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EFFECTS OF DIFFERENT SOURCES OF LIMING MATERIALS ON GROWTH AND DEVELOPMENT OF AMARANTHUS (*Amaranthus hybridus*) 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 growth of maranthus (*Amaranthus hybridus*). 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 growth of Amaranthus (*Amaranthus hybridus*). Growth parameters such as plant height at 5 Weeks after Transplanting (WAT) had significantly higher value with the application of V_1L_2 (2000kg/ha) compared to other treatments and control. There was no significant effect on treatments and control at 2, 3 and 4WAT. Leaf count showed significant influence at 5WAT with the application of V_1L_1 (1000kg/ha), at 2 and 3WAT, there was no significant effect on treated plots and control. At 4WAT treatments had no significant effect on number of leaves. Plot treated with limes had no significant effect on Shoot Fresh Weight (SFW) at 4 and 5WAT. There was no significant effect on SFW at 2 and 3WAT. Shoot Dry Weight (SDW) showed a significantly higher value at 5WAT with V_1L_1 (1000kg/ha) compared to other treatments and control. At 4WAT control plot had a significant higher value on SDW. There was no significant effect on SDW at 4WAT with treatments. At 2 and 3WAT, SDW showed no significance difference on amended plots and control. Based on the following results, the use of ultrasol lime (V_1) both at 1000kg/ha and 2000kg/ha could be recommended for improving growth of Amaranthus (*Amaranthus hybridus*).

Keywords: Abuja, Amaranthus, Different Sources of Lime, Growth.

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. This is due to the usual accompanying effects of Aluminum (Al) and manganese (Mn) toxicity and nutrients deficiencies and their consequential detrimental effects on crop growth and yield (Oguntoyinbo *et al.,* 1996). 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). The use of liming materials demonstrates that even small locally produced local limes and industrial liming materials can be used to increase crop production on acidic soils. In some area in Abuja, the use of lime has proved to be agronomically effective, significantly enhancing the yield of maize (Hassan *et al.,* 2007). *Amaranthus hybridus* is specie of the genus *Amaranthus hybridus* is a multipurpose crop which leaves are tasty and of high nutritional value (Venskutonis and Kraujalis, 2013). *Amaranthus hybridus* is among the vegetable Amaraths that has been used in China over 400 years (O"Brien and Prince, 2008). It exhibits the highest diversity of species exploited as traditional vegetables (Wambugu and Muthamia, 2009). *Amaranthus hybridus* is mostly grown for its edible leaves which are regular food component of most local community diets in the country (Grubben, 2004).

The production of *A. hybridus* is threatened by widespread acidity in many parts of the country, and application of lime in Alfisols has been reported to significantly improve growth of crops (Hassan *et al*., 2007).

MATERIALS AND METHODS

The Study Area

This field experiment was conducted at University of Abuja Teaching and Research farm, main campus Gwagwalada. Gwagwalada is one of the six Area Councils making up the Federal Capital Territory Abuja. Gwagwalada is a large municipality and the headquarters of a large district in central Nigeria. Gwagwalada, 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. Gwagwalada, Nigeria elevation is 205 meters height. Gwagwalada Wikipedia (2017).

Limes Source

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

Calculation of Lime Requirement

Lime requirement (LR) was determined following the method as outlined by Beernaert (1999) due to its ability to neutralize all extractable Al in soil. In this method LR is determined by multiplying the factor by extractable Al ($cmolkg^{-1}$). The factor depends on the amount of organic matter in the soil. For soils with 4 to 5% organic matter content, lime application rates should be increased by 20% (David *et al*., 2011).

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).

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Method of Data Collection

In this 2018 planting season, the experimental field that was used for this study was demarcated into six plots per block and various treatments comprising of different sources of lime were assigned to each of the plot where *Amaranthus hybridus* was cultivated. Cultivation was done on the field under irrigation.

After two weeks of transplanting, the *Amaranthus hybrirdus* growth parameters (plant height, number of leaves, and fresh and dry shoot weight) were measured weekly.

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 analyzed for some important properties the soil of the study area following discrete procedures.

