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RESEARCH ARTICLE

Effects of Cocoa Pod Husk Ash and NPK Fertilizer on Soil Nutrient Status and Sweetpotato Yield in an Ultisol in Southeastern Nigeria

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Abstract

The single effects of cocoa pod husk ash (CPHA) - 5 tons per hectare, NPK (15-15-15) and their combinations were evaluated on soil chemical properties and yield of sweetpotato (*Ipomoea batatas* L. *(Lam)* in an Ultisol in Southeastern Nigeria. The treatments were: 5 tons/ha of Cocoa pod husk ash (A), 200 kg/ha of NPK Fertilizer + 5 tons/ha of Cocoa pod husk ash (B), 300 kg/ha of NPK Fertilizer + 5 tons/ha of Cocoa pod husk ash (C) 200 kg/ha of NPK Fertilizer (D), 300 kg/ha of NPK Fertilizer (E) and No treatment –Control (F). All the applied treatments increased soil pH except the sole application of 200 kg/ha NPK fertilizer, which reduced the soil pH than what it was before treatment application. Other soil nutrients such as % organic carbon, % total nitrogen and exchangeable potassium were increased when 5 tons CPHA was combined with 200 kg/ha NPK fertilizer. While 300 kg/ha NPK applied singly significantly increased soil Available P after harvest. Saleable tubers of sweetpotato were significantly ($P<0.05$) higher in plots treated with 200 kg of NPK fertilizer combined with 5 tons/ha CPHA, followed by treatment with 300 kg/ha of fertilizer combined with 5 tons/ha of CPHA. 200 kg of NPK fertilizer combined with 5 tons/ha CPHA is therefore recommended.

Introduction

Soils of the Southeastern Nigeria and indeed the humid tropics are acidic and contain appreciable mineral oxides (Uzoho and Oti, 2005). Under acid conditions, exchangeable iron and aluminum come into solution, presenting some toxicity problems and causing the deficiency of nutrients especially phosphorus. Most soils in Southern Nigeria are acidic due to the nature of parent material, heavy leaching and weathering. In addition to acidity, the soils suffer from nutrient deficiency (Owolabi *et al*., 2003).

Sweetpotato is an important root crop to man. It is the seventh most important crop in the world. The potential of sweet potato to guarantee food security is under-estimated as its use is often limited to a substitute food in African countries. Sweetpotato is valued for its tubers which are boiled, fried, baked or roasted for humans or boiled and fed to livestock as a source of energy. The tubers can also be processed into flour for bread making, starch for noodles as well as used as raw material for industrial starch and alcohol (Ukom *et al*., 2009). The leaves are used as vegetables in yam and cocoyam porridge and are rich in proteins, vitamins and various minerals. Sweetpotato tubers are rich in vitamins A, B, and C; and minerals such as K, Na, Cl, P and Ca (Onwueme & Sinha, 1991). It can therefore be a high value-added food particularly for children and pregnant women who are more often exposed to vitamin A deficiency in sub-saharan Africa (Degras, 2003).

Although sweet potato crop is easy to cultivate, it is faced with some production and economic constraints. Labour costs are high in some localities; yields remain poor on account of low fertility status of the over-cropped soils (Uwah *et al*., 2013). Studies have shown that fertilizers supply plants with the nutrients; however, organic and inorganic fertilizers supply nutrients to soil in different ways. Organic fertilizers create a healthy environment for the soil over a long period of time, while inorganic fertilizers work much more quickly, but fail to create a sustainable environment.

Adu- Dapaah *et al*. (1993), Ayeni, *et al*. (2008a) and Onwuka *et al*. (2010) among other researchers have reported cocoa pod ash (CPHA) as an organic source of soil nutrients, and NPK fertilizer is a popular source of inorganic fertilizer.

This study however, aims at combining them to get the best of both options.

Materials and Methods

Description of the experimental site

The Experiment was conducted at the Michael Okpara University of Agriculture, Umudike; latitude 05^0 29' N and longitude 07^0 33' E with an elevation of 122m above the sea level.

