Effects of Poultry Manure and Plant Population on Soil Properties and Agronomic Performance of Sweet Maize (*Zea mays* L. saccharata Strut)

Donatus Felix Uwah

Cynthia Chinenye Ogar

Department of Crop Science
University of Calabar
P. M. B. 1115, Calabar
Nigeria

Roseline Joseph Akpan
National Biotechnology Development Agency
Abuja
Nigeria

Abstract

A two-year field experiment was conducted during the late planting seasons from September to December of 2011 and 2012 on the acidic soils at Uyo and Calabar, to evaluate the effects of four rates of poultry manure (PM) (0, 5, 10 and 15 t/ha) in factorial combinations with four plant populations (PP) (57,142, 66,666, 80,000 and 100,000 plants/ha) on soil chemical properties and agronomic performance of sweet maize (Zea mays L. saccharata Strut). The treatments were fitted into a randomized complete block design with three replications. The application of PM significantly (P≤ 0.05) raised soil pH, organic matter (OM) content, total N, available P, exchangeable K, Ca, Mg and the effective cation exchange capacity (ECEC) status of the soil. The exchangeable acidity (EA) of the soil was reduced by more than two-fold in the two cropping seasons. The highest plant density (100,000 plants/ha), registered the lowest values for soil pH, OM and residual soil N, P, K, Ca, Mg and ECEC in both locations compared with other population densities. The 15 t/ha PM rate maximized sweet maize growth attributes, total dry matter (TDM) and grain yields and also hastened days to 50% tasselling and silking. On average over the two seasons, the application of 5, 10 and 15 t/ha PM rates increased TDM and grain yield by 9.11, 57.29 and 77.67%; and 52.32, 117.18 and 144.28% respectively, compared with the 0 t/ha PM rate. The highest PP registered the maximum leaf area index and the lowest TDM production whereas, the 66,666 PP maximized TDM, weight of grains/ear, 1000-grain weight, ear and grain yields in the two-seasons. Averaged over the seasons, the 66,666 plants/ha density out-yielded the 57142, 80,000 and 100,000 plants/ha densities by 56.05, 18.41 and 29.55% respectively, in terms of total grain yield. Plant population of 66,666 plants/ha in combination with 10-15 t/ha PM is therefore recommended as appropriate for late season sweet maize production in the south eastern Nigerian environment.

Keywords: Poultry manure, Plant population, Soil properties, Sweet maize, Yield

1.0 Introduction

Sweet maize (*Zea mays* L. saccharata Strut) also known as sweet corn, sugar corn or vegetable corn differs from all other maize types because it produces and retains large amount of sugar (13-15%) in the immature kernels (Walter, 1991; Bhatt, 2012). It is a mutant of the dent and flint sub-species mostly grown in the United States of America, East Asia, and some European countries; and has become popular among the elites in African countries (Badu-Apraku and Fakorede, 2006). Sweet maize is consumed at the soft dough stage with succulent grains as a vegetable side dish, roasted ears or added as an ingredient to other dishes such as soups, stews and salads (Bhatt, 2012). Sweet maize can also be processed into syrup, sugar used as sweeteners in soft drinks, starch and cereals. In Nigeria, it is gradually becoming an important vegetable crop as it finds usage as ingredient in the preparation of salad, fried rice and other foods both at home and in restaurants.

Sweet maize production in Nigeria is currently enjoying an increasing trend due to increasing demand in big cities and metropolis.

Soil fertility depletion, a problem in small holder farms, is one of the major causes of declining crop yield in Nigeria. Continuous cropping as a result of scarcity of land, removal of crop residues after cropping for feeding livestock and over-grazing between cropping seasons with little or no external inputs, nutrient depletion through erosion and leaching leading to increased soil acidity have jointly reduced the productive capacity of the arable land in Nigeria (Brady and Weil, 2008). Since enhanced soil fertility and improved environmental quality are both important goals of today's agriculture, the mere application of chemical fertilizers to degraded or over-cropped soil does not trigger crop productivity. For these highly leached soils, it is necessary to provide the balance of nutrients and to neutralize the acidity simultaneously with the use of animal manures and organic residues. Soil enhancing benefits from these manures in addition to those from macro and micro nutrients are related to the organic matter that improves soil structure, moisture relations and increases mobility of P, K and micro nutrients and also stimulates microbial activities (Marerere *et al*., 2001; Garg and Bahla, 2008).

