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Influence of Local Lime Materials and Organomineral Fertilizer on Fluted Pumpkin (Telfairia Occidentalis) Performance in an Ultisol of Southeastern Nigeria

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Abstract: A field experiment was conducted in 2013 and 2014 cropping seasons at the University of Calabar Teaching and Research Farms in Cross River State, Nigeria to evaluate the influence of locally sourced liming materials and organomineral fertilizer on the performance of fluted pumpkin (*Telfairia occidentalis*). Eight treatments used were: control (no amendment), sole application of wood ash (WA), cocoa pod ash (CPA), periwinkle shells ash (PSA), organomineral fertilizer (OMF) each applied at 8 t/ha and the combinations of each of the lime materials with OMF. The experiment was laid out in a Randomized Complete Block Design with three replications. Chemical composition of the amendments used showed that the pH values of the materials varied in the order CPA > WA > OMF > PSA. Calcium (Ca) and potassium (K) contents were highest in CPA (44.80 cmol/kg, 0.17 cmol/kg) while magnesium (Mg) was highest in WA (20.40 cmol/kg). Results showed that lime and OMF applied separately or in combination increased soil pH values significantly ($P < 0.05$) relative to the control with the highest value of 5.87 obtained from plots treated with OMF +WA. There were also significant increases in soil available phosphorus (P), basic nutrients (Ca, Mg, K) and base saturation. Significant ($P<0.05$) increases in growth parameters (vine length, number of leaves) and yield of fluted pumpkin were observed. The highest yield (596.82 kg/ha) obtained at 10 WAP from OMF + CPA treated plot was not significantly higher than the yields of 586.67 and 577.67 kg/ha obtained from OMF + PSA and OMF + WA treated plots, respectively. Therefore, for improved soil nutrients, sustainable and better performance of fluted pumpkin in an acid Ultisol of South Eastern Nigeria, the combination of any of the lime materials with OMF is recommended.

Keywords: Lime materials, organomineral fertilizer, soil properties, coastal plain sand soil, fluted pumpkin

Introduction

All creatures depend directly or indirectly on the soil for their sustenance. The soil provides a medium for plant growth, provides nutrients which encourages their sustainability and productivity. Thus, for crops to be productive, the soil must be able to provide a conducive physical, chemical and biological environment. Over the years, southern Cross River State soils that are developed on sand stones or coastal plain sand parent materials are strongly weathered, leached and highly acidic in nature. This is due to the predisposition of the soil to leaching and soil erosion resulting in high preponderance of hydrogen ions [H^+], aluminum ions [Al^{3+}] and sulphur in the soil thus causing acidity and loss of soil nutrients such as nitrogen in large proportions (Njoku *et al.*, 1987). One of the major causes of soil acidity in the humid tropics is the excessive losses of the basic cations by high and intensive rainfall. Besides, soil acidity can develop from continuous use of acid forming fertilizer without adequate liming programme and through heavy industrialization that lead to acid rains (Oguntoyinbo, 1990).

Soils with high acidity have the tendency of aluminum, hydrogen and manganese toxicity as well as nutrient deficiencies of calcium and magnesium. Aluminum toxicity is the most widespread problem

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as it is present in all soils and dissolved Al^{3+} is toxic to plants. Aluminum enters plant roots passively by osmosis and inhibits the growth of roots; root tips are thickened and lack fine branching. Liming acid soils provides a more favourable environment for plant growth by reducing toxic concentrations of available aluminum and manganese (Mn) and increasing the microbial activity and availability of major plant nutrients. Liming is a soil amendment management strategy of applying substances to manage or raise the pH of the soil to a favorable level. It is the most widely used method to neutralize acidity and improve crop performance in acid soils.

Organomineral fertilizers are made up of natural components enriched and complemented with chemical elements for fast action. The organic substances act as added enrichment for the humus content of the soil.

Fluted pumpkin is often sensitive to high soil acidity in the tropics and responds well to soil amendments (Iren *et al*., 2013; Iren *et al*., 2014; Iren *et al*., 2015) hence is used as a test crop in this study. Fluted pumpkin is a tropical vine grown in West Africa as a leaf vegetable and for its edible seeds. It is a member of the Curcurbitaceae family and is indigenous to southern Nigeria. Although the fruit is inedible, the seeds produced by the gourds are high in protein and fats and can therefore contribute to a balanced diet.

