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Research Article

Yield and Nutrient Composition of Sweetpotato (*Ipomoea batatas* (L) Lam) as Influenced by Application of Three Different Sources of Ash

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ABSTRACT

Three different ash materials (kitchen wood ash –KWA, oil palm bunch ash-PBA and timber saw mill ash- SDA) applied at the rates of 0, 2, 4, 6 and 8 tons/ha were incorporated in an Ultisol planted with sweetpotato to evaluate their effects on yield and crop quality, using sweet potato as a test crop. The soil was acidic and deficient in N, % O.C., K, Ca, Mg and Na. Considering the total tuber weight of sweet potato, all the ash sources increased yields over the control, but only the KWA produced a significant (P<0.05) increase in yield over the control. Total tuber weight of sweet potato increased with amount of ash applied; 4 tons/ha which gave 53.76 % increase in the total tuber weight was optimum. SDA also, significantly (P<0.05) increased the nitrogen, phosphorus and potassium contents of sweet potato. 8 tons/ha of the same gave the highest contents of N, P and K.

INTRODUCTION

Sweetpotato is an important staple food crop in Africa in general and Nigeria in particular. It contains Vitamin A with sufficient quantities of a precursor known as beta-carotene (Odebode *et al*., 2008). Sweetpotato provides as much protein as cereals and beans per hectare (CIP, 1991). It has a high nutritional value that provides a good source of energy supplying sugars as well as other carbohydrates, calcium, iron and some minerals. Potassium is one of the most important essential nutrient elements in root and tuber crops production.

Among the mineral nutrients, potassium affects the yield of root and tuber crops most; it prolongs leaf area duration and increases the net assimilation rate and sink capacity in crops (Obigbesan, 1981).

Potassium influences crop yields and quality and is also known to be responsible for translocation of photosynthates to storage organs (Obigbesan, 1981; Jian-wei *et al.,* 2001).

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).

In Umuahia southeast Nigeria, large quantities of saw-mill wastes and oil palm bunch accumulate from numerous saw-mills and palm oil making villages located at various parts of the state, as well as kitchen wood ash from local women's kitchen. Despite the magnitude of these wastes generated daily and the possible effects on the environment, no serious attempts have been made either for their effective utilization or disposal. The only disposal attempt (for saw-mill wastes) is the partial burning of wastes at the dumping grounds, after which little or no agricultural uses for the wastes have been applied as a way of recycling (Nwite *et al*., 2009).

Ash derived from burnt vegetation is known to reduce soil acidity, increase availability of cationic nutrients and improve yield of millet in Zambia (Araki, 1993).

Due to unavailability of straight K fertilizer in the market, wood ash could be an alternative and cheap source of K that is available; the K_2O concentration in the wood ash was analyzed and discovered to be about 3% (Sokoto *et al*., 2007), thus, ash could be an important source of potassium for sweet potato production.

The study is aimed at evaluating the effect of the ashes of varied origin on yield of sweetpotato as to ascertain the best ash source that will give optimal sweetpotato production as well as influence the Nitrogen, Phosphorus and potassium contents of sweetpotato in an Ultisol of southeast Nigeria.

MATERIALS AND METHODS

Description of the experimental site

Field trial was conducted in 2007 cropping season 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 loamy sand 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 and design

The treatments comprised three sources of ash (kitchen wood ash, timber saw- mill ash and oil palm bunch ash) at the rates of 0, 2, 4, 6 and 8 tons per hectare. These were combined factorially in a randomized complete block design with three replications.

Before the ashes were used for the research, they were passed through a 3mm sieve to ensure homogeneity. Each of the samples was analyzed for their chemical compositions.

