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SOME PHYSICAL AND CHEMICAL PROPERTIES OF SOIL AFFECTED BY THE APPLICATION OF DIFFERENT SOURCES OF LIME IN ABUJA, NIGERIA

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ABSTRACT
A field experiment was conducted at University of Abuja Teaching and Research farm, F.C.T-Abuja, Nigeria to determine the effects of different sources of lime on soil properties. The experiment was laid out in a Randomized Complete Block Design (RCBD) in factorial fashion comprising six treatments replicated three times. The treatment includes two types of industrial lime (ultrasol - V_1 and agricultural lime – V_2) applied at three different levels. Data collected from the study were analyzed using Analysis of Variance (ANOVA) and means were separated with Duncan's New Multiple Range Test (DNMRT). The result obtained showed a high significant effects of treatments on soil chemical properties. The soil chemical properties were calcium (Ca), with the application of V_2L_1 (1000kg/ha) giving the highest value relative to other treatments and control. Soil exchangeable magnesium showed a significant effect in the control plot (V_2L_o). Percent organic carbon and percent organic matter content in the soil were highly significant in plots treated with V_1L_2 (ultrasol lime at 2000kg/ha). Exchangeable potassium (k) and sodium (Na) produced the highest values in plots amended with V_1L_1 (ultrasol lime at 1000kg/ha) though not significant. Base saturation was increased though not significant in V_2L_1 (agricultural lime at 1000kg/ha) treated plot. CEC (Cation Exchange Capacity) increased in the V_2L_0 (agricultural lime at 0kg/ha) but was not significant. Exchangeable acidity reduced greatly in V_1L_2 and V_2L_1 treated plots. Electrical conductivity in the soil and percent total nitrogen showed no significant difference but produced the highest values in plots amended with V_1L_1. Manganese (Mn) and copper (Cu) in the soil were influenced by treatments with the lowest values in plots treated with V_2L_2 (agricultural lime at 2000kg/ha) though not significant. Iron (Fe) was reduced in plot treated with V_1L_0 (ultrasol lime at 0kg/ha) but was not significantly different. Zinc (Zn) was completely eliminated on the application of both agricultural and ultrasol limes. Available phosphorus had no significant influence on the amended plots and control. Soil pH (in water (H_2O), potassium chloride (KCl) and in calcium chloride ($CaCl_2$) showed no significant effect on treatments and control. Based on the following results, the use of agricultural lime (V_2) and ultrasol lime (V_1) both at 1000kg/ha and 2000kg/ha could be recommended for improving soil properties.

Keywords: Abuja, Chemical Properties of Soil, Physical, Sources of Lime.

INTRODUCTION
Liming is an important practice to achieve optimum yields of all crops grown on acid soils. According to Kaitibie *et al.* (2002), liming is the most widely used long-term method of soil acidity amelioration, and its success is well documented. Application of lime at an appropriate rate brings several chemical and biological changes in the soils, which are beneficial or helpful in improving crop yields on acid soils (Fageria and Baligar, 2008).

Industrial liming materials including locally available carbonates are relatively common in many countries of sub-Saharan Africa and are well suited for small scale mining and processing (Van-Straaten, 2002). Nigeria has relatively good source of lime mainly in the Southwest and middle belt regions of the country such as factories at Calabar, Cross River State; Sokoto, Sokoto State; Nkalagu, Enugu State; Okpella, Edo State; Ashaka, Gombe State; Gboko, Benue State; Ewekoro and Shagamu, Ogun State, Lagos State and Obajana in Kogi State. The resource base of the known limestone deposits is about 2.3 trillion metric tons and 568 million tons of proven reserves (Oguntoyinbo *et al.,* 1996). However, all of the available industrial liming materials have not been evaluated and compared to determine their effects on soil properties and crop production in Abuja.

Acidity affects the fertility of soils through nutrients deficiencies (phosphorous (P), Calcium (Ca) and magnesium (Mg)) and the presence of phytotoxic nutrients such as soluble Al and Mn. Application of lime reduces Al toxicity, improves pH, Ca, Mg and increases both P uptake in high P fixing soil and plant rooting system (Black, 1992).

