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Research Paper

USE OF ASH TO IMPROVE THE NUTRIENT CONTENT OF AN ULTISOL AND ITS EFFECT ON MAIZE (Zea mays L.) GROWTH AND DRY MATTER YIELD

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Abstract: This study evaluated the effect of ash from different sources on soil properties ,growth and dry matter yield of maize(Zea mays L) in 2010 and 2011 cropping seasons. The experiment was laid out as a randomized complete block design with four treatments [wood ash(WA), cocnut shell ash(CA) and mixture of WA+CA (WCA)] and five replications. A control was also included. Ash application significantly (p=0.05) increased soil pH, % OM, available P,and Total N in both seasons. Results also show increased ca,k,Na,Mg and ECEC in ash amended plots relative to the control in both seasons. Similarly significantly higher plant height,and dry matter yield were observed in ash amended plot compared to the control in both seasons .Observed results show highest improvement in dry matter yield, plant height and soil properties in plots amended with mixed ash(WCA) in both seasons.

Keywords: ash,dry matter yield,plant height,maize,soil properties.

Introduction

Changes in mineral composition of soils and plants usually result in serious alterations in the plant metabolism. Ash is as valuable as fertilizers and herbicides and as such used as liming materials to reduce the effect of acidity which hinders proper agricultural production in the tropics. According to Tayalakshmi *et al.,* (2007) ash improves soil texture, bulk density, permeability, water holding capacity/aeration, fertility status, resistance to pest attack and reduce crust formation. Research results (Jacobson, 2001; Vuorinen and Kurkela, 2000; Demeyer *et al*., 2001) revealed positive effects of woodash on Ca and K contents of the soil as well as increase of K, Mg, S, Bo, Fe, and Zinc tissues of the Scott pine. Adekayode and Olujugba (2010) reported significantly higher maize grain yield in a plot with a mixture of ash and 200 kgha^{-1} NPK 15 – 15 – 15 fertilizer. Mbah *et al*. , (2010) reported reduction in soil acidity to levels required for maize production in ash amended plots relative to the control. Similarly, Odedina *et al*., (2003) observed reduced acidity and increased cation availability in soils amended with wood ash. Saarsalm *et al*.,(2001) reported increase in the concentration of soil nutrients except N in soil amended with woodash. Bramyrd and Fransman (1995) and Arvidson and Lunkvrst (2003) noted that the enrichment of soil due to ash would cause changes in the metabolism and physiological activity of plants which may manifest in crop yield. However, research efforts on ash have concentrated on wood with little or no research on other types of ash and their effect on soil properties and crop yield. The aim of this study was to find out the effect of ash from different sources and their combination on soil properties and maize dry matter yield.

Materials and Methods

Study area

The experiment was conducted during the growing seasons of 2010 and 2011 at the Teaching and Research Farm of the department of Soil Science and Technology, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri. The area lies between latitude 04^{o}40^{1}N and 08^{o}15^{1}N and longitude 06^{o}40^{1}E and 08^{o}15^{1}E. The area is characterized by high rainfall and high temperature with ranges of 2000 – 2500mm and 26^{o}C – 29^{o}C, respectively. The predominant parent material underlying Imo State from which most of the soils are formed are the coastal plain sands popularly known as acid soil (Orajaka, 1975). The soil is classified as plinthic Tropudult/plinthic acrisol (FDALR, 1985). The main vegetation of the study area is rainforest with poor soil nutrient content as a result of high rainfall enhancing leaching. Farming constitutes a major socio-economic activity in the study area.

Field methods

The site was slashed and cleared of grasses. A total land area of 15.0 m X 13.5 m (202.5 m^{2}) was mapped out on the same plots in the 2010 and 2011 planting seasons. The field was divided into four blocks with each block having five experimental units giving a total of 20 plots. The experimental units were demarcated by 1 m alleys and each plot measures 3 X 3 m (9 m^{2}). The experimental design was randomized complete block design (RCBD). The treatments were: 4 t ha^{-1} wood ash (WA), 4 t ha^{-1} coconut shell ash (CSA), 2 t ha^{-1} WA + 2 t ha^{-1} CSA (WCA) and 0 t ha^{-1} (control). The choice of 4 t ha^{-1} as the rate of the treatments was based on the recommendation of Mbah *et al*., (2010). The experimental plots (raised beds 30 cm high) were prepared manually with traditional hoes and the treatments incorporated into the beds during tillage. The maize variety used was Oba Super 11. Two grains of maize were planted per hole at a depth of 5 cm using 50 cm apart intra and inter – row spacing. The maize plants were thinned to one stand/plot at two weeks after germination.

