EFFECTS OF MORINGA (*Moringa oleifera* Lam.) LEAF EXTRACT AND POULTRY MANURE ON THE GROWTH AND YIELD OF SWEET CORN (*Zea mays* var *saccharata* Stuart)

BY

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DECLARATION

I declare that this work is an original research work carried out by me in the Department of Agronomy

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CERTIFICATION

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DEDICATION

I dedicate this work to God Almighty, for the courage to carry on. Also to my parents Mr Rufus Adetuwo Alubiagba.and Mrs Maria Ibilola Alubiagba for their patience

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ABSTRACT

The study was carried out in the Teaching and Research farm of the Faculty of Agriculture Asaba campus, Asaba during the 2015/2016 early/late cropping seasons. The aim was to evaluate the effects of moringa leaf extract (MLE) and poultry manure (PM) on the growth and yield of sweet maize (Zea mays var. saccharata Stuart). The experiment was a Randomized Complete Block Design (RCBD) replicated three times involving nine treatments namely : control (no extract), 3% MLE, 6% MLE, 9% MLE, 35 MLE + 15 tha^{-1} PM, 65 MLE + 15 tha-^{1} PM, 9% MLE + 15 tha^{-1} PM, 15 tha^{-1} PM and 30 tha^{-1} PM. Growth and yield parameters such as plant height, number of leaves per plant, stem girth, leaf area, number of days to 50% tasseling, number of days to 50% silking, weight of de-husked cobs, number of seeds per cob and grain yield were evaluated and data collected were subjected to Analysis .The results of the study showed that there were significant differences (P=0.05) among the treatments as plots that received 30 tha^{-1} of poultry manure (PM) performed best on plant height, 193.6 cm and 152.8cm; number of leaves, 13.1 and 10.1; stem girth, 3.75cm and 3.22cm and number of seeds per cob, 545 and 491.7 in the early and late seasons respectively. This was followed by plots that received 9% MLE and 15 tha^{-1} PM with values of 189.0 cm and 152.2 cm; 12.5 and 10.0; 3.58 cm and 3.15 cm and 512.2 and 467.0 in the corresponding treatments respectively. On the whole, MLE significantly increased plant height, leaf area, weight of de-husked cobs, number of seeds per cob and grain yield of sweet corn. The results showed that 30 tha^{-1} of poultry manure (PM) could be used alone and 9% MLE + 15 tha^{-1} PM could be used in combination for better yield of sweet maize in the study environment.

CHAPTER ONE

INTRODUCTION

Maize (*Zea mays* L.) or corn is a cereal crop that is widely grown throughout the world across various agro-ecological environments (Okonmah and Eruotor, 2012). It is the most productive grain crop in the world, with over 1 billion tons produced in 2013 from 232 million hectares (FAOSTAT, 2014).From its introduction into Africa in the 16th century by Portuguese traders, it has grown to become, along with cassava, one of Africa's most dominant food crops (Phiri, 2010; Mvumi, Tagwira and Chiteka, 2012; Enujeke, 2013). It is consumed roasted, boiled, fried, baked or fermented in Nigeria (Agbato, 2003; Abdulrahaman and Kolawole, 2006; Olaniyan, 2015). In developed countries, maize is a source of such industrial products as corn oil, syrup, corn flour, sugar, brewers grit and alcohol (Dutt, 2005), while as an energy supplement in livestock feed, maize is cherished by various species of animals, including poultry, cattle, pigs, goats, sheep and rabbit (D*IPA, 2006).*

Sweet corn (Zea mays var.*Saccharata*) is a maize variety in which the tender, sugar delicious kernels are eaten as a vegetable. In contrast to traditional field corn, sweet corn varieties are harvested when the kernels have just reached the milk stage and used sooner. Sweet corn has achieved a major commercial success in many tropical and sub-tropical countries (Okonmah and Eruotor, 2012).The commercial success of maize crop notwithstanding, production in Nigeria has been bedeviled by low yields due to such factors as rapid reduction in soil fertility and negligence of soil amendment materials (DIPA, 2006; Enujeke, 2013). While manures and fertilizers are the life wire of increased crop productivity, Phiri (2010) noted that the dependence on the use of inorganic fertilizers is associated with land and soil degradation as well as environmental pollution (Anyaegbu, 2015).

In recent years, there is increasing awareness among maize farmers of the benefits of organic fertilizer application. This is because organic fertilizers not only increase physical soil properties such as porosity, structure and water-holding capacity and chemical soil properties but also increase mineral deposition, which is essential for proper development of plants (Amujoyegbe, Opabode and Olayinka, 2007 ; Mishra, Singh, Singh, Das and Prasad, 2013).

In order to fill the demand for organic fertilizers, one increasingly viable option is the use of plant extracts (botanicals/biopesticides) such as *Moringa oleifera* leaf extract (MLE) as fertilizer (Davis, 2000). In agriculture and horticulture, MLE has proved beneficial for crop growth and yield (Chang, Chung and Yuong, 2007), deeper root development and better seed germination (Kannaiyan, 2000), delay of crop senescence and improved plant vigour and yield quality/quantity (Hossain, Mah,Ahmed and Sarmin, 2012). MLE also impacts to crops the ability to withstand adverse condition (Chang *et al.* 2007).

The general objective of this study therefore was to investigate the effect of *Moringa oleifera* leaf extract (MLE) and poultry manure (PM) on the growth and yield of sweet corn (*Zea mays* var. *saccharata*).

The specific objectives were :

1) to evaluate the effects of MLE and poultry manure as single treatments on the growth and yield of sweet corn ,
2) to evaluate the effects of the combination of MLE and PM at different concentrations on some growth and yield indices of sweet corn.

CHAPTER TWO

LITERATURE REVIEW

2.1 Maize: Origin and Distribution

Maize (*Zea mays* L.) is the most widely grown crop in the world, with 1.016 billion tones produced worldwide in 2013 (FAOSTAT, 2014). It is a cereal composed of the endosperm, germ and bran. Ensminger (1994) reported that the word “maize”is derived from the Spanish form of the indigenous Taino Indian word for the plant, mahiz. However, the crop is known by other names around the world. In North America, Australia and New Zealand, it is called “Corn” a shortening of “Indian corn”. In Southern Africa, it is called ‘mealie (Afrikaans). In Nigeria, maize is known by various names among the different ethnic groups; “agbado” or “oka” by the Yoruba, “Oka” in igbo, “masara” in Hausa and “Okah in Isoko (Olaniyan, 2015).

Wilkes (2004) elucidated on the following theories about the specific origin of maize in Mesoamerica:

1. It is a direct domestication of a musician annual, teosinte (*Zea mays* subsp. *Parviglumis*) native to the Balsas River valley in southeastern Mexico, with up to 12% of genetic materials obtained from *Zea mays* subsp. *mexicana* through introgression.
2. It has been derived from hybridization between a small domesticated maize (a slightly changed form of wild maize) and a teosinte of section luxuriant either Z. *luxurians* or Z. *diploperennis*.

3. It has undergone two or more domestications, either of a wild maize or of a teosinte.
4. It has evolved from a hybridization of Z. *diploperennis* by T*ripsacum dactyloides.*

Among the four theories, the teosinte origin is supported experimentally and by recent studies of the plants genomes because maize and teosinte are able to crossbreed and produce fertile offspring (Eubanks, 2001; Vollbrecht and Sigmon, 2005; Bryant, 2007 ; Liu, Garcia, McMullen and Flint-Garcia, 2016).

From its initial cultivation in the Balsas River valley in Mexico's South Eastern highlands, maize is presently grown in most tropical, sub-tropical and temperate countries of the world and is presently a staple food to over 300 million people in sub-Saharan Africa (Phiri, 2010).

McCann (2005) reported that maize arrived in Africa around 1500 AD as part of the massive global ecological and demographic transformation highlighted by the violent exploitations of the native populations by Portuguese, Spanish, English and Dutch nationalities. However, the exchange process provided the continent with new cultigens (cassava, beans, potatoes and maize) that re-invented Africa's food supply (Crosby, 1972).McCann (2005) argued that the rapid advances of maize as a major food crop in Africa has caught the imagination of agricultural economies and international policy planners who see it as an agricultural sea change, possibly equivalent to Asia's Green Revolution of the 1970s. Infact, Nobel laureate, Norman Bourlag, the icon of Asia's wheat/rice based Green Revolution argues that the technologies and crop varieties already exist to launch Africa's equivalent, using maize as its basic crop (Bourlag, 1997).

The United States remains the largest producer of maize, with 354 million tonnes in 2013, representing 35% of total global production. Next were China, Brazil, Argentina and Ukraine.(FAOSTAT, 2014).

Table 1 : Major producers of maize in 2013

Country	Production (tonnes)
United States	353,699,441
China	217,730,000
Brazil	80,516,571
Argentina	32,119,211
Ukraine	30,949,550
India	23,290,000
Mexico	22,663,953
Indonesia	18,511,853
France	15,053,100
South Africa	12,365,000
World	1,016,431,783

Source: FAO STAT, 2014

Africa produced about 6% of the global total and the largest producer South Africa with 12.365 million tonnes from 3,250,000 hectares followed by Nigeria with 10.4 million tonnes from 5,200,000 hectares. The average yield in Nigeria is therefore 2.0 tonnes/ha^{-1}while South Africa's is 3.8 tonnes/ha^{-1}. In contrast, average yield in the USA is 9.97 tonnes/ha^{-1}.

The need to increase the productivity of maize has therefore become increasingly important to all stakeholders in the maize industry – researchers, government, extension workers, farmers, industrialists etc. (Fakorede, 2001; Olaniyan, 2015)

2.2 Sweet corn

Sweet corn (*Zea mays* var. *saccharata*), is characterized by it's high sugar content. Sweet corn is the result of a naturally occurring recessive mutation in the genes which controls conversion of sugar to starch inside the endosperm of the corn kernel (Okonmah and Eruotor, 2012). Consequently, unlike field corn varieties which are harvested when the kernels are dry and mature, sweet corn must be harvested at the milk stage and consumed as a vegetable. This is especially true of the humid rainforest vegetation belt of Nigeria where there is no significant dry spell to facilitate the drying of grain crops (Olaniyan, 2015).

2.2.1 History of sweet corn cultivation

According to Schultheis (1998), the Iroquois tribe of American Indians gave the first recorded sweet corn (papoon) to European settlers in 1779. It soon became a popular food in the Southern and Central regions of the USA. Open pollinated cultivars started becoming widely available in the 19th century while the 20th century witnessed two key developments:

1. **Hybridization**: which allowed for more uniform maturity, improved quality and disease resistance.
2. Identification of the separate gene mutation responsible for sweetness in corn and the ability to breed cultivars based on these characteristics:
    a. Su (normal sugary)
    b. Se (Sugar enhanced)

c. Sh_2 (Shrunken-2) (Levey, 2003)

In most of Latin America, sweet corn is traditionally eaten with legumes, each plant is deficient in essential amino-acids that are abundant in the other, altogether forming a protein complete meal. In Indonesia, sweet corn is traditionally ground or soaked with milk, which makes available the B-Vitamin, Niacin, the absence of which would otherwise lead to pellagra, while in Europe, China, Korea, Japan and India, the kernels are boiled or steamed as corn-on-the-cob. The kernels are also served as pizza or creamed corn, which is sweet corn served in a milk or cream sauce. It also features in salads, stews, seasoned white rice, risottos, soups, pasta and whole sausage, hot dogs. In Africa, sweet corn is consumed boiled or roasted and in fried rice and salads.

