Tropical and Subtropical Agroecosystems

SHORT NOTE [NOTA CORTA]

AMELIORATION OF SOIL ACIDITY USING COCOA HUSK ASH FOR MAIZE PRODUCTION IN UMUDIKE AREA OF SOUTH EAST NIGERIA.

[ALEVIACIÓN DE LA ACIDEZ DEL SUELO PARA LA PRODUCCIÓN DE MAÍZ MEDIANTE EL EMPLEO DE CENIZA DE CÁSCARA DE CACAO, EN NIGERIA]

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SUMMARY

A pot experiment was conducted at Michael Okpara University of Agriculture Umudike to evaluate the effect of cocoa husk ash in ameliorating soil acidity and improving maize yield. Five levels of the cocoa husk ash at 0,2,4,6 and 8 t/ha were applied and replicated three times in a completely randomized design. The results obtained showed that different rates of cocoa husk ash increased soil pH, total N, available P, exchangeable K, Ca and Mg. It also significantly increased the number of roots, plant height and dry matter yield when compared with the control. The 8t/ha of cocoa husk ash gave the highest maize dry matter yield of 163% over the control. Plant height, number of leaves, number roots and dry matter yield correlated positively with some soil chemical parameter except exchangeable acidity that correlated negatively with the yield parameters.

Key words: Cocoa husk ash, Soil acidity and Amelioration.

RESUMEN

Se realizó experimento para evaluar el efecto de la ceniza de la cáscara de cacao para reducir la ácidez del suelo y mejorar la producción de maíz. Se aplicaron cinco niveles de ceniza; 0,2,4,6 y 8 t/ha. Los resultados mostraron un incremento en el pH del suelo, N total, P disponible, K intercambiable, Ca y Mg. Se incremento igualmente el número raíces, altura de las plantas y la producción de materia seca. La aplicación de 8t/ha resultó en la mayor producción. Se encontró una correlación positiva de la producción y altura de las plantas, el número de raices y la producción de materia seca y negativa con la ácidez del suelo.

Palabras clave: ceniza de cáscara de cacao, reducción de la ácidez del suelo.

INTRODUCTION

Soil acidity in recent time has posed a serious problem in the Umudike area of South East Nigeria. The acidity is due to the nature of the parent material, weathering processes and heavy leaching (Owolabi *et al.*, 2003) which led to the deterioration of the soil, thus giving rise to low soil pH and nutrient deficiency among others. The most notable effects of soil acidity is drastic reductions in crop yield which come as a result of decrease in nutrient elements uptake especially calcium, magnesium and potassium, direct injury to plant roots which is caused by aluminum toxicity at soil pH below 5.5 (Adams, 1984). To improve acidic soils for better crop performance liming is inevitable. Liming not only raises the soil pH, it also affects the solubility and availability of most plant nutrients, by reducing toxic concentrations of Aluminum and Manganese (Biswas and Mukherjee, 1994). These Liming materials could be either conventional or non conventional. Attention is now gradually being shifted to the use of non conventional liming materials especial plant ash to reduce the acidity of the soil while serving as source of nutrient (Obi and Ekperigin, 2001, and Ojeniyi *et al.*, 2002) as well as being the most effective means of disposing these wastes which sometimes constitutes a nuisance in the farmer's farm and as acts as breeding places for harmful pests. The cost of conventional lime is beyond the reach of the farmer hence the emphasis on the non conventional lime that is relatively cheaper and more available.

Cocoa husk ash as a plant source of liming has being found to contain high amount of plant nutrients especial potassium, this was reported by Odedina *et al.* (2003) who on analysis found out that cocoa ash contained 116.6g kg^{-1} while wood ash, saw dust ash and rice bran ashes had 26.9,57.9 and 9.7 g kg^{-1} of potassium respectively. The objective of this work is therefore: to determine the effect of cocoa husk ash on soil properties and on maize performance.

MATERIAL AND METHODS

Soil samples for the study were collected from the research farm of National Root Crops Research Institute and Michael Okpara University of Agriculture Umudike, (latitude 5° 29°N and longitude 7° 32°E) in the rainforest area of South East Agro climatic zone of Nigeria). Soil surface samples (0 – 15cm) were collected and bulked together, air dried, sieved through 2mm sieve and used for routine analysis and pot experiments.

The physical and chemical characteristics of the soil before the experiment are shown in table 1 while the composition of the cocoa ash is shown in table 2.

