Spatial dimensions and poultry manure rate effects on sweet corn (*Zea mays* L. saccharata Sturt.) varieties in Calabar

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Abstract

The study evaluated the effect of variety, planting distance and rates of poultry manure on the performance of sweet corn in the humid rainforest of South Eastern Nigeria. The study was a 2 x 2 x3 factorial experiment laid out in a randomized complete block design (RCBD) and treatments consisted of two sweet corn varieties (TZMS and TZIS), two planting distances (40 cm x 25 cm and 50 cm x 25 cm) and three rates of poultry manure (0, 10 and 20 t ha^{-1}) giving 12 treatment combinations which were replicated three times, giving 36 experimental plots. Data were collected per plant for plant height, number of leaves, leaf area, leaf area index; while yield data were taken for the number of seed rows per cob, green cob yield and cob yield per hectare. The data was subjected to a two–way analysis of variance (ANOVA) and means were compared using the Fisher's Least Significant Difference at 0.05 probability level. The result showed that the application of 10 and 20 t ha^{-1} PM significantly ($p<0.05$) increased the vegetative growth of sweet corn. The highest ($p<0.05$) leaf area and leaf area index occurred at PM rates of 20 t ha^{-1}followed by 10 t ha^{-1} which were statistically similar. Apart from these however, poultry manure did not have any other salutary effects on the performance of sweet corn during the study.

Keywords: Sweet corn, spatial dimensions, poultry manure

Introduction

Sweet corn (*Zea mays* L. Saccharata Sturt) is a member of the family Poaceae and is believed to have originated from the Americas (New World) along with other sub-species of *Zea mays* (L), whose domestication began at least 6,000 years ago (Matsuoka *et al*. 2002). Sweet corn is a vegetable with wrinkled translucent seeds. Unlike other types of field corn, the plant's sugar is not converted to starch, due to natural recessive mutation in the genes controlling sugar conversion to starch within the endosperm (IALF, 2015). Normal sugary varieties are best suited to being picked, husked and eaten within a very short time.

Sweet corn is typically grown near where it is consumed and usually harvested fresh. The earliest corn matures in about two months, the latest in about 3 months. At optimum maturity, sweet corn contains sugar 5-6%, starch 10-11%, water soluble polysaccharides 3%, water 70%, moderate levels of protein, vitamin A and potassium (Oktem and Oktem, 2005). Sweet corn can be processed into syrups, sweeteners, starch, breakfast cereal and confections. It is also cooked and eaten off the cobs, as a vegetable or side dish, added as an ingredient to other dishes such as soups, stews, casseroles and salads. The corn can be preserved by canning or freezing, when not immediately consumed.

Maize production is greatly affected by varying planting density than other members of the grass family because of its monoecious floral organization, its low tillering capacity to fill the gap among plants (Ali *et al*., 2017). Spacing requirement for maize is an important consideration. According to Eskandarnejad *et al*. (2013), the highest average grain yield of 15.03 ton/ha was recorded with 55 cm row spacing in sweet corn. Getaneh *et al*. (2016) reported that spacing combinations of 65 x 25 cm responded favourably in attaining higher grain yield of maize in Ethiopia. However, Belay (2019) maintained that 75 x 25 cm spacing gave the best maize yields in Ethiopia. According to *Uwah et al.* (2014), highest yields of sweet corn were obtained at 60 cm inter-row spacing. Tahmasbi and Mohasel (2009) reported that increased plant density resulted in increased yield; with the highest grain yield of 11.13 t ha^{-1} occurring at 85,000 plants ha^{-1} in maize. Saddat *et al*. (2010) observed that 40,000 stands ha^{-1}, resulted in highest number of rows and grains ear^{-1}, while Abuzar *et al*. (2011) reported highest maize yields at 40,000 stands ha^{-1} population. Mashiqa *et al*. (2012) however reported highest grain yields of maize (2773.60 kg ha^{-1}) at lower density of 16,670 plants ha^{-1}. Zamir *et al*. (2011) observed that corn kernel yield was enhanced from 10.1 ton/ha to 10.8 ton/ha when the plant population increased from 59000 to 89000 plant/ha. Eskandernejad *et al*. (2013) reported that the highest average of grain yield was recorded with 55 cm row spacing (15.03 ton/ha average) which was due to the tassel length, ear length, 1000-kernel weight and harvest index. Manure is one of the most important inputs contributing to crop production because it increases productivity and improves crops' yield.