MATERIALS AND METHODS

The Study Area

Field experiment was conducted at University of Abuja Teaching and Research farm, main campus Gwagwalada during the 2017 cropping season. It is a small agricultural and industrial center of the FCT. Gwagwalada, Nigeria is located at Nigeria country in the Towns place category with the GPS coordinates of 8° 57' 2.9988" N latitude and 7° 4' 36.2532" E longitude. It has an annual rainfall of 1271 mm with average temperature ranging between 27.2^{0}C to 37^{0} C in the prescribed zone (Gwagwalada Wikipedia, 2017).

Limes Source

Agricultural lime and Ultrasol lime were purchased from the local market.

Field Experimental Design

The experimental design was a Randomized Complete Block Design (RCBD) in factorial fashion with six treatments replicated three times. The treatments comprised of Agricultural lime and Ultrasol lime that was applied at three levels each. Each experimental unit was 1 m X 1 m in size.

Land Preparation

Land was prepared using hand hoe (first and second ploughing) before lime application. Application of limes were done two weeks before transplanting by broadcasting method on each prepared bed and incorporated into the soil, after which the soil was moist for two weeks (Fageria and Baligar, 2008). An alley of 1m was left between blocks and 0.5m between plots.

Soil Sampling and Analysis

Composite soil samples on the field were collected with an auger at a depth of 0-20 cm per plot using the zig-zag method (Carter and Gregorich, 2008), before application of limes and transplanting, and after harvest for soil analysis. Soil samples were taken from each plot for selected soil physical and chemical properties. The samples were placed in a clean and well labeled nylon.

Furthermore, the samples were air dried on a clean sheet of paper, crushed and sieved with a 2 mm size sieve to remove materials greater than 2 mm.

Some important physical and chemical properties of the Soil such as Soil texture, Soil pH, Organic carbon content, Total Nitrogen, Available phosphorous (Bray 1–P), Exchangeable bases Exchangeable acidity (H^{+} and Al^{3+}), C E C and few available micronutrients were analyzed using discrete procedures. Base saturation percentage was determined by calculation thus.

Statistical Analysis

The data were subjected to Analysis of variance (ANOVA) using R-Statistical Software Version 3.5.1. Significant means separation among treatment was done using standard error of difference between means and Duncan's New Range Multiple Test (DNRMT) at the 5% probability level.

RESULTS AND DICUSSION

Properties of Soil of the Study Area

The properties of soil of the study area are shown in Table 1. The soil was sandy loam in texture according to the textural classification (USDA) (Soil Survey Division Staff, 1993). The pH of soil in water, potassium chloride and calcium chloride medium with the following values of 6.45, 5.34 and 5.98 shows that the soil was slightly acidic. This confirmed the findings of the Soil Survey Staff (1993). Exchangeable bases in the soil were generally low with the following values of 3.98 cmol/kg, 1.94 cmol/kg, 0.72 cmol/kg and 0.30 cmol/kg recorded for calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na). These values are in conformity with the values recorded by Asadu and Nweke (1999). Exchangeable acidity (H+Al) was low with the value 1.34cmol/kg. This reflects that such value may not hinder crop production in the ecological zone as reported by Ukpong (1995) who worked in a more acidic soil in the mangrove swamps of south-eastern Nigeria. Electrical conductivity (EC) was low with the value 0.088 dS/m which shows that the soil was slightly acidic. Available phosphorus was low with value 0.005%. This value was lower than the critical level of 0.0073% according to Howeler (1991). Cation Exchange Capacity (8.28cmol/ kg) was low. This was compare to the findings of Asadu and Nweke (1999) in their report. Percent Total Nitrogen (N) with the value 1.86% was high. This value was higher than the value of 0.2%N, given by Howeler (1991). Base saturation was high (83.82%). This was compared to the high base saturation value (>50%) reported by the Soil Survey Staff (1993). Percent organic carbon and organic matter contents were low with the value 0.68% and 1.17%.This confirmed the findings of the Soil Survey Staff (1993).

