Response of Maize (Zea mays L) to Different Rates of wood-ash Application in acid Ultisol in Southeast Nigeria

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Abstract.Maize (Zea mays L) is an important cereal crop in Southeast Nigeria. Yet few data exists on the effect of soil acidity on its production. A field study was conducted in 2007 and 2008 cropping seasons to determine the effect of different rates of woodash on soil properties and maize grain yield. Results of the study showed significant difference ($p< 0.05$) in soil pH , ECEC (Cmolkg-^{1}),OM%, total N%, aggregate stability%, among treatments in both seasons while dispersion ratio (DR) was not significant in the second season. Organic matter concentration ranged between 4.4-15.6 and 4.2-14.8 (g/kg) in the first and second cropping seasons respectively. Maize grain yield varied significantly among treatments except at 4 and 6 t ha-^{1} in both seasons. Wood-ash application generally improved soil properties which in turn enhanced maize grain yield. [Journal of American Science 2009;5(7):53-57]. (ISSN: 1545-1003).

Keywords: *soil acidity, wood-ash, degradation, agricultural soils, lime materials.*

1. Introduction

Maize (*Zea mays L*) belongs to the grain under the family graminae and class of cereals that thrive under a wide range of environmental conditions. Maize does well with pH of 5.5-5.7 while strongly acidic soil (pH $\leq$ 5.0) is unsuitable for good yield. In southeast Nigeria soil acidity is a problem hindering proper agricultural production since most of the crops grown are susceptible to dangerous effects of acidic soils. Ohiri and Ano (1989) attributed the acidic nature of the soils in South east Nigeria to their parent material, leaching and degradation in soil physical properties. To reduce or make the soil less acidic it is common practice to apply lime to agricultural soils. However, the unavailability and high cost of lime materials led to the invention and research into low cost, affordable and adoptable organic and inorganic material like wood-ash (Igbokwe *et al.* 1981). Ojeniyi *et al.* (2001) found that yield of vegetable crops and nutrient content were improved by wood-ash in South east Nigeria. Similarly, Odedina *et al.* (2003) and Adetunji (1997) reported reduced acidity and increased cation availability in soils amended with wood-ash. Omoti *et al.* (1991) indicated that there was great potential of reducing fertilizer and lime bills in maize production of an acidic soil by replacing it with application of wood-ash, since it helps to increase soil pH, available cations and yield. In the study area, Agbani in Enugu South East Nigeria farmers apply wood-ash with out specific recommendation due to lack of research works. The objective of this study was to find out the effects of different rates of wood-ash on soil properties and maize yield with a view to make recommendations on appropriate level for maize production.

2. Material and Methods.

The study was conducted for two consecutive cropping seasons in the Teaching and Research Farm of Faculty of Agriculture and Natural Resources Management, Enugu State University of Science and Technology, Enugu-Agbani Campus. The area lies between latitude 06^{0} 25^{1}N and 07^{0} 15^{1}E with mean elevation of 450m above sea level. The rainfall pattern is bimodal between April and October, while the dry season is between November and March. The soil is lateritic and is of the sandy loam textural class. It is an Ultisol and classified as Typic Haplustult (FDALR,1985).

2.1 Experimental layout and Management.

The experiment was established in April 2007 and laid out as a randomized complete block design (RCBD) with plot sizes of 3m x 4m replicated five times. The land was cleared of vegetation and manually tilled. Four levels of wood-ash (0, 2, 4 and 6 t ha-^{1}) were applied (spread evenly on the soil surface) and incorporated into the soil during tillage. Maize variety oba super 11 was planted at a spacing of 0.5m x 0.5m inter and intra- row, respectively and two maize grains planted per hill. This was thinned down to one plant per hill ten days after germination to give a total plant population of 53,333 plants / hectare. At maturity in 2007 cropping season, maize grain was harvested, air dried and the dry weight taken and expressed on a 12.5% moisture basis. In 2008 cropping season, the area was cleared, tilled and maize planted without addition of woodash to test the residual effect.

