetative to reproductive phases occur about 24^{th} leaf stage, 4 – 5 months after planting (Ndubuizu, Obiefuna and Manufor, 1981) but may be longer as a result of environmental factors such as climate change etc.

Banana and plantain *(Musa species L.)* are important staple food crops and sources of rural income in most parts of sub – Sahara Africa, especially for the small holders who grow them in compound garden (Chandler, 1995). Apart from the production in heavily manured compound farms, produced in small fields, *Musa* crops are produced under shifting cultivation and bush fallow, with yield declining rapidly after a few production cycle (Wilson, Swennen and De Langhe, 1989).

It has been reported that plantain responds positively to large amounts of mulch and organic matter. The high productivity of plantain under small holder compound production systems has always been attributed to continuous heavy application of organic manure in the form of compound sweeping, livestock and kitchen wastes, including miscellaneous wastes, water and wood ash thrown around the cultivation. (Ani and Baiyeri 2008 and Association of Officals of Analytical Chemists (AOAC, 1990), animal manure is a valuable source of crop nutrient and organic matter which improves soil biophysical conditions thus making the soil more productive and sustainable (Mugwira, 1979).

Plantain is a versatile crop in the kitchen as well as raw material for many popular delicacies and snacks. However, while the snacks and delicacies may be widespread throughout the country, it is only in the humid region that it is a major staple food (Ogazi, 1996). Devos, Wilson and De-langhe (1978) reported that plantains are the sources of the cheapest carbohydrate foods in terms of cost per hectare, per ton and per calorie. Nutritionally, plantain is a good source of carbohydrate and is also rich in potassium and pro-vitamin A (Carotene). Gastro intestinal disorders such as diarrhea and vomiting can be treated with plantain. Plantain has also been found useful for medicinal practices by traditional doctors. Derivatives are used by herbalist as a component of treatments for gonorrhea, vomiting, sour throats and as a source of virility in curing diabetes. (Ogazi,1996). Plantain is also used as raw materials for the baking industries. The plantain flour is a close substitute to wheat flour (Ogazi, 1982).

2.3 Organic plantain production

Organic plantain production is an old practice in a relatively new concept in Nigeria agriculture. Before now, the subsistence plantain production is based on zero fertilizer application with the crop invariably in the soil. When planted in backyard gardens, household residue is commonly used to enrich the soils. Lack of fertilizer application or inadequate nutrient availability is cited as one of the causes of low plantain yield in Nigeria (Baiyeri and Ajayi, 2005). The empirics of organic plantain production in Nigeria are still scanty. Up until now, only a handful of studies of economic aspects of organic farming in tropical countries have been published (Gibbon and Bolwig, 2007). A lot of research works have nevertheless been conducted on the use of different rates of chemical fertilizers (inorganic fertilizers) in plantain production in Nigeria. (Aiyelaagbe and Kiatomo, 2002; Anjorin and Obigbesan, 1983).

Generally, plantain production in Nigeria is in small farm holdings with an average size of 1 hectare and the enterprise is confronted with a diversity of problems, which include among others, attacks by black Sigatoka disease (Obiefuna, *et al.,* 1981), lack of disease free materials, rapid yield decline (Obiefuna and Ndubuizu, 1983), high stem borer and nematode susceptibility (Braide and Wilson, 1982), slow suckering, lodging, seasonality of productivity and low storage life, and pilfering (Karikari, Marrioh and Hutuchins, 1979). Tisdale, Nelson, Beaton and Halvin (1990) reported the importance of adequate supply of plant nutrients to ensure efficient crop production for a long period of time. Contrarily, Palm, Myers and Nandwa (1997) reported on the use of organic manure alone to sustain cropping to be inadequate due to unavailability in the required quantities and its relatively low nutrient content. It is however reported that the nutrient contained in organic manure are however released more slowly and are stored for a longer time in the soil, thereby ensuring long residual effect (Sharma and Mittra, 1991). The nutrients for organic source may be adequate for a long duration crop like plantain, which requires that nutrients be supplied to the plant throughout the growing period. (Obiefuna and Ndubizu, 1983).

Adeoye (2005) stated that organic manure has been known to stabilize soil aggregates and impact beneficial effects on the structure of the soil. Nwajiuba and Akinsanmi (2002), in their study conducted in a humid tropical environment reported that returns per hectare were higher for organic farms, though output was slightly less in such farms.

The importance of Soil Organic Matter (SOM) in restoration of soil fertility and development of good soil structure has been widely studied by (Igwe and Nwokocha, 2006; Palm, *et al.,* 1997; Palm, Gachengo, Delve, Cadesch and Giller, 2001; Koulika, Bartoli, Andreux, Burtin, Chome and Phlipy, 1997). Furthermore, organic matter in soil serves several functions, such as source and sinks of trace and plant available elements, improving soil aggregation and stability, maintaining soil tilth and minimizing soil erosion. The overall functions of organic matter are through its different fractions (Adesodun, Mbagwu and Oti, 2007).

Braide and Wilson (1980); Swennen and Vuyisleke (1989) both put forward other reasons for rapid yield decline in plantain production to include inhibited suckering, low levels of soil organic matter, reduced root ramification and the presence of pests and diseases. Echiribi (1996) stated that low yield in plantain production could be due to diseases and pests, weeds topping of plantains weakened by infestation of weevils and nematodes, inherent low soil fertility, poor crop and soil management and the use of poor quality propagules.

Organic farming uses organic manure which is basically waste materials such as decomposed animal dung, farm yard manure, oil cakes, animal bone crush etc. which are natural sources of major plant nutrients like Nitrogen (N), Phosphorous (P), and Potassium (K). The advantage of using organic manure include; release of plant nutrients slowly for the uptake of plants, preservation of the quality of soil to bear the plant on sustainable bases as well as provision of proper aeration and food as the useful soil microbes such as bacteria and fungi which assist the plant to prepare and assimilate food (Ihejirika, Nwufo and Amadi, 2009).

2.4 Merits of Organic Agriculture

Organic agricultrue is based on production standard that require no synthetic inputs, instead using practices modeled on ecological processes to increase soil fertility and discourage pest infestation and disease infestation in the fields, pens and ranges. In other words, animals such as pigs lie in pens, while cows feed on rangelands. (Ibeawuchi, Obiefuna, Tom Ihejirika and Omobvude, 2015). Priors to era of inorganic ferlizers, our forefather farmers usually restore fertility through the length of fallow period which may be 8 -16 years and at times 20 years. Organic matter has been found to exerts a profound influence on crop nutrition, soil structure and cultivation. (Zhang, Li, Zhang, Christie and Li, 2020).

The merits of organic agricultrue are as follows:

Soil Management: The use of crop rotation in organic agriculture is helpful in the provision of nitrogen through legumes. Intercropping is also used for insects and diseases control in organic farming. Crop residue can be ploughed back into the soil and different plants leave different amounts of nitrogen, potentially aiding synchronization (Asiabaka, 2009).

Low Cost of Production: "Organic method requires no synthetic fertilizers and pesticides. The decreased cost of these inputs increases profit for organic farmers. In 2008, the United Nations International Childrens Emergency Fund (**UNICEF)** issued a report that stated that "Organic agriculture can be more conducive to food security in Africa than conventional production system, and that is more likely to be sustainable in the long run". The report which assessed 114 projects in 24 African countries found that yields had been more than doubled where organic or near-organic practices had been used and that soil fertility and drought resistance improved.(http://www.independent.co.uk/new/world/africa/organic-farming-cold-feed-africa-96864.html). (Howden, 2000).

Food Safety: Food produced from organic agriculture is widely believed to be healthier than conventional agricultural production, though not fully supported by research on humans; animals fed on organic food appear to have slightly better health and reproductive performance.

High Antioxidant Level: Food produced from organic agriculture contains several antioxidants (almost 30%). This assists in fighting the oxidants in the body. There is absence of growth hormones in crops and animals produced in organic agriculture. Organic foods are free from Genetically Modified (GM) products. This makes food natural and less harmful.

2.5 Crop mixture (Plantain / Cassava)

The response of plantain to spacing and densities are variable. Yield increases were not readily obtained in plantain production between 800 – 1300 plants / ha (Vincente and Figerella, 1962). Nevertheless, Obiefuna (1989) observed sharp increases in number of fruits per acre by increasing plant density from 1000 – 1450 (2439 – 3036/ha) plants, per acre. Irizarry *et al., (*1989) suggested that close plant spacing prolonged the time before the main harvest. In their work on plant spacing and sucker management for commercial plantain in the rainforest belt of Nigeria, Obiefuna, Majumder and Ucheagwu (1982) reported that yield of plantain significantly increased with increased plantain population per hectare. Plant population of 2000, 1600 and 1333 per hectare were evaluated. They recommended that maintaining two suckers per root at a spacing of 2.5 m x 2.5 m (1600 plants/ha) be recommended for farmers considering the sustained high yield and acceptable finger size for over three harvest cycles.

Obiefuna (1989) in his investigation on the productivity of plantain intercropped with cassava, cocoyam and yam, fertilized annually with and without nitrogen respectively observed that yield from Nitrogen fertilized intercrops were higher than those of unfertilized treatments. Obiefuna (1989) recommended plantain + yam or cocoyam intercropping system fertilized with 320 kg N/ha because of improved plantain established and increased combined crop yield. It has been reported that plants with ample space will compete with less environmental factors (Baloch, Soomro, Javed, Ahmed, Bughio, Bughio and Maston, 2002).

Trenbath, (1974) reported that the main problems of fertilizer use in intercropping systems are that the companion crops have different nutritional needs and that the periods of maximum demand for one crop does not necessarily coincide with the associate crops. It is therefore important to keep as much as possible about the nutritional requirement and growth characteristics of the crop which are to be grown together in a specific cropping pattern. Maize for example, requires high amount of nitrogen for a good yield allowed by phosphorus and potassium. Cassava requires large amount of nitrogen, phosphorous and potassium from the soil because of high root yield only.

2.6 Sources of organic manure

Fertilizers are substances when added to the soil supply one or more plant nutrients. Organic manures have been known to improve soil structure, water, air and nutrient retention in the soil, buffer soil chemical imbalances and support living organisms etc. (FAO, 2006).

Lombin and Abdullahi (1997), reported that poultry manure is the richest known animal manure. Its cheepness and effective contribution to soil enrichment is essential for establishing and maintaining the optimum soil physical conditions for plant growth and yield (Mangila, Tabilitan, Naguit and Malate (2007); Enujeke, 2013a; Adekiya and Ojeniyi (2002) reported that high rate of poultry manure improve moisture availability which results in improved nutrient release to plants for increased growth and yield. Poultry manure has long been used by early farmers as a source of nutrient and its benefits has been fully realized because of its cheapness (Wehner and Gunner, 2004). Improvement in environmental condition with respect to public health has been observed as some of the major reasons for the need to adopt organic farming by farmers in the world (Eifediyi and Remison, 2010).

Table1: Average composition of some common natural organic materials.

Organic material	Composition (% by weight)						
	N	P	K	Ca	Mg	S	Cl
Activated sewage sludge	6.0	1.0	-	1.8	0.9	0.4	0.5
Blood (dried)	13.0	-	-	0.4	-	-	0.6
Bone meal (raw)	3.5	19.8	-	22.5	0.6	0.2	0.2
Bone meal (steamed)	2.0	12.2	-	23.6	0.3	0.2	-
Castor pomace	6.0	0.6	0.4	0.4	0.3	-	0.3
Cocoa meal	4.0	0.6	2.1	0.4	0.6	-	-
Cocoa shell meal	2.5	0.4	2.5	1.1	0.3	-	-
Cocoa tankage	2.5	0.6	1.0	12	-	-	-
Cottonsed meal	6.6	1.1	1.2	0.4	0.9	0.2	-
Fish scrap (acidulated)	5.7	1.3	-	6.1	0.3	1.8	0.5
Fish scrap (dried)	9.5	2.6	-	6.1	0.3	0.2	1.5
Garbage tankage	9.5	0.6	0.8	3.2	0.3	0.4	1.3
Peanut meal	7.2	0.6	1.0	0.4	0.3	0.6	0.1
Peanut hull meal	1.2	0.2	0.7	0.4	0.3	0.6	0.1
Peat	2.7	-	-	0.7	0.3	1.0	1.1
Peruvian guano	13.0	5.5	2.1	7.9	0.6	1.4	1.9
Process tankage	8.2	-	-	0.4	-	0.4	-
Soyabean meal	7.0	0.5	1.3	0.4	0.3	0.2	-
Tankage (animal)	7.0	4.3	-	11.1	0.3	0.4	-
Tobacco stems	1.5	0.2	4.2	3.6	0.3	0.4	1.2
Whale guano	8.5	2.6	-	6.4	0.3	-	-

Manure source	N	P	K	Organic
Dairy manure	0.7	0.1	0.5	30
Goat manure	2.8	0.6	2.4	60
Horse manure	0.7	0.1	0.4	60
Pig manure	1.0	0.3	0.7	30
Poultry manure	1.6	0.5	0.8	50
Rabbit manure	2.0	0.6	1.0	50
Sheep manure	2.0	0.4	2.1	60
Steer manure	2.0	0.2	1.6	60

Source: Fairbridge and Finkl (1979), from Tisdale and Nelson (1966); cf Table P.3

2.7 Application of organic manure

Srivastava and Srivastava (2007) stated that organic manure is refered to the bulky materials, mostly derived from farms and animal waste products such as compost, cow dung, farm yard manure, slurry, sewage, sludge etc. Sources of organic manure include horse, sheep, goat, pig and poultry droppings and plant residues as hay, legumes, non legumes, straw, alfalfa, pellets and seaweeds (Parnes, 1990), (see Table 1). Dunn (1994) identified compost, plant materials (straw and dry leaves), garden wastes and green manure as forms of organic manure that are commonly used by farmers to improve soil fertility. Organic manure through their multi-benefical soil amendment (Ibeawuchi, Nwufor, Oti, Opara and Eshett, 2007), served as nurtient sources in crop production and agent of soil micro-climate regulation and conservation (Ibeawuchi, Obiefuna, Alagba, Okoli, Ofor, Emma-Okafor, Iwuanyanwu, Nze and Peter-Onoh, 2015; Emma-Okafor Obiefnna, Iwuanyanwu, Okoli Keyagha, Alagba and Ibeawuchi, 2019; and Ibeawuchi *et al.*, 2015). Dupriez and De Leener (1988) reported that manures promote the activities of soil micro organism and convert organic matter into humus and promote plant growth. It has been reported that improvement of soil organic matters is favoured where decomposition is slow, nevertheless, decomposition of organic matter is strongly influenced by temperature and soil moisture. This indicates that nutrients may be released when the plants does not need them owing to the fact that nutrient content is low in organic fertilizers, and only a limited growth of organic materials is available to many regions, it is generally hard to meet crop nutrient demand through organic fertilizer alone (Morris, Kelly, Kopock and Bayerlee, 2007).

Organic manures have been known to promote nutrients and contribute to the quality of soil by improving the chemistry and biological activities of the soil. To that effect, they are known for the gradual release of nutrients and also increase soil organic matter (Sarkar, Singh and Singh, 2003). It has been reported by Tisdale, Nelson, Beaton, and Halvin, (1990) that organic matter from manure provides energy for microbial activity, increases water holding capacity and yield of crops. Wolf (1997) reported that the required quantities of organic manure applied to the soil will directly affect vegetative growth and yield of green manure as obtained from legume crops which are grown as cover crops and later worked into the soil.

A report from Xu, Wang, Xu, Mridha and Goyal (2005) showed that vegetables grown with higher levels of organic manure grew better and resulted in a final higher, total yield than those grown on lower amounts along with those grow with mineral fertilizer. Zhang, Xu and Zhang (2009) also reported that regular application of organic manure brings about increase in nitrogen, phosphorus and soil organic carbon (SOC). Report from Tiamiyu, Ahmed and Muhammad (2012) showed that higher yield response of crops as a result of application of organic manure could be as a result of improved physical and biological properties of the soil bringing about better supply of nutrients to the plants. Furthermore, Jahan, Koocheki, Gborba, Nassiri and Salari (2013) reported that fruit and seed yield of squash was increased by application of higher rate of organic manure. In an experiment conducted by Hochmuith, Hochmuth and Donely (1993) to investigate the response of cabbage yield, head quality and leaf, nutrients status to poultry manure fertilization, observed that yield of cabbage responded quardratically to increasing rates of poultry manure with maximum yield of

28t/ha. Olatunji, Ayuba and Oboh (2006) reported that poultry manure gives the greatest increase in growth and yield in okra and tomatoes. Similarly, Kahangi (2004) recommended the application of 10 – 20t/ha poultry manure for improved growth and yield of carrot in the tropics. In their experiments, Dauda, Ajayi and Ndor (2008) and Agbede, Ojeniyi and Adeyamo (2008), attributed the vigorous growth of water melon to increased supply of nutrient elements from higher rates of poultry manure. Agba and Enyi (2005); Eifediyi and Remison, (2009) and Lawal (2005) had all reported increase in growth and yield components of cucumber to applied fertilizer. Hussain (2009) observed in his experiment that nutrients present in the leaves of cucumber increased gradually with increasing levels of sewage sludge application. It was very obvious in the plant tissue analysis data which showed that micro nutrients increased with increasing levels of sewage sludge application. Ebrahim, Hassan, Ashad and Tanveer (2010) reported positive effect of cow manure and urban waste compost on length of wheat plant. Adeloju, Fawole, Abubakar and Olaniyan (2010) also reported that nutrients from mineralization of organic matter promoted growth and yield of cucumber. Similarly, Frempong, Ofasu-Anim and Blay (2006) reported a significant increase in the number of branches on poultry manure treated plots compared to the control. More so, Collen and Chitamba (2014) reported that 20t/ha of cattle manure supplied enough nutrients, that could support appropriate nutrient and growth of cucumber plant than when no treatment was applied. An experiment conducted by Elamin (2006) showed that fertilizer treatment (Chicken manure) significantly delayed time of flowering of squash compared to control.

Ewulo (2005) reported that poultry manure contains high percentage of nitrogen and phosphorus for the healthy growth of plants. Adenawoola and Adejoro (2008) found that poultry manure at application rate of 30 to 50 tons/ha gave higher biomass marketable and edible yield of *Corchorus olitorus*, compared to application of 10 and 20 t/ha and recommended the rate of 40 t/ha as the best for the crop in southearthen Nigeria. Shafiee Zargar (1996) also reported that 30t/ha of cow manure produced the highest number of cucumber per plant.

Enujeke (2013a) and Mangila *et al.*, (2007) reported that poultry manure is essential for establishing and maintaining the optimum soil physical condition for plant growth. Enujeke (2013b) also attributed the higher yield of improved maize from the application of high rates of poultry manure. In separate experiment El-Badawin (1994) and Lawal (2000) attributed the significant response of cucumber fruit weight per plant to applied organic manure. Similarly, John, Jamer, Samuel and Warner (2004) observed vigorous growth and increased fruit yield of water melon to higher supply of nutrient elements from applied organic manure. The yield of water melon was high owing to adequate supply of nutrient elements from the applied organic manure. In an experiment carried out by Rue (1998) using compost manure obtained from dairy manure and municipal solid waste to find out effects on broccoli, observed beneficial effect on growth, yield and nutrient components with compost application.

Ogunremi (1990) reported increased yield of water melon fruit due to organic manure application. In the same vein, Lawal (2000) reported that improved supply of plant nutrients to cucumber by the application of pig manure would lead to better utilization of carbon and subsequent synthesis of assimilates.