2.3 Botany of sweet corn

Taxonomically, sweet corn is classified as follows:

Kingdom: Plantae
Sub-kingdom: Tracheobionta
Super phylum: Spermatophyta
Phylum: Magnoliophyta
Class: Liliopsida
Sub-class: Commelinidae
Order: Cyperales
Family: Poaceae
Sub family: Panicoideae

Tribe: Andropogoneae

Genus: Zea

Species: *Zea mays*

Sub species: *Zea mays* convar.*saccharata* var. *rugosa*

Source: USDA, 2014

Maize is a tall annual grass averaging 2.5m (8 ft) in height although some natural strains can grow up to 12m (40 ft) (Karl, 2013). The stem has the appearance of a bamboo cane and is commonly composed of clearly defined nodes and inter nodes. The leaves which grow from the nodes, are usually 9 cm (3.5 in) in width and 120 cm (4ft) in length, and are arranged alternatively on the stem. The apex of the stem ends in the tassel and inflorescence of male flowers. When the tassels are mature and conditions are suitably warm and dry anthers on the tassel dehisce and release pollen. Maize pollen is anemophilous (dispersed by wind) and because of its large settling velocity, most pollen falls within a few metres of the tassel and is shed for up to 14 days. It is viable for 10-30 minutes due to rapid desiccation in the air.

The female inflorescences or ears, develop above a few of the leaves in the mid section of the plant, between the stem and leaf sheath, elongating by 3mm/day to a length of 18cm (7 in) – 60 cm (24 in). Each ear is tightly enveloped by several layers of ear leaves or husks. The stigmas are elongated often pale yellow in colour and emerge from the whorl of husk leaves at the end of the ear, like bolts of hair in appearance. At the end of each stigma is a carpel, which develops into a kernel if fertilized by a pollen grain. The pericarp of the fruit is fused with the seed coat to form a caryopsis, typical of the grasses and the entire kernel is often referred to as the ‘seed’. The cob is close to a multiple fruit in structure, except that the individual fruits never fuse into a single mass (like pineapple).The grains are about the size of a pea and adhere in regular rows around a white, pithy substance, which forms the ear. An ear commonly holds 400 – 800 kernels. The kernels remain attached to the cob at maturity and consequently modern maize is completely dependent upon humans for reproduction (Purseglove, 1992).Sweet corn is a genetic variant that accumulates more sugar and less starch in the ear. However, open-pollinated sweet corn has been largely replaced in the commercial market by sweeter, earlier maturing hybrids, which also have the advantage of maintaining their sweet flavor longer.

A significant development was the production of super sweet corn by Professor John Laughnan in 1953, who was investigating two specific genes in sweet corn, one of which the Sh2 gene, caused the corn to shrivel when dry. He went on to discover that the endosperm of Sh2 sweet corn kernels store less starch and from 4 to 10 times more sugar than normal Su sweet corn (Levey, 2003). The present day popularity of super sweet corn arose due to its long shelf life and large sugar content when compared to conventional sweet corn. This has allowed the long distance shipping of sweet corn and has enabled manufacturers to can sweet corn without adding extra sugar or salt.

All of the alleles responsible for sweet corn are recessive, so it must be isolated from other corn, such as field corn and popcorn, that release pollen at the same time; the endosperm develops from genes from both parents and heterozygous kernels will be tough and starchy. The Se and Su alleles need not be isolated from each other but the super sweet cultivars with the Sh2 allele must be growing isolation from other cultivars to avoid cross pollination and resulting starchiness, either in space (30 – 120m) or in time (ensuring that super sweet corn does not pollinate at the same time as other corn in nearby fields).

2.4 Climatic requirements

Maize is cultivated worldwide from latitude 50°N to 40°S at elevations ranging from 0 – 4000 meters above sea level (Purseglove, 1992). This is possible due to the extraordinary diversity of the crop in terms of its morphology and geographic distribution. This is a consequence of its cross – pollinating nature and genetic diversity of traditional open-pollinated varieties (Davies, 1997). Despite this diversity, as a C4 plant, maize is considerably more water-efficient than C3 plants (small grains, alfalfa and soybeans) and maintains a high level of productivity in warm climates in comparison to temperate cereals. The ideal temperature for maize cultivation ranges from 20°C to 32°C. It is cold intolerant and cannot withstand freezing temperatures (Okonmah and Eruotor, 2012).

Maize requires at least 500 – 1100 mm rainfall during the growing season though it can thrive in rainforest regimes with over 2000mm rainfall (Adetayo *et.al*.,2008). Because its root system is generally shallow, the plant is dependent on soil moisture. The importance of which is shown in many parts of Africa, where periodic drought regularly causes maize crop failure and consequent famine. The crop is most sensitive to drought at the time of silk emergence, when the flowers are ready for pollination. The crop requires deep, well-drained fertile soils (Gudugi, Isah and Giragi, 2012).

2.5 Benefits of sweet corn

Observed health benefits of sweet corn consumption include the following:

a. At 86 calories per 100g, sweet corn kernels are moderately high in calories in comparison to other vegetables, while being much less in comparison to field corn and other cereal crops like wheat and rice. This is because the calorie content comes from simpler carbohydrates like glucose and sucrose unlike the amylase and amylopectin prevalent in other cereals. Sweet corn is therefore recommended for people on controlled diets and weight loss programs.

b. Sweet corn is also a good source of the phenolic flavonoid antioxidant, ferulic acid, which has been shown to prevent cancer, aging and inflammation in humans (Kampa, Alexaki,Notas, Nifli, Nisikaki, Autzoglou, Bakogeorgou, Kouimtoglai, Blekas, Boskou, Gravanis, and Castanas. 2004; Lin, Lin, Gupta, Tournas, Burch, Selim, Monteiro-Riviere, Grichnik, Zielinski and Pinnell. 2005).

Ferulic acid is a hydroxycinnamic acid that is abundant in plant cell wall components where it serves to crosslink the lignin and polysaccharide molecules that confer rigidity to cell walls (Matthew and Abraham, 2004; Beejmohun and Fliniaux, 2007). In cereals, ferulic acid is localized in the bran, the hard outer layer of grain where it confers resistant to wheat fungal diseases (Gelinas and Mckinnon. 2006). Dewanto, Wu and Liu (2002) observed that cooking sweet corn released increased levels of ferulic acid, up to 900%

despite the loss of Vitamin C. Therefore, consumption of cooked sweet corn has debunked the notion that heat processing destroys valuable phyto nutrients (Dewanto *et al.* 2002; Adefegha and Oboh, 2011). Consequently sweet corn presents an affordable natural avenue to obtain a healthier population in third world countries like Nigeria (Odukoya, Inya-Agba, Segun, Sofidiya and Ilori, 2007)

c. Sweet corn is a gluten-free cereal and may therefore be used safely in the diet of coeliac disease individuals (Lamacchia, Camarca, Picascia, Di Luccia and Gianfrani, 2014). Gluten is a protein composite found in wheat and some related grains like barley and rye, which give elasticity to dough, helping it to rise and keep its shape and often give the final product a chewy taste (Comino, Moreno, Rodriguez-Herrera, Barro and Sousa, 2013). It is also used in cosmetics, hair products and other dermatological preparations (Edwards*,* Mulvaney, Scanlon and Dexter*,* 2003; Harding, 2011).

Coeliac disease is an autoimmune disorder that affects the digestive process of the small intestine when gluten is consumed, leading to abdominal bloating gas, diarrhea, vomiting, migraine headaches and joint pain (Fasano and Catassi, 2012). It is estimated to affect between 0.5 and 1.0% of wheat eating populations worldwide (Van Heel and West, 2006).

d. Sweet corn contains high levels of valuable B-complex vitamins as niacin, thiamin, pantothenic acid, folates, riboflavin and pyridoxine (Akinrinde, Olubakin, Omotoso and Ahmed, 2006). Many of these vitamins function as co-factors to enzymes during substrate metabolism (Bender, 2009). Furthermore, it contains healthy amounts of some important minerals like zinc, magnesium, potassium, copper, iron and manganese, thus affirming its high quality phyto-nutrition profile (Oktem and Oktem, 2005). Sweet corn is therefore a very important crop and increased consumption should be encouraged in Nigeria.

2.6 Constraints of sweet corn production

Apart from weeds, pests and diseases as well as fragmented land holding structure Phiri (2010) contends that the production of cereals has been beset with the high cost of inorganic fertilizers and its erratic availability to small scale farmers in remote areas. Stock (2004) maintained that poor nutrient supply leads to poor plant growth and increased disease pressures which results in a decline in agricultural food production. Indeed, DIPA (2006) concluded that manures and fertilizers are the live wire of improved technology, contributing about 50 to 60% increase in productivity of food grains in many parts of the world, irrespective of soil and agro-ecological zone. Likewise, Anyaegbu, Iwuanyanwu and Omaliko (2013) reported that while 20% of farmers' expenditure goes into the purchase of inorganic fertilizers, 15% goes into weeding and other attendant soil practices. Crop fertilization is therefore the major constraint to increasing grain yields.

2.7 Organic fertilizers

The alternative to inorganic fertilizers is the use of organic manures (Ayoola and Makinde, 2007 ; Phiri, 2010). These have been shown to increase the availability of soil minerals and the transfer of nutrients from rangeland to the crop plant (Kostchi, Waters-Bayer, Adelhelan and Hoeste, 1989). Amujoyegbe *et al* (2007) reported that poultry manure increased the leaf area, total chlorophyll content and green yield of maize and sorghum. According to Brady and Weil (2008), poultry manure mineralizes faster than other animal manures such as cattle or pig dung; hence it releases its nutrients for plant uptake and utilization rapidly. Application of poultry manure also increases carbon content, water holding capacity, aggregation of soil and decreases bulk density (Egerszegi, 1990; Hsieh and Hsieh, 1990; Adeleye, Ayeni, and Ojeniyi, 2010; Akanni and Ojeniyi, 2008; Maerere, Kimibi and Nonga, 2001; Akparobi, 2009 and Uwah, Ogar and Akpan, 2014). It also increases the water soluble and exchangeable potassium and magnesium which enhances crop yield (Jackson ,1999) while Izunobi (2002) reported that poultry manure ,especially those provided in deep litter or battery cages, are the richest known farm yard manure supplying greater amounts of absorbable plant nutrient. Similar effects were observed on sweet corn (Uwah, Eneji and Eshiet, 2011), Okra (Onwu, Abubakar and Unah, 2014), Jute *Corchorus olitorus* (Adenawoola and Adejoro, 2005), tomatoes (Ayeni, Omole, Adeleye and Ojeniyi, 2010), sacred basil (Prabhu, Kumar and Rajamani, 2010) and on maize (Ibeawuchi, Opara, Tom and Obiefuna, 2007; Agba, Ubi, Abam, Ogbechi, Akeh, Odey and Ogar, 2012)

Moreover, consumers regard organic food as better, safer, more hygienic and free of chemical residues and artificial ingredients (Winter and Davis, 2006). Consequently, the application of organic fertilizers has been receiving great attention among farmers and researchers (Kannaiyan, 2000; Chang *et al*. 2007; Mishra *et al.* 2013). Other sources of plant nutrients such as prunnings of *Sesbania sesbans*, *Leucaena leucocephala* and *Eucalyptus microtheca* have been reported as possible alternatives to inorganic fertilizers (Hussein and Abbaro, 1997). However, there technologies take long to mature and are designed as single purpose technologies, mainly for soil fertility improvement (Yasmeen *et. al.* 2013).

2.8 Foliar application

2.8.1 Exogenous foliar application of nutrients

In a comprehensive review of the role of mineral nutrients in improving stress tolerance, Grattan and Grieve (1999) observed that foliar applications of those nutrients which became deficient under stress conditions improved the nutrient status of plants thereby leading to increased stress tolerance. For instance, potassium has been extensively used as a foliar spray to enhance crop salt tolerance (Ashraf, Athar, and Kwon. 2008). For increased active uptake of $K^+$by the guard cells, exogenous application of K^+ was required (Premachandra, Saneoka, Fujjta and Ogata, 1993) under stress conditions. K^+ uptake was improved by increasing application of K^+ under water scarcity (Bague, Karim, Hamid and Tetsushi, 2006) while Akram, Athar and Ashraf (2007) found that foliar sprays of various inorganic salts of K^+ in sunflower caused considerable improvement in the ion homeostatic conditions and plant photosynthetic activity through stomatal movement. Moreover the extent of stress ameliorative effect of K^+ salt and thereby growth enhancement, depends upon plant development stage at foliar application, salt concentrate and accompanying anion in a specific salt. Thus, foliar application of mineral nutrients can be beneficial to improve crop performance (Yasmeen *et. al*. 2012).