Agronomic Data

The weekly sampling of *Amaranthus* plants for growth parameters was from 2-5 Weeks. After Transplanting (WAT), on each sampling date, one plant was uprooted randomly and carefully from each replicated plots of each treatment and was carried in labeled polythene bags to the laboratory where they were washed and dried for the determination of the growth parameters. On the fifth week, 5 plants were uprooted from each replicated plot and carried to the laboratory where the same procedure was followed for the determination of the growth parameters. Plant height was determined by measuring the plant with a meter rule from the ground to the top. The numbers of leaves were determined by counting the leaves of each plant stand per plot. Each plant was separated into shoot from the root with knife. The shoot fresh weight of each plant was determined separately on a meter balance. Each plant part were put in labeled envelope and placed in an oven at 80^0C till a constant weight was obtained, after which the dry weight of each plant part were measured. On the fifth week the same procedure was followed, but here, five plants were weighed from each replicated plot.

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

Soil Properties of the Study Area

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 Division 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 conformation with the values recorded by Asadu and Nweke (1999). Exchangeable acidity (H^++ Al^{3+}) 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).

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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 Division 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 Division Staff (1993). Heavy metals in the soil such as manganese (Mn), iron (Fe), Zinc (Zn) and copper (Cu) with the value 156.49 mg/kg, 61.23 mg/kg, 6.10 mg/kg and 1.77 mg/kg were high. These values were high in his report (Lacatusu, 1998), who reported that values >1mg/kg are high while values <1 mg/kg are low. This denotes that higher values indicate higher risk to the environment which could be toxic to plant.

Table 1: Soil Properties 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

Effects of Different Sources of Lime on Plant height of *Amaranthus*

Effects of different sources of lime on plant height of *Amaranthus* (*A. hybridus*) is shown in Table 2. Plot treated with V_1L_2 at 2000kg/ha showed significant ($P<0.05$) difference on plant height at 5WAT, and was closely followed by plot treated with V_1L_1 at 1000kg/ha. At 4WAT the control plot produced the highest value though was not significantly higher than plot treated with V_1L_2 at 2000kg/ha, but was higher than other amended plots. The least value

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was obtained in plot treated with V_2L_2 at 2000 kg/ha. There was no significant difference on plant height in plot treated with agricultural lime in all the weeks. At 2WAT there was no significant difference on all the amended plots and control.

Table 2: Effects of Different Sources of Lime on Plant Height of *Amaranthus* (*A. hybridus*)

	Plant height (cm) at			Average of five plants per plot at
Treatment (kg/ha)	**2WAT**	**3WAT**	**4WAT**	**5WAT**
V_1L_0	6.67	16.7	37.17	31.30abc
V_1L_1	7.63	21.93	30.90	39.64ab
V_1L_2	7.7	22.83	36.60	40.79a
V_2L_0	7.23	14.10	27.77	30.81bc
V_2L_1	6.3	17.13	31.83	30.33bc
V_2L_2	6. 23	13.50	27.30	26.0c
	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.

Effects of Different Sources of Lime on Leaf Count of *Amaranthus*

Effects of different sources of lime on leaf count of *Amaranthus* (*A. hybridus*) is presented in Table 3. Ultrasol lime showed a significant difference at 4 and 5 WAT. At 4 WAT, control produced the highest leaf count compared to other amended plots, while at 5 WAT, plot treated with V_1L_1 showed a significant increase, closely followed by plot treated with V_1L_2 and control.

Agricultural lime produced the least leaf count in all the amended plots and control except at 4 WAT where the values observed were higher in all the plot amended and control though not significant compared to the amended plots treated with ultrasol lime except the control (V_1L_0). The significant effect of V_1L_1 at 5 WAT and V_1L_0 (control) at 4 WAT confirmed the findings of Hassan *et al*. (2007) that leaf production increased linearly from absolute control to application of lime.

Table 3: Effects of Different Sources of Lime on Leaf Count of *Amaranthus*

	Leaf count at			Average plants per
Treatment (kg/ha)	**2WAT**	**3WAT**	**4WAT**	**5WAT**
V_1L_0	13.7	72.33	211.33a	165.2bc
V_1L_1	14.7	93.67	133.67ab	256.87a
V_1L_2	13.7	110.7	133.67ab	179.13b
V_2L_0	12.33	61.0	114.67b	128.67bc
V_2L_1	10.0	57.67	114.67b	134.87bc
V_2L_2	11.0	43.0	114.67b	106.1c
	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.

