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Use of Liming Materials To Reduce Soil Acidity And Affect Maize (*Zea mays L*) Growth Parameters In Umudike, Southeast Nigeria

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Abstract

Pot experiment was conducted at the Michael Okpara University of Agriculture Umudike to ascertain the use of various liming materials in reducing soil acidity and their effect on some maize (*Zea mays L*) growth parameters. The treatments comprised of Calcium Carbonate ($CaCO_3$), Oyster Shell Ash (OSA), Palm Bunch Ash (PBA), Kitchen Residues Ash (KRA) and Saw Dust Ash (SDA) each, at five levels: 0, 2, 4, 6 and 8 tonnes per hectare, and these were replicated three times in a split plot Completely Randomized Design. The effects of the treatments were measured on plant height, number of roots, root lengths, stem diameter and dry matter yield while, soil pH, exchangeable acidity, exchangeable hydrogen and exchangeable aluminum were determined using the standard laboratory procedures. All the data were subjected to the analysis of variance (ANOVA) and the differences between the treatments means separated using the least significant differences at 5% probability level. Linear correlation analyses were done using the GENSTAT package. Among the treatment tested, 4t/ha of kitchen residue ash significantly ($P<0.05$) increased maize yield, root length, number of roots and dry matter yield, while 4t/ha of oyster shell ash significantly reduced the soil acidity and hydrogen. The soil pH correlated positively with plant height, root number and root length. Further research is recommended for the field application of the treatment on maize production.

Key words: Soil acidity, liming materials, maize growth parameters, Pot experiment and linear correlation

Introduction

Maize (*Zea mays L.*) is a very important crop in the tropics grown for a lot of purposes ranging from direct consumption by man and animals to various industrial uses (Powell, *et al.*, 2004). The production of maize in Southern Nigeria has being in the decline for some decades now (Eleweanya, *et al.*, 2005) and part of this decline has been attributed to soil acidity problem in the area (Pandey, *et al.*, 1994), which has reduced the soil pH to less than 5.5 (Ahn 1993). Maize has been found to do well in pH values of 6.5-8 (IITA 1982) and any pH below these values will affect its growth. In order to ameliorate this problem of soil acidity, farmers in the area practice slash and burn agriculture with the aim of adding ash to the soil, so as to reduce soil acidity and also to help the soil release certain nutrients accumulated in vegetation during the fallow period (Khanna and Raison 2006). Burning of the farm land causes more harm than good, this is because it kills off most soil beneficiary micro organisms, destroys the soil aggregate stability, causes soil erosion and increase the volatilization of elements like nitrogen and Sulphur from the soil. Due to the detrimental effect of the slash and burn practice on the soil, there is need to have an organized burning of the plant residues so as to prevent the damage done by the burning on the soil properties. Many researchers (Opara-Nadi and Oranekwulu, 1988; Omoti, *et al*., 1991; Olu-Obi and Akinsola, 1995) had worked on the complementary effect of conventional lime or ash and fertilizer or animal manure in improving soil fertility but not much work had been carried out on comparing different types of non-conventional liming materials on maize production. Therefore the objectives of this work were to determine the effects of the liming materials and rates interactions on soil acidity indices and maize growth parameters in Umudike area of Southeast Nigeria.