In order to obtain maximum yield from crops, it is necessary to identify management practices which allow crops to maximize the use of growth resources in their environment. Low plant population and poor nutrient management practices are the major yield reducing factors in maize production. For every production system, there is a population that maximizes the utilization of available resources, allowing the expression of maximum attainable grain yield in that environment (Cox, 2001). Increasing plant density would require increasing the nutrient supply to the crop and this could be achieved better with organic manures. Poultry manure (PM) is an excellent organic fertilizer as it contains high N, P, K and other essential nutrients (Farhad *et al.,* 2009). It has been reported to supply P more readily to plants than other organic sources (Garg and Bahla, 2008). Ano and Agwu (2006); Uwah *et al.,* (2011) and Uwah *et al., (*2012) reported that PM increased soil pH, organic matter content, available P, exchangeable cations and micro nutrients, reduced exchangeable Al and Fe contents and bulk density. Poultry manure application increased soil N levels by 53%, while exchangeable cation contents also increased appreciably (Boateng *et al.*, 2006).

Plant density is one of the most important cultural practices determining grain yield as well as other important agronomic attributes of maize. Higher grain yield in crops depends heavily on optimum plant density; a function of row spacing and adequate nutrient supply. Maize differs in its response to plant density and differences in maize yield under varying plant densities have also been attributed to differences in genetic potential (Luque *et al.,* 2006). Plant population densities affect most growth parameters of maize even under optimal growth conditions and therefore, it is considered a major factor determining the degree of competition between plants. It also affects plant architecture, alters growth and developmental patterns and influences carbohydrate production. Dense population increases interplant competition for light, water and nutrients which may be detrimental to the final yield because it stimulates apical dominance, induces barrenness, decreases the number of ears per plant and kernels set per ear, crops become susceptible to lodging, disease and pest (Trenton and Joseph, 2007). Plant population at sub-optimal level on the other hand, results in lower yield per unit area since yield per unit area is the product of yield per stand and number of plants per unit area (Sangakkara *et al.,* 2004). Few investigations have been conducted on maize plant density and N fertilizer rates but none on sweet maize and poultry manure in the rainforest agro-ecology of Nigeria. In view of the fact that systematic research work has not been carried out to develop a site and situation specific production technology for this crop, there is need to establish a relationship between plant densities and poultry manure rates. The present study was therefore, formulated to optimize plant density for sweet maize production under variable PM rates in the rain forest agro-climatic conditions of south eastern Nigeria.

2.0 Materials and Methods

A two-year field experiment was carried out in the late planting season September – December, 2011 at the University of Uyo Teaching and Research Farm, Use-Offot, Uyo and 2012 at the Department of Crop Science, University of Calabar Teaching and Research Farm in south eastern Nigeria. Uyo lies between latitudes 5^o 18^1 and 5^o 28^1 N and longitude 7^o 26^1 and 7^o 57^1 E; 65m altitude. Uyo which is located in the humid rainforest zone, receives an annual rainfall of about 2,500mm during the rainy season which extends from March-November and a mean relatively humidity of 78% (Peters *et al*., 1989). The mean annual temperature varies between 22 and 32^0C and day length (sunshine hours) of 3-8 hours. The soil is acidic and belongs to the broad soil classification group *Ultisol,* formed from acid plain sand, low in organic matter, N, K and other nutrients (Brady and Weil, 2008). Calabar is located about 100km from Uyo along the coastal region of south eastern Nigeria (4^o 57^1N, 8^o19^1 E; 37m altitude).

The region is characterized by a bimodal rainfall pattern with long (March-July) and short (September-November) rainy seasons with a short dry spell of one to two weeks usually during the month of August that is traditionally referred to as “August break”. The dry season is usually from December to February. The rainfall distribution ranges from 3000-3500mm per annum, mean annual temperature ranges from 27 to 35°C and has a relative humidity range between 75-85% (Iloeje, 2001). The soil is *Ultisol,* characterized by low pH, organic matter and nutrient status, and usually deficient in multiple nutrients (Brady and Weil, 2008). The experiment evaluated the effects of four rates of poultry manure (PM) (0, 5, 10 and 15 t/ha) in factorial combinations with four plant populations (PP) (57,142, 66,666, 80,000 and 100,000 plants/ha) derived from the row spacings: 70 x 25cm, 60 x 25cm, 50 x 25cm and 40 x 25cm, on soil chemical properties and the performance of sweet maize (*Zea mays* L. saccharata Strut). Poultry manure was obtained from broiler pens of the Teaching and Research Farms of the Universities of Uyo and Calabar with the birds feed with finisher diet. The bedding materials consisted mainly of wood shaving and saw dust. Composite samples of poultry manure were air-dried, crushed, sieved and analyzed for chemical properties as described in IITA (1982). Soil samples collected from the sites at 0-30cm depths prior to manure application, were analyzed for physico-chemical properties to determine the baseline fertility status of the sites IITA (1982). Another set of soil samples were taken at the end of each planting season to determine the post-harvest soil chemical properties. The relevant results of the physical and chemical analyses of the soils and manure are summarized in Table 1.