General physical and chemical analysis of the soil

Standard methods of physical and chemical analyses for soils were used to analyze these parameters:

Soil particle size fractions were determined by the hydrometer method (Bouyoucos, 1951)**.**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 chromic acid wet oxidation method (Walkley and Black, 1934) as modified by Juo (1979). Total nitrogen was determined by the semi-micro kjeldahl method of Bremmer (1965) as described by Udo and Ogunwale (1978). Available phosphorus was extracted by the Bray -2 extractant (Bray and Kurtz, 1945) and the extracted phosphorus determined by the Murphy and Rilley method (Murphy and Rilley, 1992).

Exchangeable cations (calcium, magnesium, potassium, and sodium) were extracted by displacement with one normal neutral ammonium acetate (IN NH_4OAC, pH 7.0) using the saturated method of Grant (1982), while exchangeable calcium and magnesium were determined by the EDTA complexometric titration method of Juo (1979); sodium and potassium photometrically using the EEL flame photometer. Exchangeable hydrogen and aluminium ions (H^+ and Al^{3+}), representing total exchange acidity were extracted with 1N KCl and determined by titration 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.

Field Trial

The objective of the field trial was to determine the effect of the different sources of ash and their rates on tuber yield of sweet potato. A total land area of 0.1ha was marked out for the field trial.

The field was slashed, ploughed and made into 1m x1m 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. Each of the plots had a blanket application of 400 kg NPK/ha. 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 at harvest

At harvest the following records were taken on plot basis (n= 45). The effect of ash types and rates were evaluated based on the following:

Weight of saleable tubers: This was done by weighing the saleable roots using a 10 kg weighing balance. Roots that were more than or equal to 100g (Levette, 1993).

Weight of non-saleable tubers: This was obtained by weighing the non-saleable roots (unmarketable roots) using a 10 kg weighing balance. Roots that were less than 100g (Levette, 1993) are called non-saleable (or unmarketable) roots.

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

Tissue Analysis

Fresh harvested sweetpotato tubers from the experimental fields sampled based on the treatment plots (n=45) were sliced and oven-dried at 70^{0}C to a constant weight. The dried materials were milled with a hammer mill and the Nitrogen content was determined according to the method of Bremner (1965), Phosphorus content was determined by the vanadomolybdate yellow colour method (Allen, 1989), while potassium was determined using EEL flame photometry method.

Statistical data analysis

The data generated were subjected to analysis of variance in factorial experiment in RCBD using the Genstat software package, while the means were separated using the least significant difference (LSD).

RESULTS AND DISCUSSION

Chemical characteristics of the different sources of ash

Table 1 shows the chemical composition of the Kitchen wood ash (KWA), oil palm bunch ash (PBA) and timber saw-mill ash (SDA). From the table, all the ash sources are highly basic, having their pH ranging from 9.28 to 10.87. They are also high in phosphorus (28.95 to 55.71 %), calcium (1.37 to 1.91 %), potassium (0.26 to 0.51 %), magnesium (0.22 to 0.60 %), sodium (0.12 to 0.22 %) and organic carbon (21.29 to 25.41 %).

The high levels of the parameters assayed in the different sources of ash (Table 1) implies that these waste materials have a high potential to enrich the soil with nutrients and therefore, they are expected to support good crop performance in these soils.

Table 1: Chemical composition of the kitchen wood ash (KWA), oil palm bunch ash (PBA) and timber saw-mill ash (SDA)

Parameters	SDA	PBA	KWA
pH (1:2.5 H_2O)	9.28	10.74	10.87
Total nitrogen (%)	0.31	0.18	0.21
Phosphorus (mg/kg)	28.95	33.30	55.71
Organic carbon (%)	21.29	19.69	25.41
Calcium (%)	1.37	1.60	1.91
Potassium (%)	0.26	0.36	0.51
Magnesium (%)	0.22	0.50	0.60
Sodium (%)	0.12	0.17	0.22

The soil at the experimental site was loamy sand in texture and was low in total N, exchangeable cations (Ca, Mg, K and Na) moderate in available P and low to medium in O.C (Table 2).