Materials and Methods

Composite soil samples were collected from the Michael Okpara University of Agriculture Umudike and National Root Crops Research Institute Eastern farms located on latitude 05° 29` N and on longitude 07° 33` E, with an elevation of 122m above sea level. Umudike is located within the tropical rainfall zone with a mean rainfall of 2117mm, distributed over nine to ten months in a bimodal rainfall pattern. These are the early rains (April -July) and late rains (August -October) with five months of dry season and a short dry period in August and is popularly called August break. Soils were sampled from the depth of 0-30cm, air dried, sieved through 2mm sieve and a sub sample of ten kilograms (10kg) weighed and placed into 12 liter plastic buckets. . The treatments consisted of five liming materials namely: Kitchen residue ash (KRA), Palm bunch ash (PBA), Oyster shell ash (OSA), Calcium carbonate ($CaCO_3$) and Saw dust ash (SDA) each at five rates; 0t/ha (control), 2t/ha, 4t/ha, 6t/ha and 8t/ha laid out in a split plot completely randomized design and replicated three times giving a total of seventy- five buckets. The treatments were applied two weeks before planting. The liming materials were applied on air-dry weight basis before planting; the soil and ash were mixed thoroughly. .The test crop was maize (Oba super 11) and two seeds were sown per pot and later thinned down to one plant per pot. The plants were allowed to grow for 8 weeks and the following parameters measured; plant height, dry matter yield, number of fine branching roots, roots length and stem diameter. Chemical analysis was done on the soil before treatment application and after plant harvest. Soil pH in water was determined in soil to water ratio of 1: 2.5 (Mclean 1982); exchangeable acidity, exchangeable hydrogen and exchangeable aluminum were determined by the method of Black (1965). The data generated were subjected to analysis of variance (ANOVA) for split plot design in CRD using the MSTATC software package while the means were separated using the Fisher's Least Significant difference (Lsd) and linear correlation analysis was done using GENSTAT package.

Results

Some of the chemical properties and the textural class of the soil used are shown in Table 1. The soil belonged to the textural class of sandy loam with a pH of 5.20 and an exchangeable acidity of 2.00cmol/kg and thus it is acidic. According to Chude *et al*, (2005), soils with pH values of less than 5.50 are considered as acidic.

Table 1: Some physical and chemical properties of the soil before treatment application in the experiment

Soil properties	Value
Sand (%)	85.00
Silt (%)	9.00
Clay (%)	6.00
Textural class	Sandy loam
Soil pH (H_2O)	5.20
Exch Acidity (Cmol /kg)	2.00
Exch Hydrogen (Cmol /kg)	0.50
Exch Aluminum (Cmol /kg)	1.50

Exch = Exchangeable

Effect of liming materials and rates on soil pH

The result of the treatments on the soil pH at the end of the experiment is shown in Table 2. The soil pH was significantly (P<0.05) increased from 5.20 to 8.04 by 8 tonnes per hectare of Calcium Carbonate, while increases from 8 t/ha of other liming materials ranged between 6.05 – 6.55 a condition conductive to maize growth.

Exchangeable acidity, Exchangeable aluminum and Exchangeable Hydrogen

The result obtained from the application of the treatments on soil exchangeable acidity and exchangeable aluminum (Table 2) showed that 4t/ha of Oyster shell ash significantly (P<0.05) reduced the soil exchangeable acidity and exchangeable hydrogen among the other treatment tested although it was statistically at par with the other rates of oyster shell ash. It was also observed that 4 t/ha, 6t/ha and 8t/ha of Oyster shell ash significantly (P<0.05) reduced the soil exchangeable acidity over the other treatment interactions (Table 2).

Table 2: Effect of the liming materials and rates on soil acidity indices

Liming material	Lime rate (t/ha)	Soil pH	Exch. Acidity (cmol/kg)	Exch. Aluminum (cmol/kg)	Exch. Hydrogen (cmol/kg)
$CaCO_3$	0	5.20	1.44	1.00	0.44
	2	5.96	0.33	0.17	0.16
	4	6.16	0.34	0.18	0.16
	6	7.36	0.40	0.10	0.30
	8	8.04	0.45	0.15	0.30
KRA	0	5.22	1.47	0.74	0.73
	2	5.98	0.33	0.11	0.22
	4	6.68	0.40	0.28	0.12
	6	6.31	0.46	0.21	0.22
	8	6.55	0.50	0.25	0.25
SDA	0	5.20	1.57	1.20	0.37
	2	5.96	0.31	0.11	0.20
	4	6.25	0.50	0.35	0.15
	6	6.38	0.31	0.21	0.10
	8	6.64	0.16	0.07	0.09
OSA	0	5.21	1.47	1.21	0.26
	2	5.84	0.18	0.08	0.10
	4	6.89	0.10	0.02	0.08
	6	6.78	0.13	0.05	0.08
	8	6.64	0.13	0.05	0.08
PBA	0	5.23	1.53	0.85	0.68
	2	5.83	0.34	0.17	0.17
	4	5.76	0.22	0.10	0.12
	6	5.98	0.35	0.12	0.23
	8	6.05	0.33	0.17	0.16
Lsd	(P<0.05)				
Liming material (1)		NS	0.29	NS	0.19
Limerate (2)		0.66	0.31	0.26	0.17
1x2		0.84	0.35	0.30	0.27