According to Gupta, Gupta, Shukla and Deshmukh (2003) during post anthesis temperature stress ,the exogenous application of benzyl adenine increased grain yield in wheat by increasing the sink and source capacity. The significant increment in grain weight in wheat by attracting more assimilates towards the developing grain was also observed with the application of benzyl adenine at anthesis (Warrier, Bhardwaj and Pande, 1987). Moreover, more grain weight was observed when BAP was sprayed on ears at physiological maturity (Hosseni, Poustini and Ahmadi, 2008). Indeed, the degree of leaf senescence has been shown to be inversely proportional to cytokinin content (Xu and Huang, 2009).

2.8.3 Exogenous application of antioxidants.

Foliar application of ascorbic acid, a potent antioxidant, has also been observed to minimize the reduction of chlorophyll *a* by Sodium chloride in wheat (Khan, Ahmed, Athar and Ashraf,2006). Foliar application of ascorbic acid enhanced accumulation of macro nutrients (N, P and K) in sweet pepper (Talaat, 2003), while Emam and Helal (2008) reported that acid foliar sprays recovered the non-germinating flax seeds under saline conditions.

2.8.4 Exogenous foliar application of PGRs

Another effective approach is the exogenous application of plant growth regulators (PGRs) involved in promoting plant growth and development under normal as well as stressful conditions (Brathe, Andresen, Gundersen, Malterub and Risea 2002).

Traditionally, there are five groups of plant growth hormones: auxins, gibberellins, abscicic acid, ethylene and cytokinins (Prosecus, 2006), with each group containing both naturally occurring hormones and synthetic substances.

Prosecus (2006) maintains that cytokinins regulate cell division and stimulate leaf expansion. Cytokinins therefore enhance food production as they are involved in cell growth and differentiation and their exogenous supply delays leaf senescence (Yasmeen, Basra, Ahmad and Wahid, 2012; Mvumi*et al*. 2013).

Leaf senescence results in a photosynthetic rate that is eventually too low to support the plant metabolism, thereby affecting two important yield parameters – the number of grains per spike and grain weight (Sharma-Natu, Sumesh, Lohot and Ghildiyal, 2006; Ugarte, Calderini and Slafer, 2007). This was further elucidated by Tahir, Ali, Nadeem, Hussain and Khalid (2009) who argued that while the reduction in growth as a result of leaf senescence can be compensated by growing short-duration cultivars; the most effective approach is the exogenous applied of PGRs involved in promoting plant growth and development under normal and stressful conditions. Although plants are capable of producing PGRs endogenously, they respond well to the exogenous application, which is stored in the form of reversible conjugates that are released in active form when needed in any plant part during growth (Brathe *et al.* 2002).

2.9 Sources of nutrients, PGRs and antioxidants

The exogenous use of commercially available nutrients, antioxidants and cytokinin to accelerate crop growth is expensive (Yasmeen *et. al*., 2012; Abdalla, 2013). It is therefore necessary to explore natural sources of PGRs for exogenous use such as algae extract (Hanaa, El- Baky, Hussein and EL-Baroty, 2008), humic acid (HA), seaweed extract (SE) (Zhang and Ervin, 2008) and extract obtained from moringa (*Moringa oleifera*) leaves (Foidle, Makkar and Becker, 2001).

2.9.1 Algae extract

Micro algae can provide a potential source of antioxidant, vitamins, carotenoids, poly saccharides, phycobili protein and possess immune-modulating agent properties (El-Baz, Aboul-Enien, El-Bartoty, Youssef and El-Baky, 2002). It can be widely used in medicine, industry, marine culture and in combating pollution (Thajuddin and Subrammanian, 2005). The presence of auxin, cytokinins, gibberellins and other PGRs make it a plant growth stimulating agent (Ordog, Stirk, Staden, Novak and Strand, 2004). For example, sea weed extracts (SE) have been used as a cytokinin – like growth regulator and exhibits multiple functions including stimulation of short growth and branching (Temple and Bomke, 1989), increase root growth and lateral root development (Metting, Zimmerman, Crouch and Staden*.,* 1990), improve nutrient uptake (Yan, 1993), enhance resistance of disease and environmental stresses such as drought and salinity (Nabati, Schmidt and Parrish, 1994). Hanaa *et al* (2008) observed increment in the chlorophyll *a* and *b* levels under foliar spray of algal extract, producing a positive correlation of the antioxidant status in wheat.

2.9.2 Humic acid

The foliar spray of humic acid not only improved growth and nutrients uptake of some crops but also enhanced their yields (Padeem, Ocal and Alan, 1999; Neri, Lodolini, Savini, Sabbatini, Bonanomi and Zucconi, 2002). Humic acid nutrient composition led to a 25% reduction in soil applied NPK fertilizer requirement with increase in uptake N,P,K,Ca, Mg, Fe, Mn, Zn and Cu nutrients by the crop resulting to enhanced yield (Shaaban, Manal, and Afifi, 2009). According to Neri *et al* (2002), the wetting action and slow speed of droplet drying makes the humic acid best suited for foliar spray. Significantly higher nutrient contents were observed in leaves as compared to control (Guvenc, Dursun, Turan, Tuzel, Burrage, Bailey, Gul, Smith and Tuncay, 1999) while (Shuixiu and Ruizhen, 2001) reported significant positive effects of humic acid application on yield of faba bean and chlorophyll contents of soybean.

2.9.3 *Moringa oleifera*

The ‘moringa’ tree is grown mainly in semi-arid, tropical and subtropical areas. It is native to the sub-Himalayas tracts of India, Pakistan, Bangladesh and Afghanistan (Fahey, 2005). It grows best in dry sandy soils; it tolerates poor soil including coastal areas.

2.10.1. Classification of moringa

Kingdom: Plantae
Sub kingdom: Tracheobionta
Super division: Spermatophyta
Division: Magnoliophyta
Class : Magnoliopsida
Sub class: Dilleniidae
Order: Capparales
Family : Moringaceae
Genus: MoringaAdans
Species: M. *oleifera*, M. *stenopetala*, M. *ovalifolia*etc

Source: USDA (2014)

Fuglie (2001) classified the thirteen species of plants in the genus moringa based on their growth habits.

a. **Bottle trees**: Comprise M. *drouhardii*, M. *hildebrandtii*, M. *stenopetala* and M. *ovatifolia*. These are indigenous to Kenya, Madagascar, Ethiopia, Angola and Namibia.
b. **Slender trees**: Comprise *M. concanensis, M. oleifera* and *M. peregrine*. These species are indigenous to India, Pakistan, Bangladesh and Arabia.
c. **Tuberous shrubs and trees of Northeast Africa**: include the remaining six species – *M. arborea, M. rivae, M. borziana, M. pygmaea, M. longituba, M.*

raspoliana. These are found in Kenya, Ethiopia and Somalia. *M. oleifera* is the most widely cultivated species now widely distributed worldwide in the tropics and sub-tropics – Africa, Central and South America, Sri Lanka, India, Mexico, Malaysia, Indonesia and the Philippines (Fahey, 2005).

2.10.2. Botanical description of *M. oleifera*

M. oleifera is a short slender, deciduous, perennial tree about 10m tall with drooping branches, brittle stems and branches, corky bark, feathery pale green 30 – 60 cm long compound leaves, with many small leaflets which are 1.3 – 2 cm long, 30 – 60cm wide (Fuglie, 2001).

The flowers are fragrant white or cream coloured and are about 2.5cm in diameter. They are borne in pendulous panicles 10 – 25 cm long. The five reflexed sepals are linear lanceolate. The five petals are slender-spatulate; they surround the five stamina and five staminodes and are reflexed except for the lowest (Fahey, 2005).

The fruits are three lobed, pendulous, brown triangular pods about 20 – 60 cm long. When dry, they split length wise into three parts each pod containing between 12 and 35 seeds. The seeds are round with a brownish semi-permeable seed hull. The hull itself has three white wings that run from top to bottom at 120 degree intervals. Each tree can produce between 15000 and 25000 seeds/year. Average seed weight is 0.3g and the kernel is hull ratio is 75:25. The main root is thick (Foidl *et al*, 2001)

2.10.3 Uses of moringa

M. oleifera is considered one of the world's most useful trees as almost every part of the plant can be used for food, medication or industrial purposes (Fuglie, 2001). In the tropics, it is used as forage for livestock and in many countries, moringa micro nutrient liquid, a natural anthelmintic and adjuvant (to aid or enhance another drug) is used as a metabolic conditioner to aid against endemic diseases in developing countries (Foidl *et al,* 2001). *Moringa oleifera* has the rare combination of nutrients, amino acids, antioxidants, anti-aging and anti-inflammatory properties for which it is being utilized in the indigenous medical systems in South Asia (Morimitsu, Hayashi, Nakagama, Horio and Osawa, 2000; Siddhuraja and Becker, 2003; Anwar, Latif and Gilani, 2007; Jacob and Shenbaraghan, 2011). *M. oleifera* is a miracle tree with a great indigenous source of highly digestible proteins Ca, Fe and Vitamin (Fahey, 2005). Several studies have reported that the dry leaves of *M. oleifera* contains 7 times more vitamin C than orange, 10 times Vitamin A than carrot, 17 times calcium than milk, 15 times potassium than bananas, 25 times iron than spinach and 9 times protein than yoghurt (Fuglie, 1999). In addition, it contains Vitamin B complex, chromium, copper, magnesium, manganese, phosphorus and zinc (Fuglie, 2000). Thurber and Fahey (2009) described *M. oleifera* leaves as a rich protein source which can be used by doctors, nutritionist and community health conscious persons to solve worldwide malnutrition or under nutrition problems.

Another important fact is that *moringa* leaves contain all of the essential amino acids, which are the building blocks of proteins (Makkar and Becker, 1996). It is very rare for a vegetable to contain all of these amino acids. However, moringa contains these amino acids in a good proportion so that they are very useful to our bodies (Morimitsu *et al*. 2000). Given its nutritional value, it can be utilized in fortifying sauces, juice, spices, milk, bread and instant noodles. In Nigeria, *moringa* is presently being marketed as tea and powder.

2.10.4 Moringa leaf extract (MLE)

A plant growth spray made from moringa leaves increased crop production by 20 – 35% and produced longer life span, heavier roots, stems and roots resulting in greater production of larger fruit (Foidl *et al.* 2001), highlighting its potential as a foliar spray as accelerate growth of young plants. MLE induced growth and yield increases in such diverse crops as peanuts, soybeans, maize, sorghum and sugar cane (Makkar and Becker, 1996), while Nouman *et al.(*2011) reported similar effects on rangeland grasses.

Concerted efforts have been made to ascertain the active ingredients of MLE by various researchers. Makkar *et al* (2001) reported that *moringa* leaves are a source of PGRs, antioxidants, B-carotene, Vitamin C and antioxidant agents, while in a related study, Siddhuraju and Becker (2003) demonstrated that the antioxidant properties of moringa leaf extract resulted in the following :

1. Reduced potassium ferricyanide
2. Scavenged super oxide radicals

3. Prevented the peroxidation of lipid membranes in liposomes
4. Could donate hydrogen and scavenge radicals.

Similarly, Makkar *et. al.* (2007) found that MLE contains significant quantities of calcium, potassium and cytokinin in the form of zeatin, antioxidants, proteins, ascorbates and phenols. Fresh moringa leaves sampled from various parts of the world were found to have high zeatin concentrations of between 5 – 200 mcg/gram of leaves (El-Awady, 2003).