Table 2: Physico-chemical properties of the soil used for the experiment

Parameter	Values
Soil pH (1:2.5 H_2O)	4.73
Total Nitrogen (%)	0.096
Organic carbon (%)	1.36
Available P (mg/kg)	17.71
Exchangeable K (cmol/kg)	0.20
Exchangeable Na (cmol/kg)	0.10
Exchangeable Ca (cmol/kg)	1.26
Exchangeable Mg (cmol/kg)	0.37
TEB (cmol/kg)	1.93
Exchangeable acidity (cmol/kg)	1.9
ECEC (cmol/kg)	3.83
Base saturation (%)	50.33
Sand (%)	80.19
Silt (%)	7.82
Clay (%)	11.99
Soil texture	LS

LS = loamy Sand

Effect of Ash on Some Yield Parameters of Sweetpotato

Effects of ashes of varied origin and their rates on the Non-Saleable Tuber Weight (NSTWt)

Table 3 shows the effect of the different ash sources on the weight of Non-Saleable Tubers (tons/ha). No significant interaction was observed between the sources of ash and rates of application. The result showed no significant difference (P>0.05) among the sources of ash, However, the highest weight of non-saleable tubers (tons/ha) was obtained from the Kitchen wood ash, followed by the Oil Palm Bunch Ash, then the Timber Saw-mill Ash

Table 3: Effects of Ashes of varied origin and their rates on the Non-Saleable Tuber Weight (tons/ha) of sweet potato

Ash Source	Rates of application (tons/ha)					
	0	2	4	6	8	Means
KWA	0.65	0.83	0.65	3.40	0.73	1.25
PBA	0.49	0.63	0.89	0.53	0.81	0.67
SDA	0.54	0.76	0.91	0.57	0.48	0.65
Means	0.56	0.74	0.82	1.50	0.67	0.86

$LSD_{(0.05)\,source}$ (S) =NS
$LSD_{(0.05)\,rate}$ (R) = NS
$LSD_{(0.05)}$ S x R = NS

Effects of the sources of ash and rates on the Saleable / marketable tuber weight

Table 4 shows the effect of different sources of ash and rates on the saleable tuber weight of sweetpotato; highest weight of marketable tubers was produced from the kitchen wood ash. However, the increase in the weight of saleable tubers was not significant (P>0.05) among the sources of ash.

There were significant increases in the saleable tuber weight of sweet potatoes as the rate of ash application increased, except that an increase in oil palm bunch and timber saw-mill ashes above 4 tons/ha resulted in a reduction in the weight of saleable potato tubers. This reduction in weight of saleable tubers from 6 tons/ha of PBA and SDA application could be due to nutrient imbalance and negative interaction in plants due to excess supply of some nutrients such as potassium (Owolabi *et al*., 2003).

Generally, Kitchen wood ash increased the weight of saleable potato tubers more than other ash sources but this increase in weight was not significantly different (P>0.05) from that produced by the oil palm bunch ash but was significantly higher (P<0.05) than that produced by the saw dust ash. This result is in agreement with the findings of Owolabi *et al*. (2003), who reported that wood ash significantly increased the tuber weight of yam and those of Ezekiel *et al.* (2009), who reported that oil palm bunch ash increased the fresh root yield of cassava at Umudike.

No significant interaction was observed between the sources of ash and the rates of application.

Table 4: Effects of Ashes of varied origin and their rates on the Saleable Tuber Weight (tons/ha) of sweetpotato

Ash Source	Rates of application (tons/ha)					
	0	2	4	6	8	Means
KWA	8.69	7.83	10.78	11.42	10.81	9.91
PBA	5.91	6.92	10.91	9.50	12.80	9.21
SDA	6.44	7.56	10.77	9.26	7.86	8.38
Means	7.01	7.44	10.82	10.06	10.49	9.17

$LSD_{(0.05)\ source}$ (S) = NS
$LSD_{(0.05)\ rate}$ (R) = 2.94
$LSD_{(0.05)}$ S x R = NS

Effects of ashes of varied origin and rates on the Total tuber weight of sweetpotato

Table 5 presents the effects of different sources of ash on the total tuber weight of sweetpotato. From the table, KWA significantly (P<0.05) increased the total tuber weight of sweetpotato more than the SDA but only numerically increased same more than the PBA.