Sinnadurai (1992) reported that poultry manure being an organic manure source has a significant amount of nitrogen. John, Rusell and Andrew (2013*)* assessed the effect of different cattle manure levels on organic production of squash. They observed that increasing the manure levels had a significant effect on fruit and seed yields of squash. Barrelo and Dynia (1998) also reported that 42 t/ha of cattle manure was economically beneficial to cowpea.

Ewulo, Hassan and Okeniyi (2007) reported that 10 t/ha of cow dung when compared with control gave highest growth and yield parameter of pepper. It has also been reported by Esse, Buekert, Hiernauz and Assa (2001,) in a experiment using pearl millet at the applied dry matter rate of 18.8 t/ha, the quantities of N, P and K released from the sheep and goat manure dungs during the wet season was 10 times more than the annual nutrient up take. Sharma, Saurabi and Kumar (2009) reported that organic manure improved the physical and chemical properties of the soil and supply nutrients sufficient for plant growth. Aliyu (2000) also reported increase in seed and fruit yield in sweet pepper as a result of poultry manure application. Dauda *et al.,* (2008) also reported that poultry manure supplied essential nutrients for enhanced productivity.

In an experiment by Dauda (2002), who reported that days to 50 % flowering is a function of nitrogen concentration supported by poultry manure. Similarly, Jiliani, Afzad and Waseem (2008) reported that deficiency of major nutrients was brought about by longer days to flowering. According to Nimala, Vadivel and Azakiamanavalan (1999); the induction of early flowering due to the application of the process of bio regulators which have an influence in early flowering. Aboul El-Magad, Hoda and Fawzey (2005) also reported that when poultry manure was applied, it improved the soil physical and biological properties and provided the macro and micro nutrients requirements of the plant thereby increasing yield of broccoli.

Suge, Omunyin and Omami (2011), reported a significant effect of fruit diameter of egg plant under organic manure application. Devi, Maity, Pavia and Thapa (2012) found that combined form of organic manure brought about highest yield of egg plant, Ullah, Islam and Haque (2008) also reported a positive impact of organic manure application on the fruit diameter of bringa. Ullah, Islam, and Haque (2008) in an experiment also carried out using egg plant observed that more fruit lengths of egg plant could be attributed to combined application of organic manures. Similarly, Moradiotchaee, Bozorgi and Halajisani (2011), observed that the use of vermicrompost significantly increased fruit length by supplementation of optimum nutrient that helped in improving growth and yield attribution of egg plants. Aliyu (2000) and Dauda, Aliyu and Chuzey (2005), reported increased growth of plant with increased poultry manure rates. Adekiya and Ojeniyi (2002) found that increased growth of crop plants were as a result of release of more nutrient elements through the moisture that have been made available by organic manure.

Olayinka and Ailenubhi (2011) stated that a greater part of the benefit of animal sources lied in their slow mineralization and the addition of organic matter to the soil which offered a definite advantage over inorganic fertilization. Ajari, Tsado, Oladiran and Salako (2003), reported that organic manure especially poultry manure could increase plant height and branches of crops. Similar, Correy, (2003) reported that organic manure release nutrients such as nitrogen and phosphorous for the healthy growth of plants. Rodrigo, Del-Val, Roberto, Horacio and Erick (2012), reported that nitrogen concentration increased flower production of *Cucurbita pepo L.* According to Arancon, Edwards, Bierman, Welch and Metzer (2004), there is positive effect of vermin compost on the growth and yield of strawberry especially increase in leaf area, shoot dry weight and fruit weight under field condition.

Sanwal, Lakminaryam, Yadav, Rai, Yadaw and Mousumi (2007), obtained higher yield of crops due to organic manure applications as a result of improved physical and biological properties of soil.

Aliyu (2000), reported that the use of FYM at 5 t/ha resulted in higher fruit yield of egg plant. Dauda (2003) reported that fruit girth may increase with increase in manure application, furthermore, Akanbi, Adeboye, Togun, Ogunride and Adeyeye (2007), reported that cassava peel compost gave the highest growth, shoot and fruit yield. Also Awodun (2007) also reported that poultry manure increased leaf nitrogen, phosphorus, potassium, calcium and magnesium content in fluted pumpkin.

It has been reported by Obiefuna (1990), that organic manure significantly ($P \leq 0.05$) influenced the general performance and productivity of crops. The increased growth rate, early flowering, large, biomass, heavier canopy, early harvest and improved yield in the study as a result of organic manure application was made possible by nutrient release by poultry manure. Similar response has been found in several other species including plantain, (Obiefunna, (1990), pearl millet, (Gupta, Aggarwal, Gupta and Kaul (1983) passion fruit, (Ani and Baiyeri (2008), straw berry, (Ramesh, Chandrasakara, Balasubramaman, Banagaru, Sany, Sivasany and Sankaran (2002) and corn, (Sims (1987). Manure of animals and other origin is a slow release fertilizer and valuable source of crop nutrients and organic matter which can improve soil biophysical conditions thereby making the soil more productive and sustainable for food production, (Mugwira, 1979), as such a great proportion of plantain and banana crops benefit from application of large doses of house hold refuse which is high in organic matter.

It has also been reported by Obiefuna (1990) that manuring plantain with a combination of poultry manure, house hold waste and wood ash improved plantain growth, yield and establishment and greatly reduced infestation by borer weevils and nematodes. In a field study at the Federal University of Technology in Owerri, Nigeria, this combination out performed cattle manure, compost refuse, compost, application of furadan which is commonly used in commercial plantain production and the application of chemical NPK fertilizer. The organic manures also maintained soil acidity, regulated soil temperature and conserved soil moisture, while commercial inputs significantly increased acidity.

It has also been reported that poultry manure has high N. content as well as other nutrients which are gradually released to the plant (Awodun, 2007; Ewulo, 2005). Anyaegbu, Iwuanyanwu and Ekwugha (2010) reported that increasing level of PM resulted in high nitrogen which is known to stimulate growth.

CHAPTER III

3.0 MATERIALS AND METHOD

3.1 Location of the experimental site

The study was conducted at the Teaching and Research Farm site of School of Agricultrure and Agricultural Technology (SAAT), Imo State Polytechnic, Umuagwo. The area is in the humid rain forest zone of Southeastern Nigeria and situated between, latitude 05^0 17^1N and longitude $06^0 54^1$E (Imo State Polytechnic Bulletin, 2013 and NIMET, 2012). The soils are derived from coastal plain sands otherwise known as Benin Formation (Orajiaka, 1975), while the vegetation is dominated by secondary forest (Ofomata, 1975).

The area has a bimodal pattern of rainfall, April to August being the longer and September to November being shorter wet period. The area has a minimum and maximum annual ambient temperatures of 28^0C and 35^0C respectively, and mean annual rainfall is about 2,500 mm and relative humidity of about 89.5% during the wet period. Crops such as yams, oil palms, banana, plantain, cassava, maize, cocoyam, and fluted pumpkin are grown. The experiments were carried out in 2013 and 2014 cropping seasons.

3.2 Soil sample for physical and chemical analysis

Soil samples were randomly collected before and after the experiment from the experimental site from 0-20 cm depth using a soil auger. The samples were bulked to produce composite samples, which were air dried and sieved with 2 mm sieve.

Physical and chemical properties including textural class, Nitrogen, pH, exchangeable bases, exchangeable acidity, available phosphorus and organic carbon were determined before and after the experiment.

3.2.1 Mechanical analysis

The percentage of the different fractions (sand, silt and clay) in the soil was determined using the bouyoucos method (Bouyoucos, 1962; Gee and Or, 2002). Fifty grams of the soil sample was weighed into a moisture can and 50 ml calgon (Sodiumhexameta phosphate) added. This was stirred vigorously for about 15 minutes and the contents transferred completely into a 1 litre measuring cylinder and made up to mark with water. The contents were shaken by covering the open end of the cylinder and turning upside – down 3-4 times. The cylinder was allowed to stand and the hydrometer introduced immediately to obtain the first hydrometer reading H_1. The temperature of the water, T_1, was taken at the same time using a mercury thermometer. After 3 hours the readings were taken again to obtain H_2 and T_2.

The temperatures T_1 and T_2 were converted from Celsius to Fahrenheit and the different soil fractions calculated using the following formula:

$$\% \text{ Sand} = 100 - (H_1 + 0.2 (T_1 - 68) - 2.0) \times 2$$

$$\% \text{ Clay} = (H_2 + 0.2 T_2 - 68) - 2.0) \times 2$$

$$\% \text{ Silt} = 100 - (\% \text{ Sand} + \% \text{ Clay})$$

3.2.2 Soil pH

The soil pH was determined in water using 1:2.5 soil: water ratio and glass electrode pH meter (Hendershot, Ialande and Dugugette, 1993). The air-dried soil sample was stirred in distilled water and allowed to stand for 30 minutes with occasional stirring. The glass electrode of the pH meter was introduced into the suspension to measure the soil pH. The post harvest soil pH was measured again at harvest to determine the soil status due to organic manure application. While bulk density was measured by core method (Grossman and Reinsch, 2002).

3.2.3 Exchangeable bases

The exchangeable bases in the soil sample namely calcium, magnesium, potassium and sodium were determined by leaching with neutral ammonium acetate. Fifty cm^3 of 1 N ammonium acetate was added to 5 g of the sample and shaken mechanically for 2 hours. It was centrifuged at 2000 rpm and the supernatant collected in a 100 ml volumetric flask. Centrifugation and collection of supernatant was repeated twice more but with only 30 minutes shaking. The volumetric flask was made up to the mark with ammonium acetate and used to determine sodium and potassium using the flame photometer and calcium and magnesium by the EDTA titration method (Hendershot *et al.*, 1993).

3.2.4 Exchangeable acidity

The exchangeable acidity (aluminum and hydrogen) was determined by leaching with potassium chloride. Fifty cm^3 of 1 N potassium chloride was added to 5 g of the soil sample and shaken mechanically for 1 hour. It was centrifuged at 2000 rpm for 15 minutes and the supernatant collected in a 100 ml volumetric flask. Centrifugation and collection of supernatant were repeated twice more but with only 30 minutes shaking. The volumetric flask was made up to mark with potassium chloride and used to determine aluminum and hydrogen concentration. To do this, 3-5 drops of phenolphthalein indicator was added to 20 ml of the leachate. One hundred ml of distilled water was added and the solution titrated with 0.05 N NaOH to a permanent pink end point. A blank titration was carried out using NaOH. The amount of base used was equivalent to the amount of acidity (H + Al) in the aliquot taken. One drop of 0.05 N HCl was added to the same flask to bring back the colourless condition. Before adding 10 ml of NaF solution (the pink colour returns if Al is present) and titrating the solution with 0.05 N HCl until the colour disappeared. The miliequivalents of acid used was equal to the amount of exchangeable Al in the aliquot used. This value was subtracted from the miliequivalents of total acidity from the base titration to obtain the miliequivlanet of exchangeable H. This was expressed in Meq. Per 100 g by the equation:

$$\text{Exch. Acidity (meg/100g)} = (T - B) \times \frac{E}{A} \times \frac{100 \times N}{W}$$

Where T = ml NaOH sample

B = ml NaOH Blank

E = Extract volume

A = Aliquot volume taken

W = Weight of soil used

N = Normality of base

3.2.5 Organic carbon

The organic carbon content of the soil was determined by the Walkley-Black method (Walkely and Black, 1934; Nelson and Sommers, 2008). Unto 1 g of soil in a 250 ml flask was added 5 ml 1 N $K2cr20_7$ and 10 ml concentrated H_2SO_4. The flask was swirled gently for about 1 min. allowed to stand for 30 min and 50 ml of distilled water and about 3 drops of indicator (phenanthroline) added. The content was titrated with 0.5 FeSO4 to a maroon colour end point. After standardizing the titre with a blank titration, the titre value was calculated by the formula; the soil organic carbon content was calculated by the formula;

$$\% \text{ of carbon in soil} = \frac{\text{Meq } K_2 + Cr_20_7 \text{ x Meq } FeSO_4 \text{ x } 0.003 \text{ x } 100 \text{ (1)}}{\text{Weight of air – dry soil (g)}}$$

Where Meq = Miligram equivalent

3.2.6 Available phosphorus

The available P in the soil sample was determined by Bray 1 method (Bray and Kurtz, 1945). One gram of soil sample was crushed and put into a centrifuge tube. Seven mls of the extracting solution (15 ml N NH_4F + 25 ml 0.5 N HCl + 460 ml distilled water) was added and the contents shaken vigorously for 1 min. It was be centrifuged for 15 min at 2000 rpm. Into 2 ml of the supernatant in a test tube, added 5 m water, 2 ml ammonium molybdate (NH_4) $MO_7O_{24}H_2O$) and stannous chloride ($SnCl_2$). After mixing thoroughly, the optical density was determined using atomic absorption spectrophotometer (AAS) at 660 nm. The stock solution was used to prepare various standard solutions of P in order to obtain a standard curve. The p content of the sample was then determined from the curve. While total nitrogen will be determined using the procedure by (Brady and Weil, 2007).

3.3 Treatments

The treatments comprised 10 t/ha each of four organic manure sources: poultry manure, pig dung, and cow dung) and three population densities of cassava (20,000 plants/ha, 10,000 plants/ha and 5,000 plants/ha). There was a blanket application of ash at 5 tons/ha. Rehabilitation of 3½ years existing plantain was embarked upon. The plantain was de-suckered leaving only the healthy sword suckers planted. The plantain was cleared of weeds and other stump growths. All the plantain stands were hilled up.

The cassava densities were intercropped with the ratoon plantain spaced at 3.0 x 2.0 m (1600 plants/ha). There was an unmanured plantain/ cassava mixture which served as check. There were a total of twelve treatments replicated three times. The cassava variety NR 8083, the plantain variety (*Musa AAB*) and cured organic manure sources used in the experiment were obtained from the research farm of Imo State Polytechnic Umuagwo.

3.4 Experimental design

The 5 years fallow experimental site was cleared and allowed to dry for three weeks. The trash was packed and heaped on windrows bordering the experimental site. The experimental design was a 3 x 4 factorial experiment laid out in Randomized Complete Block Design (RCBD) with three replications. The twelve treatment combinations of 3 cassava densities (20,000 plants/ha, 10,000 plants/ha and 5,000 plants/ha) and 4 organic manure sources (no manure (control), poultry droppings, pig dung and cow dung) were randomized for each replicate using Gomez and Gomez (1984) table of random numbers. There was a blanket application of ash in all the treatments at the rate of application of 5 tons/ha.

3.5 Land preparation

The experimental site was manually cleared with machete. Hole measuring 60.0 cm x 60.0 cm x 60.0 cm were dug for the plantain sword suckers while ridges were made using spade in the plantain alleys for the different cassava densities. Furadan 3G was applied at 4 kg/ha for the control of termites (*Macrotermis evuncifer).* This was achieved by spreading 3G Furadan into each plantain planting hole.

3.6 Planting

The experiment was established in August 2013 on a land area of 2600 m^2 (26 m x 100 m). The plantains were spaced 3.0 x 2.0 m (1600 plantains/ha) and planted in holes dug 60.0 x 60.0 x 60.0 cm, the sword suckers were trimmed, planted and compacted in an experimental plot of two standard ridges which were constructed within the 3.0 m alleys for planting cassava cuttings each measuring 20.0 cm. Cassava cuttings were spaced 50.0 x 100.0 cm for 20,000 cassava/ha; 100.0 x 100.0 cm for 10,000 cassava/ha and 200.0 x 100.0 cm for 5,000 cassava/ha. Three weeks after planting plantain/cassava mixture, four organic manures sources each at 10 tons/ha (zero, cured poultry waste, pig dung and cow dung) and ash were broadcast on the appropriate plots and worked into the soil with garden fork.

3.7 Data collection

3.7.1 Plantain height (cm)

Plant height of plantain was measured at 3, 6, 9 and 12 months after planting (MAP) using a calibrated stick measure. Measurements were taken on four sample plants from the central row of each plot, from the base of the plantain at the ground level of last fully opened leaf. The mean height for the plantain was determined.

3.7.2 Number of functional leaves

Number of plantain functional leaves was determined at 3, 6, 9, 12 months after planting (MAP) and at maturity. This was determined by physically counting the number of functional leaves produced by each plantain from the rows of four sampled plantain plot. The mean number of plantain functional leaves from the sampled plants was determined.

3.7.3 Stem girth (cm)

Stem girth of plantain was determined at 3, 6, 9 12 months after planting (MAP) and at maturity, using a flexible measuring tape. Measurements were taken on four sampled plants from the central row of each plot from the centre of the plantain. The mean stem girth for the plant was determined by measuring the circumference of the girth at the center of the plant.

3.7.4 Leaf area (cm^2) of plantain leaves

Leaf area of plantain leaves was measured at 3, 6, 9, 12 months after planting (MAP) and at maturity by multiplying the length and the broadest width of each sampled leaf from the tip of the leaf to the base of the leaf with a constant (0.8 x (L x W) (Obiefuna and Ndubizu, 1979). Measurements were taken on four sampled plantain from each plot. The mean leaf area from the sampled plant was determined.

3.7.5 Days to 50 % flowering (months) (Anthesis)

At the commencement of flowering, the field was visited daily to determine the number of days taken for 50 % of the plant in each plot to flower. Measurements were taken on four plants from central row of each plot. This was done by physically counting and reckoned from sowing date.

3.7.6 Number of hands / bunch at harvest

The number of hands / bunch at harvest was determined by physically counting the number of hands produced by each plantain from the rows of each sampled plantain plant. The mean number of hands /bunch from the sampled plant was determined and subjected to statistical analysis.

3.7.7 Number of fingers / bunch at harvest

Number of fingers per bunch at harvest was determined by physically counting the number of fingers produced by the plantain from the sampled plantains in each treatment plot. The mean number of fingers per bunch from the four sampled plants was determined and subjected to statistical analysis.

3.7.8 Bunch weight (tons/ha) of plantain at harvest

The bunch weight of plantain was obtained by using a Saltere weighing balance. The mean yield of the bunch/plot from the sampled plants of plantain was determined and later subjected to statistical analysis.

3.7.9 Number of suckers / plant at harvest

The number of suckers / plant at harvest was determined by physically counting the number of suckers from the sampled plantain plot. The mean numbers of plantain suckers from the four sampled plants were determined and subjected to statistical analysis.

3.7.10 Cassava plant height (cm)

Plant height of cassava was measured at 3, 6, and 9 months after planting (MAP), using a flexible measuring tape. Measurements were taken on four sampled cassava plants in each plot from the ground level to the tip of the plants. The mean height for the four sampled cassava plants was determined and subjected to statistical analysis.

3.7.11 Number of branches of cassava

The number of branches of cassava was measured at 3, 6 and 9 months after planting (MAP), by physically counting the number of branches each cassava plot had produced. Measurements were taken on four sampled cassava plants in each plot. The mean number of branches for the four plants was determined and subjected to statistical analysis.

3.7.12 Plant canopy cover of cassava (m^2)

Plant canopy cover (m^2) of cassava was measured at 3, 6, and 9 months after planting (MAP), using flexible measuring tape. Measurements were taken on four sampled cassava plants in each plot from tip to tip of each cassava spread in opposite direction. The two figures were multiplied to give the plant canopy cover in m^2.