Phiri (2010) reported that early contact with MLE as seed priming agent enhanced the germination of sorghum, length of maize radicles and hypocotyls of wheat, thereby affecting cereal germination and establishment. This was in line with the findings of Phiri and Mbewe (2010) who observed that MLE increased the duration of first germination of beans, increased germination percentage of cowpea but caused reduced germination percentage of groundnut and caused overall lower seedling survival in all three legumes, thereby leading to the postulation that MLE should not be used as a priming agent for legumes due to the presence of inhibitory substances absorbed through the various seed coats. However this was not supported by the findings of Yasmeen *et. al.* (2012) who reported MLE to be an excellent priming agent for stress-grown wheat.

Muhamman, Auwalu, Manga and Jibrin (2013) observed that MLE significantly increased the plant height, crop growth rate, net assimilation rate and yield of tomatoes at 3% concentration. Consistent results were obtained by Abdalla (2013) wh*o* reported that the foliar spray of the aqueous extracts of the leaves and twigs of *M. oleifera* produced significant increases of all measured growth parameters as well as growth promoting hormones (auxins, gibberellins and cytokinins) while simultaneously decreasing the levels of lipid peroxidation. This is in support of Balakumbahan and Rajamani (2010) who found that 2% MLE application raised all measured growth and yield parameters above control plants in Senna (*Cassia augustifolia* var. KKMI) . This could be attributed to the rich protein content of MLE which is essential for the formation of protoplasm and PGRs which facilitate rapid cell division, multiplication and enlargement (Makkar and Becker, 1996 ; Moyo *et. al*. 2011 ; Abdalla, 2013).

In an evaluation of the exogenous application of various PGRs, Chattha, Sana, Munir, Ashraf, Ul-Haq and Zamir (2015) found that MLE produced the highest crop growth rate and number of leaves in maize and significantly affected maize quality parameters (protein and starch content). Similar results were earlier obtained by Emongor (2015) who observed that MLE foliar spray increased vegetative growth, leaf chlorophyll content, plant dry matter, yield components and fresh pod yield of snap beans (*Phaseolus vulgari*s L). This could be attributed to the presence of endogenous cytokinins (zeatin, dihydrozeatin and isopentyladenine) which by stimulating cell division result in greater leaf area thereby increasing loading and unloading of assimilates across membrane boundaries of the phloem tissues and creation of new source – sink relationships (Emongor, 2007).

This was supported by Muhamman and Mohammed (2014) who observed that the aqueous extract of M. *oleifera*, in combination with an adequate nitrogen source, significantly increased all the growth and yield indices of Sesame (*Sesamum indicum* L.). Similar results were obtained by Mvumi *et. al*. (2012) and Bashir, Bawa and Mohammed

(2014) who reported that increasing foliar applications of MLE increased all the growth and yield parameters of tomatoes . Likewise, Muhamman and Kwada (2015) observed that aqueous foliar applications of MLE outperformed coconut milk on all the growth parameters of pawpaw (*Carica papaya* L.) seedlings.

Mishra, Singh, Singh, Das and Prasad (2013) investigated the effects of MLE application on pea (*Pisum sativum*) yield and observed that foliar application of MLE enhanced the fresh and dry weight of pea pods as well as fresh and dry biomass weights thereby affirming the work of Mishra (2012) who reported the presence of significant amounts of cytokinin- like substances in M. *oleifera* leaves. Similar results were obtained by Yasmeen *et. al.*(2012) who observed that foliar application of MLE induced an increase of 10.73%, 6%, 10.70% and 4.0% in the 1000 grain weight, biological yield, grain yield and harvest index, respectively in late sown wheat. The greater seed and biological yields could be attributed to the delayed crop maturity and extended leaf area duration (LAD) induced by the PGRs in MLE. This delayed onset of leaf senescence is reported to cause 11% more carbon fixation in *Lolium temulentum*(Thomas and Howarth, 2000).

According to Mohammed, Olorukooba, Akinyaju and Kambai (2013) the foliar application of MLE at 3 and 6 weeks after planting increased the growth and yield parameters of onion (*Allium cepa* L.). Similiarly, Anyaegbu (2014) evaluated the effects of Moringa extracts on soil properties and growth characteristics of garden egg plant (*Solanum melongena* L.) and concluded that MLE significantly enhanced the soil characteristics as well as growth and yield parameters of garden egg. Soil pH was increased from 5.4 to 6.7 but the highest fruit yields were obtained from crops that received a combination of MLE and N-P-K fertilizer at the rate of 100 kg ha. This was in line with earlier studies conducted on the effect of MLE on the growth performance of fluted pumpkin (*Telfairia occidentalis* L.) which observed significant increases in the yield and yield components (Anyaegbu and Iwuanyanwu, 2013).

This combination of MLE with a balanced nutritional fertilizer program was also advocated by Jason (2013). This was in consonance with the recommendation of Fuglie (2000) who showed that to obtain optimum results from MLE foliar sprays on crops, it should be used in addition to (and not in lieu of) fertilizers, irrigation and sound agricultural practices. The soil nutrient status is complimentary to the effectiveness of moringa extract sprays (Mvumi *et. al.*2013).

In further studies, Anyaegbu (2014) and Anyaegbu (2015) reported that aqueous foliar spray of MLE incited the highest plant height, number of leaves and leaf area per plant in Okra (*Abelmoschus esculentus*) in an Okra / garden egg intercrop, while the highest fruit yields were obtained in plots treated with poultry manure. It was observed that using extracts from any part of the moringa plant –leaves, twigs, bark or cut branches – tremendously boosted soil characteristics and crop growth and yield parameters. This was confirmed by Anyaegbu (2015) who observed that the growth and yield parameters of okra treated with MLE foliar spray was superior to stands treated with *Leucaena leucocephala*, *Gliricidia septum* and *Parkia biblosa*, while being similar to yields obtained from the N-P-K treatment.

In a related study, Zaki and Rady (2015) reported that MLE used as seed soaking and / or foliar applications significantly increased all growth attributes, physico- chemical qualities, antioxidant enzymes and yields in salt-stressed common beans. Furthermore, combining the MLE foliar spray with seed soaking resulted in even greater performance relative to either of the single treatments (foliar spray or seed soaking). This is in consonance with earlier studies by Mvumi *et. al.*(2013) who observed the highest dry matter accumulation, plant height and crop yields in greenhouse and field experiments for beans , and for maize in the field only, were obtained with a fortnightly application of MLE. This affirms the earlier observation by Mvumi *et. al.*(2012) that the growth and yield of tomatoes in both greenhouse and field planting was significantly increased by fortnightly foliar application of MLE.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the experimental site

A field study was carried out from August to November 2015 and April to July 2016 at the Research and Teaching Farms of the Department of Agronomy, Delta State University, Asaba Campus. The experimental site is located within latitude 06º14`N and longitude 06º49`E of the equator. Asaba is located in the humid tropical zone with a mean annual rainfall of 1,650mm (NIMET, 2011). The rainfall has a bimodal distribution pattern with peaks in July and September and an interrupted dry spell in August.

The mean annual temperature is about 37.3ºC and the mean relative humidity is 73.2% (NIMET, 2011). By nature of its geomorphological settings, the study area falls within the classification of ancient metamorphic crystalline basement complex formation that are more acid than base (Egbuchua, 2007). They are essentially gneisses and pegmatites that gave rise to coarse-textured soils that are deficient in dark ferromagnesium minerals (Egbuchua, 2011).

The topography is undulating with pockets of hills and land use is typically based on rain-fed agriculture with root, tuber, spices, pulses and vegetables prominently cultivated. The vegetation is of rainforest origin but has been drastically reduced to derived savannah due to continuous use of land.

3.2 Sources of maize seeds and moringa leaves

Sweet corn seeds of the TZ variety were procured from the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo state, while young leaves and branches of moringa were harvested from young fully grown trees located at the Delta State University Campus, Asaba.

3.3 Analysis of moringa leaves

The oven dried moringa leaves were analysed for their nutrient contents i.e. total nitrogen (Ryan *et al.* 2001), phosphorus, potassium, calcium, magnesium, copper, iron, manganese and zinc (Bingham, 1982 ; Ryan *et al*. 2001) .

3.4 Preparation of moringa leaf extract

Moringa leaf extract was prepared using the method of Price (2007), by grinding young shoots (leaves and tender branches) with a pinch of water (1 litre/10kg fresh material) in a blender for 15 minutes and then filtering the homogenized solution through No 2 Whatman filter paper. This wasthen proportionally diluted with water to obtain 3%, 6% and 9% concentration levels for the various treatments.

3.5 Pre-planting Soil Analysis

Soil samples were randomly collected from the 0 – 15 cm layer of the experimental plot using a soil auger. The samples were purged of stones, roots and leaves before being air-dried in a room temperature of 27ºC for three days and pulverized using a porcelain mortar and pestle. The crushed samples were then sieved using a 2 mm aperture sieve and analyzed. The analysis was done at the Animal and Environmental Biology Laboratory of the Delta State University, Abraka Campus.

Particle size distribution was determined by the Hydrometer method (Gee and Baudee, 1986) after destroying the organic matter with hydrogen peroxide and dispersing the soil with 0.5 N Sodium hexameta phosphate, while soil pH was measured using Pyeunican model MK2 pH meter in a 1:2:5 soil/water suspension ratio. Organic carbon was determined by the Walkey-Black wet oxidation method (Nelson and Sommers, 1982). Total nitrogen was evaluated by micro-Kjeldahl distillation technique as described by Breminer and Mulvaney, (1982). Available phosphorus was measured by Bray No. 1 method (IITA, 1979) while exchangeable potassium (k), calcium (ca),magnesium (mg) and sodium (Na) was determined by flame photometry (Chapman, 1965). Cation Exchange Capacity (CEC) was evaluated by Ammonium acetate saturation method (Roades, 1982).

The chemical analysis of the poultry manure used for the experiment was also evaluated using appropriate methods as described in the IITA manuals, 1979.

3.6 Field Procedure

The study was carried out in a Randomized Complete Block Design (RCBD) with three replicates. Plots measuring 3.0m x 1.5m were prepared in a land area measuring 663.0 m^2 which was selected for the study and prepared manually by clearing and marked out using basin formation according to the experimental layout. Improved sweet corn seeds of the TZ variety obtained from the International Institute of Tropical Agriculture (IITA), Ibadan was sown on the plots at the rate of 2 seeds per hole at a depth of 2 – 3 cm using 75 cm x 25 cm spacing .At 2 weeks the maize crop was thinned to 1 plant per stand leaving the most vigorous seedling to give a population density of 53,333 plants/ha .Weeding was done manually three times using hoe at the 3rd, 6th and 9th weeks after sowing.

3.6.1 Treatments

Nine treatments were involved: T_1, T_2 …T_9

Where

T_1 = Control (No extract)
T_2 = 3% MLE
T_3 = 6% MLE
T_4 = 9% MLE
T_5 = 3% MLE + 15 tha^{-1} poultry manure
T_6 = 6% MLE + 15 tha^{-1} PM
T_7 = 9% MLE + 15 tha^{-1} PM
T_8 = 15 tha^{-1} poultry manure
T9 = 30 tha^{-1} Poultry manure

The MLE was applied at 2 WAP, 4 WAP, 6 WAP and 8 WAP by spraying the entire plants in the designated study plots using a knapsack sprayer. The following parameters were obtained from the innermost ten plants of each study plot.

3.7. Growth parameters

Growth parameters measured were plant height, number of leaves, stem girth and leaf area with details given below:

3.7.1 Plant height

Plant height was measured to the nearest centimeter using a measuring tape from the base to the highest growing point.

3.7.2 Number of leaves/ plant

The leaf number was determined by counting the number of the opened leaves starting from the base of the plant upwards.

3.7.3 Stem girth

The stem girth was measured at the base of the maize plant with the aid of Vernier calipers to the nearest millimeter.