$CaCO_3$ = Calcium Carbonate, KRA= Kitchen residue ash, SDA= Saw dust ash, OSA= Oyster shell ash, PBA= Palm bunch ash. Exch= exchangeable

Maize plant height

The effect of the liming materials and rates on maize plant height is shown on Fig 1. The result obtained revealed that 4t/ha of kitchen residue ash significantly (P<0.05) increased the plant height.

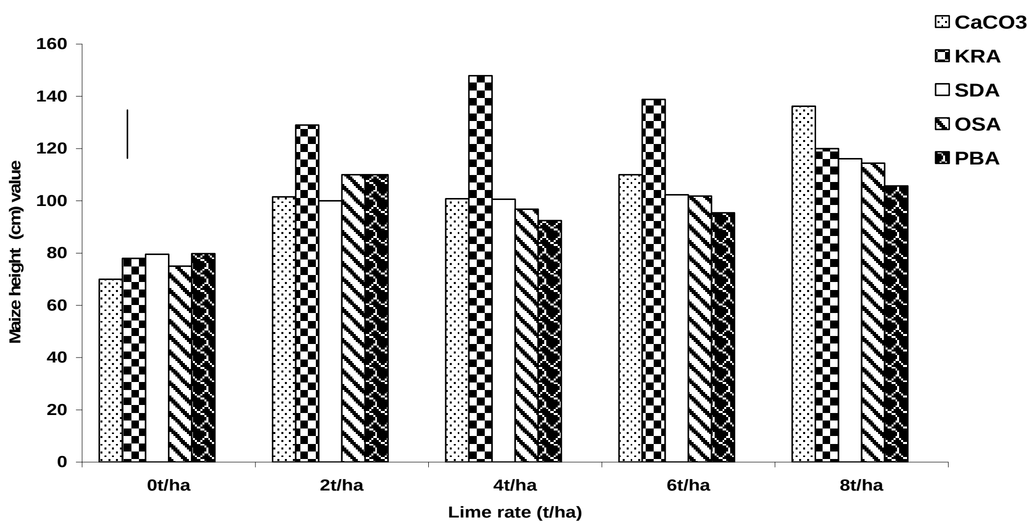

Fig 1: Effect of liming material and lime rate interaction on maize height (cm) at 8 weeks after planting. Vertical bar represent lsd 0.05

Stem diameter

The effect of the liming materials on stem diameter is shown in Fig 2. The result showed that 4t/ha of palm bunch ash significantly (P<0.05) increased the stem diameter over the other treatments tested.