3.7.13 Stem yield (Bundles / 100 stems)

The plantable stems of cassava in each treatment plot were cut at 1m each and arranged in bundle of 100 stems. This was done to determine the stem yield. The mean stem yield (bundles) for treatment was determined and subjected to statistical analysis.

3.7.14 Weed dry weight (kg/ha)

Weed biomas was determined by randomly placing 1 x 1m quadrat in two locations of each plot and weeds within the quadrat was up-rooted and counted. The weed samples were put in labeled envelops and over dried at 80^0C, for 48 hours in carbolite electronic moisture extraction oven and weighed with the sensitive electronic weighting balance. Reading was taken from samples at 3, 6, and 9 months after planting (MAP).

3.7.15 Cassava root weight (tons/ha)

The cassava root weight (tons/ha) was obtained by a 10 kg weighing scale at harvest. The yield per plot was used to proportionate yield per hectare and then subjected to statistical analysis.

3.8 Statistical analysis

All the data were subjected to analysis of variance (ANOVA) for factorial design fitted into a Randomized Complete Block Design (RCBD) using Genstat Release. 10.3 DE (2013). Mean separation was carried out using Least Significant Difference (LSD) at 5% level of probability. The analysis of variance (ANOVA) format and ANOVA generated in Genstat output are presented in Appendices 1-72.

CHAPTER IV

4.0 RESULTS AND DISCUSSION

4.1 Results

4.1.1 Meteorological Data

The total annual rainfall for 2013 and 2014 and 2015 were 2287.5, 2346.5 and 2644.9 mm respectively (Table 4.1).

The greater bulk of the rains fell from May to October in 2013, 2014 and 2015. The mean maximum temperature for 2013, 2014 and 2015 cropping seasons were 31.2 ^{0}C, 31.7 ^{0}C and 32.0 ^{0}C respectively and the relative humidity ranged from 80.3 % in 2013, 81.5 % in 2014 and 81.3 % in 2015 respectively.

4.1.2 Soil Composition

The soil of the experimental site was texturally sandy soil for 2013, 2014 and 2015 (Table 4.2). The soil pH was in each case acidic 4.409 and slightly acidic 6.055 in 2014. The soils were low in organic matter and nitrogen content, and high in potassium in 2014.

4.1.3 Nutrient Composition of the Organic Manure Sources

The pH of poultry manure, pig dung and cow dung, used in the experiment was 7.45, 6.56 and 5.92 respectively in 2013 and 7.52, 6.60 and 5.23 respectively in 2014. (Table 4.3) with organic carbon and organic matter 26.56 %, 22.4 3% and 19.43 % for poultry manure, pig dung and cow dung respectively in 2013 and 26.79 %, 22.52 % and 19.56 % for poultry, pig dung and cow dung respectively in 2014. The result showed that poultry manure was richest in Nitrogen, followed by pig dung and then cow dung.

Table 4.1 Meteorological data of the experimental site for 2013, 2014 and 2015 cropping seasons

Months	Rainfall (mm)			Temperature (°C)			Relative humidity (%)		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
January	60.0	70.0	75.5	33.8	33.7	33.5	65	64	71
February	40.0	21.4	72.2	33.6	34.7	34.2	77	78	73
March	130.9	100.2	61.0	33.3	33.2	33.5	78	82	80
April	190.5	157.0	61.4	33.0	32.5	33.6	81	84	81
May	253.2	289.4	236.6	31.8	31.9	32.6	84	87	86
June	188.7	236.4	404.5	27.2	30.4	29.9	88	88	87
July	254.1	202.5	401.3	28.9	29.0	29.3	87	89	89
August	409.1	336.3	359.2	28.5	28.7	29.0	87	87	88
September	279.0	406.6	416.6	29.4	29.8	30.3	86	83	87
October	301.0	405.5	455.5	30.7	30.8	31.2	81	83	82
November	48.6	91.3	78.1	31.8	31.9	33.1	80	82	79
December	132.4	30.0	23.0	32.0	33.2	33.7	69	71	72
Total	2287.5	2346.6	2644.9	374	379.8	383.9	963	978	975
Average				31.2^{0}C	31.7^{0}C	32.^{0}C	80.3%	81.5%	81.3%

Source: Imo State Polytechnic Umuagwo Meteorological Observation 2013, 2014, 2015

4.2 Soil Physical and Chemical properties before and after the experiment

Soil physical and chemical properties	Properties before the experiment	After the experiment
	2013	2014
pH in H_20(P:2.5)	4.409	6.055
% organic carbon	0.918	0.926
% organic matter	1.582	1.596
% nitrogen	0.129	0.120
% phosphorus (ppm p/g)	8.54	10.34
Calcium (C mol/kg)	0.350	0.726
Magnesium (C mol/kg)	0.233	0.355
Sodium (C mol/kg)	0.010	0.082
Potassium (C mol/kg)	0.026	0.096
Exchangeable acidity (C mol/kg)	0.512	0.380
Exchangeable AC (C mol/kg)	0.100	0.064
% sand	92.80	92.67
% clay	2.52	2.35
% silt	4.68	4.98
Bulk density (g/cm^3) Rep I	1.712	1.708
Rep II	1.833	1.829
Rep III	1.702	1.697

Table 4.3 Nutrient composition of organic manure sources used during 2013 and 2014 cropping seasons

Nutrient composition			**value**			
	2013			2014		
	Poultry manure	Pig dung	Cow dung	Poultry manure	Pig Dung	Cow dung
pH	7.45	6.56	5.92	7.52	6.60	5.23
Nitrogen (%)	2.25	1.60	1.30	2.26	1.63	1.32
Phosphorus (%)	0.566	0.393	0.256	0.582	0.41	0.27
Potassium (%)	0.745	0.654	0.456	0.762	0.672	0.463
Calcium(%)	2.78	1.86	1.652	2.793	1.883	1.672
Magnesium(%)	0.874	0.64	0.43	0.892	0.67	0.47
Organic matter (%)	26.56	22,43	19.43	26.79	22.52	19.56

4.1.4 Plant Height (cm)

Organic manure x cassava density did not influence the plantain height at 3 months after planting (3 MAP) (Table 4.4). However, organic manure sources significantly increased the plantain height at 2013 cropping seasons. The plantains that received poultry manure produced the tallest plantains with 128.80 cm, followed by the plantain that received pig dung 100.70 cm, and then cow-dung 92.00 cm and the shortest plantain heights were obtained from the plantain that received no organic manure source 61.00 cm.

In 2014 cropping season, the same trend occurred, organic manure x cassava density did not influence the plantain height. The plantains that received poultry manure produced the tallest plantains 124.68 cm, followed by the plantains that received pig dung 99.22 cm, followed by the plantains that received cow dung 91.52 cm, while the shortest plantains were obtained for the plants that received no organic manure source.

At 6 MAP (Table 4.5), organic manure sources significantly ($P \leq 0.05$) increased plantain height in 2013 cropping season. When no organic manure source was applied, plantain height, of 85.21 cm was obtained, there was an increase of 173.46 cm, 123.77 cm and 108.10 cm of plantain height when poultry manure, pig dung and cow dung were applied respectively. The same trend occurred in 2014 cropping season. Organic manure sources significantly increased the plantain height. Result showed that when no organic manure source was applied, plantain height of 86.14 cm was obtained. There was an increase of 177.33 cm, 124.67 cm and 107.82 cm of plantain height when poultry manure, pig dung and cow dung was applied respectively. The same trend occurred at 9 MAP (Table 4.6). In 2013, organic manure sources significantly ($P \leq 0.05$) increased the plantain height. Results showed a plantain height of 229.96 cm. was obtained when poultry manure was applied, followed by 174.91 cm when pig dung was applied and then followed by 155.25 cm when cow dung was applied. The shortest plant height was obtained when no organic manure source was applied 136.41 cm. In 2014 cropping season, organic manure sources significantly ($P \leq 0.05$) increased the plantain height. Result showed a plantain height of 236.20 cm when poultry manure was applied, followed by 167.10 cm when pig dung was applied, and then followed by 157.80 cm when cow dung was applied. While the shortest plantain height was obtained when no organic manure source was applied 136.00 cm.

At 12 MAP (Table 4.7), organic manure types significantly ($P \leq 0.05$) increased the plantain heights in 2013 and 2014 cropping seasons, with 243.20 cm when poultry manure was applied 174.40 cm when pig dung was applied, and then 159.40 cm when cow dung was applied. The same trend occurred in 2014 cropping season. The plantain that received poultry manure produced significantly ($P \leq 0.05$) tall plantains of 246.6 2 cm, followed by 177.21 cm when pig waste was applied and 161.06 cm when cow dung was applied, while shortest plantains were obtained when no organic manure source was applied with 141.88 cm.

Table 4.4: The effect organic manure sources, ash and different densities of cassava on the Plant height (cm) of plantain at 3 months After Planting (MAP) during 2013 and 2104 cropping seasons.

2013

Plant Height (cm) at 3 MAP					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	65.40	117.90	101.20	96.50	92.25
10,000	52.50	123.50	101.00	92.20	92.30
5,000	65.10	122.00	100.00	87.50	93.65
Mean	61.00	128.80	100.70	92.00	

LSD (0.05) for organic manure source = 8.09
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	64.53	121.47	99.73	95.23	95.24
10,000	68.73	129.03	100.73	92.07	97.64
5,000	64.73	123.53	97.20	87.27	93.18
Mean	66.00	124.68	99.22	91.52	

LSD (0.05) for organic manure source = 2.11
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Tale 4.5: The effect organic manure sources, ash and different densities of cassava on the Plant height (cm) of cassava at 6 months After Planting (MAP) during 2013 and 2104 cropping seasons.

2013

Plant Height (cm) at 6 MAP					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	84.83	170.40	126.97	112.83	123.76
10,000	86.67	177.00	122.17	102.07	121.98
5,000	84.13	172.97	122.17	109.40	122.17
Mean	85.21	173.46	123.77	108.10	

LSD (0.05) for organic manure source = 3.18
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	86.20	176.00	126.67	111.43	124.95
10,000	87.37	178.17	123.20	101.97	122.68
5,000	84.87	177.83	122.67	110.07	123.86
Mean	86.14	177.33	124.01	107.82	

LSD (0.05) for organic manure source = 2.14
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.6: The effect of organic manure sources, ash and different densities of cassava on the Plant height (cm) of Plantain at 9 months After Planting (MAP) during 2013 and 2014 cropping seasons.

2013

Plant height (cm) at 9 MAP					
Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	152.93	223.30	172.64	161.63	174.25
10,000	139.67	234.03	174.83	152.47	173.22
5,000	134.75	232.53	172.67	152.93	173.22
Mean	136.41	229.96	174.91	155.25	

LSD (0.05) for organic manure source = 5.16
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	134.50	231.80	155.00	160.20	170.40
10,000	138.20	240.50	174.00	153.10	176.50
5,000	135.30	236.30	172.00	160.00	176.00
Mean	136.00	236.20	167.10	157.80	

LSD (0.05) for organic manure source = 10.36
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.7: The effect organic manure sources, ash and different densities of cassava on the Plant height (cm) of plantain at 12 months After Planting (MAP) during 2013 and 2014 cropping seasons.

2013

Plant Height (cm) of Plantain at 12 MAP					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	94.20	243.10	179.60	161.70	169.70
10,000	139.60	243.90	175.10	154.90	178.40
5,000	135.50	242.60	168.90	161.70	177.00
Mean	123.10	243.20	174.40	159.40	

LSD (0.05) for organic manure source = 5.82
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	136.97	244.90	180.60	162.90	181.34
10,000	141.00	247.03	176.93	156.27	180.31
5,000	147.67	247.93	174.10	164.00	183.42
Mean	141.88	246.62	177.21	161.06	

LSD (0.05) for organic manure source = 5.81
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

4.1.5 Number of Functional Leaves

Organic manure x cassava densities did not influence the numbers of functional leaves of plantain, however organic manure sources significantly ($P \leq 0.05$) increased the number of functional leaves of plantain at 6 MAP during 2013 and 2014 cropping seasons (Table 4.8).

At 6 months after planting (MAP) poultry manure increased the number of functional leaves by 9.56, followed by pig dung 6.56 and then cow dung, 5.11, while the lowest number of functional leaves was obtained when no organic manure sources was applied 4.33. In 2014, poultry manure also increased the number of functional leaves 10.44, followed by pig dung 6.67, then cow dung 5.67. While the lowest number of functional leaves were obtained when no organic manure sources was applied 4.89.

At 9 months after planting (MAP) organic manure x cassava densities did not influence the number of functional leaves (Table 4.9). However, organic manure source significantly ($P \leq 0.05$) increased the number of functional leaves with 10.67, when poultry manure was applied, followed by 7.78 when pig dung was applied and 6.11 when cow dung was applied. The least number of leaves was obtained from the plantain that received no organic manure source 6.11. In 2014 poultry manure influenced the number of functional leaves with 11.67, when poultry manure was applied, followed by 7.67 when pig dung was applied and the 6.11 when cow dung was applied. The least number of functional leaves was obtained from the plantain that did not receive any organic manure source with 5.78.

At 12 months after planting (MAP) (Table 4.10) poultry manure significantly ($P \leq 0.05$) increased the number of functional leaves, in 2013 and 2014 cropping seasons. In 2013 the highest number of functional leaves was obtained from the plantains that received poultry manure with 11.78, followed by 9.00 when pig dung was applied, and then 6.67 when cow dung was applied. The least number of functional leaves was obtained from the plantains that received no organic manure source 6.22. In 2014, poultry manure showed significant ($P \leq 0.05$) increase in the number of functional leaves with 12.56, followed by 8.67, 7.78 when pig dung and cow dung were applied respectively. While the least number of functional leaves was obtain when no organic manure source was applied 6. 78.

At 15 months after planting (Table 4.11), organic manure and cassava density did not influence the number of functional leaves of plantain during, 2013 and 2014 cropping seasons. However, organic manure sources significantly influenced the number of functional leaves in 2013 with poultry manure producing the highest number of functional leaves, 13.44, followed by pig dung 10.00 and then cow dung 8.56, while the least number of functional leaves was obtained from the plantains that did not receive no organic manure source 7.78.

In 2014 poultry manure produced the highest number of functional leaves at 15 MAP, 13.67, this was followed by 9.89, 9.67 and 7.78 with cow dung, pig dung and no organic manure source respectively.

Table 4.8: The effect organic manure sources, ash and different densities of cassava on the Number of Functional Leaves of Plantain at 6 months After Planting (MAP) during 2013 and 2014 cropping seasons

2013

Number of Functional Leaves at 6 MAP					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	4.00	9.33	6.67	5.33	6.33
10,000	4.33	9.67	6.67	5.33	6.50
5,000	4.67	9.67	6.33	4.67	6.33
Mean	4.33	9.56	6.56	5.11	

LSD (0.05) for organic manure source = 0.60
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	4.33	10.33	6.67	5.67	5.33
10,000	5.33	10.67	6.67	5.67	7.09
5,000	5.00	10.33	6.67	5.67	6.92
Mean	4.89	10.44	6.67	5.67	

LSD (0.05) for organic manure source = 0.54
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.9: The effect organic manure sources, ash and different densities of cassava on the Number of Functional Leaves of Plantain at 9 months After Planting (MAP) during 2013 and 2014 cropping seasons.

2013

Number of Functional Leaves at 9 MAP					
Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	5.00	10.67	8.33	6.33	7.58
10,000	5.33	10.67	7.67	6.33	7.50
5,000	5.00	10.67	7.33	5.67	7.17
Mean	5.11	10.67	7.78	6.11	

LSD (0.05) for organic manure source = 0.60
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	5.67	11.67	7.67	6.67	7.92
10,000	5.67	11.67	7.67	7.00	8.00
5,000	6.00	11.67	7.67	4.67	7.50
Mean	5.78	11.67	7.67	6.11	

LSD (0.05) for organic manure source = 11.02
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.10: The effect organic manure sources, ash and different densities of cassava on the Number of Functional Leaves of Plantain at 12 months After Planting (MAP) during 2013 and 2014 cropping seasons.

2013

Number of Functional Leaves at 12 MAP					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	6.00	11.67	9.33	7.33	
10,000	6.33	11.67	9.00	7.33	
5,000	6.33	12.00	8.67	5.33	
Mean	6.22	11.78	9.00	6.67	

LSD (0.05) for organic manure source = 0.99
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	6.67	12.67	8.67	7.67	8.92
10,000	6.67	12.33	8.67	8.00	8.92
5,000	6.67	12.67	8.67	7.67	9.00
Mean	6.78	12.56	8.67	7.78	

LSD (0.05) for organic manure source = 0.47
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.11: The effect organic manure sources, ash and different densities of cassava on the Number of Functional Leaves of Plantain at 15 months After Planting (MAP) during 2013 and 2014 cropping seasons.

2013

Number of Functional Leaves at 15 MAP					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	7.67	13.33	10.33	9.00	10.08
10,000	7.33	13.67	10.00	8.33	9.83
5,000	8.33	13.33	9.67	8.33	9.92
Mean	7.78	13.44	10.00	8.56	

LSD (0.05) for organic manure source = 0.24
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	7.67	13.67	9.67	8.67	9.92
10,000	7.67	13.67	9.67	12.33	10.83
5,000	8.00	13.67	9.67	8.67	10.00
Mean	7.78	13.67	9.67	9.89	

LSD (0.05) for organic manure source = 1.76
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

4.1.6 Stem Girth (cm)

The result in Table 4.12 showed that organic manure sources x cassava densities did not influence the stem girth in 2013 and 2014 cropping seasons at 3 months after planting (MAP). However in 2013 organic manure sources significantly ($P \leq 0.05$) increased the stem girth from 21.00 cm when no organic manure source was applied to 26.55 cm (26.42 %) increase when poultry manure was applied, followed by 22.89 cm (9.00 %) increase when pig dung was applied and then followed by 22.33 cm (6.33 %) increase when cow dung was applied. In 2014 cropping season the same trend occurred. Organic manure sources significantly ($P \leq 0.05$) increased the stem girth from 21.78 cm when no manure was applied to 26.56 cm (21.9 %) increase when poultry manure was applied, followed by 22.67 cm (4.59 %) increase when pig dung was applied, followed by 22.44 cm (3.0 %) increase when cow dung was applied.

At 6 months after planting, organic manure x cassava densities did not influence the stem girth of plantain in 2013 and 2014 cropping season (Table 4.13). However, in 2013, organic manure sources significantly ($P \leq 0.05$) increased the stem girth from 24.33 cm when no organic manure source applied to 34.78 cm (42.95 %) increase when poultry manure was applied, followed by 26.22 cm (7.77 %) increase when pig dung was applied then followed by 25.22 cm (3.65 %), when cow dung was applied. The same trend occurred in 2014 cropping season. There was no organic manure x cassava density interaction effect on the stem girth of plantain. However, organic manure sources significantly ($P \leq 0.05$) increased the stem girth of plantain from 24.89 cm when no organic manure was applied to 35.56 cm (42.86 %) increase when poultry manure was applied, followed by 25.89 cm (4.0 %) increase when pig dung was applied, followed by 25.56 cm (2.6 %) increase when cow dung was applied.

