EFFICIENCY OF LIME TYPES FOR SOIL ACID AMENDMENT AND PRODUCTION OF GROUNDNUT (*Arachis hypogea*) ON ULTISOLS OF SOUTHEASTERN NIGERIA

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ABSTRACT
Soil acidity and infertility are the major constraints of crop production in acidic soils of southeastern Nigeria. The study investigated the efficiency of three limes: inorganic calcium oxide, organic wood and palm bunch ashes at three rates each (2, 4 and 6 t ha^{-1}) and the zero lime (control) for soil acid amelioration. Groundnut (*Arachis hypogea*) was the test crop. The experiment was laid out in a Randomized Complete Block Design (RCBD) and replicated four times. The emergence, growth and yield of groundnuts were significantly ($P \leq 0.05$) high in soils limed with wood ash at 2 t ha^{-1} and palm bunch ash at 4 t ha^{-1}. No liming (control) strongly inhibited performance of groundnut. Two tonnes per hectare of wood ash was consistently significantly ($P \leq 0.05$) efficient and superior to other limes rates with regards to pod weight (0.72 t ha^{-1}) and number of pods per plant (93.82) and is therefore recommended for groundnut production in southeastern Nigeria.
Keywords: Amendment, Groundnut, Ultisol, Soil acidity

Introduction

Groundnut (*Arachis hypogea* L.) a *leguminoceae* is an important legume grown for human consumption and livestock feed in Nigeria. Groundnut is a valuable cash crop and an important source of edible oil that generates employment on the value chain of production, transportation, processing and marketing (Uguru, 2011).

Groundnut is grown in the Savannah agro ecology of northern states of Nigeria and rarely in the rainforest of southeastern Nigeria agroecology. Furthermore, rich well drained soils are best for groundnut production. Ultisols of southeastern Nigeria agroecology are formed from coastal plain sands and are low in mineral reserves and fertility (FPDD, 1989). The soils are inherently infertile and are high in acidity, low in cation exchange capacity and base saturation, usually suffering from multiple nutrient deficiencies (FPDD, 1989). Thus, liming is a necessity for the ultisol for maximum performance of some crops including groundnut. Various liming materials are used in treating acid soils. Inorganic (calcium oxide) and organic (ash) limes are common, although the use of inorganic lime is conventional (Uguru, 2011). However, the use of organic lime especially, various ash sources holds the promise in acidic soils because of the multi-beneficial qualities including supplementary balanced nutrient supply for increased crop yields (Odedina *et al.,* 2003) and improved soil health (Ibeawuchi *et al.,* 2009). This paper investigated the efficiency of organic and inorganic limes for acid amelioration in the ultisols of Southeastern Nigeria for groundnut production.

Materials and Methods

The experiment was carried out at the Teaching and Research Farm of the Federal University of Technology, Owerri, which is located in the humid tropics of Nigeria (latitude 5° 27' N and 7° 02' E). The annual rainfall is about 2500 mm and is bimodal with peaks in July and September. The area is characterized by daily minimum and maximum temperatures of 20°C and 32°C, respectively. In terms of geology, the predominant parent material from which most of the soils are formed is the Coastal Plain Sands popularly known as "Acid Sands" (Orajaka, 1975).

The field was ploughed, harrowed and marked into 3 m x 2 m plot size. The treatments consist of three limes (one inorganic and two organic); Calcium oxide, palm bunch ash and wood ash. Each lime was applied at three rates (2, 4 and 6 t ha^{-1}). The control had no lime. A total of ten treatments were soil incorporated in a Randomized Complete Block Design (RCBD) and replicated four times. Erect groundnuts (Ex-Dakar) were collected from the University Plant Genetic Resources Unit; viable seeds planted at 60 cm x 60 cm spacing between and within rows. Weeding was manually carried out and no chemical pest control was practiced. Data on number of leaves, leaf area, number of seeds per pod, number of pods per plant and weight of pod were collected, analyzed and reported. Data collected were analyzed using Genstat 2000 and means were separated using LSD at 5% level of probability.

Laboratory studies

Five soil samples were collected randomly from the experimental site at 0-20 cm depth before planting and on per treatment basis after harvest. Samples were analyzed for physico-chemical properties at the Crop Science Laboratory, Federal University of Technology, Owerri. Soil pH was analyzed by the use of pH meter (Hendershot *et al*., 1993), organic carbon was determined by Walkley and Black method, (1934), organic matter values were obtained by multiplying total carbon with 1.724 (Van Bemmelen's correlation factor) (Nelson and Sommers, 1982), available phosphorus according to the procedure of Olsen and Sommers (1990), total nitrogen was by microkjeldahl digestion technique (Bremner and Mulvaney, 1982), calcium and magnesium by Versenate titration method and potassium by flame photometer method. Palm bunch ash and wood ash were analyzed for their nutrient status (N, P, K, Ca, Mg and C) using the same procedures as for the soil analysis.

Results

Palm bunch ash was alkaline (8.86), with 1.08% organic nitrogen and 2.21% potassium. Wood was alkaline (10.1), with 1.68% nitrogen content and 3.57% potassium (Table 1).

