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Comparative Evaluation of Animal Manures on Soil Properties, Growth and Yield of Sweet Maize (*Zea mays* L. saccharata Strut.)

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Abstract

Alternative sources of plant nutrients have now become imperative especially for vegetable crop production in Nigeria because of the escalating costs of inorganic fertilizers with the attendant environmental and health problems associated with excessive use of these inputs on continuously cropped fields. A two-year field experiment was conducted during the early planting seasons from March to June of 2011 and 2012 on the acidic coastal plain soils at Calabar, to evaluate the combined effects of four rates each (0, 5, 10 and 15 t/ha) of poultry manure (PM) and goat manure (GM) on soil chemical properties and agronomic performance of sweet maize (*Zea mays* L. saccharata Strut.). Factorial combinations of the treatments were fitted into a randomized complete block design with three replications. The application of the manures significantly ($P \leq 0.05$) raised the soil pH, organic matter content, total N, available P and exchangeable K, Ca and Mg status of the soil. Except for pH, total N, and available P contents, GM had superior responses for all other chemical properties than PM. The 15 t/ha rate of both manures maximized sweet maize growth attributes, total dry matter (TDM) and grain yields and also hastened days to 50% tasselling. On average, the application of 5, 10 and 15 t/ha PM rates, increased TDM by 8.5, 35.1 and 53.9%, whereas the corresponding values for GM were 15.6, 27.8 and 33.2% respectively compared with the unamended control plots. The grain yield increases at 15 t/ha PM and GM were 11.2, 59.8 and 126.9% ; and 4.2, 20.0 and 45.8% respectively, above the 10, 5 and 0 t/ha rates of both manures. The growth and yield attributes showed greater responses to PM than GM in terms of the values obtained. The co-application of PM at 15 t/ha and GM at 10 t/ha had the best effects on TDM and grain yield and is thus recommended for sweet maize production in this agro-ecology.

Keywords: Goat manure, poultry manure, soil properties, sweet maize, yield

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1.0 Introduction

Sweet maize (*Zea mays* L. saccharata Strut) also known as sweet corn, sugar corn or vegetable corn is one of the maize types popular for human consumption as contrasted with other types which are produced primarily for feeding livestock and industrial uses such as ethanol production, cooking oil production etc. It is a mutant of the dent and flint sub-species mostly grown in the United States, East Asia and some European counties and has now become popular among the elites in African countries (Badu-Apraku and Fokorede, 2006). Sweet maize is consumed at the soft dough stage (immature grain stage) containing 13-15% sugar with succulent grains as an alternative dish of urbanites, as a vegetable side dish or added as an ingredient to other dishes such as soups, stews and salads (Bhatt, 2012). Sweet maize can also be processed into syrup, sugars used as sweeteners in soft drinks, starch and cereals. In Nigeria, it is gradually becoming an important vegetable crop since it forms a useful ingredient in the preparation of salad, fried rice and other foods both at home and in restaurants.

Presently, production of sweet maize at commercial level is increasing in Nigeria due mainly to increasing demand and partly to augment the income of the small holder farmers dwelling in the out skirts of big cities and metropolis. The same however, cannot be said of farmers in south eastern Nigeria where sweet maize has just been newly introduced. So, the need to carry out trials on cultural practices such as nutrient requirements, adequate spacing, pests and diseases as well as weed management on the various varieties available becomes imperative. Soil fertility depletion in small holder farms is one of the major causes of declining crop yield in Nigeria (Brady and Weil, 2008) . 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 which lead to increased soil acidity have jointly reduced the productive capacity of arable land in Nigeria (Akinrinde and Obigbesan, 2000.).

Achieving food security for a rapidly expanding population in Nigeria would mean intensifying food production on the existing over-cropped fragile soils through enhanced nutrient input and recycling (Ogunbanjo *et al.,* 2007).

Since enhanced soil fertility and improved environmental quality are both important goals of todays' agriculture, deliberate efforts are required to promote the utilization of animal manures and organic residues for crop production.

Locally available organic materials and animal manures which though contain low amount of macro and micro nutrients could be used as low cost sources of nutrients for vegetable crops. 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 and moisture relations and increases mobility of P, K, and micro nutrients and stimulates microbial activities (Maerere *et al.,* 2001, Garg and Bahla, 2008).

