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Response of Bambara Groundnut and Soil Physicochemical Properties to Different Lime Materials

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Abstract

The study was conducted at the Teaching and Research Farm of the Department of Soil Science Chukwuemeka Odumegwu Ojukwu University, Igbariam Campus. The treatments studied were paper ash (PA) and wood ash (WA) of rates 4.8 $kgha^{-1}$ respectively and calcium carbonate (CA) of rate 120g (equivalent of 300$kgha^{-1}$) and control (CO). The experiment was laid out in a randomized complete block design (RCBD) and was replicated four times. Data collected were subjected to analysis of variance and treatment means were separated using LSD at 5% alpha level. The result recorded for the study showed that root and pod weight of bambara groundnut were not significant among the treatments but values obtained from treated plots were better than the untreated plots. Soil properties tested were greatly improved by the lime materials when compared their values on the control soil. Hence the results indicated that the lime materials especially the wood ash and paper ash could be ideal for famers as they are cheap affordable and available since it has proved through this study that these lime materials could improve crop yield and soil nutrient status and characteristics.

Keyword: Ash, charcoal, lime, paper ash, soil properties, wood ash

1. Introduction

Soil fertility is considered to be a measure of the soils compatibility to sustain crop growth and yield both in short and long term periods, as soil is centre for sustainable farming system. The fertility status of soil can be a product of a set of interactions between the biological activities, biophysical activities biochemical activities and physicochemical environments of the system. The traditional agricultural system widely practiced in tropical African soil especially in the eastern soils of Nigeria, has changed. The change brought the shortening of the fallowing periods which are usually used in the zone to restore and maintain soil productivity. This was as a result of rapid increase in both human population and the rate of urbanization. In addition south eastern soils of Nigeria which are mainly ultisols are characterized by very low inherent fertility, multiple nutrient deficiency and nutrient imbalances. Consequently, the effect is decline in crop yield despite the introduction of the improved cultivars in virtually all crops produced in the area. The disappointing results observed in strongly acid ultisols in south eastern Nigeria according to Faulkner (1994) was mainly due to poor establishment of cover crops. Continuous cultivation on the available land further compounds the problems. Cultivation destroy the regeneration of the soil by hastening the decomposition of the protective layer of organic colloids associated with virgin aggregates without supplying fresh difference in productive level of soils (Woodruff 2009; Nweke, 2015). Organic colloid is linked intrinsically to soil fertility because of its importance in maintaining good soil physicochemical condition and equally important nutrient reserve. Soil fertility is greatly affected by not only quantity but also quality of the organic matter as it influences the electrical charge systems in a soil. Plant nutrient movement in soils are markedly affected by permanent and variable charges as soils can have both permanent and variable surfaces though more likely to be occupied by a single one. Variable charged soils are mainly found in tropical soil like south eastern soils of Nigeria, because the climate conditions of the area such as high temperature and rainfall accelerate the development of variable charged minerals. The addition of organic matter in particular wood ash according to Nweke et al. (2017) increased the soil pH and thus the variable charge of the soil. The buffering capacity of a soil is very important in determining the rise in pH from lime application. Wood ash induces a strong lime effect when used as soil ameliorant and has the ability to correct nutrient deficiency induced by leaching and soil acidity (Mbah et al., 2010; Nweke et al., 2017; Nweke 2017). This is as a result of its high acid neutralizing ability. On the other hand, the addition of calcitic lime will improve soil nutrient level as it supplies the soil with Ca and Mg in the form of carbonate, hydroxide or oxide. With the presence of the two elements acidity will be neutralized and neutralization

continues until all carbonate, hydroxide and oxide in the soil are exhausted. Thus when a lime is applied (organic or inorganic) to highly weathered soils like the tropical soils, the pH increases and subsequently the cat ion exchange capacity of the soils though the efficiency of these attributes is dependent on the type of lime applied. Thus this study was design to evaluate the efficiency of three different lime materials on the soil properties and bambara groundnut yield.

2. Materials and Methods

2.1 Experimental Site

The field experiment was conducted at the Faculty of Agriculture Teaching and Research Farm, Igbariam campus in Anambra east LGA of Anambra state. The area is located within latitude 06 014'N and longitude 06 045'E south east of Nigeria agro ecological zone. The annual rainfall of the area ranges between 1800mm-2000mm and the temperature range is between 21-28^{0}C. The soil of the study area which fall under the class of sandy clay loam, was acidic and has low content of organic carbon (0.7%) and organic matter (1.23%) as well as low values in major plant nutrients hence the soil of the experimental site was found to be deficient in the major plant nutrients (Nweke et al., 2014).