Since the majority of farmers active in the food crop sector of southeastern Nigeria are poor and the cost of purchasing commercial lime materials is beyond their reach, there is, therefore the need to introduce agricultural practices which are cheaper and more readily available to them. The aim of the study was to determine how soil acidity could be reduced and soil nutrients improved through sole and combined use of locally sourced lime materials and organomineral fertilizer in acid Ultisol soil grown to fluted pumpkin.

Materials And Methods

Experimental Site

The research was conducted at the University of Calabar Teaching and Research Farm, Calabar (latitude 5º 32' and 4º 27' N and longitude 7º 15' and 9º 28' E) with annual rainfall of 2000 to 3000 mm in two peaks giving a double maxima of rainfall with characteristic dry spell in August (Bulktrade and Investment Company Limited, 1989). The study area is characteristically under continual cultivation by researchers and students of the Faculty of Agriculture of the University and thus is low in pH, exchangeable bases, organic carbon and total nitrogen (Iren *et al.*, 2015).

Experimental Design and Treatments

The experimental site was manually cleared, tilled and flat beds measuring 3 m x 1.5 m made. An alley of 1.2 m was left between blocks and 0.6 m between plots. The experiment was laid out in a randomized complete block design with three replications. The experiment comprised of eight treatments; control (no amendment), sole application of wood ash (WA), cocoa pod ash (CPA), periwinkle shells ash (PSA), organomineral fertilizer (OMF) each applied at 8 t/ha and the combinations of each of the lime materials with OMF. The combined treatments were made up of half of each liming materials (4 t/ha) with half of organomineral fertilizer (4 t/ha). Treatments were evenly spread on each plot surface and lightly tilled to mix evenly with the surface soil using a hand trowel. Lime treatments were applied two weeks before planting (Njoku *et al.*, 1987), while OMF treatments were applied three days to planting.

Planting and Field Maintenance

Fluted pumpkin seeds were separated from the pulp and dried before planting. Two seeds of the fluted pumpkin were placed flat in the soil per hole at a planting distance of 50 cm x 50 cm. It was later thinned down to one plant per stand few days after emergence giving a plant population of 40,000 plants/ha. The experimental plots were kept weed free throughout the period of the experiment.

Soil sampling and processing

Soil samples were taken from the experimental site before and after experiment using soil auger at a depth of 0-15 cm. About 8-10 auger points were taken from each block, mixed thoroughly to make a composite sample before commencement of experiment, while one composite soil sample was taken per plot after the experiment for laboratory analysis. The soil samples were air-dried, ground and sieved with 2 mm sieve to remove materials greater than 2 mm in diameter before analysis.

Field studies

Five plants were randomly selected, tagged and used for growth measurements. Growth parameters measured include vine length and number of leaves per plant. These parameters were assessed at 4 weeks of planting (WAP) and continued at 2 weeks interval till the end of the experiment. Vine length was determined by measuring the distance from the base of the plant to the tip of the most vigorous branch on each plant with the use of a measuring tape. The number of leaves was determined by the counting of all the fully opened leaves. Weight of freshly harvested vine was taken at 4 WAP, 7 WAP and 10 WAP.

Laboratory studies

The soil samples, lime materials and the organomineral fertilizer were subjected to chemical analysis using standard procedures as described by

Udo *et al.* (2009). Particle size distribution was determined by the Bouyoucous hydrometer method, using sodium hexametaphosphate as a dispersant. Soil pH was determined in 1:2.5 soil: water ratio with a pH meter. Organic carbon was determined by Walkley Black Dichromate Oxidation Method. Total nitrogen (N) was determined by the micro-kjeldahl method. Available phosphorus (P) was extracted by the Bray 1 extraction method, and the content of P was determined colorimetrically using a Technico AAII auto analyser (Technico, Oakland, Calif). Exchangeable bases (K, Na, Ca, Mg) were extracted with 0.1N ammonium acetate, K and Na were read with a flame photometer while Ca and Mg were determined through the EDTA titration method. Exchangeable acidity was determined by leaching the soils with 1N KCl and titrating aliquots with 0.01 NaOH. Effective cation exchange capacity (ECEC) was calculated as the sum of Ca, Mg, K and Na and exchangeable acidity. Base saturation was calculated by dividing the sum of exchangeable bases by ECEC and multiplying by 100.