Few farmers that apply animal manures, lack the scientific basis for appropriate rates, timing of application, method of application and storage techniques. Furthermore, there is also a need for comparing different types of animal manures under similar field conditions for vegetable crop production. Higher crop growth, yield, greater ability to tolerate stressful conditions and product quality in relation to application of organic manures have been widely reported (Khaliq *et al.,* 2004, Boateng *et al.,* 2006, Ano and Ubochi, 2007, Uwah *et al.,* 2011). Ojeniyi and Adegboyega (2003) reported that goat manure (GM) significantly increased growth and yield of okra, amaranthus, celosia and maize in south western Nigeria. Goat Manure was also found to be an efficient source of N, P, K, Ca, Mg and organic matter for pepper production (Awodun *et al.,* 2007). Application of GM to P-fixing soils in South Africa was reported to have reduced the sorption of added P and this effect was largely attributed to the liming potential of GM (Gichangi and Mnkeni, 2009).

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, and decreased exchangeable Al and Fe contents and soil bulk density. Poultry manure application increased soil N levels by 53% while exchangeable cation contents also increased appreciably (Boateng *et al.,* 2006). Soil N and P contents have been shown to increase with increasing rates of poultry, goat and dairy cow manures (Maerere *et al.,* 2001).

Comparing the effects of different manures on yield of *amaranthus*, Maerere *et al.,* (2001) indicated that PM application resulted in significantly higher yields relative to goat and dairy cow manures. The objective of this study was to comparatively evaluate the effects of PM and GM on selected soil chemical properties and the agronomic performance of sweet maize under a tropical rainforest zone.

2.0Materials and Methods

A field experiment was conducted in two consecutive early planting seasons from March to June (2011 and 2012) at the Department of Crop Science, University of Calabar Teaching and Research Farm. Calabar is located along the humid coastal region of south eastern Nigeria (4^{o} 57^{1}N, $8^{o}19^{1}$ E; 37m altitude). The region is characterized by a bimodal rainfall distribution ranging from 3000- 3500mm per annum with a long rainy season which starts in March while the short rainy season extends from September-November after a short dry spell of one to two weeks in August. The dry season is usually from December to February. The mean annual temperature ranges from 27 to 35^{o}C (Iloeje, 2001). The soil is an *ultisol,* characterized by low pH, organic matter and nutrient status, and usually deficient in multiple nutrients (Brady and Weil, 2008). The experiment evaluated the combined effects of four rates of poultry manure (PM) (0, 5, 10 and 15 t/ha) in factorial combinations with four rates of goat manure (GM) (0, 5, 10 and 15 t/ha) on soil chemical properties and the performance of sweet maize (*Zea mays* L. saccharata Strut) variety TZ developed by the International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria.

The treatments were fitted into a randomized complete block design with three replications. Poultry manure was obtained from broiler pens of the Teaching and Research Farm of the University of Calabar with the birds fed with finisher diet. The bedding materials consisted mainly of wood shaving and sawdust. The goat manure was sourced from the goat sheds of the Teaching and Research Farm, University of Calabar, composted and allowed to stabilize for 90 days before use. Composite samples of the manures 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 applications, were analyzed for physico-chemical properties to determine the baseline fertility status of the sites (IITA, 1982).

Another set of soil samples was 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 manures are summarized in Table 1. A new site was used each year for the trial. The sites were manually cleared of vegetation, ploughed to a depth of 20cm and marked out into three blocks of 16 plots each. Each gross plot size was 2.0m x 3.6m (7.2m^2), and the net plot size from which growth and yield attributes were measured was 1.0 x 2.4m (2.4m^2). Plots were separated by paths of 1m, while blocks were kept 1.5m apart. Sowing was done on tilled flat beds on 15th March each season at three seeds per hole spaced 60cm x 25cm. Thinning of seedlings to one per stand was carried out two weeks after sowing to give 48 plants per plot and 66,666 plants per hectare. The manures were incorporated into the soil of the replicated plots in a single dose as 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.