Adequate use of organic manure in crop production can sustain the yield of crops under continuous cultivation on most soils (Maynard, 1991). However, the slow release of nutrients may make them not available to crops in the year of application and thus short season crops may not fully benefit from organic manure applied shortly before planting (Sharma and Mittra, 1991; Muoneke and Asiegbu, 1997), except when such manures are cured over a period of time before application. Also, nutrients are stored for a longer period of time in the soil ensuring longer residual effects, improved root development and higher crop yields under fallow conditions. Manure is usually applied at a higher rate, relative to inorganic fertilizers, which gives residual effects on the growth and yield of succeeding crops

(Makinde and Ayoola, 2008). Although organic manures contain plant nutrients in small quantities as compared to inorganic fertilizer, their growth promoting constituents like enzymes and hormones, besides plant nutrients, makes them useful for improvement of soil fertility and crop productivity.

Many workers have assessed the importance of manures in crop production. Senjobi *et al*. (2010) reported that the use of poultry, plant and sheep/goat manures improved all the growth parameters of leafy vegetables. Other workers have reported beneficial effects of organic manure on soil properties (Fawole *et al*., 2011). Many materials which are waste products of agricultural enterprises and the saw-mill industry can be used beneficially to produce crops and amend the soil for sustainable crop production. Frequent and consistent use of high rates of inorganic fertilizers has been associated with some drawbacks such as environmental pollution. Also, the recent increase and relative unavailability of inorganic fertilizer has necessitated the reduction of dependence on mineral fertilizers. As is common to maize, sweet corn is a heavy feeder and adequate soil fertility is critical for high yields. Manure increases productivity and improves crop yield. Animal dung and farm yard manure are usually used for soil fertility improvement.

With the great potential of sweet corn arising from its demand, there is a need to carry out trials on establishing nutrient requirements and spacing options for optimum yields. This is more so because recommendations for field corn might not be wholly imposed on sweet corn. The present study which sought to examine the effects of poultry manure and spacing on sweet corn varieties in Calabar, South East rainforest agro-ecological zone of Nigeria, was therefore carried out in an effort to address sweet corn production peculiarities in the study area.

Materials and methods

Site information

A field experiment was conducted in 2019 at the Teaching and Research Farm of the University of Calabar, Nigeria (Latitude 4.5 - 5.2^{0} N and longitude of 8.0 - 8.3^{0}E), about 39m above sea level. The area is characterized by a bimodal rainfall pattern that ranges from 3,000 – 3,500 mm, mean annual temperature range of 27^{0}C to 35 ^{0}C and relative humidity between 75 – 85% (NIMET, 2010). The soil is regularly cropped, year in year out due to continuing trials but in the previous year, the site was in fallow.

Soil sampling and analysis

Random soil samples were collected from the experimental site at 0-30 cm depth prior to application of treatments and planting. Samples were air-dried, bulked and a composite sample analyzed for physico-chemical properties using suitable methods.

Experimental design

The study adopted a 2 x 2 x 3 factorial experiment in randomized complete block design (RCBD) having twelve treatment combinations in all. The main effects were two sweet corn varieties (TZMS and TZIS), two inter-row spacing dimensions (40 cm x 25 cm and 50 cm x 25 cm) and three poultry manure rates (0, 10 and 20 t ha^{-1}); zero being the control where no fertilizer treatment was applied. These were replicated three times giving a total of 36 experimental plots.

Sources of experimental materials

Poultry manure was sourced from the University of Calabar Poultry farm. The manure was cured by spreading out under shade for two weeks before field application, three weeks before planting. Seeds of sweet corn varieties; TZMS and TZIS (Lowland sweet corn) were obtained from the Seed Bank of the International Institute for Tropical Agriculture, Ibadan, Nigeria.

Field planting and maintenance

Two seeds of corn were sown per stand at a spacing of 40 x 25 cm and 50 x 25 cm into a previously ploughed and harrowed field on April 20th, 2019. They were later thinned to one per stand giving respective plant population densities of 100,000 and 80,000 plants ha-^{1}. Experimental plots measured 2.0 m x 2.0 m (4.00 m^2) with a net plot size of 1.5 m x 1.5 m (2.25 m^2), respectively.

Data collection

Plants were sampled every two weeks starting from 3 - 11 weeks after planting (WAP). Data were collected on growth variables: plant height, number of leaves, leaf area, leaf area index; while yield data were taken for the number of seed rows per cob, green cob yield and cob yield per ha.

Data analysis

Data collected were subjected to a two –way analysis of variance (ANOVA) at 5% level of significance following procedures outlined by (Gomez and Gomez, 1984). Significant means were compared using the Fisher's Least Significant Difference at 0.05 probability level.