Effects of Different Sources of Lime on Soil Properties

The effects of different sources of lime on particle size distribution of the trial area are shown no significance. Effects of different sources of lime on soil reaction (pH) in water, potassium chloride and calcium chloride are shown in Table 2. Soil reaction (pH) in water was higher though not significant in plot treated with V_2L_1 (Agricultural lime) at 1000kg/ha with the value 7.1 compared to other amended plots while the least value of soil pH (H_2O) was recorded in the control. Since reactivity of limestone depends on how finely it is ground, it therefore reflects that agricultural lime has a finer particle size compared to ultrasol lime. This further confirmed the findings of Snyder and Leep (2007) that lime is lowly soluble in water, so particles must be finely ground to neutralize soil acidity for a reasonable period of time. And that effectiveness depends on the purity of the liming material and how finely it is ground. Soil pH in potassium chloride increased but not significant with the value 6.5 in plot treated with V_2L_1 at 1000 kg/ha closely followed by V_1L_1 (ultrasol lime) at 1000kg/ha. The increase of soil pH in potassium chloride was in the order V_2L_2 (Agricultural lime) at 2000kg/ha > V_2L_o (control) > V_2L_0 (control) > V_1L_2 (ultrasol lime) at 2000kg/ha. The application of limes did not have any significant difference on soil pH in calcium chloride, though it increases the soil pH. And plot treated with V_2L_1 at 1000kg/ha recorded the highest value (6.42) relative to other amended plots and control.

Table 1: Properties of Soil of the Study Area

Soil Parameters	Unit	Value
pH (H_2O)		6.45
pH (KCl)		5.34
pH ($CaCl_2$)		5.98
EC	dS/m	0.088
Organic carbon (OC)	%	0.68
Organic carbon (OM)	%	1.17
Total Nitrogen (N)	%	1.86
Available phosphorus (P)	%	0.005
Mn	$mgkg^{-1}$	156.49
Fe	$mgkg^{-1}$	61.23
Cu	$mgkg^{-1}$	1.77
Zn	$mgkg^{-1}$	6.10
Exchangeable acidity (H+Al)	$cmolkg^{-1}$	1.34
Exchangeable bases	$cmolkg^{-1}$	
Ca		3.98
Mg		1.94
K		0.72
Na		0.30
CEC	$cmolkg^{-1}$	8.28
TEB	$cmolkg^{-1}$	6.94
Base saturation	%	83.82
Clay	%	10
Silt	%	34
Sand	%	56
Textural class		Sandy loam

Table 2: Effects of Different Sources of Lime on Soil Electrical Conductivity (EC), Organic Carbon (OC), Organic Matter (OM), Total Nitrogen (N) and Available Phosphorus (P)

Treatment (kg/ha)	EC (ds/m)	OC (%)	OM (%)	Total Nitrogen (%)	Available P (%)
V_1L_0	0.34	1.51b	2.5ab	9.35	0.0082
V_1L_1	0.53	1.73ab	2.97ab	13.63	0.0051
V_1L_2	0.23	1.92a	3.3a	6.35	0.0036
V_2L_0	0.20	1.73ab	2.97ab	6.03	0.0062
V_2L_1	0.24	1.67ab	2.87ab	8.65	0.0038
V_2L_2	0.25	1.75ab	3.01ab	7.77	0.0033
	NS	*	*	NS	NS

V_1 = Ultrasol lime, V_2 = Agricultural lime, L_0 = at 0kg/ha, L_1 = at 1000kg/ha, L_2 = at 2000kg/ha. WAT = Weeks after Transplanting. NS= Not Significant; * Significant at 5% level of significance.

Responses of pH to lime application were also observed (Figure 1 and 2) in tropical soils in several regions of the world as reported by Caires *et al.* (2006). The rise in pH and reduction of soil exchangeable acidity is associated with the presence of basic cations (Ca^{2+} and Mg^{2+}) as reported by Fageria *et al.* (2007) and anions (CO_3^{-2}) in lime that are able to exchange H^+ from exchange sites to form $H_2O + CO_2$. Cations occupy the space left by H^+ on the exchange leading to the rise in pH.

Electrical conductivity (EC) of the soil (Figure 3) showed no significant effect on treatments application, though treatments increased its values, and the highest mean value (0.53dS/m) was observed in plot treated with V_1L_1 compared to other treated plots and control.