The soil of the experimental site is well-drained loamy sand of coastal plain sands parent material, classified as Typic kandiudult (Lekwa and Whiteside, 1986). It's an Ultisol, and belongs to the sandy clay loam textural class. The soil is usually strongly weathered and acidic, with low cation exchange capacity, low base saturation, low organic matter content and low total nitrogen content (Enwezor *et al*., 1989).

Treatment

There were six treatments. The treatments were cocoa pod husk ash with NPK fertilizer thus:

A = 5 tons/ha of Cocoa pod husk ash
B = 200 kg/ha of NPK Fertilizer + 5 tons/ha of Cocoa pod husk ash
C = 300 kg/ha of NPK Fertilizer + 5 tons/ha of Cocoa pod husk ash
D = 200 kg/ha of NPK Fertilizer
E = 300 kg/ha of NPK Fertilizer
F = No treatment (Control)

Preparation/Analysis of cocoa pod husk ash

Cocoa pod husks were sun dried and burnt in the open air.

The nutrient composition of cocoa pod husk ash were also determined after ashing. Total N was determined by Kjedahl method. For other nutrients, ground samples were digested with nitric – perchloric acid mixture using (AOAC, 1990). The filtrate was used for nutrients determination as done in routine soil analysis. Total P was determined by colorimeter, K by flame photometer and Ca, Mg and Na by AAS.

The treatments were applied (incorporated within the ridge) and left for one week before the sweetpotato vines were planted. This experiment was conducted in 2012 cropping season

Field trial

The objective of the field trial was to determine the effect of the treatments on tuber yield of sweet potato. The field was slashed, ploughed and made into ridges. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The plot size was 3m by 4m. Sweetpotato TIS 87/0087 vines were planted at 1m x 0.3m to give a plant population of 33,333/ha. The inter-plot spacing was 1m. Weeding was done manually at 5 weeks after planting followed by rouging at 8 weeks after planting. The Sweetpotato was harvested at 5 months after planting.

Records of Agronomic measurements

Agronomic measurements were done on plot basis. The effect of ash sources were evaluated based on the following:

Saleable tuber weight. This was gotten by weighing the saleable roots using a 10 kg weighing balance.

Non-saleable tuber weight. This was obtained by weighing the non-saleable roots (unmarketable roots) using a 10 kg weighing balance.

Total tuber weight. Obtained as the sum of weights of both marketable and unmarketable roots.

Soil physical and chemical characteristics.

Soil samples (at 0-30 cm depth) were collected before treatment application and after harvest; air-dried and sieved with 2mm sieve and the following methods were used to determine parameters in the samples collected. Soil particle size fractions were determined by the hydrometer method (Bouyoucos, 1951), the soil having been dispersed with 5% sodium hexametaphosphate (Calgon). The soil pH was determined (in H_2O) in the ratio of 1:2.5 using a glass electrode pH meter. Organic carbon was determined by the dichromate wet oxidation method (Walkley and Black, 1934); total nitrogen by the micro kjeldahl distillation method (Jackson, 1964). Available phosphorus was extracted by Bray and Kurtz (1945) number 1 method. Exchangeable cations (Ca, Mg, K, and Na) were determined by the IN NH_4OAC extraction procedure; Na and K were read up by flame photometry, while Ca and Mg were determined by the EDTA titration method.

Exchangeable acidity (H^+ and Al^{3+}) were determined by extraction with IN KCl and titrating with 0.1N NaOH and 0.05N HCl respectively, using phenolphthalein as indicator. Effective Cation Exchange Capacity of the soil was computed as the sum of exchangeable bases and exchangeable acidity.

Statistical analysis

The data generated were subjected to analysis of variance in factorial experiment in RCBD using the Genstat soft ware package while the means were separated using the Least significant difference (LSD) at 5% level of probability.