3.7.4 Leaf area

The leaf area was measured by tape using the non-destructive analysis method:

Length x Width x 0.75 according to Duke and Dulelar as reported by Enujeke (2013) i.e

LA (cm^2) = 0.75 x L x W

3.7.5 Number of days to 50% tasseling

This parameter was measured by observing the number of days taken for 50% of the maize plants in each plot to develop the male inflorescence (tassels) .

3.7.6 Number of days to 50% silking

This was measured by observing the number of days between sowing and silk emergence for 50% of the observed plants to show silk emergence

3.8 Yield parameters

3.8.1. Number of seeds per cob.

The number of seeds per cob was evaluated by counting the number of seeds in each harvested cob in the sample areas of each plot.

3.8.2 Weight of dehusked green cobs

Green cobs were de-husked and weighed to the nearest kilogram on the weighing scale to ascertain the dehusked cob weight

3.8.3 Grain yield (t/ha^{-1})

At physiological maturity, fresh cobs were harvested per treatment and dried to 14% moisture content and weighed using a weighing scale and converted to t/ha$^{-1.}$

3.9 Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) and means were separated with Duncan Multiple Range Test (DMRT) according to SAS(2010).

CHAPTER FOUR

RESULTS

4.1 Physico-chemical properties of the experimental site

4.2 The physico-chemical properties of the study area is presented in Table 2.The particle size fraction revealed that the soil was sandy loam in texture . Soil pH was mildly acidic with a mean value of 6.48 and 5.36 for the early and late seasons, while the available phosphorus (P), and water-soluble potassium (K) were moderate with mean values of 11.18 mgKg^{-1}/ 6.35 mgkg^{-1}and 0.75 cmolkg^{-1}/0.63 cmolkg^{-1}respectively. The exchangeable cations were also moderate in status with values of 7.41 cmolKg^{-1} for Ca and 2.34 cmolKg^{-1} for Mg, with the ECEC 19.19 cmolKg^{-1}.The late season showed a marked decrease in these nutrients with 6.98 cmolkg^{-1} for Ca, 2.14 cmolkg^{-1} for Mg and 10.12 cmolkg-^{1} for the ECEC.

Table 2: Physico-chemical properties of the soil (0-30cm depth) at the experimental site in Asaba

Soil Properties	Early season	Late season
Particles Size distribution (%)		
Sand	50.0	62.4
Silt	33.3	27.3
Clay	16.7	10.3
Textural class :Sandy loam		
Soil PH(H_2O)	6.48	5.36
Organic Carbon (g Kg^{-1})	0.22	0.18
Total Nitrogen (g Kg^{-1})	0.03	0.02
Available Phosphorus (mg kg^{-1} Soil)	11.18	6.35
Exchangeable Cation (cmolkg^{-1})		
Ca	7.41	6.98
Mg	2.34	2.14
K	0.75	0.63
Na	0.58	0.41
ECEC (Cmol Kg^{-1})	19.19	10.12
Base Saturation (%)	57.7	46.97

Legend: % =Percentage, H_2O =Water, g Kg^{-1}=gram per Kilogram, mg kg^{-1}=milligram per kilogram, cmolkg^{-1}=Centimole per kilogram, Ca=Calcium, Mg=Magnesium, K= Potassium, Na=Sodium, ECEC=Exchangeable Cation Exchange Capacity.

4.2 Proximate analysis of *Moringa oleifera* leaves/ 100 g used in the study

The results of the proximate analysis of *Moringa oleifera* leaves /100g used in the study is shown in Table 3. The results showed that it contained 10.51g moisture, 86.2 calories, 21.95 g Protein, 2.64 g Fat, 49.31 g Carbohydrate, 9.83 g Fibre, 5.76 g Ash, 4.0 g Calcium, 0.08 mg Copper, 18.7 mg iron, 22.25 mg Potassium, 5.0 mg Phosphorus and 0.02 mg Sulphur.

Table 3: Proximate analysis of *Moringa oleifera* leaves used in the study per 100 gram

Components	Value
Moisture	10.51
Calories	86.2
Proteins (g)	21.95
Fats (g)	2.64
Carbohydrate (g)	49.31
Fibre (g)	9.83
Ash	5.76
Calcium (mg)	4.0
Copper (mg)	0.08
Iron (mg)	18.7
Potassium (mg)	22.25
Magnesium (mg)	45.0
Phosphorus (mg)	5.0
Sulphur (mg)	0.02

4.3. Chemical composition of the poultry manure used in the study.

The chemical composition of the poultry manure used in the study is shown in Table 3. Analysis of the chemical composition of the manure showed that it contained 0.61 ppm Magnesium, 1.48 ppm Calcium, 0.29 ppm Sodium, 1.18 ppm Phosphorus, 2.67 % Nitrogen, 0.74 ppm Potassium, 1.20 % organic carbon, 2.57 % organic matter, while the carbon – Nitrogen ratio was 0.45g.

Table 4 :Chemical Composition of the poultry manure used in the 2015 growing season

Element	Value
Magnesium (ppm)	0.61
Calcium	1.48
Sodium	0.29
Phosphorus	1.18
Nitrogen (%)	2.67
Potassium (ppm)	074
Organic carbon (%)	1.20
Organic matter	2.57
Carbon-Nitrogen ratio	0.45

4.4. Effects of moringa leaf extract (MLE) and Poultry manure (PM) on plant height of sweet corn

The response of plant height to MLE and PM is shown in Table 5. Plant height of sweet corn gradually increased from 2 to 8 weeks after planting and the treatment applications caused significant differences in plant height of sweet corn. At 2 weeks after planting, sweet corn that received PM application rate of 30t/ha^{-1} had the highest plant height (39.5 cm and 42.3 cm) during the early and late season planting respectively, while the sweet corn that did not receive PM or MLE (control plot) had the lowest plant height of 27.9 cm and 30.7 cm for the early and late seasons respectively. During the early season planting, there was no significant difference between sweet corn that received 3 % MLE + 15 tha^{-1} PM, 6 % MLE + 15tha^{-1} PM, 9 % MLE + 15 tha^{-1} PM and 15 tha-^{1} PM. Likewise, the control plot was statistically similar with plots that received 3 % MLE, 6 % MLE and 9 % MLE. During the dry season, there were no significant differences between sweet corn that received 9 % MLE + 15 tha^{-1} PM, 15 tha^{-1} PM and 30 tha^{-1} PM.

Similar trend was observed during the 4th week after planting: sweet corn which received 30tha^{-1} PM application rate in the early and late seasons had the highest plant height (65.8 and 53.4cm), followed by plants that received 9% MLE+ 15tha^{-1} of PM and 15tha^{-1} of PM with 62.2 cm and 53.1cm respectively. Sweet corn that received 3% MLE had the lowest plant height of 33.7cm during the late season. Sweet corn plants that received no amendment materials had plant heights of 44.1 cm and 34.2 cm during the early and late season respectively.

At 6 weeks after planting, sweet corn that received 30tha^{-1} of PM had the highest plant height (152.6 cm and 144.2 cm), followed by plants which received 9% MLE and 15tha^{-1} of PM during the early and late seasons respectively. Sweet corn plants that received neither MLE nor PM had the lowest plant height of 81.6 cm and 76.7 cm during the early and late seasons respectively. The trend did not change during the 8th week of after planting; sweet corn which received 30 tha^{-1} of PM had the highest plant height (193.6cm and 152.8 cm) during the early and late seasons respectively, while crops that received neither MLE nor PM had the lowest plant height (139cm and 92.8 cm) for the dry and wet season plantings.

Table 5 : Effects of moringa leaf extract (MLE) and poultry manure (PM) on plant height of sweet corn (cm)

	← Weeks After Sowing (WAS) →							
	2		**4**		**6**		**8**	
	Early season	**Late season**	**Early season**	**Late season**	**Early season**	**Late season**	**Early season**	**Late season**
Control (0%)	27.9^{c}	30.7^{b}	44.1^{c}	34.2^{b}	81.6^{d}	76.7^{c}	139.0^{c}	92.8^{b}
3% MLE	28.6^{c}	32.6^{b}	45.3^{c}	33.7^{b}	84.4^{d}	84.4^{c}	146.2^{c}	106.1^{b}
6% MLE	28.7^{c}	33.2^{b}	47.9^{c}	35.7^{b}	95.6^{d}	94.2^{b}	153.6^{c}	109.7^{b}
9% MLE	29.2^{c}	31.8^{b}	52.1^{b}	39.1^{b}	98.6^{d}	96.1^{b}	162.6^{c}	118.6^{b}
3% MLE + 15 tha^{-1} PM	33.9^{b}	33.1^{b}	55.9^{b}	39.8^{b}	111.7^{c}	107.2^{b}	166.3^{c}	132.8^{b}
6% MLE + 15 tha^{-1} PM	35.2^{b}	33.2^{b}	58.6^{b}	38.3^{b}	121.1^{c}	111.4^{b}	176.3^{c}	148.7^{a}
9% MLE + 15 tha^{-1} PM	35.1^{b}	39.0^{a}	62.2^{b}	53.1^{a}	148.3^{b}	142.2^{a}	189.0^{b}	152.2^{a}
15 tha^{-1} PM	35.5^{b}	41.7^{a}	61.5^{b}	52.1^{a}	146.3^{b}	138.1^{a}	188.0^{b}	151.4^{a}
30 tha^{-1} PM	39.5^{a}	42.3^{a}	65.8^{a}	53.4^{a}	152.6^{a}	144.2^{a}	193.6^{a}	152.8^{a}

Means with the same letter(s) under the same column are not significantly different at $P<0.05$ using Duncan Multiple Range Test (DMRT)

4.5 Effects of MLE and PM on the number of leaves of sweet corn

Table 6 shows the response of the number of leaves of sweet corn at different weeks after planting. In all the treatments, the number of leaves consistently increased from 2 to 8 weeks after planting. There were significant differences in the number of leaves of sweet corn.

At 2 weeks after planting, sweet corn that received PM application rate of 30tha^{-1}during the dry season had the highest number of leaves (4.6), followed by crops that received 15 t/ha^{-1} of PM (4.2) while sweet corn that received 3% MLE had the lowest number of leaves (3.8).There was a slight difference during the wet season as once again, sweet corn that received 30 tha^{-1} of PM had the highest number of leaves (4.6), followed by crops that received 15 tha^{-1} of PM (4.3). However, the sweet corn plants that received no amendment materials had the lowest number of leaves (4).In the early season, all treatments were statistically similar except sweet corn that received 30 tha-^{1} PM.

The same trend was observed at 4 weeks after planting in both planting seasons: sweet corn which received PM application rate of 30 tha^{-1}had the highest number of leaves (7.8 and 8.1) followed by crops that received 9% MLE + 15 tha^{-1}of PM with 7.3and 7.8 number of leaves. The sweet corn plants that received no amendment materials in both planting seasons had the lowest number of leaves (5.7 and 6.8 respectively)

At 6 weeks after planting, there was a slight difference in the dry season study as sweet corn plants which received 6% MLE had the lowest number of leaves (7.9), while plants that received 30 tha^{-1} of PM had the highest number of leaves (8.1).There was no significant difference between the various treatments. During the rainy season planting however, sweet corn plants that received 30 tha^{-1} of PM had the highest number of leaves (10.8) while the sweet corn in the control plots that received no amendment materials had the lowest number of leaves (8.8). At 8 weeks after planting, sweet corn plants that received 30 tha^{-1}of PM had the highest number of leaves in both experiments (10.1and 13.1) while plants in the control plot that received no amendment materials had the lowest number of leaves (9.5 and 10.2). In the early season, there were no significant differences between sweet corn that received 9 % MLE + 15 tha-^{1} PM, 15 tha-^{1} PM and 30 tha^{-1} PM.