Results and discussion

The result of soil analysis (Table 1) indicated a sandy loam texture with pH of soil in water of 6.30, quite ideal for crop growth. Organic carbon and organic matter percentages were quite low, characteristic of sandy soils. The content of macro elements in the manure was 1.42, 1.82, 0.70, 0.30 and 3.8 % for P, N, Ca, Mg and K respectively. Manure however had a pH of 7.75, high organic carbon of 43.01%.

Effects of spacing on the growth and yield of sweet corn

The plant height, number of leaves, leaf area and leaf area index of sweet corn as affected by Inter-row spacing, poultry manure and variety at nine weeks after planting are presented in Table 2. Inter-row spacing did not significantly ($p>0.05$) affect the plant height or number of leaves of sweet corn. The leaf area and leaf area index were significantly ($p<0.05$) higher at 40 x 25 cm, than at the 50 x 25 cm spacing intervals. Crop growth can be enhanced when competition is minimal. Spacing is vital in crop production systems due to its influence on competition for plant growth resources. When plants are well spaced, they utilize soil moisture and nutrients more effectively as well as avoid excessive intra specific competition. Optimum leaf area spread and the optimization of leaf area index enhances interception of incident solar radiation, photosynthesis and eventually the rate of photo-assimilate production and partitioning for maximum yield. Among the phenological and yield indices (Table 3), only grain yield of sweet corn was significantly ($p<0.05$) increased at the 50 x 25 cm (2.27 t ha^{-1}). This is at variance with Uwah *et al.* (2014) who reported that highest yields of sweet corn were obtained at 60 cm inter-row spacing. Eskandernejad *et al*. (2013) reported the highest grain yield of sweet corn at 55 cm row spacing which is closely related to results in this study as against Akbar *et al.* (1996) report that the most proper sowing density for corn was 100,000 plants ha^{-1}. The higher grain yield at the 50 x 25 cm spacing may have been as a result of higher exploitation of available plant growth resources to increase yield, arising from higher solar interception efficiency and conversion to yield.

Effects of poultry manure on growth and yield of sweet corn

Poultry manure at 10 and 20 t ha^{-1} significantly ($p>0.05$) increased the plant height, number of leaves, leaf area and leaf area index of sweet corn respectively above the untreated control (Table 2). The effects of poultry manure were not significant ($p>0.05$) on 50 % tasseling and days to 50 % silking, and the grain yield. The dry matter and cob yield (Table 3) were significantly ($p<0.05$) higher at 20 t ha^{-1} than 10 t $ha^{-1}$and the control, which were statistically at par ($p>0.05$). At 20 t ha^{-1} the plants received a higher supply of N and other associated nutrients. According to Havlin *et al*. (2007) and Akmal *et al*. (2012), adequate N supply is associated with high photosynthetic activities and vigorous plant growth. However, 10 t ha^{-1} poultry manure did not show any influence on sweet corn. Poultry manure amendment has also been shown to increase soil organic carbon, total nitrogen and available phosphorus (Lv *et al.,* 2011). Incorporation of poultry manure into the soil promotes transformation and mineralization of less mobile inorganic and organic phosphorous into mobile phosphorous in the rhizosphere, and better physiological processes of the crop.

Effect of varieties on performance of sweet corn

Varietal effects on the plant height, number of leaves, leaf area and leaf area index of sweet corn were positively significant, with TZMS having significantly ($p<0.05$) higher growth indices compared to TZIS. However, number of days to 50 % tasseling, days to 50 % silking and the yield aspect such as dry matter, cob yield and grain yield of sweet corn was not significantly($p>0.05$) affected by variety.

Effects of interactions

Except for the spacing x poultry manure x variety interaction on grain yield, all other interactions were not significant ($p>0.05$). From the interactions (Table 4), both TZMS and TZIS at 10 and 20 t ha^{-1} of poultry manure, spaced at 50 x 25 cm were significantly ($p<0.05$) higher in yield than all other treatment combinations and statistically similar ($p>0.05$) to each other.

Plant population density per square meter affects root spread as well as effective rooting area and available aerial space to each stand for the mining and exploitation of available growth resources. The 50 x 25 cm spacing with 10 t $ha^{-1}$of PM had the highest yields (2.36 t ha^{-1}) of TZIS sweet corn as observed in this study. However, this was not significantly ($p>0.05$) different from the yields that were obtained from this spacing at 10 t ha^{-1} with variety TZIS and TZMS.