Observation and data collection

Composite soil samples were collected from ten points at a depth of 0 – 20 cm for pre-planting laboratory analysis. Similarly, auger samples were collected from each plot at 90 days after planting (DAP) for post harvest analysis. Maize dry matter yield was measured at harvest 90 DAP. For plant height and maize dry matter yield measurements, 10 plants were randomly selected, tagged and sampled. The ten plants were uprooted, air-dried and their root cut off. The dried plants were weighed for dried matter yield.

Laboratory methods

The pre and post – harvest soil samples were analyzed in laboratory for N, P, K, Ca, Mg, Na, pH, organic carbon, and CEC. Total N was determined by the macro-kjeldahl method (Bremner and Mulvaney, 1982). Available P was determined using Bray 11 method as outlined in Olsen (1982). Organic carbon was analyzed by Walkley/Black procedure (Nelson and Sommers, 1982). Soil pH in KCl was by the glass electrode pH meter (Mclean, 1982). The exchangeable cations were determined by the method described by Thomas (1982) while the ECEC was determined by summation. Particle size distribution was determined by hydrometer method (Gee and Bauder, 1986).

Data analysis

The data collected from the study was analyzed using analysis of variance test based on RCBD (using F-LSD at $P < 0.05$ according to the procedure outlined by Steel and Torrie (1980).

Results and Discussions

Table 1 shows that the soil of the study area has low OM % content and medium total N and available P contents (Landon, 1991). Application of WA, CA, and WCA significantly ($p < 0.05$) increased the soil OM %, TN%, and available P relative to control in both planting seasons (Table 2). In the first planting season highest available P (73.27 $Mgkg^{-1}$) and OM% (2.33%) contents of the soil was observed in WCA amended plots. The observed OM% of 2.33% in WCA amended plot in 2010 planting season was 29%, 18% and 16 % higher than OM% values in C, CA and WA, respectively. The order of increase in TN% and available P values in 2011 planting season was WA>CA=WCA>C and WCA>WA>CA>C, respectively. Similarly, application of ash increased soil pH in amended plots relative to the control in both seasons. In 2010 planting season observed ash value in C plot was 9%, 6% and 10% lower than values in WA, CA and WCA amended plot, respectively.

Table 1: Initial soil properties of the study site

Parameter	Value
pH	5.30
Organic Matter (%)	1.99
Total N (%)	0.17
Available P ($Mgkg^{-1}$)	25.80
Exchangeable cations ($Cmolkg^{-1}$)	
Ca	4.80
Mg	1.93
Na	0.16
K	0.17
ECEC	8.91
Particle size (%)	
Sand	87.50
Silt	5.88
Clay	6.62

The order of decrease in soil pH in the 2011 planting season was C<CA<WA<WSA. Results of the study (Table 3) show significant ($P < 0.05$) higher exchangeable cations and ECEC values in ash amended plots relative to the control in both seasons. In 2010 planting season Mg and Ca content ranged between 1.83 – 2.98 $Cmolkg^{-1}$and 4.56 – 6.01 $Cmolkg^{-1}$in ash amended plots, respectively. Similarly, Na, K, and ECEC values were observed to be within the range of 0.10 – 0.19 $Cmolkg^{-1}$, 0.12 – 0.17 $Cmolkg^{-1}$and 6.06 – 13.19 $Cmolkg^{-1}$,respectively, in 2011 planting season. In both seasons lowest values of Na, K, Ca, Mg and ECEC were observed in the control (C) plots. Table 4 shows that ash application as soil amendment significantly ($P < 0.05$) increased plant height and dry matter yield relative to the control in both seasons. In 2010 and 2011planting seasons observed plant height in ash amended plots ranged between 98.57 – 110.73 cm and 104.50 – 120.20 cm, respectively. The Table also show significantly higher dry matter yield in amended plots relative to the control. In both seasons WCA amendment gave highest plant height (110 cm and 120.2 cm) and highest dry matter yield (19.34g and 21.92g). The dry matter yield value of 21.92g observed in WCA amended plot in 2011 planting season was 640%, 21% and 7% higher than values in C, CA and WA amended plots, respectively. Higher values of the measured soil and plant parameters were observed in 2011 compared to 2010 planting season. For instance observed Ca, OM%, plant height and dry matter yield values in WCA amended plot in 2011 planting season were 2%, 17%, 9% and 13%, respectively higher than values obtained in 2010 cropping season.