Table 6 : Effects of MLE and PM on the number of leaves of sweet corn

	← Weeks After Sowing (WAS) →							
	2		4		6		8	
	Early season	Late season	Early season	Late season	Early season	Late season	Early season	Late season
Control (0%)	4.0^b	3.8^c	6.8^c	5.7^b	8.8^b	8.0^a	10.2^b	9.5^b
3% MLE	4.1^b	4.0^b	7.0^b	5.7^b	9.0^b	8.0^a	10.5^b	10.0^a
6% MLE	4.1^b	4.0^b	7.3^b	6.1^b	9.2^b	7.9^a	11.1^b	10.0^a
9% MLE	4.1^b	4.0^b	7.5^b	7.3^a	9.3^b	8.0^a	11.4^b	10.0^a
3% MLE + 15 tha^{-1} PM	4.2^b	4.1^b	7.7^b	7.3^a	9.4^b	8.1^a	11.6^b	10.0^a
6% MLE + 15 tha^{-1} PM	4.3^b	4.2^b	7.7^b	7.2^a	9.7^b	8.0^a	11.7^b	10.0^a
9% MLE + 15 tha^{-1} PM	4.3^b	4.2^b	7.8^b	7.3^a	10.5^a	8.0^a	12.5^a	10.0^a
15 tha^{-1} PM	4.3^b	4.2^b	7.8^b	7.2^a	10.5^a	8.0^a	12.4^a	10.0^a
30 tha^{-1} PM	4.6^a	4.6^a	8.1^a	7.38^a	10.8^a	8.1^a	13.1^a	10.2^a

Means with the same letter(s) under the same column are not significantly different at $P < 0.05$ using Duncan Multiple Range Test (DMRT)

4.6 Effect of MLE and PM on the stem girth of sweet corn

The response of stem girth of sweet corn to MLE and PM is shown in Table 7. Stem girth of sweet corn consistently increased from 2 to 8 weeks after planting in both planting seasons. MLE and PM caused significant differences in stem girth of sweet corn at 2 weeks after planting. In the early season planting, sweet corn plants that received 30tha^{-1} of PM had the highest stem girth (1.33 cm) followed by crops that received 15 tha^{-1} of PM (1.08 cm). The control plot that received neither MLE nor PM had the lowest stem girth of 0.75 cm. In the late season cropping, the application of 30 tha^{-1} of PM recorded the highest stem girth (1.20 cm), followed by sweet corn that received 15 tha^{-1} of PM, with stem girth of 1.14 cm. Sweet corn plants in the control plot that received neither MLE nor PM recorded the lowest stem girth of 0.71 cm.

The same trend was observed during the 4th week after planting. Plants in the control plot also had the lowest stem girth (1.33 cm) during the early season planting, while the sweet corn that received 30 tha^{-1} of PM had the highest stem girth (2.50cm). A slight difference was observed during the late season planting :sweet corn plants that received 30 tha^{-1} of PM recorded the highest stem girth (2.02 cm), followed by crops that received 9% MLE + 15 tha^{-1} of PM (1.85 cm). The control plot that received no amendment materials had the lowest stem girth of 0.85 cm.

At 6 weeks after planting, sweet corn plants that received 30 t/ha^{-1} of PM had the highest stem girth (3.08cm) followed by plants that received 9% MLE + 15 tha^{-1} of PM (2.58 cm) during the early season planting. Sweet corn plants in the control plot that received neither MLE nor PM had the lowest stem girth (1.67cm).This pattern was repeated in the late season planting as the highest stem girth of 2.68 cm was recorded in sweet corn plants that received 30 tha^{-1} of PM, followed by crops that received 9% MLE + 15 tha^{-1} of PM (2.58 cm). Sweet corn crops in the control plot that received no amendment materials had the lowest stem girth of 1.56 cm. The trend did not change during the 8th week after planting in both early and late planting seasons. Sweet corn plants that received 30 t/ha^{-1} of PM had the highest stem girth (3.75 cm and 3.21 cm respectively) while the crops that received neither MLE nor PM had the lowest stem girth (2.17cm and 2.12 cm, respectively) .There were no significant differences observed among the various treatments during the early season planting.

Table 7 : Effect of MLE and PM on the stem girth of sweet corn (cm)

	← Weeks After Sowing (WAS) →							
	2		**4**		**6**		**8**	
	Early season	**Late season**	**Early season**	**Late season**	**Early season**	**Late season**	**Early season**	**Late season**
Control (0%)	0.75^{b}	0.71^{b}	1.33^{b}	0.85^{c}	1.67^{b}	1.56^{b}	2.17^{a}	2.12^{b}
3% MLE	0.92^{a}	0.85^{b}	1.50^{a}	1.24^{b}	1.92^{a}	1.88^{a}	2.58^{a}	2.30^{a}
6% MLE	0.83^{a}	0.85^{b}	1.58^{a}	1.42^{b}	2.17^{a}	2.16^{a}	2.88^{a}	2.55^{a}
9% MLE	0.83^{a}	1.03^{a}	2.00^{a}	1.80^{a}	2.42^{a}	2.33^{a}	3.17^{a}	3.08^{a}
3% MLE + 15 tha^{-1} PM	1.08^{a}	1.03^{a}	2.08^{a}	1.78^{a}	2.50^{a}	2.41^{a}	3.25^{a}	3.11^{a}
6% MLE + 15 tha^{-1} PM	1.08^{a}	1.07^{a}	2.17^{a}	1.78^{a}	2.58^{a}	2.55^{a}	3.33^{a}	3.04^{a}
9% MLE + 15 tha^{-1} PM	1.08^{a}	1.10^{a}	2.33^{a}	1.88^{a}	2.91^{a}	2.58^{a}	3.58^{a}	3.15^{a}
15 tha^{-1} PM	1.08^{a}	1.14^{a}	2.17^{a}	1.84^{a}	2.83^{a}	2.56^{a}	3.58^{a}	3.15^{a}
30 tha^{-1} PM	1.33^{a}	1.20^{a}	2.50^{a}	2.02^{a}	3.08^{a}	2.68^{a}	3.75^{a}	3.22^{a}

Means with the same letter(s) under the same column are not significantly different at $P<0.05$ using Duncan Multiple Range Test (DMRT)

4.7. Effects of MLE and PM on the leaf area of sweet corn

The response of the leaf area of sweet corn to MLE and PM is shown in Table 8. Leaf area of the crops gradually increased from 2 – 8 weeks after planting in both planting seasons.

Significant differences were observed in leaf area of sweet corn at 2 weeks after planting both early and late season plantings .For the early season planting, sweet corn plots that received 30 tha^{-1} of PM recorded the highest leaf area (115.1 cm^2), there was no significant difference between crops that received 15 tha^{-1}PM , 9% MLE + 15 tha^{-1} of PM, 6% MLE + 15 tha^{-1} of PM, 3% MLE + 15tha^{-1} of PM . Sweet corn plants that received no amendment materials recorded the lowest leaf area of 68.5 cm^2.In the late season crops that received 15 t/ha^{-1} of PM had the highest leaf area (88.3cm^2), while plants in the control plot which received neither MLE nor PM had the lowest leaf area (65.3cm^2) though there were no significant differences in the leaf area of plants that received 3% MLE (65.8cm^2) and 6% MLE (68.9cm^2).

A slight difference was observed during the 4th week after planting. Crops that received 30tha^{-1} of PM had the highest leaf area (215.7$cm^2$and 185.1 cm^2, respectively) followed by plants that received 9% MLE + 15 $tha^{-1}$of PM (198.0 cm^2 and 179.1 cm^2, respectively). Plants that received no amendment materials had the lowest leaf area of 117.4$cm^2$and 110.1 cm^2 during the early and late season plantings respectively. At 6 weeks after planting sweet corn plants that received 30tha^{-1} of PM had the highest leaf area (451.3 $cm^2$and 259.6 cm^2, respectively) followed closely by crops that received 9% MLE + 15 tha^{-1} of PM (434.8 $cm^2$and 255.1 cm^2, respectively) while the control plot that received no amendment materials had the lowest leaf area of 235.9cm^{2} and 180.6 cm^{2} for the late and early season plantings.

The trend was the same during the 8th week after planting. Sweet corn that received 30 t/ha^{-1} of PM had the highest leaf area (584.9cm^{2} and 402.9 cm^{2}) followed closely by crops that received 9% MLE + 15tha^{-1}+ of PM (546.2 cm^{2} and 392.2 cm^{2}) though they were not significantly different during the late season planting. Crops in the control plot had the lowest leaf area of 308.4cm^{2} and 247 cm^{2} respectively.

Table 8 : Effects of MLE and PM on the leaf area of sweet corn (cm^{2})

	← Weeks After Sowing (WAS) →							
	2		**4**		**6**		**8**	
	Early season	**Late season**	**Early season**	**Late season**	**Early season**	**Late season**	**Early season**	**Late season**
Control (0%)	68.5^{b}	65.3^{b}	117.4^{c}	110.1^{b}	235.9^{b}	202.8^{a}	308.4^{c}	247.0^{b}
3% MLE	70.1^{b}	65.8^{b}	137.7^{b}	120.8^{b}	268.1^{b}	203.3^{a}	355.9^{b}	307.8^{a}
6% MLE	70.9^{b}	68.9^{b}	148.0^{b}	130.2^{b}	280.0^{b}	214.2^{a}	378.0^{b}	322.2^{a}
9% MLE	70.0^{b}	79.6^{a}	163.5^{b}	170.3^{a}	305.8^{b}	216.0^{a}	395.5^{b}	323.3^{a}
3% MLE + 15 tha^{-1} PM	106.7^{a}	77.8^{a}	173.9^{b}	165.6^{a}	386.2^{a}	226.7^{a}	440.2^{a}	312.2^{a}
6% MLE + 15 tha^{-1} PM	107.0^{a}	74.9^{a}	190.3^{a}	169.2^{a}	399.9^{a}	228.0^{a}	484.4^{a}	315.6^{a}
9% MLE + 15 tha^{-1} PM	107.0^{a}	81.8^{a}	198.0^{a}	179.1^{a}	434.8^{a}	255.1^{a}	546.2^{a}	392.2^{a}
15 tha^{-1} PM	107.0^{a}	82.4^{a}	198.3^{a}	171.8^{a}	429.5^{a}	245.3^{a}	528.6^{a}	347.8^{a}
30 tha^{-1} PM	115.1^{a}	88.3^{a}	215.7^{a}	185.1^{a}	451.3^{a}	259.6$_{a}$	584.9^{a}	402.9^{a}

Means with the same letter(s) under the same column are not significantly different at P<0.05 using Duncan Multiple Range Test (DMRT)

4.8. Effect of MLE and PM on number of days to 50% tasseling of sweet corn

The response of number of days to 50% tasseling of sweet corn to MLE and PM is shown in Table 9. There were no significant differences in days to 50% tasseling of sweet corn. During the early season planting, sweet corn that received 30t/ha^{-1}of PM were the first to attain 50% tasseling at 51.3 days followed by plants that received both 9% MLE + 15 tha^{-1} of PM and 15 tha^{-1} of PM which attained 50% tasseling at 52.6 days. The sweet corn plants in the control plot that received neither MLE nor PM were the last to attain 50% tasseling (58 days). There was a slight difference during the late season planting as sweet corn plants that received 30 tha^{-1} of PM and 9% MLE + 15 tha^{-1} of PM both attained 50 % tasseling at 52 days. The sweet corn that received no amendment materials achieved 50 % tasseling of 53 days

Table 9 : Effect of MLE and PM on number of days to 50% tasseling of sweet corn

	Number of days to 50% tasseling	
	Early season	**Late season**
Control (0%)	58.3^{a}	53.0^{a}
3% MLE	57.8^{a}	53.0^{a}
6% MLE	56.8^{a}	53.0^{a}
9% MLE	55.5^{a}	53.0^{a}
3% MLE + 15 tha^{-1} PM	54.3^{a}	52.7^{a}
6% MLE + 15 tha^{-1} PM	53.8^{a}	52.3^{a}
9% MLE + 15 tha^{-1} PM	52.6^{a}	52.0^{a}
15 tha^{-1} PM	52.6^{a}	52.3^{a}
30 tha^{-1} PM	51.3^{a}	52.0^{a}

Means with the same letter(s) under the same column are not significantly different at P<0.05 using Duncan Multiple Range Test (DMRT)

4.9. Effect of MLE and PM on the number of days to 50% silking of sweet corn

The response of days to 50% silking of sweet corn to MLE and PM during the early and late seasons is shown in Table10. There were no significant differences in the days to 50% silking of sweet corn in both planting seasons. During the early season, sweet corn that received 30tha^{-1} of PM were the first to attain 50% silking (57.20 days) while the plants in the control plots that received neither MLE nor PM were the last to attain 50% silking (61.5 days). There were slight changes during the late season ; though plants that received 30 tha^{-1} of PM were the first to attain 50 % silking (56.4 days), plants in the control plot, those that received 3% MLE and those that received 6% MLE attained 50% silking at thesame 57.0 days after planting.