Table 1: Physico-chemical Properties of the Soil (0-30cm Depth) of the Experimental Sites and Chemical Properties of Poultry and Goat Manures used in 2011 and 2012 Growing Seasons in Calabar

Composition	Soil			Poultry manure		Goat manure	
Physical composition (g	2011	2012	Chemical compo	2011	2012	2011	2012
Sand	858.0	762.0	pH in (H_20)(1:2.5)	7.6	8.0	8.7	8.6
Silt	52.0	86.0	Org. carbon (g/kg	284.4	468.1	316.0	280.0
Clay	90.0	152.0	Total N (g/kg)	17.5	22.1	10.5	19.8
Textural class	Sandy lo	Sandy lo	Av. P (mg/kg)	1520.0	2433.1	1600.0	2001.1
			C/N	16.30	21.18	30.1	17.51
Chemical characteristic			Ca (mg/kg)	3100.0	2011.0	3300.0	3956.0
pH (H_2O) (1:2.5)	5.8	5.9	Mg((mg /kg)	784.8	770.0	667.2	360.2
Organic Carbon(g/kg)	24.7	29.6	Na ((mg /kg)	583.0	340.0	520.0	841.0
Available P (mg/kg)	33.2	41.5	K ((mg /kg)	3993.0	5021.1	4210.0	6175.0
Total N (g/kg)	1.0	1.2	Cu (mg/kg)	62.8	30.5	45.2	33.0
			Zn (mg/kg)	83.6	36.6	88.4	69.0
			Mn (mg/kg)	95.4	76.2	93.3	76.0
Exchangeable bases (cr			Fe (mg/kg)	442.5	257.1	508.1	150.6
Ca	3.3	4.0					
Mg	1.5	2.2					
K	0.2	0.3					
Na	0.1	0.1					
EA	2.4	1.7					
ECEC	7.2	9.0					
BS (g/kg)	708.3	733.3					

EA = Exchangeable acidity

Harvesting was done in two stages – soft dough stage (green stage) and fully mature stage. Green harvesting was done 74 days after sowing from 8 randomly selected plants in the net plot area as indicated by the drying and browning of the silks, fullness of the tip kernels and firmness of the unhusked ears. The fully mature ears were harvested 90 days after sowing from the remaining 8 plants in the net plot area and sun-dried to 14% moisture content determined with Offering Ohaus moisture analyzer model MB45. From these 16 plants, the following parameters were determined: plant height, number of leaves/plant, leaf area, number of days to 50% tasselling, total dry matter/plant, weights of unhusked green and dehusked green ears, number of grains/ear, weight of grains/ear, ear yield/ha and total grain yield/ha. The data for each year were treated separately and are presented as mean values of three replicates. GENSTAT Release 7.22DE Statistical software (Lawes Agricultural Trust, 2008) was used to evaluate the effects of manure source, rates and their interactions on soil properties, growth and yield parameters 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 Manure Analyses/Meteorological Observations

Table 1 shows the initial physico-chemical properties of the experimental soils and the chemical compositions of the PM and GM used in the study. The soils were sandy loam, slightly acidic, low in total N, moderately high in exchangeable K, adequate in available P, Ca and Mg, but high in organic carbon (Akinrinde and Obigbesan, 2000). On average over the two cropping seasons, the poultry manure contained higher organic carbon, N, P, Mg, Fe and Cu than the goat manure which however, had a higher pH, K, Ca, Zn with a much higher C:N ratio than the PM. The chemical compositions of these manures were highly related to the feeds fed to the animals. The birds were fed with highly nutritious concentrates, while the goats were fed with relatively less nutritious browse materials. The application of the manures was therefore expected to be beneficial to the crop and soil which was acidic in nature and had a low N content. The meteorological data during the two years of trial are presented in Table 2.

The total amount of rainfall, average monthly temperature, relative humidity and sunshine hours during the 1st season cropping were slightly higher than those of the 2nd season, indicating that variations in seasons may not have appreciable influence on the performance of the crop.