The sites were manually cleared of vegetation, ploughed to a depth of 20cm marked out into three blocks of 16 plots each. The gross plot size for the 57,142 and 80,000 plant populations was 3.5 x 2.25m (7.88m^2), with net plot size of 2.1 x 1.75m (3.68m^2) while the gross plot size for the 66,666 and 100,000 plant populations was 3.6 x 2.0m (7.2m^2) with the net plot size of 2.4 x 1.5m (3.6m^2). Plots were separated by paths of 1m, while blocks were kept 1.5m apart. Sowing was done on tilled flat beds on 5th September, 2011 in Uyo and 4th September, 2012 in Calabar. Yellow sweet maize variety TZ developed by the International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria was sown 3 seeds per hill at (70 x 25, 60 x 25, 50 x 25 and 40 x25cm) spacings and the seedlings were later thinned to one plant per hill two weeks after sowing. The resultant plant populations were 57,142, 66,666, 80.000 and 100,000 plants/ha based on the various designated spacings. The manure was incorporated into the soil of the replicated plot in a single dose per the various treatments and allowed to further decompose for two weeks before planting. Manual weeding was done twice at 2 and 6 weeks after sowing by hand pulling and hoeing. Harvesting was done in two stages – soft dough stage (green stage) and fully mature stage. Green harvesting was done 74 days after sowing from 10 randomly selected plants in the net plot areas as indicated by the drying and browning of the silks, fullness of the tip kernels and firmness of the whole husked ears. The fully mature ears were harvested 90 days after sowing from another 10 randomly selected plants in the net plot area and sun-dried to 14% moisture content determined with an Offering Ohaus moisture analyzer model MB54. From these twenty sampled plants, the following parameters were determined: plant height, number of leaves/plant, leaf area, leaf area index, number of days to 50% tasselling and silking, total dry matter, number of ears/plant, weights of whole green and dehusked green ears, number of grains/ear, weight of grains/ear, 1000-grain weight, ear length, dehusked dry ear weight, ear yield, shelling percentage and total grain yield/ha. The data generated from each site were treated separately and are presented as mean values of three replicates. GENSTAT Release 7.22 DE Statistical software (Lawes Agricultural Trust, 2008) was used to evaluate the effects of poultry manure rates on the varying plant population and their interactions on soil properties, growth and yield attributes by applying the technique of analysis of variance for randomized complete block design with factorial concept. Differences between treatment mean values were compared using the Least Significant Difference (LSD) at 5% level of probability.

3.0 Results

3.1 Soil and Poultry Manure Analyses/Meteorological Observations

The initial physico-chemical properties of the experimental soils and the chemical compositions of the PM used in the study are presented in Table 1. The soil in Uyo was loamy sand while that of Calabar was sandy loam. Both soils were slightly acidic, low in total N, exchangeable K and organic carbon, but adequate in P, Ca and Mg. The PM used in the Calabar site contained higher levels of K, Ca, Mg, Mn, Fe, Cu and had a slightly higher pH (8.00) than the Uyo site (7.76) which however, contained higher levels of organic carbon, N, P and Zn. The meteorological data during the two cropping seasons in Uyo and Calabar are presented in Table 2.

The total amount of rainfall during the 2012 cropping season (801.7mm) exceeded that of 2011 (751.0mm) by 6.8% which resulted in higher average monthly relative humidity (78.8%) than the 2011 (75.5%) cropping season. As a result of this, the 2011 cropping season subsequently had higher sunshine hours (22.5h) and average monthly temperature (31.1ºC) as against that of the 2012 cropping season that recorded 21.3h and 25.0ºC respectively.

3.2 Effects of PM and Plant Population (PP) on Soil Chemical Properties

The post-harvest soil chemical properties as influenced by PM and PP are presented in Tables 3 and 4. The application of PM significantly ($P \leq 0.05$) increased soil pH, organic matter (OM) contents, total N, available P and exchangeable cations (K, and Mg in 2011 only, Ca) and effective cation exchange capacity (ECEC). Increasing the rate of PM application also significantly reduced the exchangeable acidity (EA) (Table 4). Each incremental rate of PM significantly increased the soil pH, whereas soil OM increased significantly with each incremental rate of PM up to the highest rate. Averaged over the two years, increasing the PM rates from 0 to 5, 10 and 15 t/ha, resulted in corresponding increases in soil OM content by 9.11, 57.29 and 77.67 percent.