2.2 Field Preparations/ Experimental Design/ Treatment Allocation/Laboratory Method

The experimental area of 13.5m x19m (256.5m^2) was measured out using tape, rope and pegs. The site was manually cleared using machete, debris removed and raised bed made using hoe. The land area was mapped out into plots each rectangular plot measured 3m x 4m (12m^2). Plots were separated by 0.5m path and each block was separated by 1m alley to allow free movement for data collection within the experimental field. The treatment comprises of 4.8kg of paper ash (PA), 4.8kg of wood ash (WA) and 120g of calcium carbonate ($CaCO_3$) (CA) equivalent of 300kgha^{-1} and control (CO). The experiment was then laid out in a randomized complete block design with four replicate to give a total of 16plots. The treatment were randomly applied evenly and incorporated into their respective plots and left for 1 week before planting of the test crop bambara groundnut. This is to allow mineralization of nutrients in the treatment applied. Weeding was carried out manually by hand using hoe. The operation started from 3 weeks after planting of the bambara groundnut and continued every 2 weeks interval till the period of maturity and harvest. A total of 15 plants were selected randomly from each plots and were tagged for data collection on yield components. The agronomical data collected are; root weight and pod weight. Paper ash and wood ash used for the study were analyzed for the determination of their nutrient values. At the end of the experiment, soil sample were collected from three observational points from each plots at depth of 0 - 25cm using soil auger. The soil sample were air dried, sieved and used for the determination of chemical properties while core samples were used for the analysis of selected physical properties. The soil pH was measured using glass electrode pH meter. The organic content of the soil was determined by the method of Walkley and Black (1934) wet oxidation method. Total nitrogen was determined by Kjeldahl digestion method of Black et al. (1965), available phosphorous was by Bray and Kurtz (1945) Bray II method. Exchangeable bases were extracted using 1N NH_4OAC, potassium and sodium was determined by EDTA titration, while cation exchange capacity was determined by ammonium acetate techniques.

2.3 Statistical Analysis

All data collected were analyzed following the analysis of variance (ANOVA) for randomized complete block design (RCBD). Treatment means were separated with least significant difference (LSD) at 5% level of significance.

3. Results

The nutrient content of wood ash and paper ash recorded in Table 1 indicates that the treatment materials are rich in nutrients, low in Na (0.38 Cmolkg^{-1} WA, 0.28 Cmolkg^{-1} PA) and K (0.29 Cmolkg^{-1}WA, 0.34 Cmolkg^{-1} PA) and have moderate level of OM (1.13% WA, 2.01% PA). The high level of pH supports that treatments have efficient lime effect and it is expected that the studied soil will benefit from their application.

Table 1. Nutrient content of wood ash and paper ash

Test parameter	Wood ash	Paper ash
pH(H_2O)	11.60	10.98
Available P	261.10Mgkg^{-1}	239.01Mgkg^{-1}
Total N	0.04%	0.06%
OC	0.06%	0.71%
OM	1.13%	2.01%

Ca	48.80 Cmolkg^{-1}	39.87Cmolkg^{-1}
Mg	9.60 Cmolkg^{-1}	10.32 Cmolkg^{-1}
K	0.29 Cmolkg^{-1}	0.34 Cmolkg^{-1}
Na	0.38 Cmolkg^{-1}	0.28 Cmolkg^{-1}

3.1 Effect of Three Different Lime Materials on The Root and Pod Weight of Bambara Groundnut and Soil Chemical Properties

The root and pod weight result presented in Table 2 indicated non-significant ($P > 0.05$) difference among the treatments. Though the result show that lime materials has no effect on the two parameters, higher values were recorded for root and pod weight in PA and CA respectively. The result scenario for pod weight indicated CA (184.59gkg^{-1}) > PA (157.25gkg^{-1}) > WA (129.75gkg^{-1}) > CO (113gkg^{-1}), while CA (22gkg^{-1}) and WA (22gkg^{-1}) recorded the same value for root weight. The result of soil chemical parameters showed statistical significant different among the treatments in all the parameters assessed. The studied soil was very much enriched with the nutrients when the values of parameters obtained from the control plots are compared with the values of parameters obtained from the amended plots (Table 2). The lime materials influenced the pH of the soil greatly, as it changed the pH of the soil from moderate acidic to alkaline especially with CA and near natural with PA (Table 2). Among all the treatments higher result for organic carbon and total nitrogen was recorded in PA and WA respectively. The result variation of CEC and available phosphorus (P) showed CA > WA > PA > CO respectively. The effect of lime materials on Ca, Mg, Na and K content of the studied soil varied among the treatments with higher values for Ca (5.0 cmolkg^{-1}) and K (0.27cmolkg^{-1}) in wood ash, Mg (3.0 cmolkg^{-1}) and Na (0.63cmolkg^{-1}) in paper ash.

Table 2. Effect of three different lime materials on the root and pod weight of bambara groundnutand soil chemical properties

Treatment	Root weight gkg^{-1}	Pod weight gkg^{-1}	pH (H_2O)	OC %	TN %	P Mgkg^{-1}	Ca	Mg	Na Cmolkg^{-1}	K	CEC
CO	24.25	113.00	5.40	0.75	0.07	18.80	3.40	1.80	0.19	0.12	14.30
CA	22	184.50	7.60	0.83	0.14	28.50	4.00	2.00	0.34	0.16	32.10
WA	22	129.75	7.2	0.87	0.18	26.10	5.00	2.40	0.32	0.27	28.90
PA	27	157.25	6.80	1.20	0.21	22.00	4.20	3.00	0.63	0.17	26.10
LSD0.05	NS	NS	0.23	0.15	0.03	3.57	1.36	0.06	0.08	0.02	0.19

CO = Control soil; CA = Calcium carbonate; WA = Wood ash; PA = Paper ash

The physical parameters of the studied soil were presented in Table 3. Aggregate stability (AS) showed that the effects of lime materials were statistically similar but significantly better than the control plots. The mean weight diameter (MWD) indicates higher values in PA > WA > CA > CO. Dispersion ratio (DR) indicated that CA and PA values as well as WA and PA values were statistically similar but significantly better than the control result.