Results and Discussion

Physico-chemical properties of the soils

The physical and chemical properties of the soil before the treatment application are shown in Table 1. The soil was sandy clay loam in texture, and acidic with pH value of 4.33. This is typical with the general status of soils of southeastern Nigeria (Ano and Agwu, 2005; and Onwuka, 2008). The soil nitrogen was more than 0.15% which is considered optimal for most crops (Adejobi *et al*., 2011), while the percentage organic carbon was low (0.59).

Soil exchangeable potassium, sodium, calcium and magnesium were low, indicating poor soil fertility. This result agrees with the findings of Nwite *et. al.* (2009); Ezekiel *et. al.* (2009) who observed that the Ultisols of southeastern Nigeria are low in exchangeable calcium, potassium and magnesium. The available phosphorus value (21.78 mg/kg) is higher than the critical level of 12-15 mg/kg for most crops (Enwezor, 1997). The insufficient levels of the major nutrients in the soil was expected to benefit from the treatments applied.

Table 1: Physico-chemical properties of soils before the application of ash

Parameters	Values
Soil pH (1:2 H_2O)	4.33
% Total Nitrogen	0.60
% Organic carbon	0.59
Available P (mg/kg)	21.78
Exchangeable K (cmol/kg)	0.11
Exchangeable Na (cmol/kg)	0.12
Exchangeable Ca (cmol/kg)	2.00
Exchangeable Mg (cmol/kg)	0.80
TEB (cmol/kg)	3.03
Exchangeable acidity (cmol/kg)	2.00
ECEC (cmol/kg)	5.03
% Base saturation	60.24
% Sand	62.80
% Silt	14.00
% Clay	23.20
Soil texture	SCL

Chemical characteristics of the cocoa pod husk ash

Analysis of the cocoa pod husk ash on Table 2 indicated that the ash is highly basic, having a pH value of 10.1. It is also high in certain nutrients: Phosphorus (63.42 mg/kg), Potassium (423.30 mg/kg), and Sodium (53.96 mg/kg). Ayeni (2008a) and Odedina *et al.* (2003) also discovered similar results from the analysis of ash.

Table 2: Chemical composition of the Cocoa pod Husk Ash (CPHA)

Parameters	SDA
pH (1:2.5 H_2O)	10.10
% Total nitrogen	0.70
Phosphorus (mg/kg)	63.42
% Organic carbon	2.47
Calcium (mg/kg)	2.88
Potassium (mg/kg)	423.30
Magnesium (mg/kg)	8.52
Sodium (mg/kg)	53.96

Effects of Cocoa Pod Husk Ash (CPHA) and NPK Fertilizer on Some Yield Parameters of Sweetpotato

The effects of NPK 15:15:15 and CPHA on some yield parameters of sweetpotato are as shown in Table 3. Saleable tuber weight was significantly ($P<0.05$) higher when cocoa pod husk ash in combination with NPK fertilizer were incorporated into the soil than the control treatment. The application of 200 kg of NPK fertilizer combined with 5 tons/ha CPHA gave the highest weight of saleable tubers, (which is 82.6% of the total tuber weight) followed by treatment with 300 kg/ha of fertilizer combined with 5 tons/ha of CPHA, followed by 5 tons/ha CPHA, then 300 kg NPK fertilizer/ha. The lowest yield of 0.42t/ha was obtained from the control; (Table 3). However, the plot treated with sole application of 200 kg/ha NPK never gave any saleable tuber. This could be attributed to the initial poor soil fertility status and continuous cultivation of the land without replenishing with organic fertilizer, and nutrient imbalance and soil acidity have been reported as problems associated with the sole use of mineral fertilizer (Ayeni *et al*. 2008).

Non-economic yield of sweetpotato tubers as part of the total yield was also evaluated. Treatment with sole application of 200 kg NPK fertilizer gave the highest percentage of non saleable tubers (100%). This is an indication of extremely poor yield, while the treatment with 200 kg of NPK fertilizer combined with 5 tons/ha CPHA gave the lowest percentage of non-saleable tubers (17.35%). In other studies as observed in the current study the combined treatments of organic and inorganic fertilizers have been found to produce the highest levels of some growth and yield parameters of some selected crops (Okwuagwu *et al*., 2003, Busari *et al.*, 2008 and Efthimiadou *et al.*, 2010) compared to the sole applications of either inputs.