Table 1. Physical and chemical properties of the soil used for the experiment

Physical and chemical properties		Concentration
Sand (%)		90
Clay (%)		6
Silt (%)		4
Texture		Sand
pH H20		4.10
pH $CaCl_2$		3.39
Organic matter (%)		3.00
Total Nitrogen (%)		0.11
Phosphorus (g/kg)		18.00
Ca (cmol kg^{-1})		1.60
Mg “		0.80
K “		0.18
Na “		1.05
Exchangeable acidity	(cmol kg^{-1})	2.00
Extractable Aluminum	“	1.50
Exchangeable Hydrogen	“	0.50
ECEC	“	5.63
% Base saturation		64.47

Table 2: Composition of Cocoa Husk Ash

Chemical properties	Concentration
pH (H_20)	11.03
N (%)	0.14
P (%)	0.42
K (%)	42.00
Ca (%)	24.20
Mg (%)	0.88

Soil Analysis

Soil pH was determined in 1:2.5 soil/water and soil/$CaCl_2$ suspensions using a soil EEL glass electrode pH meter (McLeans, 1965 as modified by IITA, 1979). Total Nitrogen was determined by Micro Kjeldahl method while available phosphorus was extracted by the Bray 1 method (Bray and Kurtz, 1945). Exchangeable cations were determined by extracting the samples with neutral normal ammonium acetate, exchangeable calcium and magnesium were determined by EDTA titration while potassium and sodium were read using flame photometer. Exchangeable acidity was determined by extracting 5g of the soil with 50ml of 1N KCl and the extract was titrated with 0.05N NaOH (Kamprath, 1967 as modified by IITA, 1979). Organic matter was determined using wet oxidation method (Walkley–Black, 1934). Particle size analysis was determined by hydrometer method (IITA, 1979).

Pot Experiment

Ten kilograms (10kg) portion of the soils were weighed and placed in twelve liters plastic buckets and laid out in a completely randomized design. The treatments consisted of five rates of cocoa husk ash (0, 2, 4, 6 and 8t/ha) and were replicated three times giving a total of fifteen buckets. The treatments were applied two weeks before planting. Five rates of cocoa husk ash, (0, 2, 4, 6 and 8t/ha) were applied before planting. The test crop was maize (Oba super 11). And two seeds were planted per pot and later thinned down to one plant per pot. Plant heights and number of leaves were measured at 2, 4, 6 and 8 weeks after planting (WAP). Dry matter yield and number of fine branching roots were taken at 8 weeks after planting. Soil samples were also collected from each of the pot at harvest and analyzed for pH, exchangeable acidity, Ca, Mg, K, available P, ECEC, Percentage base saturation and total Nitrogen. The data generated were subjected to analysis of variance (ANOVA) as outlined by Gomez and Gomez (1985), while the means were separated using the Fisher's Least Significant difference (LSD) and linear correlation analysis was done.

RESULTS AND DISCUSSION

The effect of ash on some soil chemical properties after harvesting the maize is shown on table 3. From the result, there was a significant increase ($P<0.05$) in pH in $CaCl_2$ with 8 t/ha giving the highest value of 4.65 which is 33% increase over the control, the significant effect of pH in $CaCl_2$ could be attributed to the increase in concentration of H^+ in the suspension due to it's displacement by calcium (Yagodin, 1984), this in line with Thomas (1996) who stated that the increased in pH value in the presence of salts indicate that salt is releasing more OH^- than H^+ from the soil. Odedina et al (2003) compared cocoa husk ash and wood ash and observed that the cocoa husk ash improved the soil fertility better than wood ash. They therefore attributed the improvement to quicker mineralization of the nutrients contained in the ash for crop uptake. Ash rates influenced K, Ca, Mg and Na significantly ($P<0.05$), with 8t/ha ash giving the highest K, Ca and Na status while 6t/ha ash gave the highest Mg level.

An increase in soil calcium, potassium and magnesium could have been brought about by the removal of aluminum antagonism to nutrient uptake (especially calcium) by the ash. It was observed that the percentage of potassium is relatively high from the composition of the ash, but the amount in the soil was low after the treatment application, the reason for this could be attributed to the relative high proportion of pH-dependent CEC, which results in an important shift of solution K to the exchangeable phase as pH increase, (Adams, 1984). The decrease in soil exchangeable Mg at 8t/ha of cocoa husk ash application could be attributed to an apparent enhanced uptake of soil Mg in order to offset the increasing imbalance in K/Mg ratio in the plant.