Summary and conclusion

The application of 10 and 20 t ha^{-1} PM significantly ($p<0.05$) increased the growth of sweet corn. The highest ($p<0.05$) leaf area and leaf area index occurred at PM rates of 20 t ha^{-1}followed by 10 t ha^{-1}. At the 20 t ha^{-1} rate, PM also increased the dry matter and green cob yields respectively. Apart from these however poultry manure did not have any other salutary effects on the performance of sweet corn especially the grain yield during the study.

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Table 1: Physical and chemical properties of the soil chemical composition of poultry manure.

Soil analysis (0-20cm) Physical Composition		Manure analysis	
Particle size analysis			
Sand (%)	85.6		
Silt "	7.3		
Clay "	7.1		
Soil textural class	Loamy sand		
Chemical composition			
pH	5.00		7.75
EC dsm^{-1}	0.065		3.369
Organic matter (g/kg)	1.03	Organic C	43.01 %
Total Nitrogen (g/kg)	0.10	N	1.82 %
Available P (mg/kg)	18.55	P (mg/kg)	1.42 %
Exchangeable bases (cmol/kg)		C/N ratio	23.14
Na	0.09	Na	0.42 %
K	0.12	K	3.8 %
Ca	2.2	Ca	0.70 %
Mg	2.4	Mg	0.30 %
H^+	0.86	Mn	0.34 %
Al^{3+}	1.08	Fe	0.91 %
ECEC	6.75		
Base Saturation (%)	50.41		
B/S (%)	71.2		

Table 2: Plant height, Number of leaves, leaf area and Leaf area index of sweet corn as affected by treatments

Treatments	9 weeks after planting			
	Plant height (cm)	No. of leaves	Leaf area (cm^2)	Leaf area index
Spacing (cm)				
40 x 25	195.8	10.06	3694.0	3.69
50 x 25	189.8	10.18	3178.1	2.54
LSD	NS	NS	192.9	0.18
Manure t ha^{-1}				
0	153.0	8.62	3196.0	2.91
10	206.3	10.85	3507.1	3.17
20	219.2	10.90	3604.0	3.27
LSD	23.7	0.83	236.2	0.22
Variety				
TZMS	202.8	10.71	3637.1	3.30
TZIS	182.9	9.53	3235.0	2.93
LSD	18.91	0.67	192.9	0.18
Interactions				
S x M	NS	NS	NS	NS
S x V	NS	NS	NS	NS
M x V	NS	NS	NS	NS
S x M x V	NS	NS	NS	NS

NS = Not significant; LSD = Least significant difference of means at 5% level, TZMS = TZMSWEETCY, TZIS = TZISWEETCY, S x M: spacing x manure, S X V: spacing x variety, M x V: manure x variety, S x M x V: spacing x manure x variety

Table3: Days to 50% tasseling and silking, dry matter, cob yield ha^{-1}, and grain yield ha^{-1}of sweet corn as affected treatments

Treatments	50% Tasseling	50% Silking	Dry matter (g)	Cob yield (t ha^{-1})	Grain yield (t ha^{-1})
Spacing (cm)					
40 x 25	31.78	37.78	74.8	7.24	1.86
50 x 25	32.28	38.29	73.9	7.92	2.27
LSD	NS	NS	NS	NS	0.09
Manure t ha^{-1}					
0	30.32	36.33	61.7	6.01	2.02
10	32.92	38.83	69.7	7.57	2.06
20	32.83	38.92	91.7	9.15	2.10
LSD	NS	NS	18.12	2.17	NS
Variety					
TZMS	31.72	37.96	78.1	8.00	2.07
TZIS	32.33	38.34	70.6	7.16	2.06
LSD	NS	NS	NS	NS	NS
Interactions					
S x M	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS
M x V	NS	NS	NS	NS	NS
S x M x V	NS	NS	NS	NS	*

NS = Not significant; * significant means, LSD = Least significant difference of means at 5% level, TZMS = TZMSWEETCY, TZIS = TZISWEETCY, S x M: spacing x manure, S X V: spacing x variety, M x V: manure x variety, S x M x V: spacing x manure x variety

Table 4: Effects of spacing x poultry manure x variety interactions on the grain yield of sweet corn

		Poultry Manure (t ha^{-1})					
		0		10		20	
	Variety	TZMS	TZIS	TZMS	TZIS	TZMS	TZIS
Spacing (cm)							
40 x 25		1.81	1.74	1.84	2.00	1.84	1.91
50 x 25		2.16	2.19	2.22	2.36	2.35	2.32
LSD =	0.22						

TZMS = TZMSWEETCY, TZIS = TZISWEETCY,