The observed increase in soil pH in ash amended plots relative to the control could be attributed to the effect of ash (which contains Ca) on soil acidity. In a study on the response of maize (zea mays L.) to different rates of wood ash application in an acid ultisol in south east Nigeria, Mbah *et al.,* (2010) reported increase soil pH in ash amended plot. Similarly, Adetunji (1997) observed that ash application in soil reduces soil acidity and increases availability of K, Ca and Mg in soil. Furthermore, the increase in plant height and dry matter yield observed in ash amended plots could be due to improved soil condition as a result of increased levels of exchangeable bases (Ca, Na, K and Mg), OM%, and available P content of the soil. Using ash as amendments Jacobson (2001) and Demeyer *et al*., (2001) revealed that application of ash has positive effect on the Ca and K content of the soil. Similarly, Saarsalmi (2001) reported increased concentration of soil nutrients in soil amended with ash while Arvidson and Lunkvist (2003) observed increased crop yield resulting from enrichment of soil due to ash application. Ojeniyi *et al*.,(2001) reported improved yield of vegetable crops and nutrient level of soil due to wood ash application. In a study on the effect of different crop residue management techniques on selected properties and grain production of maize, Mbah and Nneji (2011) reported improved pH and increased maize yield in plots incorporated with ash. The observed increase in ECEC in ash amended plots could be as a result of increase in soil exchangeable bases (Mg, Ca, K and Na) in line with the observations of Kayode and Agboola (1993).

Table 2: Effect of the amendments on soil pH, avail.P, Total N and organic matter

	2010 planting season				2011 planting season			
Treatment	pH	avail.P (Mgkg^{-1})	OM (%)	TN (%)	pH	avail.P (Mgkg^{-1})	OM (%)	TN (%)
WA	5.64	50.21	1.97	0.17	5.68	53.44	2.01	0.17
CA	5.32	37.02	1.93	0.16	5.29	38.26	1.97	0.16
WCA	5.63	68.71	1.99	0.14	5.74	73.27	2.33	0.16
Control (C)	5.18	25.46	1.86	0.12	5.20	25.03	1.80	0.15
LSD $_{0.05}$	0.11	1.20	0.06	0.03	0.12	0.53	0.15	0.02

WA = wood ash, CA = coconut palm ash, WCA = wood ash + coconut palm ash, C = control

Table 3: Effect of the amendments on soil exchangeable bases and ECEC (Cmolkg^{-1})

	2010 planting season					2011 planting season				
Treatment	Na	K	Mg	Ca	ECEC	Na	K	Mg	Ca	ECEC
WA	0.15	0.16	3.98	4.56	8.63	0.17	0.16	3.44	4.75	9.47
CA	0.17	0.17	1.83	6.06	10.00	0.19	0.16	1.92	8.32	11.01
WCA	0.18	0.17	2.00	6.00	12.03	0.20	0.17	2.16	6.12	13.19
Control (C)	0.11	0.13	1.70	4.50	6.32	0.10	0.12	1.66	4.06	6.06
LSD $_{0.05}$	0.02	0.01	0.38	0.61	1.20	0.03	0.02	0.09	0.19	0.05

WA = wood ash, CA = coconut palm ash, WCA = wood ash + coconut palm ash, C = control

Conclusion

Result of this study shows that ash application improves soil chemical properties leading to increase in maize growth and dry matter yield. Results also show that highest improvement in soil properties, maize growth and dry matter yield were observed in WCA amended plots in both seasons, thus indicating that mixture of ash (from different sources) are better source of soil amendment compared to ash from single source.

Table 4: Effect of the amendments on maize plant height and dry matter yield

	2010 planting season		2011 planting season	
Treatment	Height (cm)	Dry matter yield (g)	Height (cm)	Dry matter yield (g)
WA	105.60	18.33	110.50	20.37
CA	98.51	15.06	104.50	18.10
WCA	110.13	19.34	120.20	21.92
Control (C)	90.02	3.04	87.65	2.96
LSD $_{0.05}$	2.18	0.18	3.27	0.65

WA = wood ash, CA = coconut palm ash, WCA = wood ash + coconut palm ash, C = control

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