3.2 Effects of PM and GM on soil Chemical Properties

Tables 3 and 4 show the influence of PM and GM on soil chemical properties after crop harvest. The application of PM and GM significantly ($P \leq 0.05$) increased soil pH, organic matter (OM) content, total N, available P and exchangeable cations (K, Ca and Mg). Soil organic matter increased significantly with each incremental rate of PM and GM up to the highest rates. Averaged over the two years, increasing the PM rates from 0 to 5,10 and 15 t/ha, resulted in corresponding increases in soil organic matter content by 5.1, 22.7 and 30.9%; whereas the increases resulting from amending the plots with corresponding GM rates were 18.3, 30.5 and 46.1% relative to the control plots. The

Table 2: Meteorological Data at the Trial Sites During the 2011 and 2012 Growing Seasons at Calabar

Year / Month	Rainfall (mm)		Temperature (ºC) (Max)		Relative humidity (%)		Sunshine hour (Hrs)	
	2011	2012	2011	2012	2011	2012	2011	2012
January	0.0	34.8	27.0	25.4	85.0	83.1	5.4	4.8
February	113.3	402.3	27.9	27.5	80.0	79.9	6.0	4.6
March	36.7	24.5	27.6	26.4	86.0	82.1	5.8	6.4
April	152.1	85.7	28.1	25.4	83.0	75.7	3.7	5.8
May	295.1	424.7	27.1	24.9	82.0	76.8	5.6	4.2
June	421.2	344.2	25.9	24.0	86.9	77.1	3.7	5.2
July	501.8	444.6	24.5	24.4	91.0	73.0	6.2	3.8
August	505.8	363.7	24.1	23.5	76.2	69.7	6.2	5.3
September	291.9	405.8	24.4	23.8	77.2	77.1	6.8	4.8
October	373.8	312.8	24.9	25.8	82.0	79.8	3.9	4.3
November	274.8	79.4	25.6	24.6	82.4	75.6	6.5	6.2
December	3.3	3.7	26.0	25.8	81.6	82.5	5.8	6.0
Total	2,969.8	2926.2	313.1	301.5	993.3	932.4	65.6	61.4
Mean	247.5	243.85	26.1	25.1	82.8	77.7	5.5	5.1

Source: Meteorological Unit, Department of Geography and Environmental Science, University of Calabar, Nigeria.

Table 3: Effect of Poultry and Goat Manures on Soil Chemical Properties in 2011 and 2012 Growing Seasons at Calabar

Treatment	pH (H_20)		Organic matter (g		Total N (g/kg)		Av. P (mg/kg)	
	2011	2012	2011	2012	2011	2012	2011	2012
PM(t/ha)								
0	5.5	5.2	39.1	39.3	0.5	0.7	30.5	31.1
5	5.5	5.9	42.2	40.1	2.1	2.5	41.2	43.6
10	5.8	6.0	47.5	48.7	2.2	2.7	43.8	44.9
15	5.9	6.2	49.6	52.9	2.7	2.9	44.8	45.7
LSD (0.05)	0.06	0.09	0.92	0.13	0.09	0.09	2.85	0.72
GM (t/ha)								
0	5.6	5.4	41.0	40.4	0.6	0.8	30.9	36.9
5	5.7	5.6	47.5	48.8	2.0	2.2	40.0	44.1
10	5.8	5.8	56.9	49.3	2.1	2.4	43.0	44.6
15	6.0	5.9	64.2	54.7	2.2	2.6	43.6	44.7
LSD (0.05)	0.06	0.09	0.92	0.13	0.09	0.09	2.85	0.72

Table 4: Effect of Poultry and Goat Manures on Soil Chemical Properties (Exchangeable Bases) in 2011 and 2012 Growing Seasons at Calabar

Treatment	K (cmol/kg)		Ca(cmol/kg)		Mg (cmol/kg)	
	2011	2012	2011	2012	2011	2012
PM(t/ha)						
0	0.19	0.19	3.16	3.60	1.42	1.75
5	0.22	0.26	3.71	4.60	1.99	1.88
10	0.22	0.30	4.13	4.75	2.08	1.97
15	0.21	0.32	4.26	5.00	2.59	2.08
LSD (0.05)	0.009	0.010	0.02	0.130	0.011	0.087
GM (t/ha)						
0	0.18	0.25	3.22	3.60	1.40	1.64
5	0.20	0.30	3.82	4.40	2.44	1.68
10	0.24	0.32	3.93	5.35	2.62	2.08
15	0.26	0.32	4.19	5.70	2.82	2.28
LSD (0.05)	0.009	0.010	0.018	0.130	0.011	0.087

application of GM therefore, had a greater effect on soil OM at all the applied rates compared to PM. Nitrogen levels increased from 1.1 g/kg (average initial N status in soil) to 2.8 g/kg in PM amended plots at 15 t/ha and 2.4 g/kg in GM amended plots. Poultry manure amended soil had higher residual total N content than goat manure and the value at 15 t/ha PM rate was more than 2½ times the initial soil N status.