Data collected were analyzed according to the procedures outlined by Gomez and Gomez (1984) for randomized complete block design using Genstat package and significant means were compared using Fisher's least significant difference (FLSD) at 5 % level of probability.

Results and Discussion

Properties of the soil and materials used for the experiment

Table 1 presents data on properties of the soil before experiment. The soil used was extremely acid with pH in water as low as 4.0 and loamy sand in texture. The soil was generally low in organic carbon (11.8 g/kg), total nitrogen (1.0 g/kg), exchangeable bases, ECEC (9.84 cmol/kg) and base saturation (26.02%) but moderate in available phosphorus (15.13 mg/kg), when compared to the critical minimum for Nigerian soils (Aduayi *et al.*, 2002). The low organic carbon and total nitrogen contents could be attributed to continuous cropping of the soil without adequate fallow period or additional nutrient supply. The low levels of nutrients obtained in the experimental soils indicate low fertility status which necessitates the need for additional nutrient supply.

From the result of the nutrient composition of the liming materials and organomineral fertilizer (Table 2), all the materials indicated alkaline reaction when tested in water slurry. Cocoa pod ash (CPA) had the highest pH value of 12.60, followed by organomineral (OM) (10.90), while organomineral fertilizer had the highest total P value of 117 mg/kg. The ash materials had lower total N content than the unburnt materials indicating volatilization of N during the burning process.

Effects of lime and organomineral fertilizer on soil properties

The effects of sole and combined applications of liming materials and organomineral fertilizer are shown in Table 3. Application of organomineral fertilizer and lime materials either singly or in combination significantly ($P < 0.05$) increased soil pH from the initial pH value of 4.0 (before experiment) and from 4.07 obtained in control plot to values ranging from 4.67 to 5.87 with the highest value obtained from the combination of organomineral fertilizer with wood ash (OMF + WA). This is in line with the findings of Nwachukwu *et al*. (2012) who reported highest increase in soil pH in plots treated with combined application of manure and ash than their sole application in an Ultisol of South Eastern Nigeria. Increases in pH values in Ultisol of South Eastern Nigeria soil using agricultural lime had also been reported by many researchers (Onyegbule *et al*., 2012; Bello and Udofia, 2013). Akinmutimi and Osodeke (2013) also reported increases in soil pH in an Ultisol of South Eastern Nigeria using ashes of varied origin.

Soil organic carbon contents were significantly ($P < 0.05$) affected by all the treatments compared with control and significant differences existed amongst all the treatments with the highest value of 19.6 g/kg obtained from OMF + WA treated plot. There was also a significant increase ($P < 0.05$) in available P relative to control, with the application of cocoa pod ash (CPA) alone recording the highest value of 41.88 mg/kg although not significantly higher than the other treatments. There were significant ($P < 0.05$) increases in the exchangeable calcium (Ca), magnesium (Mg) and potassium (K) contents with the combined application of organomineral and wood ash (OMF + WA) giving the highest values of 6.92, 2.22 and 0.150 cmol/kg, respectively. The base saturation (BS) levels of the treated soils were significantly ($P < 0.05$) increased to values above 50 % compared to 26.02 % and 35.42 % obtained before experiment and from control plot, respectively. Onwuka *et al.* (2009) and Akinmutimi and Osodeke (2013) have shown that ash materials contain exchangeable cations, which are known to increase soil pH. Organomineral fertilizers are also high in these exchangeable cations and nutrients (Amosu and Okogun, 2011). Therefore, a combination of ash with OMF led to further increase in soil pH and soil nutrients than ash alone. The increases in soil nutrients obtained in this study as a result of the amendments applied are similar to those reported by Onyegbule *et al*., (2012) and Nwachukwu *et al*. (2012). There was general reduction in exchangeable acidity values in treated plots relative to control. This is in agreement with the findings of many researchers (Onyegbule *et al*., 2012; Nwachukwu *et al*., 2012;

Akinmutimi and Osodeke, 2013) who reported reduction in exchange acidity by liming as remedy to soil acidity problems associated with Ultisols of South Eastern Nigeria. However, there were no significant increases ($P > 0.05$) in total nitrogen, exchangeable sodium and effective cation exchange capacity (ECEC) by treatments.