Nitrogen levels increased from 0.60 and 0.70 g/kg (initial N status in soils at Uyo and Calabar sites respectively), to 2.26 and 2.50g/kg in PM amended plots at 15 t/ha rate in 2011 and 2012 cropping seasons. The residual total N values at 15 t/ha PM rate were more than 3½ times the initial soil N status in both sites. Soil available P increased slightly at higher P rates (10 and 15 t/ha) in Uyo, while each increment in PM significantly increased residual soil P in Calabar site up to the highest rate. The effect of PM on residual soil K was only significant in 2011 at Uyo in which every increase in PM rate gave corresponding increase in K status of the soil. Calcium and Mg levels and the ECEC increased significantly with incremental rates of PM with the control plots recording the least values. The magnitude of reduction in exchangeable acidity was more in 2011 than 2012 cropping seasons. In 2011 the EA was reduced from 2.53 to 1.11 cmol/kg while in 2012 EA was reduced from 1.60 to 0.77 cmol/kg at the 15 t/ha PM rate. The reduction in EA was more than two-fold in the two years.

Among the different plant densities (Table 3), higher density of 100,000 plants/ha, registered the least values for soil pH, OM content, N and P compared with those recorded by 57,142, 66,666 and 80,000 plants/ha densities. Similarly, plant densities significantly influenced the residual soil exchangeable cations (K, Ca and Mg) and ECEC in both locations with the 100,000 plants/ha density recording the lowest values for these attributes relative to the other plant populations (Table 4).

3.3 Effects of PM and PP on Sweet maize Performance

The vegetative and reproductive attributes of sweet maize as influenced by PM and PP are presented in Tables 5-7. In the two seasons, the highest rate of PM (15 t/ha) produced the tallest plants with the highest number of leaves, largest leaf area and leaf area index (LAI), which however, were all statistically at par with those obtained at 10 t/ha rate (Table 5). The control plots in both seasons had least values for all the above mentioned attributes. Plant population had no significant effect on plant height, number of leaves and leaf area but significantly influenced LAI with the highest density of 100,000 plants/ha registering maximum LAI (3.68 and 3.60) in 2011 and 2012 cropping seasons respectively (Table 5). Earliness to tasselling and silking were also enhanced significantly by the highest rate of PM in the two seasons, whereas, plots with population density of 57142 plants/ha tasselled and silked earlier than the other plant populations (Table 6). Total dry matter (TDM) production increased with increasing rates of PM in both seasons, while the effects of PM and PP on ear number per plant was not significant. On average over the two cropping seasons, the application of 5, 10 and 15 t/ha PM rates, increased TDM by 9.11, 57.29 and 77.67% above those of the control plots. Dry matter production deceased with increasing plant density with 66,666 plants/ha density producing the heaviest TDM. Greatest reduction in dry matter production was observed with increase in plant population from 80,000 to 100,000 plants/ha (Table 6).

In 2011 cropping season, the applied PM rates produced statistically similar whole and dehusked green ear weights, while a similar trend occurred in both 2011 and 2012 cropping seasons for 1000-grain weight (Table 7). The number and weight of grains/ear peaked at 15 t/ha PM rate, which however, were at par with that produced at 10 t/ha rate. Average over the two years, application rates of 5, 10 and 15 t/ha PM, increased the number of grains/ear and weight of grains/ear by 18.63, 60.42 and 67.92%; and 60.52, 120.35 and 155.42% respectively, compared with the control plots. Plant population had no significant effect on all the yield attributes except weight of grains/ear in 2012 and 1000-grain weight in both seasons (Table 7). In 2012, the weight of grains/ear obtained at the 66,666 plant population was 20.07, 49.35 and 67.40% heavier than those at 57142, 80,000 and 100,000 plant populations respectively.

Equally, the 66,666 population had heavier 1000-grain weight than the other populations; the least being 100,000 plants/ha. Ear length, dehusked dry ear weight, ear yield and total grain yield obtained at 10 and 15 t/ha PM rates were statistically at par but significantly higher than those at 0 and 5 t/ha rates (Table 8). Shelling percentage of grains was highest at 10 t/ha PM rate which however, did not differ significantly from those at 5 and 15 t/ha rates. On average over the two years, the 15 t/ha PM rate gave ear and grain yield increases of 20.03, 81.61 and 129.87%; and 12.41, 60.29 and 144.28% above the 10, 5 and 0 t/ha PM rates respectively. Grain yield increased in the order 15 > 10 > 5 > 0 t/ha PM rates.

The effect of plant population was significant for ear length, dehusked dry ear weight in 2012, ear yield and total grain yield (Table 8). Ear length was longest at 57142 PP, although this was statistically similar with that at 66,666 PP. Similar trend was observed for dehusked dry ear weight in 2012. Ear and grain yields were maximized at 66,666 PP, followed by the 80,000 PP. Average ear yield increases of 41.81, 23.26 and 78.55% and grain yield increases of 56.05, 18.41 and 29.55% were recorded at 66,666PP above 57142, 80,000 and 100,000 PP respectively. In general, the yield attributes for 2012 were observed to be higher compared to that of 2011 cropping season.

3.4 Interactions

There was no significant interaction effect among the measured parameters.