Table 3. Effect of three different lime materials on the physical properties of the studied soil

Treatment	Aggregate Stability %	Mean weight diameter mm	Dispersion ratio %
CO	25 02	2.31	0.76
CA	27.11	2.49	0.88
WA	28.11	2.71	0.84
PA	27.96	3.37	0.86
LSD0.05	2.90	0.14	0.03

CO = Control soil; CA = Calcium carbonate; WA = Wood ash; PA = Paper ash

4. Discussion

The non-significant difference among the treatments observed in pod and root weight may be due to short period of study or the rate of lime applied. This is because well developed root system of Bambara groundnut exploits the rhizosphere for moisture and mineral nutrients. Also organic material is known to be capable of activating

many species of micro organism which release phyto hormones that stimulate nutrient absorption and plant growth and yield. The higher value recorded from the amended plots indicated that limes material increases the yield value of bambara groundnut.

The soil chemical parameters presented in Table 2 indicated that the lime materials induced strong alkaline reactions (liming effect) when used as soil ameliorant. The influence of the lime materials on the pH of the studied soil was beneficial as they increased the pH to near neutral and alkaline. This necessitated the enrichment of the soil with plant nutrients that foster good growth and yield of bambara groundnut recorded in this study. Nweke and Nsoanya (2013) observed that organic lime material improved soil productivity and crop yield. The increase in soil nutrients especially with WA and PA indicated that the organic materials have affected the electrical charge systems in the soil leading to increased plant nutrients. Variable charge systems are produced as a result of the protonation and deprotonation of surface hydroxyl groups. Though soil contain both variable and permanent charge surface they are likely to be occupied by a single one. Variable charged soils are more pronounced in tropical countries like Nigeria due to its climate conditions. Variable charged soils are poorly buffered at low pH and will buffer at high pH values. Hence lime application becomes an ideal amendment for farmers in the locality. Also when lime is applied to a highly weathered soil like the south eastern soils of Nigeria, CEC increased with increase in the pH level as was observed in this study and reduction in P availability can occur due to increased Ca concentrations. These explanations might have contributed to the nature of soil chemical and physical parameters obtained in this study.

5. Conclusion

This study has shown that wood ash and paper ash are efficient liming materials as their applications improve soil nutrients content and increase the yield of bambara groundnut. Thus the fertility of soil and crop yield can be sustained by addition of ash which is available and cheap.

Reference

Black, C. A. (1965) method of soil analysis in chemical and microbiological properties AM. *Soc. Agron. Madison Wisconsin, 157*, 2.

Bray, R. H., & Kurtz, L. T. (1945). Determination of total organic and available form of phosphorous in soil. *Soil Sci., 59,* 39-45.

Faulkner, O. T. (1994). Some experiment with leguminous crops at Ibadan southern Nigeria. *Empire J. Exp. Agric., 2,* 93-102.

Mbah, C. N., Nwite, J. N., Njoku, C., & Nweke, I. A. (2010). Response of maize (Zea mays l.) to different rates of wood ash Application in acid ultisol in south east Nigeria. *Afri. J. Agric. Res., 5*(7), 580-583.

Nweke, I. A. (2017). Influence of wood charcoal from chlorophera excels on soil properties and yield components of maize. *J. Soil Sci. Environ., 8*(1), 11-16. https://doi.org/10.5897/JSSEM2016.0566

Nweke, I. A., & Nsoanya, L. N. (2013). Effect of different rate of rice mill waste on soil chemical properties and grain yield of maize (Zea may). *J. Agric. Rur. Dev., 16*(1), 1431-1436.

Nweke, I. A., Mba, C. N., Oweremadu, E. U., Dambaba, N., Orji, E. C., Ekesiobi, A. I., & Nnabuife, E. L. C. (2017). Soil pH, available P of an ultisol and castor performance as influenced by contrasting tillage methods and wood ash. *Afr. J. Agric. Res., 12*(8), 606-616. https://doi.org/10.5897/AJAR2016.12082

Nweke, I. A., Okoli, P. S. O., & Enyioko, C. O. (2014). Effect of different rate of poultry dropping and plant spacing on soil chemical properties and yield of cucumber. *Elixir Agric, 70*(2014), 23934-23940.

Walkley, A., & Black, I. A. (1934). An examination of degtjareff method for determining organic matter and proposed modification of the chromic acid titration method. *Soil Sci., 37,* 29-38.

Woodruff, C. M. (2009). Variation in the state and stability of aggregation as a result of different method of cropping. *Soil Sci. Soc. Am, 4,* 13-18.

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