This could be because plants benefited from Ca and K obtained from wood ash supplementation, the synergy K-NO^{-3} and from changes in soil chemistry similar to lime application (Voundi Nkana *et al.*, 1997). Ash rates significantly influenced the total tuber weight of sweet potatoes as significant (P<0.05) increases were observed with increase in the rates of application from 2tons/ha. No significant interaction was recorded.

Table 5: Effects of Ashes of varied origin and their rates on the Total Tuber Weight (tons/ha) of sweetpotato.

Ash Source	Rates of application (tons/ha)					
	0	2	4	6	8	Means
KWA	9.33	8.66	11.43	14.81	11.53	11.15
PBA	6.40	7.55	11.80	10.03	13.61	9.88
SDA	6.98	8.31	11.68	9.83	8.34	9.03
Means	7.57	8.17	11.64	11.56	11.16	10.02

$LSD_{(0.05)\ source}$ (S) = 2.33
$LSD_{(0.05)\ rate}$ (R) = 3.01
$LSD_{(0.05)}$ S x R = NS

Effects of different sources of ash and rates on N, P and K content of sweetpotato.

Nitrogen content of sweetpotato tubers

Effects of sources of ash and their application rates on the Nitrogen content of sweet potato tubers are as shown in Figure 1. The highest percentage of nitrogen was absorbed when timber saw-mill ash was applied, and it was significantly higher (P<0.05) than what was absorbed when soils were treated with either oil palm bunch ash or kitchen wood ash. This could be attributed to the higher % nitrogen timber saw-mill ash contains (Table 1). The rate of 8tons/ha of ash applied significantly increased nitrogen content, which was higher than all the other rates of application.

High nitrogen is an indication of high protein-content: from 60-85% of sweetpotato nitrogen is proteinaceous (Walter, 1984). However, Weite *et al.* (1998) reported root yield reduction of 41% due to high N applications, therefore the lower yield produced by the timber saw-mill ash (SDA) compared with the kitchen wood ash (KWA) could be due to the higher nitrogen level in SDA (Table 1).

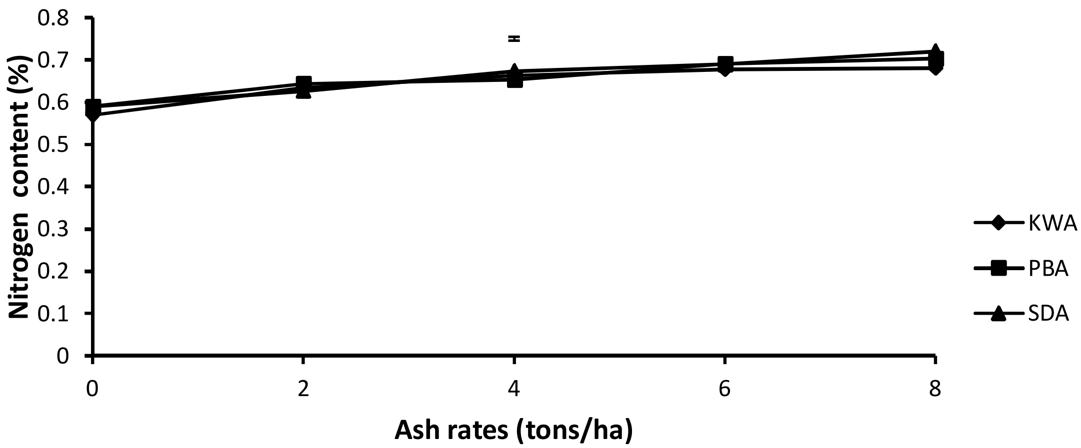

Fig. 1: Effect of ash on the nitrogen content of sweetpotato tubers

LSD
(0.05)

Phosphorus content of sweet potato tubers

The effect of different sources of ash and rates of application on the Phosphorus content of the sweet potato tubers is as shown in Figure 2. Timber saw-mill ash gave the highest value of phosphorus content in the sweetpotato tubers, followed by the oil palm bunch ash, then the kitchen wood ash. The value obtained from the timber saw-mill ash treatment was significantly ($P<0.05$) higher than the other ash treatments (oil palm bunch ash and kitchen wood ash).