Table 3: Effects of Cocoa pod Husk Ash and NPK Fertilizer on some yield parameters of sweetpotato

	STWt		NSTWt		TTWt
	(Tons/ha)	(% of TTWt)	(tons/ha)	(% of TTWt)	(tons/ha)
A	0.92	27.79	2.40	72.50	3.31
B	4.81	82.65	1.01	17.35	5.82
C	4.08	70.10	1.74	29.90	5.82
D	0.00	0.00	0.32	100.00	0.32
E	0.46	20.54	1.78	79.46	2.24
F	0.42	9.70	0.89	67.94	1.31
LSD $_{(0.05)}$	3.12		NS		NS

STWt = Saleable Tuber Weight, NSTWt = Non-saleable Tuber Weight
TTWt = Total Tuber Weight tons/ha = tons per hectare

Effects of Cocoa Pod Husk Ash (CPHA) and NPK Fertilizer on Some Soil Chemical Properties after Harvest

Table 4 shows the effects of cocoa pod husk ash and NPK fertilizer on some soil chemical properties after harvest. All the applied treatments increased soil pH except the sole application of 200 kg/ha NPK fertilizer, which reduced the soil pH than what it was before treatment application. The increases in pH of the plots treated with cocoa pod ash and its combinations show the liming effect of cocoa pod ash. Highest value of Soil Organic carbon and percent total nitrogen was observed when 5 tons CPHA was combined with 200 kg NPK fertilizer per hectare. Highest value of available P was recorded after harvest at the treatment with sole application of 300 kg NPK fertilizer. Exchangeable K was slightly increased when CPHA was solely applied and when CPHA was applied in combination with 200 kg/ha NPK fertilizer. Ayeni (2008b) noted that cocoa pod ash contained higher cations especially K and Ca than other nutrients present in it. Exchangeable Na was also slightly increased by all the treatments. However, calcium and magnesium were reduced when compared with what was recorded at the beginning of the experiment (Table 1). These reductions observed could be as a result of sweetpotato being a tuber crop has taken up most of the nutrients in the process of growth and development, thereby leaving off relatively less nutrients after harvest. It could also be induced as a result of high K: Mg ratio in the treatment applied (Table 2).

Table 4: Effect of Cocoa pod Husk Ash (CPHA) and NPK Fertilizer on Soil Chemical Properties after Harvest

	pH (H_2O)	% OC	% TN	Av. P	Ex. K	Ex. Na	Ex. Ca	Ex. Mg
A	4.92	0.53	0.57	9.52	0.14	0.14	1.47	0.53
B	4.83	0.69	0.64	14.32	0.14	0.12	1.37	0.53
C	4.56	0.59	0.56	12.11	0.11	0.12	1.37	0.57
D	4.25	0.68	0.60	10.51	0.12	0.14	1.63	0.70
E	4.36	0.64	0.56	17.50	0.12	0.13	1.27	0.50
F	4.51	0.64	0.52	12.70	0.11	0.13	1.03	0.30
$LSD_{(0.05)}$	NS	NS	NS	4.87	NS	NS	NS	NS

Conclusion

Combined cocoa pod ash and NPK 15:15:15 fertilizer increased soil pH and % OC, % TN, P, K. This led to significant yield of saleable sweetpotato tubers. The combined application of cocoa pod husk ash with reduced level of NPK fertilizer was more effective in increasing sweetpotato tuber yield than cocoa pod husk ash and NPK fertilizer applied individually. Integration of cocoa pod husk ash and NPK fertilizer had positive effect on soil fertility. From this research, 200 kg/ha in combination with 5 tons/ha CPHA is recommended.

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