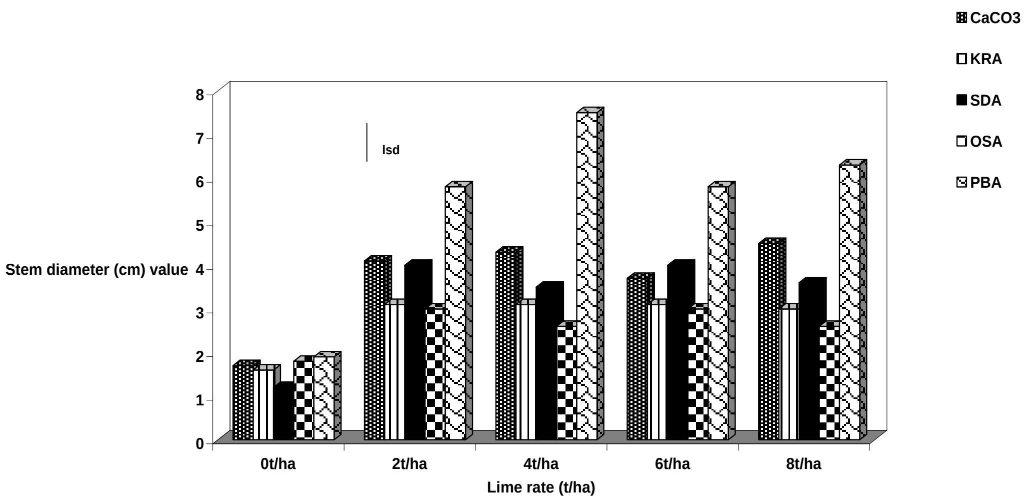

Fig 2: Effect of liming material and rate on maize stem diameter (cm) at the end of the experiment. (Vertical bar represents lsd at 0.05)

Effect of the liming materials and rates on number of roots and root length

From Table 3, kitchen residue ash applied at 4t/ha had significantly higher rootlets and root length when compared to the other treatment interactions. For the dry matter yield, 4t/ha of kitchen residue ash significantly ($P<0.05$) increased the dry matter yield and this was followed by 6t/ha of the kitchen residue ash which was not statistically different from 4t/ha.

Effect of treatments on dry matter yield of maize

The result obtained showed that 4t/ha of the kitchen residue ash (Table 3) significantly increased the maize yield over the other treatment interactions.

Correlation relationship between some acidity indices and maize growth parameters

The correlation between soil chemical properties and maize yield parameters are shown in Table 4. From the table, soil pH correlated positively with all the growth parameters except stem diameter in which it correlated negatively. There was a highly significant correlation ($P < 0.001$) between soil pH, plant height, root number and root length. Exchangeable acidity was highly significant ($P < 0.001$) but negatively correlated with number of roots and roots length, it also correlated negatively with plant height and dry matter yield. It correlated negatively but not significantly with stem diameter. Exchangeable hydrogen correlated negatively with all the growth parameters but there was no significant correlation between exchangeable hydrogen and plant height and root length. Exchangeable aluminum followed the same trend as exchangeable hydrogen by correlating negatively with all the growth parameters determined. Highly significant correlation ($P < 0.001$) existed among exchangeable aluminum, dry matter yield and root number.

Table 3: Effects of the liming materials and rates on plant parameters

Liming material	Lime rate (t/ha)	Root Length (cm)	No of rootlet	Dry matter yield (kg/pot)
$CaCO_3$	0	8.41	12.00	12.13
	2	21.00	24.00	28.40
	4	21.05	25.00	20.87
	6	21.02	23.00	26.17
	8	25.10	22.00	34.13
KRA	0	9.03	15.00	12.23
	2	22.06	20.00	46.73
	4	29.00	33.00	57.27
	6	24.08	23.00	55.77
	8	27.22	23.00	42.17
SDA	0	9.00	11.00	14.03
	2	18.10	23.00	19.07
	4	19.00	19.00	30.53
	6	22.20	24.00	39.89
	8	23.71	25.00	47.43
OSA	0	11.20	11.00	11.07
	2	21.20	23.00	23.05
	4	21.20	24.00	21.27
	6	22.21	24.00	21.67
	8	24.20	24.00	32.97
PBA	0	11.00	10.00	14.53
	2	20.30	18.00	35.93
	4	21.07	27.00	36.17
	6	25.30	27.00	49.57
	8	24.23	24.00	48.83
Lsd	($P<0.05$)			
Liming material (1)		NS	NS	NS
Lime rate (2)		8.69	3.93	12.32
1x2		9.00	3.93	14.30