Soil available P increased with each increment in PM and GM rates up to the highest rates with PM again having slightly higher values than GM.

On average over the two seasons, the 5, 10 and 15 t/ha PM rates increased the residual soil available P by 33.3, 39.3 and 42.3%, while the corresponding values for 5, 10 and 15 t/ha GM rates were 24.0, 29.2 and 30.2%, respectively, over the unamended plots. This trend was expected, given the initial differences in total N, available P and organic carbon contents of the manures (Table 1). On average, the application of PM and GM at 5, 10 and 15 t/ha rates, increased residual soil K status by 26.3, 36.8 and 39.5 %; and 16.3, 30.2 and 34.9 % respectively, over the control plots. Calcium and magnesium levels increased significantly ($P \leq 0.05$) with incremental rates of both manures with the control plots recording the least values. The increase in residual soil Mg content was more pronounced in GM amended soil than PM. Averaged over the two seasons, PM and GM at 5, 10 and 15 t/ha rates produced corresponding increases in soil Mg status of 20.0, 27.7 and 47.2 %; and 35.5, 54.6 and 67.8% respectively,

3.3 Effects of PM and GM on Sweet Maize Performance

Tables 5-7 present the influence of PM and GM on vegetative and reproductive attributes of sweet maize. For the two seasons, the highest rates of both manures produced the tallest plants with the highest number of leaves and largest leaf area. Earliness to tasselling was also enhanced significantly ($P \leq 0.05$) by the highest rates of PM and GM (Table 5).

Table 5: Effect of Poultry and Goat Manures on Plant Height (cm), Number of Leaves/Plant, Leaf Area (m^2) and Number of Days to 50% Tasselling of Sweet Maize in 2011 and 2012 Growing Seasons at Calabar

	Plant height (cm)		No. of leaves/plan		Leaf area (m^2)		No. of days to 50%	
Treatment	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
PM(t/ha)								
0	127.4	171.7	8.82	9.90	1.50	1.69	52.58	52.08
5	137.9	178.1	9.20	10.33	1.72	1.91	52.42	51.42
10	141.0	195.8	9.45	10.83	1.98	2.30	52.92	51.50
15	152.8	227.3	9.94	11.79	2.40	2.81	51.08	50.83
LSD (0.05)	7.07	13.63	0.39	0.41	0.06	0.13	1.05	0.82
GM(t/ha)								
0	129.9	166.8	8.28	9.79	1.52	1.69	53.92	53.00
5	142.5	187.6	9.03	10.45	1.78	1.98	52.67	51.83
10	146.4	200.1	9.96	11.04	2.04	2.33	51.50	50.92
15	150.2	218.4	10.13	11.57	2.26	2.71	50.92	50.08
LSD (0.05)	7.07	13.63	0.39	0.41	0.06	0.13	1.05	0.82

The control plots in both seasons had least values for all the above mentioned attributes. Total dry matter (TDM) yield, number of grains/ear, weight of grains/ear and ear yield were all significantly influenced by PM and GM treatments (Table 6). The TDM production increased with increasing rates of PM and GM in both seasons with PM having superior response at higher rates of 10 and 15 t/ha than GM. On average, the application of 5, 10 and 15 t/ha PM rates, increased TDM by 8.5, 35.1, and 53.9%; whereas corresponding GM rates gave increases in TDM of 15.6, 27.8 and 33.2% respectively, above those of the control plots. The number of grains/ear produced at 10 and 15 t/ha PM rates were statistically similar, but higher than the lower rates in 2012 season, while the effect of PM on this attribute was not significant in 2011. The same trend occurred with GM in 2011 season in which the 10 and 15 t/ha rates produced statistically similar number of grains/ear, while in 2012; each increase in rate significantly increased the number of grains/ear (Table 6). Weight of grains/ear