Effects of lime and organomineral fertilizer on growth and yield of fluted pumpkin

Application of lime and OMF singly or in combinations resulted in significant increases ($P<0.05$) in the vine length and number of leaves per fluted pumpkin plant relative to control across all the growth stages except at 4 weeks after planting (WAP) where there was no significant increase in number of leaves. The combined treatments recorded higher values than their single applications (Table 4).

The fresh yield of fluted pumpkin was significantly ($P<0.05$) increased across all the stages of growth as a result of the treatments applied relative to control, with higher yields also obtained from combined application of lime and OMF (Table 5). The highest yield of 596.82 kg/ha obtained at 10 WAP was from OMF + CPA treated plot although not significantly higher than the yields of 586.67 and 577.67 kg/ha obtained from OMF + PSA and OMF + WA treated plots, respectively but was significantly higher than the yields obtained from the sole applied plots. This means that the combined treatments have double source of soil nutrients from OMF and ash, which thereby promotes the growth and yield of fluted pumpkin more than their single application(Iren *et al*.,2013). The superiority of the sole and combined treatments over control may have been due to increased microbial activity and availability of major plant nutrients as a result of the lowering of the soil pH (Asawalam and Onyegbule, 2009; Bello and Udofia, 2013) thereby improving the soil condition and ensuring balance nutrition. Ubi *et al.* (2015) reported significant increase in number and sizes of pods of soy bean plants under lime over those without lime.

Conclusion

This study showed that the efficiency of organomineral fertilizer will be enhanced when combined with lime in an acid Ultisol soil for improved fluted pumpkin production. Therefore, for improved soil nutrients, sustainable and better performance of fluted pumpkin in an acid Ultisol of Southeastern Nigeria, the combination of any of the lime materials (ash) with organomineral fertilizer is recommended.

Table1: Properties of Soil before Experiment.

Parameter	Value
Sand (%)	84
Silt (%)	13
Clay (%)	3
Texture	Loamy sand
pH (H_2O)	4.0
Org. C (g/kg)	11.8
Total N (g/kg)	1.0
Av.P (mg/kg)	15.13
Exchangeable cations (cmol/kg)	
Ca^{2+}	2.0
Mg^{2+}	0.4
K^{+}	0.09
Na^{+}	0.07
Exchangeable acidity (cmol/kg)	7.28
ECEC	9.84
B.S (%)	26.02

ECEC = Effective Cation Exchange Capacity, B.S = Base Saturation.

Table 2: Nutrient Composition of the Liming Materials and Organomineral Fertilizer

Parameter	Material					
	CPA	CPU	PSA	PSU	WA	OMF
pH (H_2O)	12.60	78.40	9.20	10.50	12.4	10.90
Org. C (g/kg)	35.9	69.4	15.8	38.6	32.5	35.9
Total N (g/kg)	2.31	3.80	0.80	1.01	2.60	2.90
Total P (mg/kg)	29.88	107.88	6.25	8.13	46.87	117.00
Total Ca (mg/kg)	44.80	3.30	20.60	11.80	26.6	6.20
Total Mg (mg/kg)	3.60	18.90	9.60	2.00	15.6	19.40
Total Na (mg/kg)	0.12	0.11	0.10	0.11	0.13	1.10
Total K (mg/kg)	0.17	0.16	0.15	0.13	0.28	0.13

CPA= Cocoa pod ash, CPU= cocoa pod unburnt, PSA= periwinkle shell ash, PSU= periwinkle shell unburnt, WA = wood ash, OMF= organomineral fertilizer

Table3: Effects of local liming materials and organomineral fertilizer on soil properties.
CPA = cocoa pod ash, PSA = periwinkle shell ash, WA = wood ash, OMF = organomineral fertilizer, OMF+CPA = organomineral + cocoa pod ash, OMF+PSA = organomineral + periwinkle shell ash, OMF+WA =organomineral + wood ash.