At 9 months after planting (MAP), organic manure sources x cassava densities did not influence the stem girth of plantain in 2013 and 2014 cropping seasons. (Table 4.14). However in 2013, organic manure significantly ($P \leq 0.05$) increased the stem girth from 27.67 cm when no organic manure was applied to 38.44 cm (38.92 %) increase when poultry manure was applied, followed by 30.11 (8.81 %) increase when pig dung was applied, followed by 28.67 cm (3.61 %) increase when cow dung was applied. In 2014 cropping season, the same trend occurred, there was no significant organic manure x cassava density interaction effect on the stem girth of plantain. However, organic manure sources significantly increased the stem girth of plantain from 28.00 cm when no organic manure source was applied to 40.22 cm (43.64 %) increase when poultry manure was applied, followed by 29.33 cm (4.75 %) increase when pig dung was applied, and then followed by 28.78 cm (2.79 %) increase when cow dung was applied.

At 12 months after planting there was no significant organic manure x cassava density interaction effect on the stem girth of plantain during 2013 and 2014 cropping seasons (Table 4.15). However, in 2013, organic manure sources significantly increased that stem girth of plantain from 34.78 cm when no organic manure source was applied to 48.67 cm (39.94 %) increase when poultry manure was applied, followed by (40.89 cm) (17.57 %) increase when pig dung was applied and then followed by 38.11 cm (9.57 %) increase when cow dung was applied. In 2014 cropping season, there was no significant organic manure sources x cassava density interaction effect. However, organic manure sources significantly ($P \leq 0.05$) increased the stem girth plantain from 34.00 cm when no organic manure was applied to 44.70 cm (31.47 %) increase when poultry manure was applied, followed by 40.30 cm (18.53 %) increase when pig dung was applied and then followed by 38.30 cm (12.65 %) increase when cow dung was applied.

Table 4.12: The effect organic manure sources, ash and different densities of cassava on the Stem girth (cm) of plantain at 3 months After Planting (MAP) during 2013 and 2014 cropping seasons.

2013

Stem girth of Plantain at 3 MAP					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	21.00	26.33	23.67	22.33	23.33
10,000	21.00	26.00	22.67	22.67	23.08
5,000	21.00	27.33	22.33	22.00	23.17
Mean	21.00	26.55	22.89	22.33	

LSD (0.05) for organic manure sources = 0.94
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	22.33	26.33	23.00	22.33	23.50
10,000	21.67	26.33	22.67	22.67	23.33
5,000	21.33	27.00	22.33	22.33	23.25
Mean	21.78	26.56	22.67	22.44	

LSD (0.05) for organic manure sources = 0.62
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.13: The effect organic manure sources, ash and different densities of cassava on the Stem girth (cm) of plantain at 6 months After Planting (MAP) during 2013and 2014 cropping seasons.

2013

Stem girth of Plantain at 6 MAP					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	24.33	33.67	26.33	25.00	27.33
10,000	23.67	35.67	26.00	25.67	27.75
5,000	25.00	35.00	26.33	25.00	27.83
Mean	24.33	34.78	26.22	25.22	

LSD (0.05) for organic manure sources = 0.86
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	24.33	34.67	26.67	25.00	27.33
10,000	23.67	36.67	23.67	25.67	28.00
5,000	26.67	35.33	24.33	26.00	28.58
Mean	24.89	35.56	25.89	25.56	

LSD (0.05) for organic manure sources = 0.78
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.14: The effect organic manure sources, ash and different densities of cassava on the Stem girth (cm) of plantain at 9 months After Planting (MAP) during 2013 and 2014 cropping seasons.

2013					
Stem girth of Plantain at 9 MAP					
Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	27.33	38.33	30.00	28.33	31.00
10,000	27.67	38.67	30.33	28.67	31.33
5,000	28.00	38.33	30.33	28.67	31.33
Mean	27.67	38.44	30.11	28.67	

LSD (0.05) for organic manure sources = 0.88
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014					
20,000	27.67	39.67	29.33	28.67	29.08
10,000	28.00	41.67	29.67	29.33	32.17
5,000	28.33	39.33	29.00	28.33	31.25
Mean	28.00	40.22	29.33	28.78	

LSD (0.05) for organic manure sources = 4.60
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source =NS

Table 4.15: The effect organic manure sources, ash and different densities of cassava on the Stem girth (cm) of plantain at 12 months After Planting (MAP) during 2013and 2014 cropping seasons.

2013

Stem girth of Plantain at 12 MAP					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	34.67	47.00	41.00	39.00	40.62
10,000	35.00	51.33	40.67	37.67	41.67
5,000	34.67	47.67	41.00	37.67	40.25
Mean	34.78	48.67	40.89	38.11	

LSD (0.05) for organic manure sources = 2.00
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	35.30	48.00	40.30	39.00	40.70
10,000	31.70	52.00	40.30	38.30	40.60
5,000	35.00	34.00	40.30	37.70	36.80
Mean	34.00	44.70	40.30	38.30	

LSD (0.05) for organic manure sources = 7.61
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

4.1.7 Leaf Area (cm^2)

The result in Table (4.16) showed that organic manure sources x cassava densities did not influence the leaf area (cm^2) of plantain at 3 months after planting during 2013 and 2014 cropping seasons. However, organic manure sources significantly ($P \leq 0.05$) increased the leaf area from 802.83 cm^2 when no organic manure source was applied to 1116.73 cm^2 (39.10 %) increase when poultry manure was applied, followed by 938.90 cm^2 (17.00 %) increase when pig dung was applied, and then followed by 850.26 cm^2 (5.90 %) increase when cow dung was applied.

In 2014 organic manure sources x cassava densities did not influence the leaf area (cm^2) of plantain at 3 months after planting (3 MAP). Nevertheless, organic manure sources significantly ($P \leq 0.05$) increased the leaf area from 796.20 cm^2 when no organic manure source was applied to 1663.30 cm^2 (108.90 %) increase when poultry manure was applied, followed by 925.40 cm^2 (16.73 %) increase when pig dung was applied, and then followed by 866.80 cm^2 (8.87 %) increase when cow dung was applied.

At 6 months after planting (6 MAP) cassava densities x organic manure sources did not influence the leaf area of plantain during 2013 and 2014 cropping seasons (Table 4.17). However, in 2013 cropping seasons organic manure sources significantly ($P \leq 0.05$) increased the leaf area of plantain from 944 cm^2 when no organic manure source was applied to 1665.00 cm^2 (76.3 %) increase when poultry manure was applied, followed by 1172.00 cm^2 (24. 2%) increase when pig dung was applied, and then followed by 1092.00 cm^2 (15.68 %) increase when cow dung was applied.

In 2014 cropping season, the trend was not different as there was significant interaction between organic manure sources x cassava densities on the leaf area of plantain at 6 months after planting (MAP), indicating that the effect of leaf area was dependent on the organic manure and cassava densities. Organic manure sources significantly increased the leaf area of plantain from 1667.00 cm^2 when no organic manure was applied to 3062.70 cm^2 (83.73 %) poultry manure was applied followed by 1930.60 (15.8 %) when pig dung was applied and then followed by 1799.40 cm^2 (7.94 %) increase when cow dung was applied.

At 9 months after planting (9 MAP) organic manure x cassava densities did not influence the leaf area of plantain during 2013 and 2014 cropping seasons (Table 4.18). However, in 2013 cropping season organic manure sources significantly increased the leaf area (cm^2) from 1567.90 cm^2 when no organic manure source was applied to 2712.20 cm^2 (72.0 %) increase when poultry manure was applied, followed by 1712.30 cm^2 (9.2 %) increase when pig dung was applied and then 1649.60 cm^2 (5.21 %) increase when cow dung was applied.

In 2014 cropping season there was no significant organic manure x cassava densities interaction effect on the leaf area of plantain at 9 months after planting, (9 MAP) however, organic manure sources significantly ($P \leq 0.05$) increased the leaf area of plantain from 1736.00 cm^2 when no organic manure source was applied to 3162.00 cm^2 (82.1 %) increased when poultry manure was applied followed by 1986.00 cm^2 (14.4 %) increase when pig dung was applied, and followed by 1860.00 (7.14 %) increased when cow dung was applied.

At 12 months after planting (12 MAP) (Table 4.19), organic manure sources x cassava densities did not influence the leaf area (cm^2) of plantain during 2013 and 2014 cropping seasons. However, in 2013 cropping season organic manure sources significantly ($P \leq 0.05$) increased the leaf area of plantain from 1571.00 cm^2 when no organic manure source was applied to 2693.00 cm^2 (71.44 %) increase when poultry manure was applied, followed by 1725.00 cm^2 (9.80 %) increase when cow dung was applied and then 1692.00 cm^2 (7.70 %) increase when pig dung was applied. In 2014 cropping season, organic manure significantly ($P \leq 0.05$) increased the leaf area (cm^2) from 1861.00 cm^2 when no organic manure source was applied, followed by 3367.00 cm^2 (80.92 %) increase when poultry manure was applied, and the 2134.00 cm^2 (14.67 %) when pig dung was applied and then followed by 2113.00 cm^2 (13.54 %) increase then cow dung was applied.

At 15 months after planting (15 MAP) (Table 4.20) organic manure sources x cassava densities did not influence the leaf area of plantain during 2013 and 2014 cropping season. However, in 2013 cropping season organic manure sources significantly ($P \leq 0.05$) increased the leaf area of plantain from 1789.67 cm^2 when no organic manure was applied to 3242.67 cm^2 (81.19 %) increase when poultry manure was applied, followed by 2040.00 cm^2 (13.99 %) increase when pig dung was applied, and then followed by 1893.00 cm^2 (5.77 %) increase when cow dung was applied. In 2014 cropping season, organic manure sources significantly ($P \leq 0.05$) increased the leaf area (cm^2) from 1795.00 cm^2 when no organic manure source was applied to 3264.00 cm^2 (81.84 %) increase when poultry manure was applied, followed by 2044.00 cm^2 (13.87 %) increase when pig dung was applied, and then followed by 1903.00 cm^2 (6.02 %) increase when cow dung was applied.

Table 4.16: The effect of organic manure sources, ash and different densities of Cassava or the Leaf Area (LAcm²) of plantain at 3 months after planting (MAP) dung 2013 and 2014 cropping seasons.

2013

Leaf Area (LA) (cm^2)at 3 MAP					
Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	765.40	1145.30	946.40	745.30	900.40
10,000	826.60	1104.40	936.60	898.40	941.50
5,000	816.50	1100.50	933.70	906.80	939.40
Mean	802.83	1116.73	938.90	850.16	

LSD (0.05) for organic manure source = 25.42
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	746.70	1672.00	901.90	802.10	1030.70
10,000	816.00	1663.50	967.70	901.90	1087.30
5,000	825.90	1654.00	906.70	866.40	1063.30
Mean	796.20	1663.30	925.40	866.80	

LSD (0.05) for organic manure source = 34.53
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.17: The effect of organic manure sources, ash and different densities of cassava on the Leaf Area of plantain (cm^2) at 6 months after planting (MAP) during 2013 and 2014 cropping seasons.

2013

Leaf Area (LA) (cm^2) 6 MAP					
Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	912.00	1450.00	1250.00	1085.00	1175.00
10,000	935.00	1754.00	1141.00	1084.00	1229.00
5,000	984.00	1192.00	1125.00	1104.00	1251.00
Mean	944.00	1665.00	1172.00	1092.00	

LSD (0.05) for organic manure source = 18.00
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	1682.70	3171.70	2051.50	1903.30	2202.30
10,000	1694.40	3317.60	1879.80	1786.30	2170.00
5,000	1624.00	2698.70	1860.50	1706.70	1972.50
Mean	1667.00	3062.70	1930.60	1799.40	

LSD (0.05) for organic manure source = 54.56
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.18: The effect of organic manure sources, ash and different densities of cassava leaf area (cm^2) of plantain at 9 months after planting during 2013 and 2014 cropping seasons.

2013

Leaf Area (LA) at 9 MAP

Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	1579,50	2712.00	1723.20	1646.70	1915.30
10,000	1578.70	2715.70	1758.10	1690.10	1935.70
5,000	1545.50	2708.80	1655.60	1612.00	1880.50
Mean	1567.90	2712.20	1712.30	1649.60	

LSD (0.05) for organic manure source = 57.57
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	1771.00	3430.00	1951.00	1847.00	2250.00
10,000	1755.00	3289.00	2107.00	1957.00	2277.00
5,000	1682.00	2767.00	1902.00	1774.00	2031.00
Mean	1736.00	3162.00	1986.00	1860.00	

LSD (0.05) for organic manure source = 60.30
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.19: The effect of organic manure sources, ash and different densities of cassava leaf area (cm^2) of plantain at 12 months after planting (MAP) during 2013 and 2014 cropping seasons.

2013					
Leaf Area (LA) (cm^2) at 12 MAP					
Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	1604.00	2736.00	1.795.00	1725.00	1965.00
10,000	1562.00	2746.00	1679.00	1664.00	1913.00
5,000	1546.00	2597.00	1603.00	1785.00	1893.00
Mean	1571.00	2693.00	1692.00	1725.00	

LSD (0.05) for organic manure source = 99.3
LSD (0.05) for cassava densities =NS
LSD (0.05) for cassava densities x org. manure source = NS

2014					
20,000	1903.00	3520.00	2253.00	2099.00	2444.00
10,000	1886.00	3657.00	2087.00	1945.00	2394.00
5,000	1794.00	2924.00	2061.00	2295.00	2268.00
Mean	1861.00	3367.00	2134.00	2113.00	

LSD (0.05) for organic manure source = 26.41
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.20: The effect of organic manure sources, ash and different densities of cassava on the leaf area of plantain at 15 months after planting (MAP) during 2013 and 2014 cropping seasons.

2013

Leaf Area (LA) (cm^2) 15 MAP					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	1815.00	3392.00	2140.00	2008.00	2338.75
10,000	1800.00	3502.00	1998.00	1856.00	2288.00
5,000	1754.00	2834.00	1994.00	1815.00	2097.25
Mean	1789.67	3242.67	2040.00	1893.00	

LSD (0.05) for organic manure source = 60.35
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	1821.00	3421.00	2142.00	2011.00	2349.00
10,000	1802.00	3535.00	1998.00	1860.00	2299.00
5,000	1761.00	2836.00	1993.00	1830.00	2107.00
Mean	1795.00	3264.00	2044.00	1903.00	

LSD (0.05) for organic manure source = 60.60
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

4.1.8 Days to 50 % flowering (months)

The effect of organic manure sources, ash and different densities of cassava on the days to 50% flowering during 2013 and 2014 cropping season is shown in Table 4.21.

Organic manure x cassava densities did not influence the days to 50 % flowering (months) in 2013 and 2014 cropping seasons. However, in 2013 cropping season organic manure sources significantly ($P \leq 0.05$) reduced the days to 50 % flowering (month) from 16.89 months when no organic manure source was applied to 13.33 months (21.08 %) decrease when poultry manure was applied, followed by 15.56 months (7.87 %) decrease when pig dung was applied and then followed by 16.78 months (3.65 %) decrease when cow dung was applied. Poultry manure reduced the number of months of flowering by 3.56 months from 16.89 months to 13.33 months. Days to 50 % flowering (months) was significantly different for pig dung and cow dung with 15.56 months and 16.78 months respectively.

In 2014 cropping season, organic manure x cassava densities did not influence the days to 50 % flowering (months). Nevertheless organic manure sources significantly ($P \leq 0.05$) reduced the days to 50 % flowering (months) from 17.56 (months) when no organic manure source was applied to 13.22 months (24.72 %) decrease when poultry manure was applied, followed by 15.56 months (11.39 %) decrease when pig dung was applied and then followed by 16.56 months (5.69 %) decrease when cow dung was applied.

Poultry manure reduced the number of months by 4.3 months from 17.56 to 13.22 months. The days of 50 % flowering (months) was significantly ($P \leq 0.05$) different for pig dung and cow dung 15.56 and 16.56 months respectively.

Table 4.21: The effect of organic manure sources, ash and different densities of cassava on the days to 50% flowering (months) of plantain during 2013 and 2014 cropping seasons.

2013

Days to 50% flowering (months) of plantain					
Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	14.67	13.33	15.33	16.33	14.92
10,000	18.00	13.33	15.67	17.00	16.00
5,000	18.00	13.33	15.67	1700	16.00
Mean	16.89	13.33	15.56	16.78	

LSD (0.05) for organic manure source = 1.63
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	17.67	13.33	15.33	16.33	15.67
10,000	17.33	13.00	15.67	16.67	15.67
5,000	17.67	13.33	15.67	16.67	15.83
Mean	17.56	13.22	15.56	16.56	

LSD (0.05) for organic manure source = 0.53
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

4.1.9 Number of Hands/bunch at Harvest

The effect of organic manure sources, ash and different densities of cassava on the number of hands/bunch during 2013 and 2014 cropping seasons is shown in (Table 4.22). Organic manure sources x cassava densities did not influence the number of hands /bunch during 2013 and 2014 cropping seasons. However, in 2013 cropping season organic manure sources significantly ($P \leq 0.05$) increased the number of hands/bunch from 5.44 hands/bunch when cow dung was applied to 6.67 hands/bunch (22.69 %) increase when poultry manure was applied, followed by 6.00 hands/bunch (10.29 %) increase when pig dung was applied, and then 5.56 hands/bunch when no organic manure sources was applied.

In 2014 cropping season, the same trend occurred. There was no significant cassava densities x organic manure sources interaction effect on the number of hands /bunch. However organic manure sources had significant ($P \leq 0.05$) effect on the number of hands / bunch of plantain from 5.78 hands/bunch when no organic manure source was applied to 7.11 hands / bunch (23.01 %) increase when poultry manure was applied, followed by 6.00 hands/bunch (3.81 %) increase when pig dung was applied. Cow dung however had 5.78 hands/ bunch.

Table 4.22: The effect of organic manure sources, ash and different densities of cassava on the number of hand /bunch of plantain during 2013 and 2014 cropping seasons.

		2013			
Number of hands /bunch of plantain at harvest					
Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	5.67	6.67	6.00	5.67	6.00
10,000	5.33	6.67	6.33	5.33	5.92
5,000	5.67	6.67	5.67	5.33	5.84
Mean	5.56	6.67	6.00	5.44	

LSD (0.05) for organic manure source = 0.55
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

		2014			
20,000	5.67	7.00	5.67	5.67	6.00
10,000	5.67	7.33	6.33	6.00	6.33
5,000	6.00	7.00	6.00	5.67	6.16
Mean	5.78	7.11	6.00	5.78	

LSD (0.05) for organic manure source = 0.44
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

4.1.10 Number of Fingers /bunch at Harvest

The effect of organic manure sources, ash and different densities of cassava on the number of fingers /bunch of plantain at harvest during 2013 and 2014 cropping season is shown in (Table 4.23).

Organic manure source x cassava densities did not influence the number of fingers/bunch of plantain at harvest during 2013 and 2014 cropping season. However, in 2013 cropping season organic manure sources significantly ($P \leq 0.05$) increased the number of fingers / bunch from 20.44 when no organic manure source was applied to 31.67 (54.94 %) increase when poultry manure was applied, followed by 25.33 (23.92 %) increase when pig dung was applied and then followed by 22.67 (10.91 %) increase when cow dung was applied.

In 2014, there was no significant organic manure sources x density interaction effect. However, organic manure sources significantly ($P \leq 0.05$) increased the number of fingers /bunch from 20.78 when no organic manure source was applied to 32.78 (57.75 %) increase when poultry manure was applied, followed by 25.44 (22.43 %) increase when pig dung was applied, and then followed by 22.56 (8.57 %) increase when cow dung was applied.

Table 4.23: The effect of organic manure sources, ash and different densities of cassava on the number of fingers /bunch of plantain during 2013 and 2014 cropping seasons.