Table 10 : Effect of MLE and PM on the number of days to 50% silking of sweet corn

	Number of days to 50% silking	
	Early season	**Late season**
Control (0%)	61.5^{a}	57.0^{a}
3% MLE	61.0a	57.0^{a}
6% MLE	60.8^{a}	57.0^{a}
9% MLE	60.5^{a}	56.3^{a}
3% MLE + 15 tha^{-1} PM	58.4^{a}	57.0^{a}
6% MLE + 15 tha^{-1} PM	58.7^{a}	56.3^{a}
9% MLE + 15 tha^{-1} PM	57.8^{a}	56.0^{a}
15 tha^{-1} PM	57.5^{a}	57.0^{a}
30 tha^{-1} PM	57.2^{a}	56.4^{a}

Means with the same letter(s) under the same column are not significantly different at P<0.05 using Duncan Multiple Range Test (DMRT)

4.10 Effects of MLE and PM on weight (Kg) of de-husked cobs of sweet corn

The response of the weight of de-husked cobs of sweet corn to MLE and PM during the early and late seasons planting is shown in Table 11. Significant differences were observed in the weight of de-husked cobs of sweet corn. Sweet corn that received the application rate of 30 tha^{-1}of PM had the highest weight of de-husked cobs (0.17kg) during the early season planting. This was closely followed by sweet corn that received 9% MLE + 15 tha^{-1}of PM and 15 tha^{-1}of PM (0.15kg). Plants in the control plot that received neither MLE nor PM had the lowest weight of 0.09kg which was significantly different from other plants. During the late season planting, sweet corn plants that received 30 tha^{-1} of PM and those that received 9% MLE + 15tha^{-1} of PM recorded the highest de-husked cob weight of 0.12 kg. The lowest cob weight of 0.04 kg was recorded from plants in the control plots that did not receive any amendment materials but was significantly different from other sweet corn treatments.

Table 11 : Effects of MLE and PM on weight (Kg) of de-husked cobs of sweet corn

	Weight of de-husked cobs (kg)	
	Early season	**Late season**
Control (0%)	0.09^b	0.04^b
3% MLE	0.10^a	0.07^a
6% MLE	0.11^a	0.09^a
9% MLE	0.12^a	0.10^a
3% MLE + 15 tha^{-1} PM	0.13^a	0.11^a
6% MLE + 15 tha^{-1} PM	0.14^a	0.11^a
9% MLE + 15 tha^{-1} PM	0.15^a	0.12^a
15 tha^{-1} PM	0.15^a	0.11^a
30 tha^{-1} PM	0.17^a	0.12^a

4.11 Effects of MLE and PM on the number of seeds per cob of sweet corn

The response of the number of seeds per cob of sweet corn to MLE and PM during the early and late seasons planting in 2015 is shown in Table 12 . Application of MLE and PM caused significant differences in the number of seeds per cob of sweet corn. Sweet corn that received 30 tha^{-1}of PM had the highest number of seeds per cob in both early and late planting seasons (545 and 491.7, respectively), followed by 9% MLE + 15 tha^{-1}of PM (512.2 and 467, respectively).During the early season, significant differences were not observed in values of sweet corn that received 3 % MLE (362.2), 6 % MLE (373.6), 9 % MLE (389.1), 3 % MLE + 15 tha^{-1} PM (434.2), 6 % MLE + 15 tha^{-1} PM (491.8) and 15 tha^{-1} PM. These were not significantly different in values from sweet corn that received 3 % MLE (356), 6 % MLE(392), 9 % MLE (421.7), 3 % MLE + 15 tha^{-1} PM (394.7), 6 % MLE + 15 tha^{-1} PM (411.3)and 15 tha^{-1}-1 PM (438.3). Plants in the control plot that received neither MLE nor PM had the lowest number of seeds per cob in both early and late planting seasons with 334.6 and 323.3, respectively. The trend did not change during the late season.

Table 12: Effects of MLE and PM on the number of seeds per cob of sweet corn

	Number of seeds / cob	
	Early season	Late season
Control (0%)	334.6^c	323.3^b
3% MLE	362.2^b	356.0^a
6% MLE	373.6^b	392.0^a
9% MLE	389.1^b	421.7^a
3% MLE + 15 tha^{-1} PM	434.2^b	394.7^a
6% MLE + 15 tha^{-1} PM	491.8^b	411.3^a
9% MLE + 15 tha^{-1} PM	512.2^b	467.0^a
15 tha^{-1} PM	511.5^b	438.3^a
30 tha^{-1} PM	545.0^a	491.7^a

Means with the same letter(s) under the same column are not significantly different at $P<0.05$ using Duncan Multiple Range Test (DMRT)

4.12 Effects of MLE and PM on the grain yield of sweet corn

The response of the grain yield of sweet corn to MLE and PM during the early and late seasons planting is shown in Table 13 : There were significant differences in grain yield of sweet corn in both planting seasons. During the early season planting, sweet corn that received 30 tha^{-1} of PM recorded the highest grain yield of 3.2 tha^{-1} while plants in the control plot that received no amendment materials recorded the lowest grain yield of 1.21 tha^{-1}. However, there were no significant differences observed between the sweet corn plants that received 9% MLE + 15 tha^{-1} of PM (2.66 tha^{-1}) and 15 tha^{-1} of PM (2.62 tha^{-1}) and 9 % MLE (2.0 tha^{-1}), 3 % MLE + 15 tha^{-1} PM (2.52 tha^{-1}) and 6 % MLE + 15 tha^{-1} PM and 30 tha^{-1} PM (3.21 tha^{-1}).

During the late planting season, sweet corn plants that received PM application rate of 30t/ha^{-1}had the highest grain yield (1.70 tha^{-1}). This was followed by plants that received 9% MLE + 15 tha^{-1} of PM (1.61 tha^{-1}). Sweet corn plants in the control plot that received neither MLE nor PM applications had the lowest grain yield of 0.85 tha^{-1}. There were no significant differences in the yields of sweet corn that received 6 % MLE (1.05 tha^{-1}), 9 % MLE (1.10 tha^{-1}), 3 % MLE + 15 tha^{-1} PM (1.24 tha^{-1}), 6 % MLE + 15 tha^{-1} PM (1.32 tha^{-1}), and 15 tha^{-1} PM (1.31 tha^{-1}).The superiority in grain yield (tha^{-1}) of sweet corn with respect to different rates of MLE and PM received was T9 > T7 > T8 > T6> T5 > T4 > T3 > T2 > T1.

Table 13 : Effects of MLE and PM on the grain yield of sweet corn

	Grain yield (tha^{-1})	
	Early season	**Late season**
Control (0%)	1.21^{b}	0.85^{b}
3% MLE	1.42^{b}	0.93^{b}
6% MLE	1.73^{b}	1.05^{a}
9% MLE	2.00^{a}	1.10^{a}
3% MLE + 15 tha^{-1} PM	2.21^{a}	1.24^{a}
6% MLE + 15 tha^{-1} PM	2.52^{a}	1.32^{a}
9% MLE + 15 tha^{-1} PM	2.66^{a}	1.61^{a}
15 tha^{-1} PM	2.62^{a}	1.31^{a}
30 tha^{-1} PM	3.21^{a}	1.70^{a}

Means with the same letter(s) under the same column are not significantly different at $P<0.05$ using Duncan Multiple Range Test (DMRT)

CHAPTER FIVE

DISCUSSION

5.1 Physico-chemical properties of the soil of the experimental site

The results of the study showed that physico-chemical properties of the soil are low to moderate and are capable of guaranteeing crop production. The low fertility status of the soil could be as a result of the intense precipitation with it's associated erosion effects and subsequent leaching of nutrients. While on the other hand, the moderate fertility status of the soil could be associated with the rich exchangeable cations as observed in the study. These observations are in line with the studies of Egbuchua (2007) and Egbuchua (2011) respectively in his characterization of the soils of the environment.

5.2 Effects of MLE and PM on growth parameters of sweet corn

The poultry manure application rate of 30 tha^{-1}had a greater effect on the growth parameters than other rates of MLE and PM applied. This could be attributed to its special characteristics of faster mineralization than other organic manures and rapid release of nutrients for plant uptake and utilization. This is similar to the findings of Izunobi (2002) who identified poultry manure as the richest animal manure which has the ability to enhance growth increases with respect to plant height, leaf area and total chlorophyll content of crops. It is also in tandem with the findings of Brady and Weil (2008) who reported that poultry manure mineralizes faster and releases its nutrients rapidly for growth increases in crops. This is in harmony with the findings of Akanni and Ojeniyi (2008). Ayoola and Makinde (2009) and Uwah *et al.* (2011) who observed that higher rates of poultry manure application resulted in increased plant height, number of leaves and leaf area in Amaranthus and maize crops. It is also consistent with the findings of Adejoro (2005) and Ayeni *et al*. (2010) who reported that poultry manure application rate of 30 tha^{-1}increased such growth parameters of tomato as plant height, leaf area and stem girth, which eventually influenced the fruit yield positively.

Poultry manure application rate of 30 tha^{-1}had better performance over other rates of MLE and PM received by sweet corn plants. This was probably because that rate satisfied the crop requirements in the agro-ecological environment where the experiment was conducted, and the peculiar characteristics of poultry manure. This result is in harmony with the findings of Akanni and Ojeniyi (2008), Ayoola and Makinde (2009) and Agba *et al.* (2012), which attributed the increase in number of leaves, plant height, stem diameter and leaf area index of maize to the possibility that the rate satisfied the agro-ecological requirement of the experimental site and the essential nutrients supplied by poultry manure that are associated with increased photosynthetic activity. This is also consistent with the findings of Zaki and Rady (2015) who observed that MLE application increased the number of leaves, shoot length, leaf area per plant old dry leaf weight of *Phaseolus vulgaris* (common bean). It is also synonymous to the findings of Anyaegbu (2015) who reported that plant height of okra that received with N.P.K. fertilizer was not significantly different from those that received MLE, thus confirming the assertions that *Moringa oleifera* is a fertility plant. It is also similar with the findings of Prabhu *et al.* (2009) who reported that the plant height and number of leaves per plant of Kalmegh *(Andrographis paniculata*) was highest with 2% MLE compared to other sources of plant growth regulatory substances. This report attributed the enhanced cell division and elongation of crops to the role of MLE as a plant growth promoting substance.

Sweet corn crops treated with 30 tha^{-1} of poultry manure had the highest stem girth at 8 weeks after planting and were statistically similar to maize plants that received 9% MLE + 15 tha^{-1} of PM. This could be attributed to the adequacy of macro and micro nutrients present in the amendments, fast mineralization and ease of absorption, which promotes the establishment, growth and maturation of crops at all stages of their life cycle. This is similar to the findings of Foidl *et al.* (2001) who reported that the aqueous extract of *M. oleifera* influenced the apical growth both in tomato and sorghum. The report further argued that MLE also gave highest (100%) vigorous and good quality of tomato seedlings with respect to plant height, number of leaves and time of flowering. This is in consonance with the findings of Anyaegbu *et al.,* (2013) who observed that the application of various forms of MLE positively influenced the growth and development of Fluted pumpkin (*Telfaria occidentalis)*.