The rate of application of ash had some effects on the phosphorus content of the sweet potato tubers. The phosphorus content was increasing as the rate of ash application increased; 8 tons/ha gave the highest value of phosphorus content in the sweetpotato tubers and it was significant over the other rates of application. Awodun (2007) reported that 8 tons/ha of saw dust (timber saw mill ash) gave higher N, P and K in cowpea leaf.

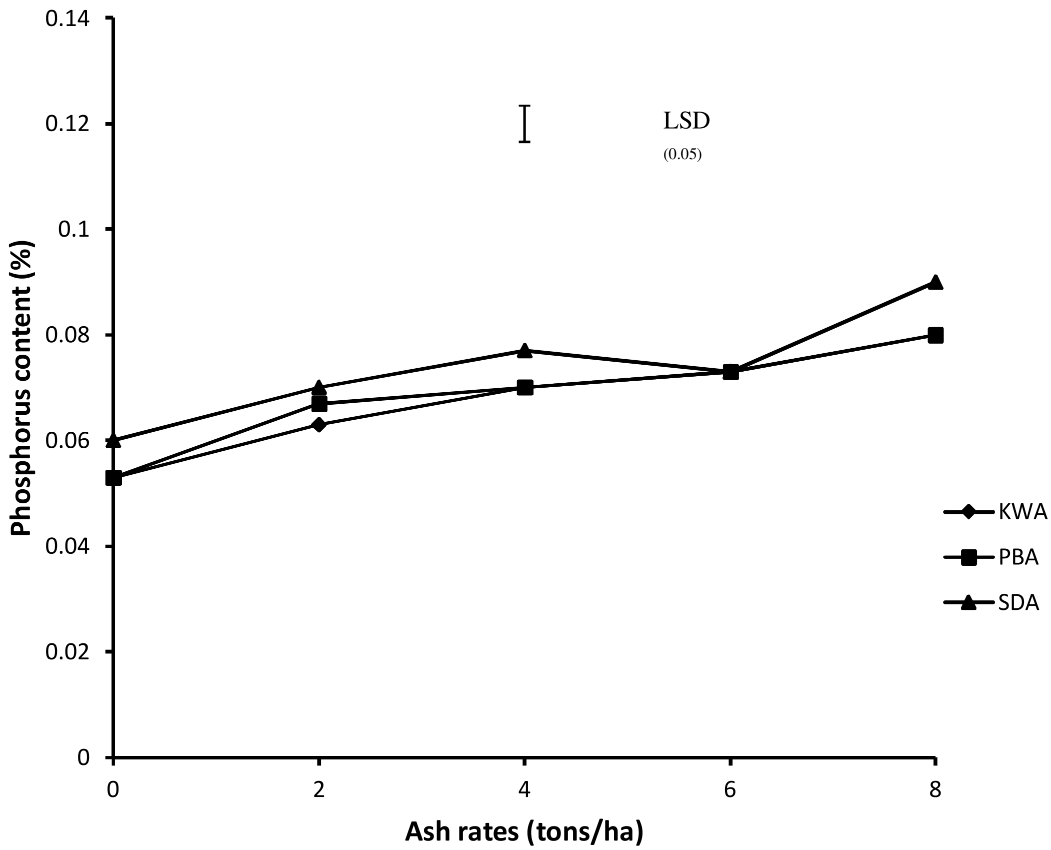

Fig. 2: Effect of ash on the phosphorus content of sweetpotato tubers

Potassium content of sweetpotato tubers

The effect of different sources of ash and their application rates on potassium content of sweetpotato are as shown in Figure 3. The result showed that the highest potassium content was produced by timber sawmill ash treatment; it was significantly higher ($P<0.05$) than that recorded for the oil palm bunch ash and the kitchen wood ash. There was an