2013

Number of fingers /bunch of plantain at harvest

	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	20.33	31.00	25.00	22.67	24.75
10,000	20.67	33.00	26.00	23.00	25.67
5,000	20.33	31.00	25.00	22.33	24.67
Mean	20.44	31.67	25.33	22.67	

LSD (0.05) for organic manure source = 0.87
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	21.00	31.67	24.67	22.33	24.92
10,000	20.67	33.67	26.33	23.00	22.92
5,000	20.67	33.00	25.33	22.33	25.33
Mean	20.78	32.78	25.44	22.56	

LSD (0.05) for organic manure source = 0.70
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

4.1.11 Bunch weight (tons/ha)

The effect of organic manure sources, ash and different densities of cassava on the bunch weight of plantain during 2013 and 2014 cropping seasons is shown in (Table 4.24)

Organic manure sources x cassava density did not influence the bunch weight (tons/ha) of plantain during 2013 and 2014 cropping seasons. However, organic manure sources significantly ($P \leq 0.05$) increased the bunch weight of plantain (tons/ha), from 5.3 tons/ha when no organic manure sources was applied to 9.47 tons/ha (79.25 %) increase when poultry manure was applied, followed by 7.3 tons/ha (37.74 %) increase when pig dung was applied, and then followed by 6.3 tons/ha (18.87 %) increase when cow dung was applied.

The same trend occurred in 2014 cropping season. There was no significant organic manure sources x cassava density interaction effect on the bunch weight (tons/ha) of plantain. However, organic manure sources significantly ($P \leq 0.05$) increased, the bunch weight of the plantain from 6.51 tons/ha when no organic manure source was applied to 10.52 tons/ha (61.59 %) increase when poultry manure was applied, followed by 7.44 tons/ha (32.62 %) increase when pig dung was applied, and then followed by 6.51 ton/ha (16.04 %) increase when cow dung was applied.

Table 4.24: The effect of organic manure sources, ash and different densities of cassava on the bunch weight (tons/ha) of plantain at harvest during 2013 and 2014 cropping seasons.

2013

Bunch weight of plantain at harvest (tons/ha)

Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig Dung	Cow dung	Mean
20,000	5.50	9.60	7.40	6.30	7.20
10,000	5.90	9.40	7.30	6.40	7.25
5,000	5.20	9.40	7.20	6.20	7.00
Mean	5.30	9.47	7.30	6.30	

LSD (0.05) for organic manure source = 0.13
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	6.43	10.63	7.40	6.43	7.53
10,000	6.63	10.43	7.63	6.63	7.60
5,000	6.46	10.50	7.30	6.46	7.43
Mean	6.51	10.52	7.44	6.51	

LSD (0.05) for organic manure source = 0.141
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

4.1.12 Number of suckers of plantain at maturity

The effect of organic manure sources, ash and different densities of cassava on the number of suckers of plantain at maturity during 2013 and 2014 cropping seasons is shown in (Table 4.25).

Organic manure x cassava densities did not influence the number of suckers of plantain during 2013 and 2014 cropping seasons. However, organic manure sources significantly ($P \leq 0.05$) increased the number of suckers from 2.11 when no organic manure source was applied to 4.44 (110.43 %) increase when poultry manure was applied, followed by 3.33 (57.82 %) increase when pig dung was applied, and then followed by 3.11 (47.39 %) increase when cow dung was applied.

In 2014 cropping season, there was no significant organic manure sources x cassava density interaction on the number of suckers of plantain at maturity. However, organic manure sources significantly ($P \leq 0.05$) increased the number of suckers of plantain from 2.67 when no organic manure source was applied to 5.78 (116.47 %) increase when poultry manure was applied, followed by 3.44 (28.84 %) increase when pig dung was applied, and then followed by 2.89 (8.24 %) increase when cow dung was applied.

Table 4.25: The effect of organic manure sources, ash and different densities of cassava on the Number of suckers of plantain at maturity during 2013 and 2014 cropping seasons.

2013

Number of suckers of plantain at maturity

Cassava densities/ha	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	2.00	4.33	3.67	3.33	3.33
10,000	2.33	4.67	3.33	3.33	3.42
5,000	2.00	4.33	3.00	2.67	3.00
Mean	2.11	4.44	3.33	3.11	

LSD (0.05) for organic manure source = 0.48
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	3.00	5.00	3.33	2.67	3.75
10,000	2.67	5.67	3.67	3.33	3.84
5,000	2.33	5.67	3.33	2.67	3.50
Mean	2.67	5.78	3.44	2.89	

LSD (0.05) for organic manure source = 0.52
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

4.1.13 Plant height of cassava (cm)

Organic manure x cassava densities did not influence the height of cassava during 2013 and 2014 cropping seasons at 3 months after planting (Table 4.26). However, in 2013, organic manure sources significantly ($P \leq 0.05$) increased the cassava height from 63.76 cm when no organic manure source was applied to 106.42 cm (66.91 %) increase when poultry manure was applied, followed by 74.81 cm (17.33 %) increase when pig dung was applied, and then followed by 66.00 cm (3.51 %) increase when cow dung was applied.

In 2014 cropping season at 3 months after planting (3 MAP), relative to cassava height of 64.78 cm when no organic manure source was applied, result showed an increase in cassava height of 108.07 cm representing (66.83 %) increase in cassava height, when poultry manure was applied, followed by (75.49 cm) (16.53 %) increase when pig dung was applied and then followed by 66.22 cm (2.22 %) increase when cow dung was applied.

At 6 months after planting (6 MAP) (Table 4.27), organic manure sources significantly ($P \leq 0.05$) increased the cassava height from 100.91 cm when no organic manure sources was applied to 156.57 cm when poultry manure was applied representing an increase of (55.16 %) over no organic manure application, followed by 111.64 cm (10.63 %) increase when pig dung was applied and then followed by 103.79 cm (2.76 %) increase when cow dung was applied (Table 4.28).

At 9 months after planting (9 MAP) (Table 4.28) organic manure sources, significantly influenced the cassava height from 144.24 cm when no organic manure source was applied to 222.46 (54.22 %) increase when poultry manure was applied, followed by 162.61 cm (12.74 %) increase when pig dung was applied, and then followed by 152.59 (5.79 %) increase when cow dung was applied. In 2014 cropping season, organic manure significantly ($P \leq 0.05$) increased the cassava height from 131.91 cm when no organic manure source was applied to 194.29 cm (47.26 %) increase when poultry manure was applied, followed by 144.01 cm (9.14 %) increase when pig dung was applied, and then followed by 134.59 (2.01 %) when cow dung was applied.

Table 4.26: The effect of organic manure sources, ash and different densities of cassava on the height of cassava at 3 months after planting MAP during 2013 and 2014 cropping seasons.

2013

Height of cassava at 3 MAP					
Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	64.30	103.67	75.83	66.93	77.63
10,000	64.03	108.20	75.37	67.27	78.72
5,000	62.93	107.40	73.43	63.80	76.89
Mean	63.76	106.42	74.81	66.00	

LSD (0.05) for organic manure source = 1.13
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	65.57	106.07	76.43	67.63	78.57
10,000	64.87	109.13	75.27	64.83	79.22
5,000	63.90	109.00	74.77	66.20	78.12
Mean	64.78	108.07	75.49	66.22	

LSD (0.05) for organic manure source = 1.06
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.27: The effect of organic manure sources, ash and different densities of cassava on the height of cassava (cm) at 6 months after planting (MAP) during 2013 and 2014 cropping seasons.

2013

Height of cassava at 6 MAP

Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	100.73	151.63	112.67	104.10	117.28
10,000	101.20	156.70	111.40	104.37	118.42
5,000	100.80	161.37	110.87	102.63	118.92
Mean	100.91	156.57	111.64	103.70	

LSD (0.05) for organic manure source = 1.07
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	100.73	151.63	112.67	104.10	117.28
10,000	101.20	156.70	111.40	104.27	118.42
5,000	110.87	161.37	110.81	102.63	118.92
Mean	100.91	156.57	111.64	103.70	

LSD (0.05) for organic manure source = 1.07
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.28: The effect of organic manure sources, ash and different densities of cassava on the height of cassava (cm) at 9 months after planting (MAP) during 2013 and 2014 cropping seasons.

2013

Height of cassava (cm) at 9 MAP					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	142.17	214.07	161.83	153.10	167.54
10,000	144.37	237.27	164.27	152.20	174.53
5,000	146.20	216.03	161.73	153.47	169.36
Mean	144.24	222.46	162.61	152.59	

LSD (0.05) for organic manure source = 1.61
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	131.10	193.07	145.07	13	151.42
10,000	132.23	194.40	145.13	134.17	151.48
5,000	132.50	195.40	141.83	133.77	150.83
Mean	131.94	194.29	144.01	134.79	

LSD (0.05) for organic manure source = 1.39
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

4.1.14 Number of branches

There was no cassava organic manure sources x cassava density interaction effect on the number of branches of cassava at 3, 6, and 9 months after planting (MAP) during 2013 and 2014 cropping seasons. (Table 4.29 - 4.31). However, application of organic manure sources significantly ($P \leq 0.05$) increased the number of branches of cassava at 3 months after planting (MAP) from 1.00 when no organic manure was applied to 2.56, this was followed by pig dung with 1.44, and then followed by cow dung 1.22. In 2014 cropping season, application of organic manure significantly ($P \leq 0.05$) increased the number of branches of cassava at 3 months after planting (MAP). Poultry manure produced the highest number of branches of cassava from 1.00 when no organic manure source was applied to 2.56 when poultry manure was applied, followed by 1.33 when pig dung was applied, and then 1.22 when cow dung was applied.

Result in (Table 4.30) showed that at 6 months after planting (MAP) the same trend occurred. In 2013, organic manure significantly ($P \leq 0.05$) increased number of branches of cassava from 1.22 when no organic manure sources was applied to 2.89, when poultry manure was applied, followed by 1.56 when pig dung was applied. Cow dung however produced the same number of branches of 1.22 as when no organic manure source was applied. In 2014 the same trend occurred as poultry manure produced highest number of branches at 6 months after planting from 1.33 to 3.00 when poultry manure was applied, followed by 1.56 when pig dung was applied and then followed by 1.44 when cow dung was applied.

At 9 months after planting (MAP) (Table 4.31), during 2013 cropping season, organic manure significantly ($P \leq 0.05$) increased the number of branches from 1.22 when no organic manure source was applied to 3.00 when poultry manure was applied, followed 1.56 when pig dung was applied and then 1.22 when cow dung was applied.

In 2014 cropping season poultry manure produced the highest number of branches 3.56, while the other organic manure source produced number of branches 2.00.

Table 4.29: The effect of organic manure sources, ash and different densities of cassava on the number of branches of cassava at 3 months after planting (MAP) during 2013 and 2014 cropping seasons.

2013

Number of branches at 3 MAP

Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	1.00	2.00	1.33	1.33	1.42
10,000	1.00	3.00	1.33	1.00	1.58
5,000	1.00	2.67	1.67	1.33	1.67
Mean	1.00	2.56	1.44	1.22	

LSD (0.05) for organic manure source = 0.40
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	1.00	2.33	1.33	1.33	1.50
10,000	1.00	2.67	1.33	1.00	1.50
5,000	1.00	2.67	1.33	1.33	1.58
Mean	1.00	2.56	1.33	1.22	

LSD (0.05) for organic manure source = 0.47
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.30: The effect of organic manure sources, ash and different densities of cassava on the number of branches of cassava at 6 months after planting (MAP) during 2013 and 2014 cropping seasons.

2013

Number of branches at 6 MAP

	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	1.67	3.00	1.67	1.33	1.92
10,000	1.00	3.00	1.33	1.00	1.58
5,000	1.00	2.67	1.67	1.33	1.67
Mean	1.22	2.89	1.56	1.22	

LSD (0.05) for organic manure source = 0.44
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	1.67	3.00	1.67	1.67	2.00
10,000	1.33	3.00	1.33	1.33	1.83
5,000	1.00	3.00	1.67	1.33	1.67
Mean	1.33	3.00	1.56	1.44	

LSD (0.05) for organic manure source = 0.43
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.31: The effect of organic manure sources, ash and different densities of cassava on the number of branches of cassava at 9 months after planting (MAP) during 2013 and 2014 cropping seasons.

2013

Number of branches at 9 MAP					
Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	1.00	3.00	1.67	1.33	1.92
10,000	1.00	3.00	1.33	1.00	1.58
5,000	1.67	3.00	1.67	1.33	1.75
Mean	1.22	3.00	1.56	1.22	

LSD (0.05) for organic manure source = 0.41
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	2.00	3.33	2.00	2.00	2.33
10,000	2.00	3.67	2.00	2.00	2.42
5,000	2.00	3.67	2.00	2.00	2.42
Mean	2.00	3.56	2.00	2.00	

LSD (0.05) for organic manure source = 0.29
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

4.1.15 Plant canopy cover (m^2)

The effects of cassava density, ash and organic manure sources on the plant canopy cover are presented in (Tables 4.33 -4.35). There was no significant cassava density x organic manure sources interaction effect at 3, 6 and 9 months after planting (MAP) (Tables 4.32 – 4.34). In 2013 cropping season, organic manure sources significantly ($P \leq 0.05$) increased the plant canopy cover from 1.27 m^2 when no organic manure source was applied to 1.97 m^2 (55.12 %) increase when poultry manure was applied, followed by 1.53 m^2 (20.47 %) increase when pig dung was applied and the followed by 1.34 (5.57 %) increase when cow dung was applied.

In 2014 cropping season, organic manure sources significantly ($P \leq 0.05$) increased the plant canopy cover from 1.30 m^2 when no organic manure source was applied to 1.86 m^2 (43.1 %) increase when poultry manure was applied, followed by 1.54 m^2 (18.46%) increase when pig dung was applied and then followed by 1.36 m^2 (4.62%) increase when cow dung was applied.

At 6 months after planting (MAP) (Table 4.33), organic manure sources significantly ($P \leq 0.05$) increased the plant canopy cover during 2013 cropping season. However, organic manure sources significantly ($P \leq 0.05$) increased the plant canopy cover from 2.07 m^2 when no organic manure sources was applied to 2.92 m^2 (41.06 %) increase when poultry manure was applied, followed by 2.30 m^2 (11.1 %) increase when pig dung was applied, and then followed by 2.18 m^2 (5.31 %) increase when cow dung was applied.

In 2014 there was no significant density x organic manure interaction effect on the plant canopy cover at 6 months after planting (MAP). However, organic manure sources significantly increased the plant canopy cover from 2.07 m^2 when no organic manure sources was applied to 3.13 m^2 representing (51.21 %) increase when poultry manure was applied, followed by 2.31 m^2 (11.59 %) increase when pig waste was applied, and then 2.27 m^2 (9.66 %) increase when cow dung was applied.

At 9 months after planting (MAP) (Table 4.34), organic manure sources significantly ($P \leq 0.05$) increased the plant canopy cover of cassava during 2013 cropping season from 2.80 m^2 when no organic manure source was applied to 4.65 m^2 (66.07 %) increase when poultry manure was applied, followed by 3.55 m^2 (26.79 %) increase when pig dung was applied and then followed by 3.26 m^2 (16.43 %) increase when cow dung was applied.

The same trend occurred in 2014 cropping season. Organic manure sources significantly ($P \leq 0.05$) produced the highest plant canopy cover from 2.83 m^2 when no organic manure source was applied to 4.76 m^2 (68.20 %) increase when poultry manure was applied, followed by 3.58 m^2 (26.50 %) when pig dung was applied, and then followed by 3.32 m^2 (17.31 %) when cow dung was applied.

Table 4.32: The effect of organic manure sources, ash and different densities of cassava on the plant canopy cover of cassava at 3 months after planting (MAP) during 2013 and 2014 cropping seasons.

2014

Plant canopy cover (m^2) at 3 MAP					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	1.22	1.96	1.51	1.31	1.50
10,000	1.29	1.97	1.53	1.32	1.53
5,000	1.28	1.98	1.54	1.38	1.55
Mean	1.27	1.97	1.53	1.34	

LSD (0.05) for organic manure source = 0.02
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	1.27	1.94	1.53	1.33	1.52
10,000	1.32	1.98	1.55	1.35	1.55
5,000	1.32	1.66	1.55	1.41	1.48
Mean	1.30	1.86	1.54	1.36	

LSD (0.05) for organic manure source = 1.39
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.33: The effect of organic manure sources, ash and different densities of cassava on the plant canopy cover of cassava at 6 months after planting (MAP) during 2013 and 2014 cropping seasons.

2013

Plant canopy cover (m^2) at 6 MAP					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	2.09	2.69	2.35	2.13	2.32
10,000	2.10	3.08	2.20	2.20	2.40
5,000	2.03	2.98	2.34	2.22	2.40
Mean	2.07	2.92	2.30	2.18	

LSD (0.05) for organic manure source = 0.16
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	2.05	2.05	2.35	2.27	2.43
10,000	2.06	3.17	2.38	2.17	2.45
5,000	2.11	3.17	2.22	2.21	2.43
Mean	2.07	3.13	2.31	2.27	

LSD (0.05) for organic manure source = 0.033
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.34: The effect of organic manure sources, ash and different densities of cassava on the plant canopy cover of cassava at 9 months after planting (MAP) during 2013 and 2014 cropping seasons.

2013

Plant canopy cover (m^2) at 9 MAP					
Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	2.89	4.61	3.53	3.26	3.57
10,000	2.64	4.60	3.62	3.25	3.53
5,000	2.85	4.76	3.51	3.29	3.60
Mean	2.80	4.65	3.55	3.26	

LSD (0.05) for organic manure source = 0.14
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	2.93	4.63	3.54	3.28	3.51
10,000	2.68	4.85	3.65	3.39	3.64
5,000	2.89	4.81	3.54	3.31	3.63
Mean	2.83	4.76	3.58	3.32	

LSD (0.05) for organic manure source = 0.12
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

4.1.16 Stem yield of cassava (bundles/100 stems)

The effect of the stem yield of cassava (bundles /100 stems) is as shown in (Table 4.35). There was no significant cassava density x organic manure sources interaction effect on the stem yield of cassava (bundles / 100 stems) in 2013 and 2014 cropping seasons. This indicated that cassava density and organic manure sources acted differently from each other. In 2013, organic manure sources significantly ($P \leq 0.05$) increased the stems yields of cassava (bundles /100 stems) from 2.72 bundles / 100 stems when no organic manure sources was applied to 5.65 bundles /100 stems representing (107.72 %) increase when poultry manure was applied, followed by 3.72 bundles / 100 stems (36.76 %) increase when pig dung was applied and then followed by 3.30 bundles / 100 stems (21.69 %) increase when cow dung was applied.

In 2014, there was no significant density and organic manure sources interaction effect, indicating that cassava densities and organic manure sources acted differently from each other. However, organic manure sources and densities significantly ($P \leq 0.05$) increased the stem yield of cassava, from 2.86 (bundles/ 100 stems) when no organic source was applied to 5.31 (bundles /100 stems) representing (85.66 %) increase when poultry manure was applied, followed by 3.78 (bundle/100 stems) representing (32.17 %) increase when pig waste was applied, and then followed by 3.58 (bundles /100 stems) representing (22.38 %) increase when cow dung was applied.

Table 4.35: The effect of organic manure sources, ash and different densities of cassava on the stem yield of cassava (bundles /100 stems) at harvest during 2013 and 2014 cropping seasons.