The application rates of 30 t/ha^{-1}of poultry manure had a better performance than other treatments at 8 weeks after planting. This could be attributed to the increased quantum and availability of macro and micro nutrients in poultry manure, its fast mineralization and ease of absorption which enhanced crop growth and development. This is similar to the findings of Muhamman and Kwada (2015) who reported. It is also in tandem with the findings of Mohammed (2014), Chattha *et al.* (2015), Anyaegbu (2014) and Anyaegbu (2015) who reported growth and yield increases of various crops including maize, okra and garden egg.

5.2 Effects of MLE and PM on the yield parameters of sweet corn

Sweet corn plants that received 30 tha^{-1} of poultry manure were first to attain 50% tasseling and silking compared with other plants probably because they obtained a preponderance of nutrient elements from that rate of amendment which enhanced rapid growth and development of the crop. This is in harmony with the findings of Akparobi (2009) ,Ayoola and Makinde (2009) , Uwah *et.al*.(2011) , Enujeke (2013) and Anyaegbu (2015) on Amaranthus, maize, sweet maize and T*elfairia occidentalis*, respectively.

Weights of de-husked green cobs obtained from sweet corn that received 30 tha^{-1} of PM was outstanding among other plants, followed by crops that received 9% MLE + 15tha^{-1} of PM.This could be attributed to the increased availability of nutrient elements, and greater production of photosynthetate, translocated for development of reproductive parts, which causes initial vigorous growth in leaf area, leading to increased grain filling and higher weight of cobs. This is consistent with the findings of Adeleye *et al.* (2010) and Uwah *et al*. (2014), Maerere *et al.* (2001), Akanni and Ojeniyi (2008) and Brady and Weils (2008), who attributed the increased filling of grains and higher weight of cobs of sweet corn to the positive influence of poultry manure, that improved soil physical conditions, microbial activities, and enhanced the supply of adequate amount of nutrients for crop use.

The outstanding performance of the application rate of 30 tha^{-1} of poultry manure over all other rates of amendment materials used with respect to number of seeds per cob could be attributed to its fast mineralization and quick release nutrients to promote not only rapid and vigorous growth, but also the efficient transfer of assimilates to the ear sink. This is similar to the findings of Akparobi (2009) who attributed the enhanced growth as well as the increased fresh and dry weight of *Amaranthus cruentus* which received 35 $tha^{-1}$of poultry manure to accelerated decomposition of the manure which made nutrient elements readily available to crops. It is also in harmony with the findings of Hsieh and Hsieh (1990), Ayeni *et al.* (2010) and Ojeniyi (2011) which reported that poultry manure has the efficiency of increasing soil nutrient content, soil physico-chemical properties and leaving a positive residual effect that is capable of enhancing crop quantity and quality.

The combination 9% MLE and 15 $tha^{-1}$of PM had the next highest number of seeds per cob (467 and 512.2) of sweet corn probably because of the crude proteins and growth promoting hormones (auxins and cytokinins) in MLE. Proteins are essential for the formation of the protoplasm while growth hormones favour rapid cell division, cell multiplication and enlargement (Abdalla, 2013). This is synonymous to the findings of Foidl *et al.,* (2001) who reported that foliar spraying of some crops with MLE produced such notable effects as overall increase in yield between 20 and 35% and higher sugar and mineral levels. This is also in consonance with the findings of Abdalla (2013) who attributed the enhanced accumulation of both proteins and total sugars in rocket plants (*Eruca vesicaria subsp. sativa*) in response to aqueous MLE to the high protein, sugar and starch content of the entire *M. oleifera* plant.

The sweet corn plants that received 30 $t/ha^{-1}$of poultry manure recorded the highest grain yield in both planting seasons, implying the compatibility of that rate with the maize crop requirement in the agro-ecological area, which favours the release of such plant nutrients as water soluble and exchangeable potassium and magnesium that enhance crop yield. This is consistent with the findings of Jackson *et al*. (1999) and Ibeawuchi *et al.* (2007) who reported that higher rates of poultry manure application increased the water soluble and exchangeable potassium and magnesium that enhances grain yield and dry matter of maize. It is also similar with the findings of Onwu *et al*. (2014) who reported that higher doses of poultry manure increases the growth and yield of crops, improves such soil chemical properties as soil pH, total nitrogen, available phosphorus, organic matter, exchangeable cations and cation exchange capacity.

CHAPTER SIX

SUMMARY,CONCLUSION, RECOMMENDATIONS AND CONTRIBUTIONS TO KNOWLEDGE

6.1 Summary

A study was carried out in the Teaching and Research Farm of Delta State University, Asaba Campus during the early and late seasons of 2015 to evaluate the effects of Moringa leaf extract and poultry manure on the growth and yield of sweet corn. It was a randomized complete block design experiment involving nine different treatments replicated three times. The treatments were: Control (No extract), 3% MLE, 6% MLE, 9% MLE, 3% MLE + 15 tha^{-1} PM, 6% MLE + 15tha^{-1} PM, 9% MLE + 15tha^{-1} PM, and 30 tha^{-1} PM.

Nine parameters were assessed and these include: plant height(cm), number of leaves, stem girth(cm), leaf area(cm^{2}), days to 50% tasseling, days to 50% silking, weight of de-husked cobs (kg), number of seeds per cob and grain yield of sweet corn (tha^{-1}). The results of the study showed that plants that received poultry manure application rate of 30 tha^{-1} was superior in all the parameters investigated, followed by plants that received 9% MLE + 15tha^{-1} PM. Sweet corn plants in the control plot which received no amendment materials had the least values with respect to both growth and yield indices tested.

6.2 Conclusion and Recommendations

The result indicated that the use of PM and MLE, either as single amendment, or in a combined form, are capable of positively influencing the growth and yield of sweet corn in the study area. The recommended application rates for optimum yield are :

(i) 30 tha^{-1} of poultry manure alone

(ii) 9% MLE alone, or

(iii) 15 tha^{-1} of PM and 9% MLE in a combined form.

6.3 Contribution to knowledge

The study established that :

(i) the application of 30 tha^{-1} poultry manure alone is good for sweet corn production in the study area.

(ii) the application of 9% MLE as a nutrient source can increase the yield of sweet corn in the study area

(iii) the combination of 9% MLE and 15 tha^{-1} PM is adequate for enhanced performance of sweet corn in the study area.

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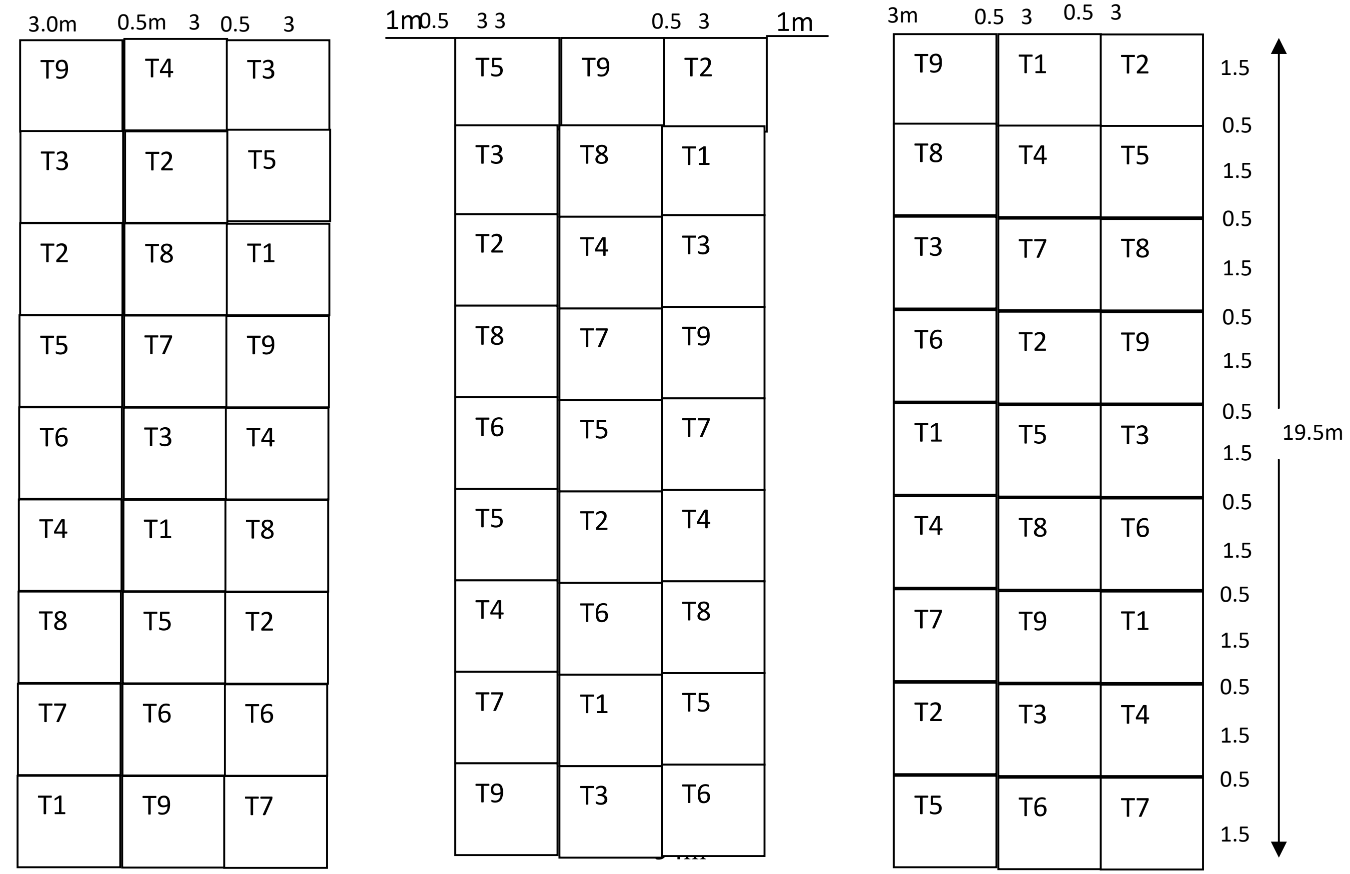
APPENDIX

Table 1: Weather data at the experimental site during the 2015 growing season

Month	**Rainfall (mm)**	**Relative Humidity (%)**		**Temperature °C**
		0600hrs	**1800hrs**	**Mean (°C)**
January	0.0	25	31	34.5
February	35.7	93	69	35.7
March	101.4	92	70	35.4
April	0.4	98	78	35.0
May	123.4	93	75	33.9
June	12.2	93	84	31.9
July	223.9	94	80	31.5
August	202.9	95	88	30.4
September	250.6	95	89	31.0
October	58.6	93	83	32.6
November	0.7	92	73	34.2
December	0.0	63	48	34.7

Source: Nigeria Meteorological Unit (NIMET), Asaba International Airport, Asaba, Delta State.



T9	T4	T3
T3	T2	T5
T2	T8	T1
T5	T7	T9
T6	T3	T4
T4	T1	T8
T8	T5	T2
T7	T6	T6
T1	T9	T7

T5	T9	T2
T3	T8	T1
T2	T4	T3
T8	T7	T9
T6	T5	T7
T5	T2	T4
T4	T6	T8
T7	T1	T5
T9	T3	T6

T9	T1	T2
T8	T4	T5
T3	T7	T8
T6	T2	T9
T1	T5	T3
T4	T8	T6
T7	T9	T1
T2	T3	T4
T5	T6	T7

Active Plot = 4.5m x 81
= 364.50
663m^2