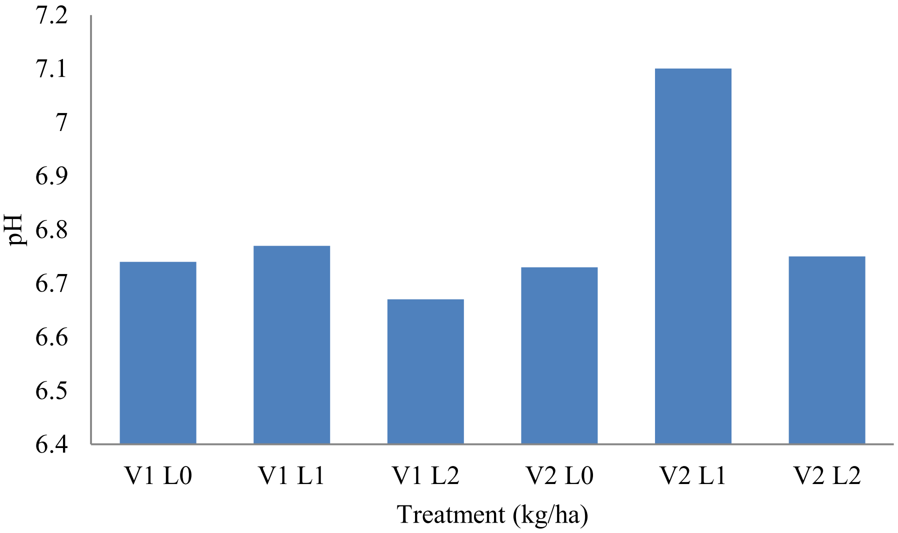

Figure 1: *Effects of different sources of lime on soil reaction (pH) in water (H_2O), pH (H_2O)*