Table 6: Effect of Poultry and Goat Manures on Total Dry Matter (g/plant), Number of Grains/Ear, Weight of Grains/Ear (g) and Ear Yield (t/ha) of Sweet Maize in 2011 and 2012 Growing Seasons at Calabar

	Total dry matter		No. of grains/ear		Weight of grains/e		Ear yield (t/ha)	
Treatment	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
PM(t/ha)								
0	141.7	155.5	260.5	270.3	25.63	35.22	2.67	2.88
5	149.0	173.3	285.9	322.4	33.42	39.13	2.98	3.20
10	197.7	203.9	298.2	339.0	35.68	43.72	4.40	4.80
15	214.9	242.6	313.2	359.3	39.01	48.92	4.70	5.15
LSD (0.05)	8.06	9.48	NS	31.64	3.77	NS	0.36	0.11
GM (t/ha)								
0	144.8	165.5	233.4	249.2	25.83	27.5	2.90	3.24
5	172.3	186.3	269.1	298.2	32.23	34.8	3.53	3.71
10	192.8	203.7	318.9	345.3	36.78	59.8	4.16	4.48
15	193.3	219.9	336.5	398.4	38.89	44.8	4.22	4.60
LSD (0.05)	8.06	9.48	35.20	31.64	3.77	NS	0.36	0.11
Interaction								
PM x GM	*	*	NS	NS	NS	NS	*	*

* = Significant at 5% probability level
NS = not significant

Table 7: Effect of Poultry and Goat Manures on Weights of Unhusked Green Ear (kg), Dehusked Green Ears (kg) and Total Grain Yield (t/ha) of Sweet Maize in 2011 and 2012 Growing Seasons in Calabar

Treatment	Unhusked green ear (kg		Dehusked green ears (kg)		Total grain yield (t/ha)	
	2011	2012	2011	2012	2011	2012
PM(t/ha)						
0	0.17	0.27	0.14	0.19	1.45	1.67
5	0.18	0.29	0.16	0.21	2.08	2.35
10	0.22	0.32	0.20	0.26	3.00	3.37
15	0.23	0.36	0.20	0.29	3.31	3.77
LSD (0.05)	0.007	0.011	0.00	0.012	0.124	0.115
GM (t/ha)						
0	0.17	0.26	0.15	0.19	1.93	2.20
5	0.20	0.30	0.17	0.23	2.38	2.64
10	0.21	0.34	0.18	0.25	2.69	3.08
15	0.22	0.37	0.19	0.27	2.85	3.17
LSD (0.05)	0.007	0.011	0.00	0.012	0.124	0.115
Interaction						
PM x GM	*	*	NS	NS	*	*

* = Significant at 5% probability level
NS = not significant

produced at 10 and 15 t/ha rates of both manures were statistically at par but heavier than other rates in 2011, while their effects were not significant in the 2012 cropping season. Averaged over the two years trial, PM out-performed GM in sweet maize ear yield. Poultry manure and GM at 15 t/ha rate maximized ear yield by as much as 77.3 and 43.7% respectively, above those at the control plots.

In both seasons, each incremental rate of the manures resulted in significant ($P \leq 0.05$) increases in unhusked and dehusked ear weights and total grain yield (Table 7). Averaged over the two seasons, each application rate of PM and GM produced unhusked green ear weight of 6.8, 22.7 and 34.1%; and 16.3, 27.9 and 37.2% respectively, compared with the control plots. The 15 t/ha PM rate gave grain yield increases of 11.2, 59.8 and 126.9%; whereas the 15t/ha GM rate gave a corresponding grain yield increases of 7.1, 22.7 and 49.2% respectively, above the 10, 5 and 0 t/ha PM and GM rates. On average, the grain yield increased in the order: 15 > 10 > 5 > 0 t/ha PM and GM rates.