4.0 Discussion

In general, the low soil organic carbon, N and K contents indicated poor soil fertility. The application of PM was therefore expected to be beneficial to the crop and soils that were acidic in nature with low nutrient status. The PM used in the two sites were alkaline in reaction and generally high in macro and micro nutrients (Table 1). The high Ca content of the PM was probably responsible for the relatively high pH in amended plots (Cooper and Warman, 1997). In addition, during microbial decomposition of the incorporated manure, basic cations are released which would raise the initial pH of the soil to a more favourable level for good crop production (Pucknee and Summer, 1997). Similar results have been obtained by other workers on organic amendments on soils (Okwuagwu *et al*., Boateng, *et al.*, 2006*;* Islam *et al.*, 2011*)*. In support of these findings, recent studies have also shown that PM increased soil organic matter, pH, N, P and CEC (Mbah and Mbagwu, 2006; Akanni and Ojeniyi; Islam *et al.*, 2011; Uwah *et al*., 2012). This was attributed to the availability and adequate supply of organic matter by the PM.

The reduction in exchangeable acidity on addition of organic manures to the soil has been reported (Ano and Ubochi, 2007). The explanation given was that as organic manures mineralize, Ca ions are released into the soil solutions which get hydrolyzed. The calcium hydroxide ($Ca(OH)_2$) formed, reacts with soluble aluminum ions in the soil solution to give insoluble $Al(OH)_3$. The hydroxide of calcium hydroxide reacts with hydrogen ions to form water. The results of these reactions bring about the reduction of EA in the soil as observed in this study. The increase in soil available levels of N and P with increasing application rates of PM could also be attributed to increased microbial activities which could have resulted in enhanced decomposition of the organic forms of N and P, hence, increased availability of residual N and P in the soil. The low values of the increase in soil residual P could be as a result of crop uptake, fixation by Al, Fe and Mn oxides and hydroxides and immobilization by microorganisms (Boateng *et al.,* 2006). Similar results were reported by other workers who observed that PM had highest effect on soil available levels of N and P compared to other animal manures (Maerere *et al*., 2001; Akanni and Ojeniyi, 2008). Positive changes in soil contents of K, Ca, Mg and reduction in values of EA accompanied by increases in ECEC upon application of animal manures, have been documented by several workers (Boateng, *et al*, 2007., Ano and Ubochi, 2007; Adeleye *et al*., 2010 and Uwah *et al*., 2012).

The highest plant population (100,000 plants/ha) recording the lowest values for all the soil chemical properties except EA, could be attributed to maximum utilization of the soil and other environmental resources by the crop. The highest plant density extracted more of the available nutrients resulting in less availability of these nutrients in soil. This finding is supported by observations made by Zamir *et al*., (2011).

All the growth parameters were significantly and positively responsive to increasing rates of PM application. Sweet maize being a heavy feeder, responded to the applied input at higher doses to support the crop’s requirements. Poultry manure at the 15 t/ha rate promoted better growth probably as a result of higher uptake of inherent nutrients in the manure as compared to lower rates.

The nutrients triggered the vigorous growth of plants thereby achieving higher leaf area, LAI and this further boosted the dry matter production and hastened the flowering and maturity period. Superior growth attributes obtained with high rates of PM in this study, have been reported by other workers (Akanni and Ojeniyi, 2008; Ayoola and Makinde, 2009; Uwah et al., 2011).

Increase in plant height associated with high plant density (100,000 plants/ha) did not translate to increase in dry matter production, but rather resulted in highest LAI (Table 5). This clearly showed that increase in number of plants per unit area beyond optimum level will reduce the amount of light available to the individual plants, especially, to lower leaves in the canopy due to shading. As the intensity of shading increased due to high population densities, the plant tended to grow taller. This result is consistent with those of other workers (Ashok, 2009; Bhatt, 2012). The increase in LAI with increase in plant densities was due to more number of plants per unit area. Other research findings have also indicated that high plant density recorded more LAI as compared to low plant density (Bhatt, 2012). Earliness to tasselling and silking was enhanced by lower population densities (57142 and 66,666 plants/ha), suggesting that translocation of assimilates from source to sink was more at lower plant densities. In addition, plants at lower densities attained early flowering stage as a result of early vigorous growth due to less competition among the plants. This result is in conformity with those of other researchers (Muniswamy et al., 2007; Bhatt, 2012).

Several studies have shown that TDM yield decrease progressively as the number of plants increase in a given area because the productivity of the individual plant is reduced (Bhatt, 2012). The highest TDM obtained at 66,666 plants/ha which had comparatively lesser plant population was possibly due to optimum utilization of the soil and other environmental resources by the crop. Increased dry matter production at the density of 66,666 plants/ha might be due to less interplant competition for space, light, nutrients and moisture and better utilization of available resources. Individual plant had adequate quantities of plant nutrients from relatively large volume of soil up to reaching an optimum density of 66,666 from 57142 plants/ha and further increase in plant density to 80,000 plants/ha enforced a heavy competition for resources resulting in decreased dry matter production. Our result is in consonance with the findings of other workers (Muniswamy *et al.*, 2007; Bhatt, 2012).