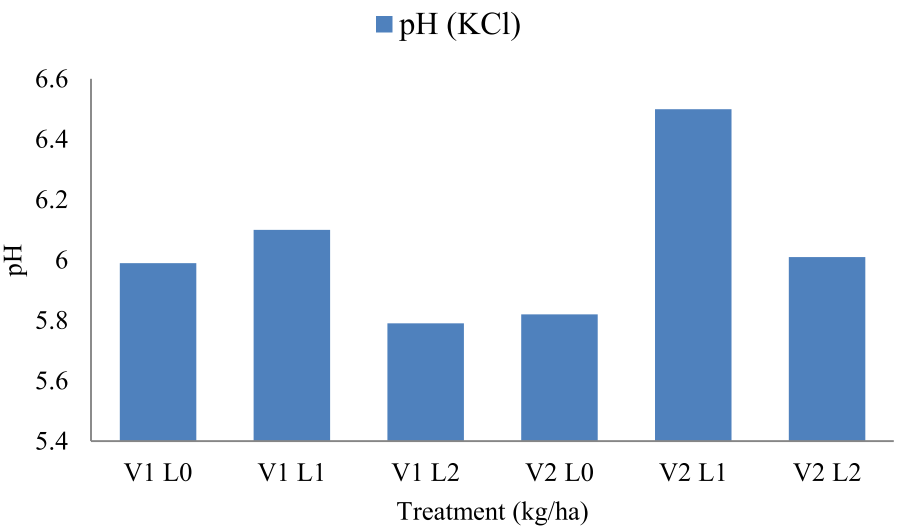

Figure 2: *Effects of different sources of lime on soil reaction (pH) in KCl*

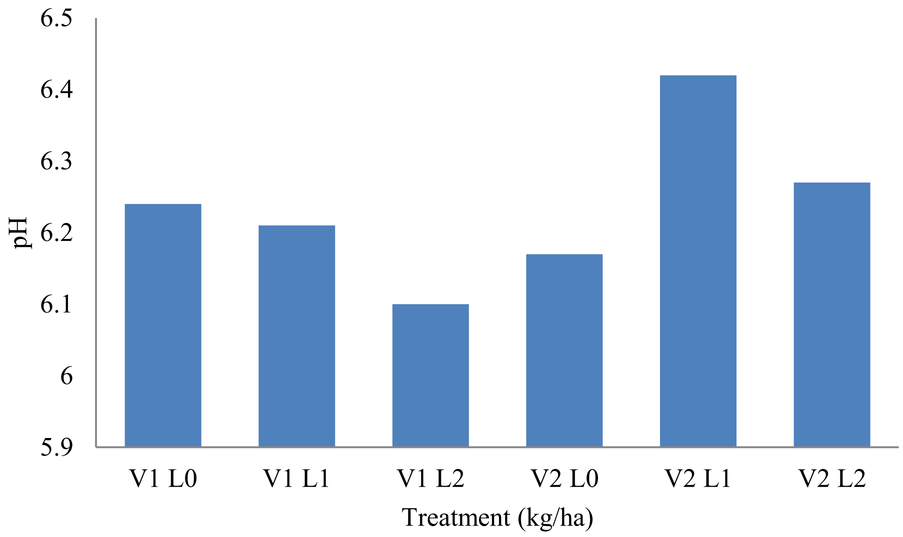

Figure 3: *Effects of different sources of lime on soil reaction (pH) in calcium chloride ($CaCl_2$) pH ($CaCl_2$)*

The increase in percent organic matter content in the soil was in the order V_2L_0 (control) and $V_1L_1 > V_2L_1$. The lowest mean value was observed in the V_1L_0 (control) plot. The significant increase in the percent organic carbon and percent organic matter content of the soil with the application of V_1L_2 depicts that this lime at this rate had the ability to improve the percent organic carbon content of the soil as well as the percent organic matter content of the soil compared to agricultural lime. This confirmed the findings of Fageria and Stone (2004) who showed that liming raises soil pH, base saturation, and Ca and Mg contents and reduces aluminium concentration in acidic soils.

Percent total nitrogen showed no significant effect on lime application. However, the plot treated V_1L_1 produced the highest mean value (13.63%) compared to the control and other treated plots. V_2L_0 (control) showed the least value (6.03%) of percent total nitrogen. Available phosphorus showed no significant difference on plots with treatment, but rather, the highest value (0.0082%) was observed in the V_1L_0 (control), while the least value was obtained in plot treated with V_2L_2 at 2000kg/ha. This confirmed Haynes (1992) report who studied the effect of liming on phosphate adsorption availability in acid soils.

The Effects of different sources of lime on soil exchangeable acidity is shown in Figure 4. Exchangeable acidity in the soil showed no significant difference but was greatly influenced on limes application. Plot treated with V_1L_2 and V_2L_1 greatly reduced the soil exchangeable acidity with the values (0.47cmol/kg) and (0.47cmo1/kg) compared to other amended plots. The highest values (0.87cmol/kg) and (0.6cmol/kg) were observed in the control plots (V_1L_0) and (V_2L_0).

The lowest values obtained in plots treated with V_1L_2 and V_2L_1 show that both ultrasol lime at 2000kg/ha and agricultural lime at 1000kg/ha were more effective and faster in ameliorating the soil exchangeable acidity than ultrasol lime at 1000kg/ha and agricultural lime at 2000kg/ha.

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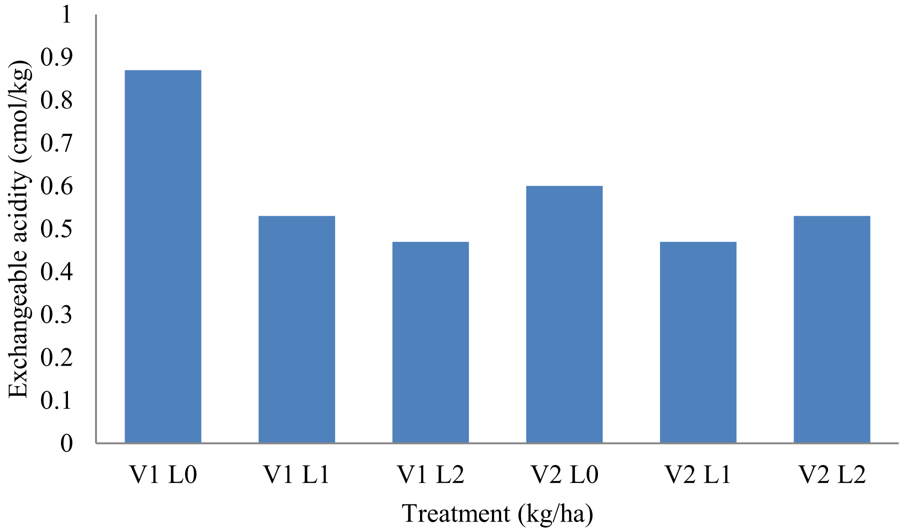