2013

Stem yield of cassava (bundles/100 stems) at harvest					
Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	2.83	5.58	4.00	3.67	4.02
10,000	2.83	5.91	4.25	4.25	4.31
5,000	2.50	5.41	2.92	2.00	3.21
Mean	2.72	5.65	3.72	3.31	

LSD (0.05) for organic manure sources = 0.43
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	2.91	5.67	4.00	3.75	4.08
10,000	3.08	6.00	4.17	3.75	5.67
5,000	2.58	4.25	3.17	3.00	3.25
Mean	2.86	5.31	3.78	3.58	

LSD (0.05) for organic manure source = 0.85
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

4.1.17 Root Yield (tons/ha)

The effect of organic manure sources, ash and different densities of cassava on the tuber yield of (tons/ha) of cassava at harvest is shown in (Table 4.36).

Organic manure sources x cassava densities did not influence the tuber yield (tons/ha) of cassava at harvest. However, organic manure significantly ($P \leq 0.05$) increased the tuber yield from 6.18 tons/ha when no organic manure source was applied to 18.92 tons/ha representing (200.25 %) increase when poultry manure was applied, followed by 15.17 tons/ha (145.55 %) increase when pig dung was applied and then followed by 12.21tons/ha (97.69 %) increase when cow dung was applied.

In 2014, there was no significant organic manure sources x cassava density interaction effect dictated. This indicated that organic manure sources and density acted independently.

Organic manure application resulted in significant yield increase of cassava from 7.29 tons/ha when no organic manure was applied to 19.98 tons/ha (174.07 %) increase when poultry manure was applied, followed by 15.41 tons/ha (111.36 %) increase when pig dung was applied and then followed by 12.41 tons/ha (70.19 %) increase when cow dung was applied.

Table 4.36: The effect of organic manure sources, ash and different densities of cassava on the root weight (tons/ha) of cassava at harvest during 2013 and 2014 cropping seasons.

2013

Root yield (tons/ha) of cassava at harvest					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	6.14	19.20	15.11	12.27	13.18
10,000	6.16	19.32	15.10	12.19	13.19
5,000	6.23	18.92	15.17	12.21	13.13
Mean	6.18	18.92	15.17	12.21	

LSD (0.05) for organic manure sources = 0.13
LSD (0.05) for cassava densities = NS
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	7.65	19.64	15.24	12.51	13.76
10,000	7.12	20.3	15.25	12.33	13.77
5,000	7.03	19.70	15.73	12.38	13.71
Mean	7.29	19.98	15.41	12.41	

LSD (0.05) for organic manure source = 0.25

LSD (0.05) for cassava densities = NS

LSD (0.05) for cassava densities x org. manure source = NS

4.1.18 Weed Dry Weight (kg/ha)

The effect of organic manure sources, ash and different densities of cassava on the weed dry weight (kg/ ha) at 3, 6, and 9 months after planting is shown in (Tables 4.37 -4.39).

There was no significant organic manure sources x density interaction in 2013. However, organic manure sources and cassava densities significantly ($P \leq 0.05$) reduced the weed dry weight (kg/ha) at (3 MAP) (Table 4.37). Organic manure sources significantly ($P \leq 0.05$) reduced the weed dry weight from 2.43 kg/ha when no organic manure was applied to 1.45 kg/ha (40.32 %) decrease when poultry manure was applied, followed by 2.34 kg/ha (3.70 %) decrease when pig dung was applied and then 2.39 kg/ha (1.65 %) decrease when cow dung was applied.

Cassava densities also significantly ($P \leq 0.05$) reduced the weed dry weight from 2.20 kg/ha when 5000 plants/ha of cassava was planted to 2.13 kg/ha (3.18 %) decrease when 10000 plants/ha and 20000 plants/ha of cassava were planted respectively.

In 2014 cropping system, there was no significant organic manure sources x cassava density interaction effect on the weed dry weight (kg/ha). However organic manure sources and cassava densities had significant ($P \leq 0.05$) effect on the weed dry weight (kg/ha). Organic manure sources reduced the weed dry (kg/ha) from 2.42 kg/ha when no organic manure source was applied to 1.45 kg/ha (40.08 %) decrease when poultry manure was applied, followed by 2.34 kg/ha (3.31 %) decreased pig dung was applied, followed 2.39 kg/ha (1.24 %) decrease when cow dung was applied.

Cassava densities significantly (P≤0.05) reduced the weed dry weight (kg/ha) from 2.20 kg/ha when 5,000 plants /ha of cassava was planted to 2.13 kg/ha (3.18 %) decrease when 10,000 plants/ha and 20,000 plants/ha of cassava was planted respectively.

At 6 months after planting (MAP) (Table 4.38) during 2013 cropping season, there was no significant organic manure sources x cassava density interaction effect on the weed dry weight (kg/ha), however organic manure sources significantly (P≤0.05) reduced the weed dry weight /ha from 2.43 kg/ha when no organic manure source was applied to 1.48 kg/ha (39.09 %) decrease when poultry manure was applied, followed 2.20 kg/ha (9.47 %) decrease when pig dung was applied and then followed by 2.22 kg/ha (8.64 %) decrease when cow dung was applied.

Cassava densities also significantly (P≤0.05) reduced the weed dry weight (kg/ha) from 2.17 kg/ha when 5,000 plants /ha of cassava was planted to 2.02 kg/ha when 20,000 plants/ha of cassava was planted, (6.91 %) decrease, followed by 2.06 kg/ha (5.07 %) decrease 10,000 plants/ha was planted.

In 2014 cropping season, the same trend occurred at the weed dry weight (kg/ha) at 6 months after planting (MAP). There was no significant organic manure sources x density interaction on the weed dry weight (kg/ha). Nevertheless, organic manure sources significantly (P≤0.05) reduced the weed dry weight (kg/ha) from 2.38 kg/ha then when no organic manure source was applied to 1.46 kg/ha (38.66 %) decrease, when poultry was applied, followed by 2.21 kg/ha (7.14 %) decrease when pig dung was applied, and then followed by 2.24 kg/ha (5.88 %) decrease when cow dung was applied.

Cassava densties also significantly ($P<0.05$) reduced the weed dry weight /kg/ha) from 2.17 kg/ha when 5,000 plants/ha was applied to 2.05 kg/ha (5.53%) decrease when 10,000 plant/ha was planted and then 2.01 kg/ha (7.37%) decrease when 20,000 plots/ha was planted.

At 9 months after planting (MAP) (Table 4.39), organic manure sources only significantly ($P\leq0.05$) reduced the weed dry weight (kg/ha), in 2013 cropping season from 2.42 kg/ha when no manure was applied to 1.50 kg/ha (38.02 %) decrease when poultry manure was applied, followed by 2.28 kg/ha (5.79 %) decrease when pig dung was applied and then followed by 2.36 kg/ha (2.48 %) decrease when cow dung was applied.

In 2014 cropping season the same trend occurred. There was no significant density x organic manure sources interaction effect. However, organic manure sources only significantly ($P\leq0.05$) reduced, the weed dry weight from 2.16 kg/ha when no manure was applied to 1.11 kg/ha (48.61 %) decrease when poultry manure was applied, followed 2.08 kg/ha (3.70 %) decrease when pig dung was applied and then 2.10 kg/ha (2.78 %) decrease when cow dung was applied.

Cassava densities also signfinantly ($P\leq0.05$) reduced the weed dry weight (kg/ha) from 1.89kg/ha when 5,000 plants/ha was planted to 1.86 kg/ha (1.59%) decrease when 10,000 plants/ha cassava density was planted, while the least 1.84 (3.64%) decrease when 20,000plants/ha cassava density was planted.

Table 4. 37: The effect organic manure sources, ash and different densities of cassava on the Weed dry weight (kg/ha) at 3 months After Planting (MAP) during 2013and 2014 cropping seasons.

2013

Weed dry weight (kg/ha) at 3 MAP

Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	2.41	1.43	2.32	2.35	2.13
10,000	2.41	1.39	2.35	2.38	2.13
5,000	2.46	1.54	2.36	2.44	2.20
Mean	2.43	1.45	2.34	2.39	

LSD (0.05) for organic manure sources = 0.04
LSD (0.05) for cassava densities = 0.04
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	2.41	1.43	2.32	2.35	2.13
10,000	2.41	1.39	2.35	2.38	2.13
5,000	2.46	1.54	2.36	2.44	2.20
Mean	2.42	1.45	2.34	2.39	

LSD (0.05) for organic manure sources = 0.04
LSD (0.05) for cassava densities = 0.04
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.38: The effect organic manure sources, ash and different densities of cassava on the Weed dry weight (kg/ha) at 6 months After Planting (MAP) during 2013and 2014 cropping seasons.

2013

Weed dry weight (kg/ha) at 6 MAP

Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha					
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	2.33	1.50	2.12	2.14	2.02
10,000	2.43	1.46	2.17	2.19	2.06
5,000	2.54	1.49	2.32	2.33	2.17
Mean	2.43	1.48	2.20	2.22	

LSD (0.05) for organic manure sources = 0.10
LSD (0.05) for cassava densities = 0.09
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	2.29	1.50	2.24	2.11	2.01
10,000	2.39	1.43	2.39	2.22	2.05
5,000	2.45	1.46	2.35	2.39	2.17
Mean	2.38	1.46	2.21	2.24	

LSD (0.05) for organic manure sources = 0.056
LSD (0.05) for cassava densities = 0.048
LSD (0.05) for cassava densities x org. manure source = NS

Table 4.39: The effect organic manure sources, ash and different densities of cassava on the Weed dry weight (kg/ha) at 9 months After Planting (MAP) during 2013 and 2014 cropping seasons.

2013

Weed dry weight (kg/ha) at 9 MAP					
	Organic manure sources each at 10 tons/ha + Ash each at 5 tons/ha				
Cassava densities/ha	No manure (control)	Poultry manure	Pig dung	Cow dung	Mean
20,000	2.40	1.53	2.24	2.28	2.12
10,000	2.38	1.42	2.29	2.36	2.11
5,000	2.46	1.56	2.33	2.45	2.20
Mean	2.42	1.50	2.28	2.36	

LSD (0.05) for organic manure sources = 0.08
LSD (0.05) for cassava densities = 0.07
LSD (0.05) for cassava densities x org. manure source = NS

2014

20,000	2.16	1.06	2.07	2.07	1.84
10,000	2.16	1.08	2.08	2.11	1.86
5,000	2.17	1.18	2.09	2.13	1.89
Mean	2.16	1.11	2.08	2.10	

LSD (0.05) for organic manure sources = 0.017
LSD (0.05) for cassava densities = 0.015
LSD (0.05) for cassava densities x org. manure source = NS

4.2 DISCUSSION OF RESULT

4.2.1 Vegetative growth performance

The result of the study showed that growth and yield of plantain ratoon crops and cassava were significantly affected by organic manure application and weed dry weight at 3, 6 and 9 months after planting.

The rainfall pattern at Umuagwo was adequate as it encouraged the establishment of the plantain ratoon crops and cassava as shown in (Table 4.1). The rainfall was adequate for both vegetative growth and reproductive stages of crops and optimal utilization of organic manure sources especially poultry manure used in the experiment. (Pawar, Parbhan, Puri and Rahuri, 2003 and Ogazi, 1996). Besides, the high rainfall, the good performance of plantain ratoon crops and cassava was probably as a result of relative high total nitrogen content, available phosphorus and potassium in the soil of the experimental site during the 2013 and 2014 cropping seasons. When fertility is very low plants cannot obtain nutrient enough for good growth and development, consequently affecting crop yield. This report is in line with Adeosun (2000) who reported that low yield of rice was obtained due to low levels of soil nutrients, pH, organic matter, available phosphorus and total nitrogen which made the crops unable to maximally utilize them for carbohydrate synthesis, growth and yield.

The significant response of growth components such as plant height, number of functional leaves, number of branches, stem girth, leaf area in both years could be attributed to the role of organic manure which was essential for plant growth. This is in line with Zhang *et al.,* (2009) who reported that regular application of organic manure brings about increase in nitrogen, phosphorus and soil organic carbon (SOC), More so, the report is also in agreement with Xu *et al.*, (2005), who reported that vegetative growth with higher levels of organic manure grew better and resulted in a final higher yield than those grown on lower amounts along with those with mineral fertilizer. Tiyamiyu, Ahmed and Muhammed (2012) also reported that higher yield response of crops as a result of application of organic manure could be as a result of inproved physical and biological properties of the soil bringing about better supply of nutrients to the plants.

The leaf area for the manured treatments was observed to be higher than the 0 tons/ha application at 9 months after planting and at harvest in various months after planting. Besides, the vigorous leaf growth and stem girth in the treatments that received organic manure especially poultry manure confirms that poultry manure is richly endowed with nitrogen needed for leaf expansion, which aided in attracting enough sunlight needed for photosynthesis. This is in line John *et al.*, (2004) who reported that poultry manure contained essential nutrient elements associated with photosynthetic activity.

The enhancement of growth attributes in plantain ratoon crops due to increase in poultry manure application may have been related to direct addition of limiting plant nutrients. Poultry manure has high nitrogen content as well as the nutrients which are gradually released to the plants (Killi and Altanby, 2005, Awodun, 2007, Ewulo 2005). It can only be adduced that application of poultry manure may have resulted in an increase in the amount of nitrogen made available to the plants through mineralization as nitrogen is known to stimulate growth in plants (Anyaegbu *et al.*, 2010).

The result of the study showed that growth and yield of plantain ratoon crops and cassava were significantly affected by organic manure application, ash and different densities of cassava.

The better growth performance of poultry manure due to application of poultry manure can also be attributed to lower C:N ratio (Ewulo, 2005). This study also showed that increased plant spacing led to an increase in growth, leaf area and number of branches. Plants with ample space will compete less environmental factors (Baloch *et al.*, 2002). The observation is also in line with the report by Galanopoulou – Sendouka, Ficas, Fotiadis, Gaginas and Gerakis (1980) who reported that increase in plant density reduces individual plant performance especially morphological girth attribute. Philips (2010) Morris *et al.*, (2007) reported further that well spaced plants received more solar radiation and will carry out the process of photosynthesis effectively than closely spaced ones. Dense spacing also increases plant canopy cover also competition for water and fertilizer which results in inadequate negative growth (Igwe and Nwokocha, 2006).

Organic materials such as farm yard manure (FYM), poultry manure, green manure, crop residue, water weeds and city wastes have been reported as suitable substitutes for inorganic fertilizers to maintain suitable crop production including plantain and environmental quality (Pawar *et al.*, 2003).

4.2.2 Weed suppressibility potentials in the study

The result of the study indicated that organic manure sources contributed immensely to reducing weeds in the plantain ratoon crop and the cassava densities.

The combination of plantain and cassava reduced the weeds as a result of the plant canopy cover of cassava. In the study, poultry manure significantly increased the vegetative growth as well as the yield of cassava, as a result smothering the weeds within the plots. This report is in line with Obiefuna (1990) who reported that organic manure significantly influenced the general performance and productivity of crops due to its potentials in suppressing weeds, thereby creating unconducive environment to the weeds and creating a good environment for crops. Thus, bringing about increased growth rates, early flowering, large biomass, heavier canopy, early harvest and improved yield in his study was as a result of organic manure application which was made possible in nitrogen release in poultry manure.

It was also observed that the plots where the cassava densities were 5,000 plants/ha had more weeds owing to the larger spacing which brought about more weeds which competed with the crops in the plots, leading to yield reduction. This report is in line with report of Baloch *et al.,* (2002) who reported that plants with ample space will compete less for environmental factors such as weed, water, light and nutrients etc.

Ajari *et al.,* (2003) also reported that organic manure especially poultry manure could increase plant height and number of branches of crops. Similarly, Corey (2003) reported that organic manure release nutrients such as nitrogen and phosphorus for the healthy growth of plants.

4.2.3 Residual Effect of Organic Manure and Ash

The study revealed that organic manure and ash had residual effect on the plantain ratoon crops. This was observed in the course of the experiment, during the 2014 cropping season, the yield of both plantain and cassava was higher in 2014 than in 2013 cropping season. This result is in agreement with the study of Olayinka and Ailenubhi (2011) who reported that greater part of the benefit of animals sources lied in their slow mineralization and the addition of organic matter to the soil which offered definite advantage over inorganic fertilizer. Similarly, an earlier experiment by Obiefuna (1990) showed that manuring plantain with a combination of poultry manure, house hold waste, and wood ash improved plantain growth, yield and establishment and these greatly reduced infestation by borer weeds and nematodes due to its slow release. This was observed during the course of the experiment as the plantain ratoon crops / cassava mixture were growing with vigour.

Similarly, Palm *et al.,* (1997) reported on the use of organic manure alone to sustained cropping to be inadequate due to unavailability in the required quantities and relatively low yield. This result also agrees with an early report from Obiefuna and Ndubizu (1983) who reported that nutrients from organic manure source may be adequate for a long duration crop like plantain which requires the nutrients be supplied to the plant throughout the growing season.

It has also been reported that manure of animals and other origin is a slow release fertilizer and valuable source of crop nutrients and organic matter which can improve soil bio physical conditions thereby making the soil more productive and sustainable for food production (Mugwira, 1979).

Hamma, Ibrahim and Haruna (2012) observed highest leaf number in cucumber plants treated with highest rate of 12 tha^{-1}, while the least number was recorded at 0 tha^{-1} of poultry manure. Lowest leaf number recorded in 0 tha^{-1} could be attributed to the fact that it could not support appropriate growth of the plant because the residual nutrient content of the soil was inappropate to support growth of cucumber probably the nutrient content of the soil (most probably nitrogen) was below the critical level hence poor performance of the crop. This was also applicable to the plantain ratoon crops.

4.2.4 Yield and Yield Components

From the result of the study, poultry manure application resulted in increased vegetative growth such as plant height, number of functional leaves, number of branches, stem girth and leaf area, early flowering of plantain and subsequent increase in yield and yield components such as bunch weight, number of hands / bunch, number of fingers per / bunch, number of suckers, tuber yield of cassava at harvest and increased stem yield (bundles /100 stems). This was followed by pig dung and then cow dung. In all the period of study, zero application was consistently low with all the parameters measured. This could be attributed to favourable growth environment that enhanced flowering and development due to improvement of the soil physico-chemical properties as supported by Emma-Okafor, Obiefuna, Iwuanyanwu, Okoli, Ibeawuchi and Alagba (2017); Ekpo and Ekpo (2019). This report is in line with the study of Dauda (2002) who reported that days to 50 % flowering is a function of nitrogen concentration supported by poultry manure. More so, it has been reported that the application of fertilizer reduced number of days to flowering. The release of nutrients from organic fertilizers may have improved the soil structure by increasing the water holding capacity of the soil which gave rise to good aeration and drainage that encouaged better root growth and nutrient absorption (Ndukwe, Muoneke, Baiyeri and Tenkouano 2011). Furthermore Jiliani *et al.,* (2008) reported that deficiency of major nutrients was brought about by longer days to flowering of crops, similarly Niala *et al.,* (1999) reported induction of early flowering due to application of the process of bio regulator which have effect on early flowering. Papadoopoulous (1994) reported that nitrogen obtained from organic manure promoted more female flowers. Contrarily, Elamin (2006) reported that fertilizer treatment (chicken manure) significantly delayed time to fowering of squash compared to the control.

The results of the study also showed that organic manure sources increased the vegetative growth of both plantain and cassava. When compared with the application of poultry manure, no application of organic manure source reduced plant height and above all, reduced the production of plantain suckers, plantain bunch yield and cassava tuber yield at harvest. This is due to the fact that growth and yield of plantain and cassava were significantly improved by the addition of the organic manure especially the poultry manure.