Treatment	pH (H_2O)	Org. C (g/kg)	Total N (g/kg)	Av. P (mg/kg)	Exchangeable Bases (cmol/kg)				Exch. acidity (cmol/kg)	ECEC (cmol/kg)	BS (%)
					Ca^{2+}	Mg^{2+}	K^+	Na^+			
CPA	4.87	12.8	1.03	41.88	3.80	1.20	0.132	0.11	2.94	8.18	64.08
PSA	5.17	13.9	1.20	35.17	5.60	1.80	0.130	0.09	3.74	11.36	67.08
WA	5.43	18.0	1.50	29.87	5.63	1.07	0.129	0.10	2.83	9.78	71.06
OMF	4.67	15.7	1.06	33.92	3.60	0.97	0.100	0.20	4.17	8.94	53.36
OMF+CPA	5.30	13.3	1.06	30.38	6.40	2.00	0.110	0.03	3.62	12.16	70.23
OMF+PSA	5.20	12.2	1.10	30.71	6.87	1.33	0.119	0.02	3.33	11.67	71.46
OMF+WA	5.87	19.6	1.30	30.73	6.92	2.22	0.150	0.09	2.89	12.25	76.24
Control	4.07	10.3	0.9	15.84	1.87	0.73	0.070	0.06	5.89	9.12	35.42
LSD (0.05)	0.55	0.38	NS	12.98	2.09	1.02	0.05	NS	1.28	NS	11.48

Table 4: Effects of Local Liming Materials and Organomineral Fertilizer on growth parameters of Fluted Pumpkin

Treatments	Vine length (weeks after planting)					Number of leaves (weeks after planting)				
	4	6	8	10	Mean	4	6	8	10	Mean
CPA	54.73	59.80	75.13	61.20	62.72	18.93	30.00	49.33	68.33	41.65
PSA	48.47	59.87	61.93	46.13	54.10	18.4	31.00	48.27	57.93	38.90
WA	48.32	58.93	60.84	52.11	55.05	17.00	31.92	49.16	60.12	39.55
OMF	49.80	67.13	76.27	44.67	59.47	19.00	38.40	49.27	56.13	40.70
OMF+CPA	57.87	71.27	75.53	62.60	66.82	19.07	49.47	84.73	89.73	60.75
OMF+PSA	56.67	74.73	77.87	54.93	66.05	18.73	48.73	81.73	86.47	58.92
OMF+WA	55.23	73.22	75.62	54.75	64.71	16.50	52.60	80.50	86.20	58.95
Control	32.53	40.41	46.53	35.27	38.69	12.60	19.93	21.27	27.00	20.20
LSD (0.05)	12.65	14.42	15.28	14.70		NS	8.6	9.2	11.6	

CPA = cocoa pod ash, PSA = periwinkle shell ash, WA = wood ash, OMF = organomineral fertilizer, OMF+CPA = organomineral + cocoa pod ash, OMF+PSA = organomineral + periwinkle shell ash, OMF+WA =organomineral + wood ash.

Table 5: Effects of local liming materials and organomineral fertilizer on yield of fluted pumpkin

Treatments	Fresh shoot yield (kg/ha)			Mean
	4WAP	7WAP	10WAP	
CPA	256.93	405.55	540.00	400.83
PSA	226.72	310.00	340.00	292.24
WA	224.91	315.62	339.93	293.49
OMF	253.46	342.57	345.00	313.68
OMF+CPA	413.76	482.98	596.82	497.85
OMF+PSA	356.57	459.50	586.67	467.58
OMF+WA	349.01	452.98	577.67	459.89
Control	130.99	153.25	193.33	159.19
LSD (0.05)	40.2	81.30	32.9	

CPA = cocoa pod ash, PSA = periwinkle shell ash, OMF = organomineral fertilizer, OMF+CPA = organomineral + cocoa pod ash, OMF+PSA = organomineral + periwinkle shell ash, OMF+WA =organomineral + wood ash.

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