Increased availability of nutrients to the sweet maize crop at higher rates of PM, resulted in the production of longer ears, accompanied by increased grain filling that produced more grains per ear. Superior ear and grain development was due to increase availability of adequate supply of nutrients from the PM and greater production of photosynthates and their efficient translocation for development of reproductive parts. Grain yield followed similar trend as that of LAI, dry matter yield and ear yield that were all maximized at 15 t/ha rate, while the shelling percentage however, peaked at 10 t/ha PM rate. Averaged over the two seasons, the application of 5, 10 and 15 t/ha PM, increased grain yield by 52.32, 117.18 and 144.28% respectively, when compared with the 0 t/ha PM rate. The influence of PM on sweet maize yield parameters could be ascribed to the ability of this organic manure to supply nutrients and organic matter to the soil and in improving soil physical condition (Adeleye, *et al*., 2010).

Increase in number of grains/ear, weight of grains/ear, 1000-grain weight and ear length from lower plant densities might be due to the lesser competition for radiation and nutrients that allowed the plants to accumulate more biomass with higher capability to convert more photosynthates into sink resulting in higher values for the aforementioned attributes. Low grain weight at high population density was probably due to less availability of photosynthates for grain development on account of high inter-specific competition which resulted in low rate of photosynthesis and high rate of respiration as a result of enforced mutual shading (Zamir *et al*., 2011). The decline in grain yield with increasing density beyond an optimum, represented intense interplant competition for incident photosynthetic flux density, soil nutrients and water (Dawadi and Sah, 2012). The higher yield at 66,666 plants/ha was possible due to higher number and weight of grains/ear and ear yield obtained from this treatment. Similar observations have been made by other researchers (Ashok, 2009; Dawadi and Sah, 2012 and Bhatt, 2012,)

5.0 Conclusion

Sweet maize yield could be increased substantially by adjusting the plant population with sufficient amount of poultry manure application. Plant density of 66,666 plants/ha maximized grain yield. The recommended density of 53,333 plants/ha for other maize types usually adopted for sweet maize was insufficient for sweet maize production. Therefore, closer spacing with plant densities around 66-70 thousand plants/ha is suitable for higher yield during the late planting season in south eastern Nigeria.

Although sweet maize yield peaked at the highest rate of 15 t/ha PM, the increase in yield was not significantly different at 10 and 15 t/ha PM rates. The 10 -15 t/ha PM rates was the appropriate dose for sweet maize production in the south eastern Nigerian environment depending on the inherent nutrient status of the soil and manure.

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Table 1: Physico-Chemical Properties of the Soil (0 – 30cm Depths) at the Experimental Sites and Chemical Properties of Poultry Manure Used in 2011 and 2012 Growing Seasons in Uyo and Calabar

Composition	**Soil**			**Poultry manure**	
Physical composition (g/kg)	**2011**	**2012**	**Chemical composition**	**2011**	**2012**
Sand	778.0	752.0	pH in H_2O (1:2.5)	7.76	8.00
Silt	100.0	86.0	EC (ds/m)	3.37	1.98
Clay	122.0	152.0	Organic C (g/kg)	430.1	300.0
Textural class	Loamy sand	Sandy loam	Total N (g/kg)	18.5	11.80
Chemical characteristics			Av.P (mg/kg)	2821.0	2346.0
pH (H_2O) (1:2.5)	5.85	5.90	C/N	23.14	25.20
Organic carbon (g/kg)	11.89	11.09	Ca (cmol/kg)	1837.0	2555.5
Available P (mg/kg)	74.02	28.13	Mg ,,	118.0	777.4
Total N (g/kg)	0.60	0.70	K ,,	1689.0	4507.1
Exchangeable bases (cmol/kg)			Mn ,,	34.81	88.0
Ca	3.15	3.40	Cu ,,	4.93	38.0
Mg	1.30	1.60	Fe ,,	91.7	140.8
K	0.13	0.16	Zn ,,	121.3	89.0
Na	0.05	0.06			
EA	2.53	1.60			
ECEC	7.03	6.62			
BS (g/kg)	658.61	788.52			

Table 2: Meteorological Data at the Trial Sites during the 2011 and 2012 Late Planting Seasons at Uyo and Calabar