Soil was sampled at the beginning of 2007 cropping season and at the end of the study. Soil samples were taken at six different spots per plot and then bulked to one sample and were analyzed for their nutrient content, dispersion ratio and aggregate stability. The soil sample (0-15cm) and woodash were air dried and sieved through a 2-mm sieve. The samples were analyzed for organic carbon, total nitrogen, Mg, Ca, pH, effective cation exchange capacity, Available P, soil aggregate stability and dispersion ratio. Total Nitrogen was determined by Kjeldahl method (Bremner and Mulvaney, 1982) while OC was determined by the Walkey and Black (1934) dichromate oxidation procedure. Soil pH in water (1:2.5 soil to water ratio) was determined using glass electrode pH meter while effective cation exchange capacity (ECEC) was determined by summation. Aggregate stability was determined at the macro-level (WSA>0.5mm) and micro level (dispersion ratio, DR= ratio % silt x clay dispersed in calgon) using wet sewing techniques of Kemper and Rosenau (1986) and the Middleton (1932), respectively.

Data analysis

Data collected from the experiment was analyzed using analysis of variance test based on RCBD (using F-LSD at P=0.05) according to Steel and Torrie (1980).

3. Results

Table 1 show the chemical properties of the soil before the study. The soil was sandy loam in texture with pH of 4.9. The soil OC and TN were 11.1 and 0.56 g/kg, respectively. The exchangeable bases Ca, Mg, K and Na were 0.7, 1.6, 0.09 and 0.17 Cmolkg-^{1} respectively. Analysis of the wood-ash showed that it contains all the nutrients needed by plants. Analysis showed Mg, Ca, K and Available P of 13 Cmolkg-^{1}, 8.6 Cmolkg-^{1}, 50 Cmolkg-^{1} and 10 g/kg respectively.

Table 1: Properties of the soil before study

Parameter	unit	value
Sand	g/kg	490
Silt	,,	250
Clay	,,	260
Texture		sandy loam
PH		4.9
OC	g/kg	11.1
TN	,,	0.56
Ca	Cmol kg-^{1}	0.17
K	,,	0.09
Na	,,	0.17
Mg	,,	1.6
CEC	,,	15.6
Avail P	mgkg-^{1}	3.71

Table 2: **Effect of wood ash on Selected Soil properties**

Treatment	DR	AS%	TN%	OM%	ECEC	pH(H_2O)	Avail .P
Year 1							
No woodash	0.735	38	0.48	0.44	10.6	4.7	3.6
2 t ha-^{1} **WA**	0.753	43	0.58	1.46	18.8	5.4	5.6
4 t ha-^{1} **WA**	0.803	45	0.70	1.53	20.8	5.7	8.4
6 t ha-^{1} **WA**	0.877	46	0.86	1.56	21.8	6.2	10.3
Mean	0.772	43	0.65	1.25	18	5.50	6.98
LSD 0.05	0.06	1.20	0.02	0.02	0.70	0.75	0.30

Year 11

Treatment	DR	AS%	TN%	OM%	ECEC	pH(H_2O)	Avail .P
No woodash	0.712	36	0.40	0.42	6.3	4.6	3.4
2 t ha-^{1} **WA**	0.806	40	0.48	1.30	9.8	5.1	5.5
4 t ha-^{1} **WA**	0.895	43	0.52	1.44	11.3	5.6	6.3
6 t ha-^{1} **WA**	0.883	44	0.60	1.48	12.6	5.8	7.8
Means	0.824	40.8	0.50	1.16	10.01	5.28	5.75
LSD 0.05	NS	2.1	0.02	0.02	0.14	0.14	0.24

NS=Non-significant, DR=Dispersion ratio, AS=Aggregate stability, WA = wood ash

3.1 Effect of wood-ash on soil properties

Table 2 shows the effect of wood-ash on the soil properties. Dispersion ratio (DR) showed significant (P<0.05) difference with the lowest value (0.735) from the control (no wood-ash treated soil) in the first cropping season. In the second cropping the effects of the amendments on DR were not significant. Significant differences were observed in soil aggregate stability (AS) due to wood-ash application. The highest AS value of 46% was observed in 6 t ha-^{1} in the first season. The value was 3%, 7% and 18 % higher than the O, 2 and 4 t ha-^{1} rate of application. In the second season aggregate stability values ranged between 36-44% with 6 tha-^{1} recording the highest value. Similarly, OM showed significant difference (p= 0<0.5) in the both seasons with lowest value (0.44%) in the first season from treatment receiving 0 t ha-^{1} while the highest value (1.56%) was observed in the plots where 6 t ha-^{1} wood-ash was applied. Total nitrogen (TN) content varied significantly with wood-ash levels, increasing directly with a corresponding increase in amount of wood-ash applied. The control had the lowest concentration in both seasons while 6 t ha-^{1} application ratio had the highest concentration. Table 2 also show that values of ECEC cmolkg^{-1} were highest in plots with 6 t ha-^{1} wood-ash in both seasons. Observed ECEC values ranged between 10.6-21.8 cmolkg-^{1} and 6.3-12.6 cmolkg-^{1} in the first and second cropping seasons, respectively. The results in table 2 also showed that pH increased significantly (p=0.05) with the application of different levels of wood-ash. The pH of the un-amended plot were 4.7 in the first season and 4.6 in the second cropping season while those of the amended plots ranged between 5.7-6.2 and 5.1- 5.8 in the first and second cropping seasons respectively. There was minimal difference of 1% and no-difference in yield between 6 t ha-^{1} and 4 t ha-^{1} in the first and second cropping seasons, respectively. Wood-ash treatment significantly affected the maize plant height (Table 3).