Figure 4: *Effects of different sources of lime on soil exchangeable acidity (H + Al) exchangeable acidity (H + Al)*

Effects of different sources of lime on soil exchangeable calcium, magnesium, potassium, sodium, cation exchange capacity and Base saturation are shown in Table 3. Exchangeable calcium significantly ($p<0.05$) increased in plot treated with V_2L_1 at 1000kg/ha with the value (7.23) compared to the value (6.19) observed in plot treated with V_1L_2 at 2000 kg/ha which was higher than the control plots. This result supports the findings of Fageria and Stone (2004) who observed that liming raises exchangeable calcium in acidic soils. Exchangeable magnesium in the soil showed a significantly higher value (4.09cmol/kg) in the control (V_2L_0) plot and was closely followed by V_2L_2 treated plot. The increase in soil exchangeable Mg was of the order $V_1L_2 > V_1L_1 > V_2L_1$ while the least value was observed in V_1L_0 (control) plot. The increase in the soil exchangeable magnesium after liming is attributed to Uchida and Hue (2000) report. Exchangeable potassium in the soil showed no significant difference on liming, but was increased with the value (1.52cmol/kg) in plot treated with V_1L_1 compared to the control (V_1L_0) and other amended plots.

The increase of Ca, Mg, K and Na in the soil are attributed to increase in pH that reduces toxicity of phytotoxic levels of Al compared to Fageria and Baligar (2008) report. Cation Exchange Capacity in the soil showed the highest mean value in (V_2L_0) relative to V_2L_1 and other amended plots though it was not significant and the least value (9.99cmol/kg) was observed in the control (V_1L_0) plot. The increase in CEC due to liming could be attributed to the change in pH as reported by Fageria and Baligar (2008) and the release of the initially blocked *isomorphous* and inter layer substitution negative charge by deprotonation of the variable charge minerals and functional groups of humic compounds caused by Ca^{2+}. Base saturation showed no significant difference but was influenced by the treatments and the highest value (96.18%) was obtained in V_2L_1 amended plot compared to other treated plots, while the least mean value (89.42%) was observed in the control (V_1L_0) plot.

Table 3: Effects of Different Sources of Lime on Soil Exchangeable Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Cation Exchange Capacity (CEC) and Base Saturation

Treatment (Kg/ha)	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	Na (cmol/kg)	CEC (cmol/kg)	BS (%)
V_1L_0	4.90b	2.19b	0.99	1.04	9.99	89.42
V_1L_1	5.54b	3.08ab	1.52	1.16	11.83	95.58
V_1L_2	6.19ab	3.11ab	0.72	0.73	11.21	95.87
V_2L_0	6.1ab	4.09a	0.73	1.05	12.53	94.90
V_2L_1	7.23a	2.88ab	0.66	1.01	12.25	96.18
V_2L_2	5.27b	3.25ab	0.82	0.91	10.71	95.04
	*	*	**NS**	**NS**	**NS**	**NS**

V_1 = Ultrasol lime, V_2= Agricultural lime, L_0 = at 0kg/ha, L_1 = at 1000kg/ha, L_2 = at 2000kg/ha. WAT = Weeks after Transplanting. NS= Not Significant; * Significant at 5% level of significance.

CONCLUSION AND RECOMMENDATIONS

Soil pH in water, potassium chloride and in Calcium chloride increased with the application of agricultural lime at 1000 kg/ha. Exchangeable magnesium showed a significant effect in the control plot. There was significant decrease in Exchangeable acidity with application of the treatments. Electrical conductivity and percent total nitrogen showed no significant effect but produced the highest values in plots treated with V_1L_1. Percent organic carbon and organic matter content in the soil were significantly higher in plots treated with V_1L_2. Based on this study, the application of agricultural lime and ultrasol lime at 1000kg/ha and 2000kg/ha could be used to ameliorate soil acidity by improving soil properties.

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