Organic manure and ash have been reported to be useful in soil as soil amendments to improve soil fertility, crop production and soil conservation. Furthermore, poultry manure has been reported to be an organic manure which improves the yield of crops. Organic manure is not readily available to plants due to the time it dissolves and reacts with soils, but in the long run, it facilitates the growth of plants and positively increases yield (Xu *et al.*, 2005). Farm yard manure, in form of poultry manure, pig dung and cow dung helps to improve soil fertility, provides humus which is an essential component of a fertile soil, besides, it increases porosity and water holding capacity of the soil. These help the activities of soil micro organism in the release of nutrients to crops (Ahmed, 2007).

The result on days to 50 % flowering (months) showed that poultry manure reduced the days to 50 % flowering. The application of poultry manure, at 10 tons/ha and ash at 5 tons/ha respectively significantly reduced the number of months to 50 % flowering by 3.59 months in 2013 and 4.34 months in 2014. This was less than the other organic manure sources, pig dung and cow dung. The longest days to 50 % flowering was recorded for the control (no organic manure application). It was observed that flowering in treatments that received no organic manure were significantly prolonged as a result of nutrient stress which brought about poor flower initiation (Emma-Okafor *et al.*, 2015). The treatment that received poultry manure at 10 tons/ha produced high bunch yield of 9.50 tons/ha and 10.52 tons/ha in both 2013 and 2014 cropping seasons respectively. The absence of organic manure gave a negative impact on the plantain bunch weight on the treatment that received no organic manure application especially the poultry manure. This suggests that poultry manure supplied the basic nutrients needed for growth and yield of plantain. This result is in agreement with Adejoro (1999) and Gupta (1997) who reported that poultry manure is very rich in nutrients that will boost crop growth and yield. The data on bunch weight of plantain at harvest showed that the application of poultry manure at

10 tons /ha and ash at 5 tons/ah influenced the bunch weight 9.50 tons/ha (79.25 %) which is comparable with the values produced by pig dung which were significantly higher than the least value 5.3 tons/ha produced by non application of organic manure (Table 4.24) in 2013 cropping season. More so, in 2014 the bunch weight reached up to 10.52 tons/ha (61.59 %) when poultry manure was applied compared with no manure application 6.51 tons/ha. The result was in agreement with Yayock and Awoniyi (1988) who reported that organic manure is a nutrient source in crop production. Report from Onochie (1978) and Alamu *et al.,* (2009) also reported that application of organic manure improved the soil microbial activities with soil and improved girth and yield of crops, besides the use of organic manure is a viable alternative for the maintenance of soil fertility and high fruit yield, since it is relatively cheap and readily available.

Among the cassava densities 10,000 plants /ha produced larger plant canopy cover, suppressed weeds efficiently and above all, produced better stem yield bundles/100 stems) and root yield than other cassava densities.

4.2.5 Soil physical and chemical properties

The soil physical and chemical analysis carried out before the experiment showed that the soil was acidic and low in fertility. The general increase in soil pH and exchangeable cations from post harvest analysis was as a result of the introduction of organic manure. This is in line with the similar work done by Hsich and Hsu, (1993), Jinadasa, Milham, Hawkins, Comish, William, Kaldos and Conroy (1997) and Pitram and Singh (1993) who reported that organic manure increased pH of the soil and thus neutralized the soil acidity. Bessho and Bell (1992) added that the ability of organic manure to increase the soil pH was due to the presence of cations in the organic manure.

The low yield obtained in the controlled plot will be attributed to low soil fertility and weed infetation. Similarly, Ekpo *et al.,* (2010a) reported 85.6% reduction in yield of cassava. Generally, low organic matter, low reserves of essential plant nutrients and high soil acidity characterize the main agricultural lands of South-eastern Nigeria (Udo *et al.*, 2005) and has necessitited the regular application of ferilitizers especially organic manure (Law-Ogbomo and Remison, 2008).

From the result of the experiment high organic manure application resulted in increased, number of hands/bunch, number of fingers/bunch, bunch weight of plantain tuber weight, stem yield (bundles/100 stems). This is in agreement with Eifediyi and Remison (2010) and Emma-Okafor *et al.,* (2015) who obtained higher yield of crops due to organic manure application as a result of improved physical and biological properties.

The result of the study is in agreement with Aliyu (2000) and Dauda (2003) who obtained higher yield of crops due to organic manure application as a result of physical and biological properties of the soil resulting in better supply of nutrient to the plant as observed in the study during 2014 cropping season.

4.2.6 Interaction effect

All the growth and yield parameter assessed were not influenced by the interaction between organic manure sources and cassava densities except on the leaf area at 6 months after planting (MAP) during 2014 cropping season. This indicated that organic manure sources and ocassava densities acted independently on each other during the period of the expereiment. It also showed that the effect of organic manure sources and ash did not affect the cassava densities.

The three cassava densities used the experiment 20,000 plants/ha 10,000 plants/ha and 5,000 plants/ha produced considerable number of branches of cassava during the 2013 and 2014 cropping seasons due to the application of organic manure sources. This may be attributed to the sufficient nutrients at appropriate densities provided hence increasing the ability of these organs for development and synthesis of optimal assimilate. This was in agreement with the findings of Vincent, Michael and Stanley, 2005).

This study also showed that increased plant spacing led to an increase in growth, leaf area and number of branches and plant canopy cover. Plants with ample space will compete with less environmental factor (Baloch *et al.*, 2002).

CHAPTER V

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

On the basis of the present study, the following conclusion and recommendations were made from the objectives.

Plantain ratoon crops can be grown effectively under different cassava densities.

Lack of nutrient was responsible for the reduced growth and yield of plantain and cassava. The resultant effect on the vegetative growth, reproductive growth was in reduced plant height, reduced stem girth, reduced number of functional leaves, increased days of 50 % flowering, reduced plantain sucker production, reduced plant canopy cover and above all reduced bunch weight and cassava tuber weight.

Organic manure sources reduced weeds in the plantain ratoon crops/cassava mixture. Poultry manure produced the best vegetative and reproductive growth, followed by pig dung and cow dung in that order. On the basis of bunch weight and tuber weight of cassava, the three organic manure sources improved the weight of both plantain and cassava respectively. The best yield was in the order of poultry manure at 10 tons/ha + ash at 5 tons/ha, pig dung at 10 tons/ha + ash at 5 tons/ha and then cow dung at 10 tons/ha to ash at 5 tons/ha. However, on the basis of densities of cassava, the best results on the vegetative and reproductive growth was in the order of 100 x 100 cm (10,000 plants/ha) > 100 x 50 cm (20,000 plants/ha) > 100 x 200 cm (5,000 plants/ha). Organic manure sources and ash had residual effect on the plantain ratoon crops.

5.2 Recommendations

Poultry manure at 10 tons/ha + ash at 5 tons/ha with 100 x 100 cm (10,000 plants/ha) cassava density and pig dung, at 10 tons/ha + ash at 5 tons/ha with 100 x 100 cm (10,000 plants/ha) were recommended.

Considering the quantity of stem cuttings, fewer stands with comparative yield should be more favoured.

In this study, on the basis of availability and accessibility of organic manure sources, poultry manure at 10 tons/ha + ash at 5 tons/ha with 100 x 100 cm (10,000 plants/ha) cassava density was only recommended for use in the production of plantain ratoon crops/cassava inter crop.

5.3 Contributions to Knowledge

Plantain ratoon crops can be grown effectively under different cassava densities, as the poultry manure produced the best vegetative and reproductive growths, however, organic manure sources reduced weeds in plantain ratoon crops / cassava mixture with the rapid cassava/ plantain canopy cover that smothered weeds.

Furthermore, organic manure sources and ash had residual effects on the plantain ratoon crops of which poultry manure at 10 / tons/ha + ash at 5 / tons/ha + cassava densities 10,000 plants/ha (100 cm x 100 cm) is the recommended package for use in the production of plantain ratoon crops/ cassava inter crop.

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APPENDICES

Appendix 1: Factiorial Design in RCBD ANOVA Table for Plantain height at 3 MAP during 2013 cropping season based on Genstat Release 10 3 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	163.04	81.52	0.00	
Replicatn *Units* stratum	3	17729.09	5906.70	71.49	<.001
org_manure	2	22.25	11.12	0.13	0.875
density					
org_manure density	6	597.13	99.52	1.20	0.341
Residual	22	1817.72	82.62		
Total	35	20320.24			

Appendix 2: Factiorial Design in RCBD ANOVA Table for Plantain height at 3 MAP during 2014 cropping season based on Genstat Release 10 3 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	43.724	21.862	4.69	
Replicatn *Units* stratum					
spacing	2	119.494	59.747	12.82	<.001
OM	3	15760.682	5253.561	1127.05	<.001
spacing OM	6	122.399	20.400	4.38	0.005
Residual	22	102.549	4.661		
Total	35	16148.849			

Appendix 3: Factiorial Design in RCBD ANOVA Table for Plantain height at 6 MAP during 2013 cropping season based on Genstat Release 10 3 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	67.87	33.94	3.21	
Replicatn *Units* stratum	3	37762.41	12587.47	1191.34	<.001
org_manure density	2	23.00	11.50	1.09	0.354
org_manure density	6	281.25	46.87	4.44	0.004
Residual	22	232.45	10.57		
Total	35	35366.98			

Appendix 4: Factiorial Design in RCBD ANOVA Table for Plantain height at 6 MAP during 2014 cropping season based on Genstat Release 10 3 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	13.869	6.934	1.45	
Replicatn *Units* stratum					
density	2	31.071	15.535	3.24	0.059
org_manure density	2	40851.806	13617.269	2838.24	<.001
org_manure density	6	164.916	27.486	5.73	0.001
Residual	22	105.551	4.798		
Total	35	41167.212.			

Appendix 5: Factiorial Design in RCBD ANOVA Table for Plantain height at 9 MAP during 2013 cropping season based on Genstat Release 10 3 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	110.63	55.32	1.99	
Replicatn *Units* stratum	3	43922.29	14640.76	525.46	<.001
org_manure density	2	24.81	12.40	0.45	0.646
org_manure density	6	416.85	69.48	2.49	0.054
Residual	22	612.98	27.86		
Total	35	45087.57			

Appendix 6: Factiorial Design in RCBD ANOVA Table for Plantain height at 9 MAP during 2014 cropping season based on Genstat Release 10 3 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	482.1	241.0	2.15	
Replicatn *Units* stratum					
spacing	2	274.9	137.5	1.22	0.313
OM	3	50602.2	16867.4	150.24	<.001
spacing OM	6	622.8	103.8	0.92	0.497
Residual	22	2469.9	112.3		
Total	35	54452.0			

Appendix 7: Factiorial Design in RCBD ANOVA Table for Plantain height at 12 MAP during 2013 cropping season based on Genstat Release 10 3 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	2.57	1.28	1.00	
Replicatn *Units* stratum	3	66.74	11.14	1.72	0.193
org_manure density	2	26009.10	13004.50	1.00	0.383
org_manure density	6	785.86	13.09	1.01	0.443
Residual	22	284.96	12.95		
Total	35	48209.04			

Appendix 8: Factiorial Design in RCBD ANOVA Table for Plantain height at 12 MAP during 2014 cropping season based on Genstat Release 10 3 DE (2012) procedure.

Sources of variation	d.f.	s.s .	m.s.	v.r.	F.pr.
replicatn stratum	2	1.31	0.65	0.02	
Replicatn *Units* stratum					
spacing	2	60.49	30.24	0.86	0.438
OM	3	56223.43	18741.14	530.97	<.001
spacing OM	6	298.02	49.67	1.41	0.256
Residual	22	776.51	35.30		
Total	35	57359.75			

Appendix 9: Factiorial Design in RCBD ANOVA Table for Number of functional leaves of plantain at 6 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	1.0556	0.5278	1.40	
Replicatn *Units* stratum	3	143.2222	47.7407	126.88	<.001
org_manure density	2	0.2222	0.1111	0.30	0.747
org_manure density	6	1.7778	0.2963	0.79	0.589
Residual	22	8.2778	0.3763		
Total	35	154.5556			

Appendix 10: Factiorial Design in RCBD ANOVA Table for Number of functional leaves of plantain at 6 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.5000	0.2500	0.80	
Replicatn *Units* stratum					
density	2	0.6667	0.3333	1.07	0.359
org_manure density	3	163.6389	54.5463	175.61	<.001
org_manure density	6	1.1111	0.1852	0.60	0.730
Residual	22	6.8333	0.3106		
Total	35	172.7500			

Appendix 11: Factiorial Design in RCBD ANOVA Table for Number of leaves of plantain at 9 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.5000	0.2500	0.67	
Replicatn *Units* stratum	3	159.4167	53.1389	143.15	<.001
org_manure density	2	1.1667	0.5833	1.57	0.230
org_manure density	6	1.5000	0.2500	0.67	0 .672
Residual	22	8.2778	0.3763		
Total	35	170.7500			

Appendix 12: Factiorial Design in RCBD ANOVA Table for Number of functional leaves of plantain at 9 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	2.722	1.361	1.25	
Replicatn *Units* stratum					
density	2	1.722	0.861	0.79	0.466
org_manure density	3	197.194	65.731	60.29	<.001
org_manure density	6	8.056	1.343	1.23	0.327
Residual	22	23.944	1.088		
Total	35	233.639			

Appendix 13: Factiorial Design in RCBD ANOVA Table for Number of functional leaves of plantain at 12 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	1.500	0.750	0.73	
Replicatn *Units* stratum	3	175.639	58.546	57.25	<.001
org_manure density	2	2.000	1.000	0.98	0.392
org_manure density	6	7.111	1.185	1.16	0.363
Residual	22	22.500	1.023		
Total	35	208.750			

Appendix 14: Factiorial Design in RCBD ANOVA Table for Number of functional leaves of plantain at 12 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	1.5556	0.7778	3.35	
Replicatn *Units* stratum					
density	2	0.0556	0.0278	0.12	0.888
org_manure density	3	172.5556	57.5185	247.58	<.001
org_manure density	6	0.6111	0.1019	0.44	0.845
Residual	22	5.1111	0.2323		
Total	35	179.8889			

Appendix 15: Factiorial Design in RCBD ANOVA Table for Number of functional leaves of plantain at 15 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	1.0556	0.5278	2.07	
Replicatn *Units* stratum	3	169.8889	56.6296	222.03	<.001
org_manure	2	0.3889	0.1944	0.76	0.478
density					
org_manure density	6	2.94444	0.4907	1.92	0.122
Residual	22	5.6111	0.2551		
Total	35	179.8889			

Appendix 16: Factiorial Design in RCBD ANOVA Table for Number of functional leaves of plantain at 15 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	2.167	1.083	0.33	
Replicatn *Units* stratum					
density	2	6.167	3.083	0.95	0.401
org_manure	3	164.306	54.769	16.93	<.001
density					
org_manure density	6	20.944	3.491	1.08	0.405
Residual	22	71.167	3.235		
Total	35	264.750			

Appendix 17: Factiorial Design in RCBD ANOVA Table for Stem girth of plantain at 3 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	4.2222	2.1111	2.27	
Replicatn *Units* stratum	3	152.5278	50.82426	54.71	<.001
org_manure density	2	0.3889	0.1944	0.21	0.813
org_manure density	6	6.0556	1.0093	1.09	0.401
Residual	22	20.4444	0.9293		
Total	35	183.6389			

Appendix 18: Factiorial Design in RCBD ANOVA Table for Stem girth of plantain at 3 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	2.0556	1.0278	2.63	
Replicatn *Units* stratum					
density	2	0.3889	0.1944	0.50	0.615
org_manure density	3	126.3056	42.1019	107.56	<.001
org_manure density	6	2.9444	0.4907	1.25	0.318
Residual	22	8.6111	0.3914		
Total	35	140.3056			

Appendix 19: Factiorial Design in RCBD ANOVA Table for Stem girth of plantain at 6 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	12.0556	6.0278	7.98	
Replicatn *Units* stratum	3	627.6389	209.2130	277.08	<.001
org_manure density	2	1.7222	0.8611	1.14	0.338
org_manure density	6	8.2778	1.3796	1.83	0.140
Residual	22	16.6111	0.7551		
Total	35	666.3056			

Appendix 20: Factiorial Design in RCBD ANOVA Table for Stem girth of plantain at 6 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	4.0556	2.0278	3.20	
Replicatn *Units* stratum					
density	2	9.3889	4.6944	7.41	0.03
org_manure density	3	694.7500	231.5833	365.37	<.001
org_manure density	6	14.8333	2.4722	3.90	0.008
Residual	22	13.9444	0.6338		
Total	35	736.9722			

Appendix 21: Factiorial Design in RCBD ANOVA Table for Stem girth of plantain at 9 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	17.3889	8.6944	10.66	
Replicatn *Units* stratum	3	653.1111	217.7037	266.91	<.001
org_manure density	2	0.8889	0.4444	0.54	0.588
org_manure density	6	0.8889	0.1481	0.18	0.979
Residual	22	17.9444	0.8157		
Total	35	690.2222			

Appendix 22: Factiorial Design in RCBD ANOVA Table for Stem girth of plantain at 9 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	37.50	18.75	0.85	
Replicatn *Units* stratum					
density	2	60.17	30.08	1.36	0.278
org_manure density	3	1085.89	361.96	16.35	<.001
org_manure density	6	114.28	19.05	0.86	0.539
Residual	22	487.17	22.14		
Total	35	1785.00			

Appendix 23: Factiorial Design in RCBD ANOVA Table for Stem girth of Plantain at 12 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	2.722	1.361	0.33	
Replicatn *Units* stratum	3	947.222	315.741	75.55	<.001
org_manure density	2	5.722	2.861	0.68	0.515
org_manure density	6	30.944	5.157	1.23	0.327
Residual	22	91.9444	4.179		
Total	35	1078.556			

Appendix 24: Factiorial Design in RCBD ANOVA Table for Stem girth of Plantain at 12 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	120.17	60.08	0.99	
Replicatn *Units* stratum					
density	2	120.17	60.08	0.99	0.387
org_manure density	3	530.00	176.67	2.91	0.057
org_manure density	6	443.17	73.86	1.22	0.335
Residual	22	1334.50	60.66		
Total	35	2548.00			

Appendix 25: Factiorial Design in RCBD ANOVA Table for Leaf Area of Plantain at 3 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	3175738.	15787869.	0.47	
Replicatn *Units* stratum	3	17189756.	5729919.	1.69	0.199
org_manure density	2	3591639.	1795820.	0.53	0.597
org_manure density	6	10766477.	1794413.	0.53	0.781
Residual	22	74763378.	3398335.		
Total	35	109486988.			

Appendix 26: Factiorial Design in RCBD ANOVA Table for Leaf Area of Plantain at 3 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	2813.	1406.	1.13	
Replicatn *Units* stratum					
spacing	2	19386.	9693.	7.77	0.003
OM	3	4436725.	1478908.	1185.75	<.001
spacing OM	6	15703.	2617.	2.10	0.095
Residual	22	27439.	1247.		
Total	35	4502066.			

Appendix 27: Factiorial Design in RCBD ANOVA Table for Leaf Area of Plantain at 6 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	61659.	30829.	0.91	
Replicatn *Units* stratum	3	2637247.	879082.	25.95	<.001
org_manure	2	36599.	18300.	0.54	0.590
density					
org_manure density	6	210953.	35159.	1.04	0.428
Residual	22	745390.	33881.		
Total	35	3691848.			