Table 3: Effect of ash application on some soil chemical properties after harvest

Rate	pH (H_2O)	pH ($CaCl_2$)	N%	P(g/kg)	K ←	Ca	Mg cmol/kg	Na →	ECEC	%Base Saturation
Ot/ha	4.37^{a}	3.50^{c}	0.12^{a}	22.00^{a}	0.20^{e}	3.07^{c}	1.10^{a}	1.05^{cd}	6.68^{a}	81.02^{a}
2t/ha	5.64^{a}	4.22^{b}	0.11^{a}	37.70^{a}	0.58^{d}	4.35^{b}	1.40^{a}	1.22^{c}	8.51^{a}	88.72^{a}
4t/ha	5.98^{a}	4.39^{b}	0.11^{a}	46.67^{a}	0.80^{c}	4.51^{b}	1.60^{a}	1.48^{b}	9.30^{a}	90.22^{a}
6t/ha	6.03^{a}	4.51^{ab}	0.10^{a}	31.42^{a}	0.89^{b}	4.82^{b}	1.71^{a}	1.69^{a}	10.01^{a}	91.01^{a}
8t/ha	6.08^{a}	4.65^{a}	0.09^{a}	34.05^{a}	1.15^{a}	6.06^{a}	1.24^{a}	1.69^{a}	10.93^{a}	92.77^{a}

Means having the same letter along the column are not significantly different (P=0.05)
WAP=Weeks After Planting

Table 4 showed the effect of the ash on the exchangeable acidity and extractable aluminum after harvest. The result showed that the ash reduced the exchangeable acidity and the extractable aluminum in the soil. The reduction in exchangeable acidity and extractable aluminum led to an increase in exchangeable cations as shown in table 3, this may be because of the displacement of aluminum and hydrogen ions from the exchangeable site according to Adams (1984).

The effect of ash on plant height (cm) and number of leaves per plants are shown in Table 5 respectively. At 2 WAP, 8t/ha gave a significant ($P<0.05$) increase over the control. However, the treatment did not significantly increased plant height at 4, 6 and 8 WAP. The same trend was observed for the number of leaves per plant.

From the data analyzed for dry matter yield and number of fine root branching (the table is not included in the write up), yield increase was 18, 89, 117 and 163% for 2, 4, 6 and 8t/ha respectively over the control. This increase were significantly different ($P\leq 0.05$) and the increase in the number of roots could because of the reduction in the exchangeable acidity which when in soil solution causes injury and stubby root branching. The good performances of the plant parameters measured could be because there was an improvement of the soil pH and general fertility of the soil which resulted from the application of the ash (Odedina et al 2003).

Table 6; indicate the relationship between soil chemical properties and some yield parameters. There was a positive and significantly ($P\leq 0.05$) relationship between plant height, number of leaves, root and dry matter yield with soil pH (H_2O) .There was also a positive and significantly relationship between number of leaves, number of roots and dry matter yield with exchangeable potassium and calcium. There was a negative and significant ($P\leq 0.05$) relationship between number of leaves, roots and dry matter yield with exchangeable acidity.

CONCLUSION

In summary, Cocoa husk ash which is a plant derived material has a great potential for ameliorating soil acidity as well as supplying plants nutrient elements. 8t/ha of cocoa husk ash gave the optimum value for almost all the soil chemical properties and plant parameters evaluated it is therefore recommended for these soils for maize production.

Table 4: Effect of ash application on exchangeable acidity and extractable aluminum after harvest (cmol/kg)

Rate (t/ha)	Exchangeable acidity	Extractable acidity
0	1.26 [a]	0.63[a]
2	0.96 [a]	0.45[b]
4	0.91 [a]	0.40[c]
6	0.90 [a]	0.32[bc]
8	0.79 [a]	0.22[c]

Means having the same letter along the column are not significantly different (P=0.05)

Table 5: Effect of ash application on plant height (cm) and number of leaves per plant

	Plant height per plant (cm)				Number of leaves per plant			
Rates(t/ha)	2WAP	4WAP	6WAP	8WAP	2WAP	4WAP	6WAP	8WAP
0	22.5[b]	58.1[a]	70.1[a]	87.3[a]	5 [a]	7 [a]	8 [a]	10 [a]
2	26.9[a]	58.2[a]	70.3[a]	90.9[a]	5 [a]	7 [a]	8 [a]	10 [a]
4	26.5[a]	55.2[a]	71.7[a]	102.7[a]	6 [a]	7 [a]	8 [a]	10 [a]
6	27.8[a]	67.8[a]	84.8[a]	102.3[a]	6 [a]	7 [a]	9 [a]	11 [a]
8	30.4[a]	69.1[a]	84.6[a]	92.3[a]	6 [a]	7 [a]	9 [a]	11 [a]

WAP= Weeks after planting

Table 6: Correlation coefficient (r) between soil chemical properties and some yield parameters.

	Yield Parameters			
Soil Properties	Plant height	Number of leaves	Number of root	Dry matter
SoilpH (H_20)	0.98**	0.88*	0.91**	0.79*
Exchangeable acidity	-0.07	-0.91* *	-0.98*	-0.86*
Potassium	0.03	0.87*	0.98*	0.96**
Calcium	0.89	0.90**	0.98**	0.91**
Magnesium	0.65	0.52	0.42	0.35

**r =correlation is significant at 0.01 level
*r= correlation is significant at 0.05 level

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