increase in the level of K-content of the sweetpotato tubers as the rate of application of the ashes increased; 8 tons/ha of application significantly ($P<0.05$) increased the K-content of sweetpotato over the other rates (0, 2, 4 and 6 tons/ha). Voundi- Nkana *et al.* (1997) also reported that there was an increase in plant K with application rates in wood- ash- amended soils.

There was no significant ($P<0.05$) interaction between the source and rate.

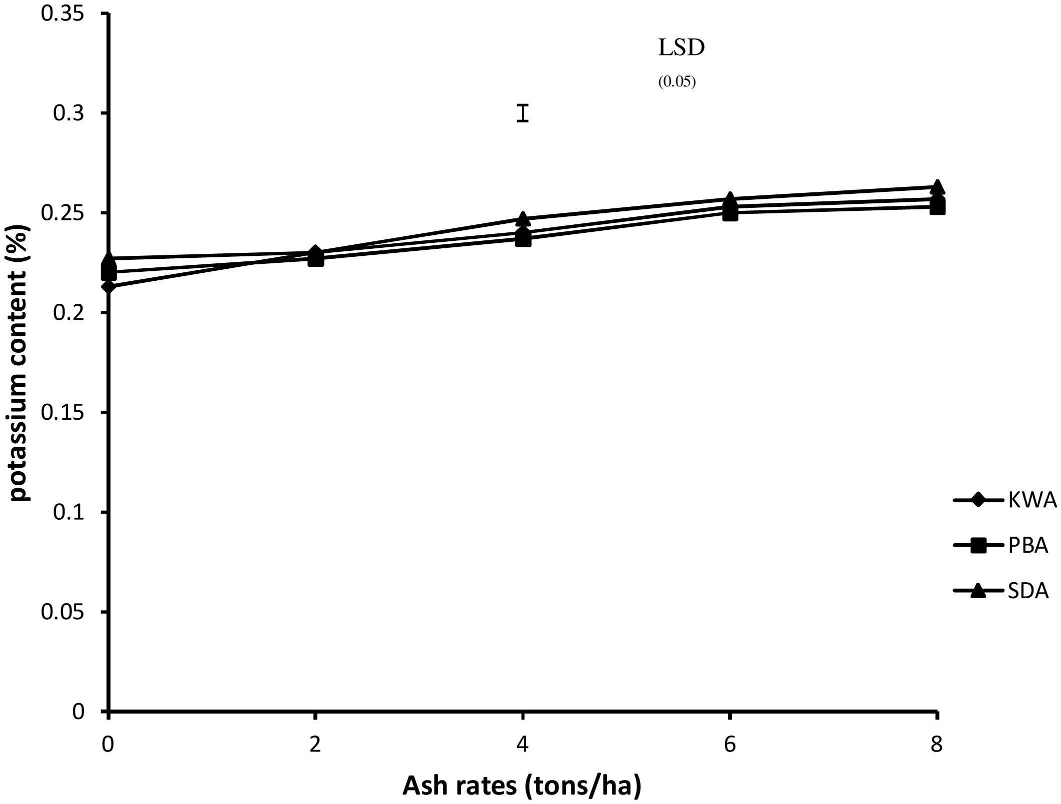

Fig. 3: Effect of ash on the potassium content of sweetpotato tubers

CONCLUSION

Investigating the effects of the three different sources of ash (KWA, PBA and SDA) on the yield and nutrient content of sweetpotato revealed that the KWA is the most effective in improving significantly the tuber yield of sweetpotato, while SDA significantly increased the nutrient content of sweetpotato.

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