Year/Month	Rainfall (mm)	Temperature (^oC) Max	Relative humidity (%)	Sunshine hour (hr)
2011 * season				
September	414.8	28.9	87.0	4.7
October	299.0	31.2	80.0	5.4
November	37.2	31.8	72.0	5.6
December	0.0	32.6	63.0	6.8
2012 + season				
September	405.8	23.8	77.1	4.8
October	312.8	25.8	79.8	4.3
November	79.4	24.6	75.6	6.2
December	3.7	25.8	82.5	6.0

Sources: * Nigerian Meteorological Unit (NIMET), Akwa Ibom International Airport, Uyo, Nigeria.
+ Meteorological Unit Department of Geography and Environmental Science, University of Calabar, Nigeria

Table 3: Effect of Poultry Manure (PM) and Plant Population (PP) on Soil Chemical Properties in 2011 and 2012 Late Planting Seasons at Uyo and Calabar

Treatment	**pH (H_20)**		**OM (g/kg)**		**Total N (g/kg)**		**Av. P (mg/kg)**	
	2011	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
PM (t/ha)								
0	5.55	5.67	19.35	17.20	0.40	0.50	64.38	18.76
5	5.87	6.10	32.18	26.10	2.00	2.30	68.23	29.90
10	5.97	6.20	39.53	36.50	2.10	2.40	74.35	31.20
15	6.32	6.42	42.41	38.40	2.26	2.50	77.68	34.10
LSD (0.05)	0.075	0.084	0.95	1.60	0.085	0.20	1.01	0.22
Plant population (plts/ha)								
57,142	6.07	5.30	29.16	24.00	2.19	1.16	73.44	31.58
66,666	6.00	5.40	29.55	25.80	2.12	1.10	71.46	30.08
80,000	5.85	4.82	28.98	25.20	2.09	0.90	69.38	29.88
100,000	5.70	4.75	28.88	23.20	1.93	0.90	64.38	19.63
LSD (0.05)	0.075	NS	0.95	1.60	0.085	0.20	1.01	0.22
Interaction								
PM x PP	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not significant

Table 4: Effect of Poultry Manure (PM) and Plant Population (PP) on Soil Chemical Properties (Exchangeable Bases and Acidity) in 2011 and 2012 Late Planting Seasons at Uyo and Calabar

Treatment	K		Ca		Mg		EA		ECEC	
	←				(cmol/kg)					→
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
PM (t/ha)										
0	0.12	0.09	3.12	3.10	1.00	1.05	2.60	1.77	7.00	6.37
5	0.19	0.09	3.77	3.80	1.58	1.17	1.35	1.11	8.15	7.68
10	0.21	0.09	4.42	4.50	1.58	1.25	1.22	0.93	8.23	8.62
15	0.24	0.09	5.04	5.50	1.65	1.37	1.11	0.77	8.78	8.81
LSD(0.05)	0.008	NS	0.17	0.21	0.087	0.18	0.08	0.161	0.088	0.336
PP (plts/ha)										
57,142	0.20	0.10	4.57	3.80	1.60	1.28	1.68	1.71	8.63	8.32
66,666	0.19	0.09	4.37	3.80	1.60	1.07	1.82	1.75	8.35	8.23
80,000	0.18	0.09	3.87	3.40	1.43	1.07	1.90	1.76	8.15	8.06
100,000	0.16	0.08	3.85	3.00	1.38	1.03	1.98	1.77	7.63	7.78
LSD (0.05)	0.008	NS	0.17	0.21	0.087	0.18	NS	NS	0.088	NS
Interaction										
PM x PP	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not significant

Table 5: Effect of Poultry Manure and Plant Population on Plant Height (cm) Number of Leaves/Plant, Leaf Area (m^2), and Leaf Area Index (LAI) at 11 WAS of Sweet Maize in 2011 and 2012 Late Planting Seasons at Uyo and Calabar

Treatment	Plant height (cm)		Number of leaves/plant		Leaf area (m^2)		Leaf area index	
	2011	2012	2011	2012	2011	2012	2011	2012
PM (t/ha)								
0	166.60	93.46	10.29	8.50	30.60	22.80	2.62	1.70
5	179.04	144.58	11.03	10.58	39.80	40.79	3.00	3.00
10	189.50	173.78	11.65	10.82	44.40	44.16	3.50	3.40
15	199.20	181.28	11.69	10.83	50.40	44.28	3.83	3.53
LSD (0.05)	12.42	31.00	0.72	0.74	6.10	9.26	0.35	0.19
PP(plts/ha)								
57,142	178.20	143.08	11.13	10.33	39.70	34.08	2.09	2.10
66,666	182.50	145.23	10.99	10.25	40.90	36.60	2.87	2.60
80,000	186.20	146.51	11.52	10.17	41.80	36.90	3.17	3.00
100,000	187.50	148.27	11.02	10.08	42.80	39.20	3.68	3.60
LSD (0.05)	NS	NS	NS	NS	NS	NS	0.35	0.19
Interaction								
PM x PP	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not significant