Appendix 28: Factiorial Design in RCBD ANOVA Table for Leaf Area of Plantain at 6 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	8889.	4444.	1.43	
Replicatn *Units* stratum					
density	2	371566.	185783.	59.64	<.001
org_manure	3	11091140.	3697047.	1186.83	<.001
density					
org_manure density	6	389990.	64998.	20.87	<.001
Residual	22	68532.	3115.		
Total	35	11930116.			

Appendix 29: Factiorial Design in RCBD ANOVA Table for Leaf Area of Plantain at 9 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	11571.	5785.	1.65	
Replicatn *Units* stratum	3	7806893.	2602298.	740.20	<.001
org_manure density	2	18705.	19352.	2.66.	0.092
org_manure density	6	9126.	1521.	0.43	0.849
Residual	22	77345.	3516.		
Total	35	7923638.			

Appendix 30: Factiorial Design in RCBD ANOVA Table for Leaf Area of Plantain at 9 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	804.	402.	0.11	
Replicatn *Units* stratum					
density	2	434642.	217321.	57.14	<.001
org_manure density	3	11710757.	3903586.	1026.30	<.001
org_manure density	6	429244.	71541.	18.81	<.001
Residual	22	83678.	3804.		
Total	35	12659125.			

Appendix 31: Factiorial Design in RCBD ANOVA Table for Leaf Area of Plantain at 12 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	93151.	46576.	4.52	
Replicatn *Units* stratum	3	7284455.	2428152.	235.55	<.001
org_manure density	2	41695.	20847.	2.02.	0.156
org_manure density	6	83870.	13945.	1.35	0.277
Residual	22	226785.	10308.		
Total	35	7729756.			

Appendix 32: Factiorial Design in RCBD ANOVA Table for Leaf Area of Plantain at 12 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	14710505.	7355252.	1.01	
Replicatn *Units* stratum					
density	2	9688998.	4844499.	0.66	0.525
org_manure density	3	23456304.	7818768.	1.07	0.382
org_manure density	6	46945162.	7824194.	1.07	0.409
Residual	22	160660137.	7302734.		
Total	35	255461105.			

Appendix 33: Factiorial Design in RCBD ANOVA Table for days to 50 % flowering of plantain during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	6.167	3.083	2.22	
Replicatn *Units* stratum					
spacing	2	3.500	1.750	1.26	0.303
OM	3	78.972	26.324	18.99	<.001
spacing OM	6	5.611	0.935	0.67	0.671
Residual	22	30.500	1.386		
Total	35	124.750			

Appendix 34: Factiorial Design in RCBD ANOVA Table for days to 50 % flowering of plantain during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	0.7222	0.3611	1.20	
Replicatn *Units* stratum					
spacing	2	0.2222	0.1111	0.37	0.695
OM	3	93.0000	31.0000	103.16	<.001
spacing OM	6	0.6667	0.1111	0.37	0.890
Residual	22	6.6111	0.3005		
Total	35	101.2222			

Appendix 35: Factiorial Design in RCBD ANOVA Table for Number of fingers/bunch of plantain during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	0.0556	0.0278	0.04	
Replicatn *Units* stratum					
density	2	636.7500	212.2500	270.26	<.001
org_manure density	3	7.3889	3.6944	4.70	0.020
org_manure density	6	3.5000	0.5833	0.74	0.621
Residual	22	17.2778	0.7854		
Total	35	664.9722			

Appendix 36: Factiorial Design in RCBD ANOVA Table for Number of fingers/bunch of plantain during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	2.8889	1.4444	2.86	
Replicatn *Units* stratum					
density	2	6.0556	3.0278	5.99	0.008
org_manure density	3	755.0000	251.667	498.30	<.001
org_manure density	6	5.5000	0.9167	1.81	0.142
Residual	22	11.1111	0.5051		
Total	35	780.5556			

Appendix 37: Factiorial Design in RCBD ANOVA Table for Number of Hands /bunch of plantain during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	0.1667	0.0833	0.26	
Replicatn *Units* stratum					
density	2	8.3056	2.7685	8.50	<.001
org_manure density	3	0.1667	0.0833	0.26	0.777
org_manure density	6	0.9444	0.1574	0.48	0.814
Residual	22	7.1667	0.3258		
Total	35	16.7500			

Appendix 38: Factiorial Design in RCBD ANOVA Table for Number of Hands/ bunch of plantain during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	0.1667	0.0833	0.26	
Replicatn *Units* stratum					
density	2	0.6667	0.3333	1.63	0.219
org_manure density	3	11.0000	3.6667	17.93	<.001
org_manure density	6	0.6667	0.1111	0.54	0.770
Residual	22	4.5000	0.2045		
Total	35	17.0000			

Appendix 39: Factiorial Design in RCBD ANOVA Table for Bunch weight of plantain during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	137.24	68.62	1.00	
Replicatn *Units* stratum	3	113.95	37.98	0.55	0.650
org_manure density	2	138.32	69.16	1.01	0.381
org_manure density	6	412.07	68.68	1.00	0.448
Residual	22	1506.50	68.48		
Total	35	2308.08			

Appendix 40: Factiorial Design in RCBD ANOVA Table for Bunch weight of plantain during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.07722	0.03861	1.86	
Replicatn *Units* stratum	3	0.16889	0.08444	4.07	0.031
org_manure density	2	123.12667	41.04222	1979.62	<.001
org_manure density	6	0.23333	0.03889	1.86	0.130
Residual	22	0.45611	0.02073		
Total	35	124.06222			

Appendix 41: Factiorial Design in RCBD ANOVA Table for Number of suckers of plantain during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.6667	0.3333	1.38	
Replicatn *Units* stratum	3	24.7500	8.2500	34.03	<.001
org_manure density	2	1.1667	0.5833	2.41	0.113
org_manure density	6	0.8333	0.1389	0.57	0.748
Residual	22	5.3333	0.2424		
Total	35	32.7500			

Appendix 42: Factiorial Design in RCBD ANOVA Table for Number of suckers of plantain during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	0.3889	0.1944	0.68	
Replicatn *Units* stratum					
density	2	1.0556	0.5278	1.85	0.181
org_manure density	3	54.9722	18.3241	64.22	<.001
org_manure density	6	0.9444	0.1574	0.55	0.763
Residual	22	6.2778	0.2854		
Total	35	63.6389			

Appendix 43: Factiorial Design in RCBD ANOVA Table for Cassava height at 3 MAP during 2013 cropping season based on Genstat Release 10 3 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	4.711	2.355	1.75	
Replicatn *Units* stratum	2	20.217	10.109	7.51	0.003
org_manure density	3	10481.763	3493.921	2596.59	<.001
org_manure density	6	48.656	8.109	6.03	<.001
Residual	22	29.603	1.346		
Total	35	10584.950			

Appendix 44: Factiorial Design in RCBD ANOVA Table for Cassava height at 3 MAP during 2014 cropping season based on Genstat Release 10 3 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	7.434	3.717	3.14	
Replicatn *Units* stratum					
density	2	7.354	3.677	3.11	0.065
org_manure density	3	10999.986	3666.662	3097.07	<.001
org_manure density	6	31.026	5.171	4.37	0.005
Residual	22	26.046	1.184		
Total	35	11071.846			

Appendix 45: Factiorial Design in RCBD ANOVA Table for Cassava height at 6 MAP during 2013 cropping season based on Genstat Release 10 3 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	8.754	4.377	3.64	
Replicatn *Units* stratum	3	18217.188	6072.396	5046.42	<.001
org_manure density	2	16.809	8.404	6.98	0.004
org_manure density	6	136.116	22.686	18.85	<.001
Residual	22	26.473	1.203		
Total	35	18405.339			

Appendix 46: Factiorial Design in RCBD ANOVA Table for Cassava height at 6 MAP during 2014 cropping season based on Genstat Release 10 3 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	164477.	82238.	1.02	
Replicatn *Units* stratum					
density	2	159364.	79682.	0.99	0.389
org_manure density	3	4750063.	158354.	1.96	0.149
org_manure density	6	503395.	83899.	1.04	0.427
Residual	22	1776766.	80762.		
Total	35	3079065.			

Appendix 47: Factiorial Design in RCBD ANOVA Table for Cassava height at 9 MAP during 2013 cropping season based on Genstat Release 10 3 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	17.460	8.730	3.23	
Replicatn *Units* stratum	2	315.047	157.523	58.30	<.001
spacing	3	33945.965	11315.322	4188.04	<.001
OM					
spacing OM	6	718.216	119.703	44.30	<.001
Residual	22	59.440	2.702		
Total	35	35056.127			

Appendix 48: Factiorial Design in RCBD ANOVA Table for Cassava height at 9 MAP during 2014 cropping season based on Genstat Release 10 3 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	11.602	5.801	2.89	
Replicatn *Units* stratum					
density	2	2.672	1.336	0.67	0.524
org_manure	3	22935.779	7645.260	3806.05	<.001
density					
org_manure density	6	42.624	7.104	3.54	0.013
Residual	22	44.192	2.009		
Total	35	23036.868			

Appendix 49: Factiorial Design in RCBD ANOVA Table for of branches of cassava at 3 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.3889	0.1944	1.18	
Replicatn *Units* stratum	3	128889	4.2963	26.17	<.001
org_manure density	2	0.3889	0.2685	1.18	0.325
org_manure density	6	1.6111	0.2685	1.64	0.185
Residual	22	3.6111	0.1641		
Total	35	18.8889			

Appendix 50: Factiorial Design in RCBD ANOVA Table for Numbr of branches of cassava at 3 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.2222	0.1111	0.48	
Replicatn *Units* stratum	3	0.0556	0.0278	0.12	0.888
org_manure density	2	13.1944	0.0648	18.93	<.001
org_manure density	6	0.3889	0.00648	0.28	0.941
Residual	22	5.1111	0.2323		
Total	35	18.9722			

Appendix 51: Factiorial Design in RCBD ANOVA Table for Number of brnaches of cassava at 6 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.2222	0.11111	0.55	
Replicatn *Units* stratum	3	17.0000	5.6667	28.05	<.001
org_manure density	2	0.72222	0.3611	1.79	0.191
org_manure density	6	0.8333	0.1389	0.69	0.662
Residual	22	4.4444	0.2020		
Total	35	23.2222			

Appendix 52: Factiorial Design in RCBD ANOVA Table for Number of bracnhes of cassava at 6 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	1.1667	0.5833	3.03	
Replicatn *Units* stratum	3	0.6667	0.3333	1.76	0.195
org_manure density	2	16.5556	5.5185	29.14	<.001
org_manure density	6	0.4444	0.0741	0.39	0.877
Residual	22	4.1667	0.1894		
Total	35	23.0000			

Appendix 53: Factiorial Design in RCBD ANOVA Table for Number of branches of cassava at 9 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.1667	0.0833	0.48	
Replicatn *Units* stratum	3	19.4167	6.4722	37.14	<.001
org_manure density	2	0.6667	0.3333	1.91	0.171
org_manure density	6	0.6667	0.1111	1.64	0.699
Residual	22	3.8333	0.1742		
Total	35	24.7500			

Appendix 54: Factiorial Design in RCBD ANOVA Table for Number of branches of cassava at 9 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.05556	0.02778	0.31	
Replicatn *Units* stratum	3	0.05556	0.02778	0.31	0.734
org_manure density	2	16.3333	5.44444	61.60	<.001
org_manure density	6	0.16667	0.02778	0.31	0.923
Residual	22	1.94444	0.08838		
Total	35	18.55556			

Appendix 55: Factiorial Design in RCBD ANOVA Table for Plant canopy cover of cassava at 3 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.0004167	0.0002083	0.33	
Replicatn *Units* stratum	3	2.7034972	0.09011657	1411.08	<.001
org_manure density	2	0.0126167	0.0063083	9.88	<001
org_manure density	6	0.0056944	0.00009491	1.49	0.229
Residual	22	0.0140500	0.0006386		
Total	35	2.7362750			

Appendix 56: Factiorial Design in RCBD ANOVA Table for Plant canopy cover of cassava at 3 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	0.06244	0.03122	1.16	
Replicatn *Units* stratum					
density	2	0.02669	0.01334	0.50	0.616
org_manure density	3	1.70272	0.56757	21.10	<.001
org_manure density	6	0.18064	0.03011	1.12	0.383
Residual	22	0.59183	0.02690		
Total	35	2.56432			

Appendix 57: Factiorial Design in RCBD ANOVA Table for Plant canopy cover of cassava at 6 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.10144	0.05072	1.83	
Replicatn *Units* stratum	3	3.81936	1.27312	45.91	<.001
org_manure density	2	0.08677	0.04339	1.56	0.232
org_manure density	6	0.22109	0.03685	1.33	0.286
Residual	22	0.61009	0.02773		
Total	35	4.83876			

Appendix 58: Factiorial Design in RCBD ANOVA Table for Plant canopy cover of cassava at 6 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	0.005939	0.002969	2.63	
Replicatn *Units* stratum					
density	2	0.002839	0.001419	1 .26	0.303
org_manure density	3	6.085186	2.028395	1799.79	<.001
org_manure density	6	0.090272	0.015045	13.35	007
Residual	22	0.024794	0.001127		
Total	35	6.209031			

Appendix 59: Factiorial Design in RCBD ANOVA Table for Plant canopy cover of cassava at 9 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.01121	0.00560	0.29	
Replicatn *Units* stratum	3	16.82450	5.60817	289.27	<.001
org_manure	2	0.03524	0.01762	0.91	0.418
density					
org_manure density	6	0.14989	0.02498	1.29	0.303
Residual	22	0.42653	0.01939		
Total	35	17.44736			

Appendix 60: Factiorial Design in RCBD ANOVA Table for Plant canopy cover of cassava at 9 MAP durig 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	0.04267	0.2134	1.44	
Replicatn *Units* stratum					
density	2	0.01451	0.00725	0.49	0.620
org_manure	3	18.09134	6.03045	406.64	<.001
density					
org_manure density	6	0.21927	0.03655	2.46	0.056
Residual	22	0.32626	0.01483		
Total	35	18.69406			

Appendix 61: Factiorial Design in RCBD ANOVA Table for Plant canopy cover of cassava at 12 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	5.3539	2.6770	4.80	
Replicatn *Units* stratum	3	33.6974	11.2325	20.15	<.001
org_manure density	2	3.3730	1.6865	3.03	0.069
org_manure density	6	1.3949	0.2325	0.42	0..860
Residual	22	12.2649	0.5575		
Total	35	56.0842			

Appendix 62: Factiorial Design in RCBD ANOVA Table for Plant canopy cover of cassava at 12 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	2.8746	1.4373	4.16	
Replicatn *Units* stratum					
density	2	4.3605	2.1803	6.31	0.007
org_manure density	3	34.7133	11.5711	33.49	<.001
org_manure density	6	1.7131	0.2855	0.83	0.562
Residual	22	7.6015	0.3455		
Total	35	51.2632			

Appendix 63: Factiorial Design in RCBD ANOVA Table for Stem yield of cassava at harvest during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	1.5556	0.7778	1.04	
Replicatn *Units* stratum	3	464.2222	154.7407	207.02	<.001
org_manure density	2	110.2222	55.1111	73.73	<.001
org_manure density	6	24.4444	4.0741	5.45	0.001
Residual	22	16.4444	0.7475		
Total	35	616.8889			

Appendix 64: Factiorial Design in RCBD ANOVA Table for Stem yield of cassava at harvest during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	2.389	1.194	0.38	
Replicatn *Units* stratum					
density	2	125.722	62.861	20.25	<.001
org_manure density	3	689.000	229.667	74.00	<.001
org_manure density	6	63.167	10.538	3.39	0.016
Residual	22	68.278	3.104		
Total	35	948.556			

Appendix 65: Factiorial Design in RCBD ANOVA Table for Root yield of cassava at harvest during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.11472	0.05736	4.34	
Replicatn *Units* stratum	3	784.05416	261.35139	19761.92	<.001
org_manure density	2	0.26375	0.13187	9.97	<00.1
org_manure density	6	1.70109	0.28352	21.44	0.001
Residual	22	0.29095	0.01323		
Total	35	786.42467			

Appendix 66: Factiorial Design in RCBD ANOVA Table for Root yield of cassava at harvest during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	0.05121	0.02560	0.38	
Replicatn *Units* stratum					
density	2	0.02507	0.01254	0.18	0.833
org_manure density	3	754.75090	251.58363	3706.38	<.001
org_manure density	6	1.90475	0.31746	4.68	0.003
Residual	22	1.49333	0.06788		
Total	35	758.22526			

Appendix 67: Factiorial Design in RCBD ANOVA Table for Weed dry weight (kg/ha) of plot at 3 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.006439	0.003219	1.73	
Replicatn *Units* stratum	3	0.042639	0.021319	11.45	<.001
org_manure density	2	5.925408	1.975136	1060.84	<.001
org_manure density	6	0.019317	0.003219	1.73	0.161
Residual	22	0.040961	0.001862		
Total	35	6.034764			

Appendix 68: Factiorial Design in RCBD ANOVA Table for Weed dry weight (kg/ha) of plot at 3 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	0.007039	0.003519	1.87	
Replicatn *Units* stratum					
density	2	0.038839	0.019419	10.31	<.001
org_manure density	3	5.903653	1.967884	1045.03	<.001
org_manure density	6	0.020806	0.003468	1.84	0.137
Residual	22	0.041428	0.001883		
Total	35	6.011764			

Appendix 69: Factiorial Design in RCBD ANOVA Table for Weed dry weight (kg/ha) of plot at 6 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.04967	0.02484	2.20	
Replicatn *Units* stratum	3	4.65912	1.55303	137.74	<.001
org_manure density	2	0.13796	0.06898	6.12	0.008
org_manure density	6	0.04884	0.00814	0.72	0.636
Residual	22	0.24806	0.01128		
Total	35	5.14366			

Appendix 70: Factiorial Design in RCBD ANOVA Table for Weed dry weight (kg/ha) of plot at 6 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	0.014022	0.007011	2.16	
Replicatn *Units* stratum					
density	2	0.155672	0.077836	2397	<.001
org_manure density	3	4.619533	1.539844	474.17	<.001
org_manure density	6	0.100817	0.016803	5.17	0.002
Residual	22	0.071444	0.003247		
Total	35	4.961489			

Appendix 71: Factiorial Design in RCBD ANOVA Table for Weed dry weight (kg/ha) of plot at 9 MAP during 2013 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s	m.s	v.r	F.pr.
replicatn stratum	2	0.013606	0.006803	1.07	
Replicatn *Units* stratum	3	5.022489	1.674163	263.97	<.001
org_manure	2	0.061939	0.030969	4.88	0.018
density					
org_manure density	6	0.036061	0.006010	0.95	0.482
Residual	22	0.139528	0.006342		
Total	35	5.273622			

Appendix 72: Factiorial Design in RCBD ANOVA Table for Weed dry weight (kg/ha) of plot at 9 MAP during 2014 cropping season based on Genstat Release 103 DE (2012) procedure.

Sources of variation	d.f.	s.s.	m.s.	v.r.	F.pr.
replicatn stratum	2	0.0001167	0.0000583	0.20	
Replicatn *Units* stratum					
density	2	0.0200667	0.0100333	34.40	<.001
org_manure	3	6.9074528	2.3024843	7894.23	<.001
density					
org_manure density	6	0.0144222	0.0024037	8.24	0.001
Residual	22	0.0064167	0.0002917		
Total	35	6.9484750			