Table 3: Effect of wood-ash on plant (cm) and grain yield (t ha-^{1})

Parameter	Plant height (cm)		Grain Yield	
	2007	2008	2007	2008
No woodash	134	80	0.63	0.52
2 t ha-^{1} **WA**	148	124	1.02	0.96
4 t ha-^{1} **WA**	162	148	1.61	1.46
6 t ha-^{1} **WA**	173	153	1.63	1.46
Mean	154.3	126.3	1.22	1.10
LSD 0.05	0.74	1.81	0.04	0.19

WA= Wood ash

The least plant height of 134 cm in the first season was recorded in the un-amended plots. Relatively higher plant heights were observed in the first cropping season. The mean height was 22% higher than the mean height value of 126.3cm observed in the second cropping season. Generally, addition of wood-ash increased maize grain yield relative to the control in both seasons. The treatment 6 t ha-^{1} of wood-ash gave the highest grain yield of 1.63 t ha-^{1} in the first season. This value (1.63 t ha-^{1}) was 1%, 60% and 159% higher than values observed in wood-ash application rates of 0, 2 and 4 t ha-^{1}, respectively. The order of yield increase in the second cropping season was 6 = 4 >2 > 0 t ha-$^{1.}$In both seasons non-significant (p=0<0.05) difference in yield were observed between 6 and 4 t ha-^{1} rate of application.

4. Discussions

Results from this study show that wood-ash when used as soil amendment reduced soil acidity to levels required for maize production. The 4 t ha-^{1} is a good estimate of amount required to significantly improve yield in soils low in pH. Hence wood-ash being a Ca containing mineral raised soil pH. Using Cocoa pod -ash as an amendment Ayeni ***et** al.* **(**2008) reported increased soil $_{P}$H relative to non- ash treated soil. Haynes and Naidu (1998) reported that at low pH acid soils are normally flocculated. As pH is raised by addition of wood-ash the net negative change on soil surface is increased and the ratio of negative to positive (+ve) charges also increases. At same time Al $^{3+}$ activity declines as Al precipitates as hydroxyl- Al polymers. As a result repulsive forces between particles dominate and lead to dispersion. The increased available P could be attributed to traces of P released from Al^{3+} in line with the observation of Ikpe *et al.* (1997). Adetunji (1997) showed that ash derived from wood reduced soil acidity and increased cations / nutrient available in the soil. Similarly, studies by Owolabi *et al.* **(**2003),Odedina *et al.* (2003**)** and Awodun *et al.* (2007) showed that **plant** derived ash increased soil nutrient content. Kayode and Agboola (1993) attributed the increased CEC in wood-ash amended soils to increased cations viz Ca, K and Na. The high ECEC observed in wood-ash amended soil was in line with the observation of Nottidge *et al.* (2006). Baath and Arnebrant (1994) observed the increased soil nutrient due to wood-ash application could be due to enhance microbial activities in the soils and production of organic matter. The increased maize gain yield could be attributed to higher organic matter in the woodash amended plots. Organic matter according to Tisdall (1993) and Brady and Weil (2006) play important roles in essential nutrient availability and soil improvement.

4. Conclusion.

The results of this study showed that wood-ash application improved soil properties and increased maize grain yield. In both seasons application of woodash at 6 t ha-^{1} gave highest grain yield. However, there was no significant difference ($p<0.05$) in grain yield between 4 and 6 t ha-^{1} rate of application. Though application of wood-ash at 6 t ha-^{1} gave highest grain yield, applying at this rate or higher may increase soil nutrient content without necessarily increasing yield. The excess nutrient may be leached to rivers and lakes causing eutrophication or other environmental degradation. This placed 4 t ha-^{1} in this experiment as the optimum rate of woodash application for maize production.

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