Table 6: Effect of Poultry Manure and Plant Population on Number of Days to 50% Tasselling/Silking, Total Dry Matter (TDM) (g/plant) and Number of Ears/Plant of Sweet Maize in 2011 and 2012 Late Planting Seasons at Uyo and Calabar

Treatment	Days to 50% tasselling		Days to 50% silking		(TDM) (g/plant)		Number of ears/plant	
	2011	2012	2011	2012	2011	2012	2011	2012
PM (t/ha)								
0	52.95	58.17	57.25	61.42	137.20	136.79	1.08	1.00
5	52.57	55.42	56.85	60.25	151.50	147.45	1.17	1.00
10	52.42	52.58	56.12	57.92	212.80	218.15	1.50	1.21
15	51.03	51.25	55.55	57.00	249.90	236.90	1.42	1.12
LSD (0.05)	1.05	1.83	1.16	1.60	43.49	38.24	NS	NS
PP(plts/ha)								
57,142	50.82	52.92	55.75	58.50	185.60	195.80	1.50	1.12
66,666	51.62	54.50	56.36	58.83	256.73	212.10	1.33	1.10
80,000	52.83	55.50	57.46	62.08	240.60	164.18	1.17	1.08
100,000	53.97	55.50	58.73	63.17	196.90	126.15	1.17	1.04
LSD (0.05)	1.05	1.83	1.16	1.60	43.49	38.24	NS	NS
Interaction								
PM x PP	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not significant

Table 7: Effect of Poultry Manure and Plant Population on Weight of Whole Green Ears (kg), Dehusked Green Ears (kg), Number of Grains/Ear, Weight of Grains/Ear (g) and 1000-Grain Weight (g) of Sweet Maize in 2011 and 2012 Late Planting Seasons at Uyo and Calabar

Treatment	Weight of whole green ears (kg)		Weight of Dehusked green ears (kg)		Number of grains/ear		Weight of grains/ear (g)		1000-grain weight (g)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
PM (t/ha)										
0	0.12	0.15	0.07	0.09	323.00	310.33	19.40	20.00	62.50	64.92
5	0.20	0.21	0.12	0.13	365.00	385.58	29.30	34.00	80.80	83.42
10	0.22	0.22	0.13	0.14	518.00	498.00	42.30	44.53	85.80	87.42
15	0.23	0.53	0.13	0.17	501.00	560.83	47.40	53.30	89.20	90.17
LSD (0.05)	0.05	0.07	0.03	0.05	90.00	78.55	8.52	7.94	11.98	10.69
PP (plts/ha)										
57,142	0.22	0.22	0.12	0.15	433.00	431.17	34.30	44.99	80.80	87.25
66,666	0.19	0.20	0.11	0.14	453.00	473.92	39.70	54.02	90.80	98.75
80,000	0.18	0.20	0.11	0.12	424.00	396.00	32.40	36.17	75.80	82.50
100,000	0.18	0.19	0.11	0.12	398.00	367.67	31.90	32.27	70.80	76.42
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	7.94	11.98	10.69
Interaction										
PM x PP	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not significant

Table 8: Effect of Poultry Manure and Plant Population on Ear Length (cm), Dehusked Dry Ear Weight (g), Ear Yield (t/ha), Shelling Percentage and Total Grain Yield (t/ha) of Sweet Maize in 2011 and 2012 Late Planting Seasons at Uyo and Calabar

Treatment	Ear length (cm)		Dehusked dry ear weight (g)		Ear yield (t/ha)		Shelling percentage		Total grain yield (t/ha)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
PM (t/ha)										
0	15.73	16.32	30.10	34.61	2.19	2.59	65.34	65.43	1.42	1.65
5	16.51	18.25	41.10	42.92	2.88	3.15	71.20	70.99	2.20	2.47
10	17.63	19.54	59.20	63.15	4.40	4.72	71.33	71.25	3.13	3.53
15	19.22	20.76	65.20	69.14	5.24	5.71	69.52	69.50	3.65	3.82
LSD (0.05)	1.89	1.72	12.44	11.54	0.86	1.05	4.05	3.95	0.65	0.48
PP (plts/ha)										
57,142	18.39	19.76	49.40	49.75	3.24	3.20	68.93	69.93	1.96	2.23
66,666	18.08	18.87	56.10	57.25	4.41	4.72	70.11	70.11	3.19	3.33
80,000	16.97	17.24	44.40	49.50	3.74	3.67	69.65	68.56	2.65	2.86
100,000	15.64	16.35	46.20	47.42	3.28	2.12	68.71	67.75	2.59	2.45
LSD (0.05)	1.89	1.72	NS	11.54	0.86	1.05	NS	NS	0.65	0.48
Interaction										
PM x PP	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not significant