3.4 Interactions

The interaction effects of PM and GM on soil properties were not significant while those on total dry matter, ear yield, unhusked green ear weight and total grain yield of sweet maize were all significant (Tables 6 and 7). Averaged over the two cropping seasons, the co-application of 15 t/ha PM with 10 t/ha GM maximized TDM production (Table 8). This combination produced 15.9 and 33.8% more TDM yield than was obtained when 15 t/ha PM and 10 t/ha GM rates were applied alone and out yielded the control plots by 90.1 percent. In the 1st season cropping, the highest ear yield and unhusked green ear weight were produced with the combination of 10t/ha of each manure, while the 15 t/ha of both manures combined to maximize these yield attributes in the 2nd season cropping. Total grain yield peaked with the co-application of 15 t/ha PM and 10t/ha GM in the two cropping seasons. On average over the two seasons, the combination gave 11.0 and 36.2% more grain yield than was obtained with either 15 t/ha PM or 10 t/ha GM when applied alone and more than 2½ times the grain yield from unamended control plots.

4.0 Discussion

The organic manures used, were alkaline in reaction and generally high in macro and micro nutrients (Table 1). During microbial decomposition of the incorporated manures, organic acids may have been released, which neutralized the alkalinity of the manures, thereby lowering the pH of the soil below their initial values especially for GM amended plots at the 5 and 10 t/ha rates (Table 3). Adenawoola and Adejoro (2005) observed a similar trend in their work on organic amendments of

Table 8: Interactions Between Poultry and Goat Manures for Total Dry Matter (g/plant), Ear Yield (t/ha), Unhusked Green Ear Weight (kg) and Total Grain Yield (t/ha) of Sweet Maize During 2011 and 2012 Growing Seasons at Calabar

Treatment	Goat manure (t/ha) 2011				Goat manure (t/ha) 2012			
	0	5	10	15	0	5	10	15
PM(t/ha)	**Total dry matter (g/plant)**				**Total dry matter (g/plant)**			
0	134.5	143.2	143.7	145.3	144.5	152.8	156.2	168.5
5	142.1	150.1	151.1	152.6	155.3	168.2	175.2	194.4
10	144.7	179.6	227.3	239.1	175.6	184.9	202.0	253.2
15	158.1	216.3	249.0	236.3	186.6	239.2	281.4	263.4
LSD (0.05)	16.12				18.96			
PM (t/ha)	**Ear yield (t/ha)**				**Ear yield (t/ha)**			
0	2.61	2.72	2.69	2.67	2.83	2.87	2.88	2.92
5	2.69	2.71	3.06	3.47	2.89	2.98	3.33	3.60
10	2.85	3.94	5.45	5.37	3.43	4.06	5.82	5.88
15	3.44	4.76	5.44	5.53	3.80	4.92	5.90	5.98
LSD (0.05)	0.72				0.22			
PM(t/ha)	**Unhusked green ear weight (k**				**Unhusked green ear weight (kg)**			
0	0.15	0.16	0.17	0.18	0.22	0.26	0.29	0.32
5	0.17	0.17	0.18	0.19	0.23	0.27	0.31	0.36
10	0.18	0.21	0.25	0.25	0.27	0.30	0.35	0.38
15	0.20	0.23	0.24	0.25	0.30	0.35	0.39	0.41
LSD (0.05)	0.013				0.022			
PM (t/ha)	**Total grain yield (t/ha)**				**Total grain yield (t/ha)**			
0	1.28	1.41	1.48	1.63	1.45	1.61	1.74	1.89
5	1.38	1.89	2.30	2.75	1.66	2.05	2.60	3.08
10	2.25	2.90	3. 38	3.48	2.56	3.24	3.71	3.7
15	2.82	3.30	3.58	3.53	3.14	3.65	4.28	4.01
LSD (0.05)	0.247				0.229			

soils. Studies by Mbah and Mbagwu, (2006) and Akanni and Ojeniyi, (2008) have shown that PM and GM increased soil OM, pH, N, P and CEC and this was attributed to the availability and adequate supply of organic matter. Boateng *et al.*, (2006) however, observed a decrease in soil OM upon amendment with PM and attributed this to the removal of vegetative cover. Poultry manure had higher values for total N, available P and narrower C:N ratio compared to goat manure. The higher N content of the PM relative to GM might be due to the high protein concentrate feeds fed to the birds.

The increase in soil available levels of N and P with increasing application rates of the manures 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. Similar results were reported by Maerere *et al*., (2001), Ogunbanjo *et al*., (2007) and Akanni and Ojeniyi (2008) who observed that PM had highest effect on soil available levels of N and P compared to other animal manures.