Table 4: Correlation between soil acidity indices and maize yield parameters

Soil properties	Plant height	Stem diameter	Drymatter yield	Root number	Root length
pH (H_2O)	0.64***	-0.09^{ns}	0.30^{ns}	0.56***	0.61***
Ex Acidity	-0.52**	0.23^{ns}	-0.54*	-0.70***	-0.62***
Ex. H_2	-0.37*	-0.26^{ns}	-0.27^{ns}	-0.33^{ns}	-0.45*
Ex Al	-0.50**	-0.14^{ns}	-0.50***	-0.70***	-0.57***

*** = Significant at P < 0.00   * = Significant at P < 0.05
** = Significant at P < 001   ns = Not significant

Discussions
The results obtained from the experiment showed that the application of the tested liming materials increased the soil pH, reduced soil exchangeable acidity, exchangeable aluminum and exchangeable hydrogen. This is because the liming materials contained basic cations (Fageria, *et al.,* 2007) and basic anions (CO_3^{-2}) that are able to pull H^+ from exchange sites to form $H_2O + CO_2$. Cations occupy the space left behind by H^+ on the exchange. This result was in agreement with Voundi Nkana *et al*. (1998) and Ojeniyi *et al* (1999) who reported that working with 2, 4, 6 and 8 tons per hectare of ash increased the soil pH. The increase in the maize root was as the result of the liming materials, which provided basic cations especially calcium that suppressed the toxicity of aluminum in the soil and this enhanced the activities of the roots by creating a better environment for the release of phosphorus, which helps in the root development and growth. Franco and Mumns (1982) reported that increasing the concentration of calcium in the soil reduced the aluminum toxicity in bean root. Dierolf, *et. al.,* (1997) also reported that application of lime to maize allowed the roots of maize to move up to 15 to 30cm of depth in an acid soil. When the plant roots are increased, it will translate to the aerial biomass increase and that could be the reason while the kitchen residue ash gave the highest roots number, length and the highest plant growth. The increase of the stem diameter by the rates of the palm bunch ash could be as the result of the potassium content of the palm bunch which according to Chude, *et al.,* (2004) is responsible for the development of the stalks and its deficiency results in weak stalk and lodging of the plants. The kitchen ash increased the dry matter yield because it also increased the plant height. Increase in plant height has been reported by some researchers to increase the plant dry matter yield. The soil properties that correlated positively with the yield parameter, implies that as the soil properties are increasing the yield parameters were also increasing. Therefore the addition of the liming materials which increase the levels

of the parameters impacted positively on the yield of maize in the soils. As the exchangeable aluminum is reduced, the plant roots performances are enhanced (Le Van, *et al.*, 1994), nutrient uptake would be effective and increased and this in return would lead to increase in the plant yield parameters. The correlation study in the work showed that aluminum affects maize root. This trend agreed with Comin, *et al* (2006) who observed in their work, on the effects of aluminum on the adventitious root system, aerial biomass and grain yield of maize grown in the field that aluminum, negatively affected the root branching and root length of two maize hybrid cultivars C525M and HS 7777 .

Conclusion

The results of the study showed that the application of the liming materials increased soil pH and reduced soil exchangeable acidity, hydrogen and aluminum and also increased maize plant height stem diameter, number of roots and root length in the study area. Among the liming materials and lime rate interaction tested, 4t/ha of kitchen residue ash significantly ($P<0.05$) increased maize plant height, number of roots, root lengths and maize dry matter yield while 4t/ha of oyster shell ash significantly ($P<0.05$) reduced soil exchangeable acidity and aluminum. The results showed that 4t/ha of kitchen residue ash and oyster shell gave the over all best performance in reducing soil acidity and supporting the production of maize in the study area. Further research is recommended for the field application of the treatments on maize production.

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