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Effects of Different Sources of Lime on Shoot Fresh Weight (SFW) of *Amaranthus*

Effects of Different Sources of lime on Shoot Fresh Weight (SFW) of *Amaranthus (A. hybridus*) is shown in Table 4. With the exception of 2 and 3WAT, ultrasol lime had a significant effect on shoot fresh weight (SFW) in control plot and at 4 and 5WAT. The control produced the highest SFW at 4 WAT, while V_1L_2 (2000 kg/ha) showed the highest SFW at 3WAT though not significant compared to other amended plots. Control recorded the highest mean value, while V_1L_2 (2000 kg/ha) showed an increase value at 2WAT though not significant. Agricultural lime showed the least mean values in all the weeks. The significant increase of SFW in V_1L_0 (control) closely followed by V_1L_2 (2000 kg/ha) at 4WAT, and in plot treated with V_1L_2 (2000 kg/ha) at 3 WAT showed that ultrasol lime greatly improved soil tilt which results in less soil crusting and improved soil aeration that leads to increased soil infiltration rate. This increase could also be as a result of this lime improvement on P efficiency and other micronutrients compared to Fageria and Baligar (2004) report. Also, this increase in SDW on ultrasol lime application showed that its high moisture content aids to enhance the activities of beneficial soil microbes compared to the report of Stephen (2011). Means in the same column followed by the same letter(s) are not significantly different by Duncan's New Multiple Range Test at P=0.05.

Table 4: Effects of Different Sources of Lime on Shoot Fresh Weight (SFW) of *Amaranthus*

	Shoot Fresh Weight (g) at		Average of five plants per plot at	
Treatment (kg/ha)	**2WAT**	**3WAT**	**4WAT**	**5WAT**
V_1L_0	0.65	5.47	43.12a	54.37a
V_1L_1	0.65	11.23	25.45abc	43.15ab
V_1L_2	0.79	15.29	36.15ab	34.64ab
V_2L_0	0.46	3.85	20.27bc	16.51ab
V_2L_1	0.35	4.79	23.64abc	19.33ab
V_2L_2	0.45	3.26	15.66c	10.29b
	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.

Effects of Different Sources of Lime on Shoot Dry Weight (SDW) of *Amaranthus*

Effects of different sources of lime on Shoot Dry Weight (SDW) of *Amaranthus (A. hybridus*) is presented in Table 5. Ultrasol lime produces a significantly higher SDW in a plot treated with V_1L_1 (1000kg/ha) at 5WAT followed by control plot at 4WAT and V_1L_2 (2000 kg/ha) at 3WAT. Shoot dry weight (SDW) at 2WAT showed no significant difference in the amended plots and control. At 5WAT, increase of SDW was followed closely by V_1L_2 at 2000kg/ha and the least value was observed in the control. Furthermore, at 4WAT, the control and plot treated with V_1L_2 (2000kg/ha) were high in SDW but not significant from each other relative to control. At 3WAT, plot treated with V_1L_2 (2000 kg/ha) was significantly higher than the control.

Agricultural lime showed the least value in plot treated with V_2L_2 at 2000 kg/ha at 5WAT. This significantly higher value in the plot treated with V_1L_1 (1000 kg/ha) depicts that, ultrasol lime contained more moisture content, so at higher rate, the moisture content seems to be high, while it is lesser at a lower rate (1000 kg/ha) which produces the highest Shoot Dry Weight (SDW)

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Table 5: Effects of Different Sources of Lime on Shoot Dry Weight (SDW) of *Amaranthus*

	Shoot Dry Weight (g) at			Average of five plants per plot at
Treatment (kg/ha)	**2WAT**	**3WAT**	**4WAT**	**5WAT**
V_1L_0	0.10	0.95	6.52a	4.76abc
V_1L_1	0.07	1.78	3.23b	7.29a
V_1L_2	0.10	2.1	5.12ab	6.17ab
V_2L_0	0.073	0.69	2.92b	4.36bc
V_2L_1	0.05	0.8	3.36b	4.2bc
V_2L_2	0.07	0.63	2.33b	2.23c
	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

Plot treated with ultrasol lime had significant effect on plant height at 5WAT with the application of V_1L_2 (2000kg/ha). Leaf count showed a significant difference at 5WAT in plot treated with V_1L_1. At 2 and 3WAT, there was no significant difference on treated plots and control. There was no significant effect on treatments at 4WAT. Shoot fresh weight had no significant effect with treatments at week four and five. There was no significant effect on SFW at 2 and 3WAT. Shoot dry weight showed a significant difference with the application of ultrasol lime at 1000kg/ha at 5WAT. At 4WAT, control plot showed the highest value of SDW. Agricultural lime showed the least value of SDW at week five. 2 and 3WAT had no significant difference on all the amended plots and control. Based on this study, the application of ultrasol lime at 1000kg/ha and 2000kg/ha could be used to by improve growth of *Amaranthus* (*A. hybridus*).

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