The low values of the increase in residual soil K status above 10 t/ha rate of both manures could probably be attributed to immobilization of soil nutrients which occurs when soils are over loaded with materials of high lignin contents resulting from the feed and litter material used for the animals (Togun et al., 2004). Onunka (2010) also observed lower soil exchangeable K in an experiment involving the use of organic manure in south eastern Nigeria. It has been suggested that the C:N ratio of organic materials, and their state of decomposition at the time of application are some of the factors affecting plant uptake of nutrients from them and their soil residual properties (Obatolu, 1995). The higher Ca status of PM and GM amended plots might partially be due to the Ca supplied to the soil from the decomposition of these organic amendments. Equally, the higher pH levels of PM and GM amended plots compared to unamended plots might be a consequence of the Ca supplied to the soil by these organic manures (Adenawoola and Adejoro, 2005). Changes in soil contents of K, Ca and Mg upon application of animal manures have been documented by several workers (Adenawoola and Adejoro, 2005; Boateng et al., 2006; Ano and Ubochi, 2007; Adeleye et al., 2010; Uwah et al., 2012).

Superior growth attributes obtained with high rates of PM and GM in this study have been reported by other workers (Awodun *et al., 2007;* Ogunbanjo *et al., 2007;* Akanni and Ojeniyi, 2008; Ayoola and Makinde, 2009).

Taller plants with larger leaf area on PM amended plots relative to GM, could be attributed to the easily and faster decomposition rate and subsequent release of nutrients by the PM into the soil and the fact that 40 - 60% of the organic N in PM are normally mineralized within 90 days (Ogunbanjo *et al., 2007*). The earliness to tasselling following PM and GM applications could be traced to the relatively high inherent nutrients in the manures which promoted vigorous foliage growth, heightened meristematic and physiological activities that favoured the synthesis of more photo-assimilates and early tasselling.

These results are consistent with those of Ayoola and Makinde, (2009) and Uwah *et al.,* (2011*)* who observed reduction in number of days to 50% tasselling in maize with increases in rates of fertilizers used.

Zhao *et al*., (2003) observed that deficiency of nutrients especially N, decrease maize leaf expansion and subsequent leaf area index resulting in short plants and lower TDM accumulation as was observed in this study. Poultry manure produced greater grain yield at higher rates (10 and 15 t/ha) than the corresponding GM rates. This could be attributed to immobilization of soil nutrients as a result of high lignin contents in the GM (Togun *et al.,* 2004). It might also be due to higher mineralization potential of PM enabling it to actively and quickly release its nutrients for plant uptake and use (Ogunbanjo *et al*., 2007). Comparison of the two manure types indicated that for all the growth and yield attributes, PM gave higher response relative to goat manure. Maerere *et al*., (2001) asserted that PM application resulted in significantly higher residual N and P in soils compared to other manures and ascribed this to higher levels of N and P in the PM which might also be the case in the present study. Also, PM contains easily decomposable materials, most of which are in the form of urea and uric acid (Maerere *et al*., 2001). Our findings are also supported by the reports of Awodun *et al.,* (2007), Akanni and Ojeniyi, (2008) and Adeleye *et al*., (2010). The increase in yield characters under combined PM + GM were mainly due to availability of more nutrients from the two manures for plant development up to ear formation. Earlier studies by Akinola and Ojeniyi, (2000) and Adeleye *et al.,* (2010) showed that PM and GM improved N, P, K, Ca Mg and organic matter status of soil, while Gichangi and Mnkeni, (2009) indicated that organic manures are known to improve soil physical, biological and chemical properties, increase soil pH by their liming potential and provide trace elements which are usually deficient in continuously cropped soils. This may be responsible for the superior performance of crops treated with the combination of PM and GM than from sole applications.

5.0 Conclusion

The findings of this study showed that both PM and GM improved the chemical properties of the soil and enhanced the agronomic performance of sweet maize. The results also revealed variations among the two manures and the trend was: PM > GM for most of the soil and crop attributes observed. The co-application of PM + GM had synergistic effects on sweet maize growth and yield.

The best synergistic benefit on grain yield was realized with the co-application of 15t/ha PM + 10 t/ha GM and is thus recommended for sweet maize production in this agro-ecology.

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