Table 1: Chemical properties of palm bunch ash and wood ash

Element	Palm bunch ash	Wood ash
Mg (%)	1.80	1.95
Ca (%)	7.90	8.80
K (%)	2.21	3.57
P (%)	0.13	0.88
organic carbon (%)	12.68	18.50
organic nitrogen (%)	1.08	1.68
Carbon-nitrogen ratio	11.74	11.01
pH in water	8.86	10.10

The pre-planting and post-planting soil physico-chemical properties showed significant variations (Table 2). The initial soil pH was low, accompanied by low exchangeable cations. The post planting soil physico-chemical properties indicated improved soil pH resulting in available exchangeable cations, specifically phosphorus (P), potassium (K), magnesium (Mg), nitrogen (N) and organic matter (OM) when the ultisols were limed with wood and palm bunch ashes respectively. Wood ash was the most efficient for soil acid neutralization.

Table 2: Pre and post planting soil physico-chemical properties

Treatments	pH (H_2O)	P mg kg^{-1}	N	OM %	Ca	Mg cmol kg^{-1}	K	Na
Pre-planting	4.94	35.40	0.04	2.76	2.20	1.35	0.09	0.37
Control	5.64	35.38	0.04	2.91	2.00	1.20	0.09	0.37
CaO (2 t ha^{-1})	6.98	34.05	0.15	3.15	11.20	2.00	0.08	0.37
CaO (4 t ha^{-1})	7.80	15.40	0.07	2.02	12.80	4.80	0.06	0.37
CaO (6 tha^{-1})	8.80	21.60	0.10	2.91	22.40	6.00	0.06	0.37
PBA (2 t ha^{-1})	5.98	33.16	0.15	2.74	2.80	1.60	0.08	0.41
PBA (4 t ha^{-1})	6.06	37.50	0.17	3.45	3.60	1.60	0.15	0.41
PBA (6 t ha^{-1})	6.76	27.85	0.13	2.91	4.00	1.60	0.26	0.46
WA (2 t ha^{-1})	6.04	35.80	0.10	2.80	4.00	1.60	0.09	0.36
WA (4 t ha^{-1})	6.58	30.95	0.14	2.62	4.00	1.60	0.14	0.40
WA (6 t ha^{-1})	6.30	44.20	0.17	3.51	8.00	3.60	0.12	0.37

Where: CaO = Calcium oxide, PBA = Palm bunch ash and WA = Wood ash, N = Nitrogen, P = Phosphorus, OM = Organic matter, Ca = Calcium, Mg = Magnesium, K = Potassium, Na = Sodium

Liming significantly ($P \leq 0.05$) influenced seedling emergence as at 2 weeks after planting (Table 3). High percentage of groundnuts planted in soils treated with limes emerged while percentage emergence was least in the control. Wood ash (2 t ha^{-1}) and calcium oxide (6 t ha^{-1}) stimulated the highest percentage emergence in groundnuts (91.97%). The height of groundnuts at 4 and 8 WAP showed variations ($P \leq 0.05$) between the various lime treatments (Table 3). Tallest groundnuts were obtained from 2 t ha^{-1} of wood ash treatment at 4 WAP (17.99 cm) and 8 WAP (30.32 cm) respectively. Dwarf groundnuts were developed in the control plot without lime at 4 WAP (10.42 cm) and 8 WAP (12.50 cm).

Leaf area was significant ($P \leq 0.05$) across the various lime rate applications at 4 and 8 WAP, respectively (Table 3). At 4 WAP and 8 WAP, largest leaf area (49 cm^2 and 98.01 cm^2 respectively) were obtained when 2 t ha^{-1} of wood ash was applied to the groundnut. The groundnuts in the control plot developed smallest leaves at 4 (29.64 cm) and 8 WAP (61.69 cm).

At 2 WAP, groundnut which received 2 t ha^{-1} of calcium oxide produced lower number of leaves (85.22) while the application of 4 t ha^{-1} of calcium oxide produced highest number of leaves (123.97) (Table 3). At 8 WAP, highest number of leaves (233.33) was produced with the application of 4 t ha^{-1} of wood ash and the control groundnut produced least number of leaves (149.07).

Liming the ultisol with 2 t ha^{-1} of wood ash resulted in the highest number of groundnut seeds per pod (3.41) (Table 4). This was closely followed by liming with 4 t ha^{-1} of palm bunch ash (3.21) while zero liming produced least seeds per pod (2.02). Liming the ultisol with 2 t ha^{-1} of wood ash resulted in the highest number of groundnut pods per plant (93.82), followed by liming with 4 t ha^{-1} of palm bunch ash (87.92) while groundnut grown on untreated soils produced least pods per plant (57.72). The application of 2 t ha^{-1} of wood ash resulted in the highest pod weight (0.72 t ha^{-1}) while groundnut produced without lime gave least pod weight (0.41 t ha^{-1}).

Table 3: Percentage seedling emergence (2 WAP), plant height (cm), leaf area (cm^2) and number of leaves at 4 and 8 WAP

Treatments	Rate	% seedling	Plant height		Leaf area		Number of leaves	
Lime	(t ha^{-1})	emergence	4	8	4	8	4	8
Calcium oxide	2.0	86.11	16.13	25.22	36.26	72.59	85.22	175.00
Calcium oxide	4.0	83.33	14.16	23.51	37.32	73.62	123.97	193.73
Calcium oxide	6.0	91.97	13.68	20.17	31.16	66.96	102.86	193.85
Palm bunch ash	2.0	74.99	14.41	21.64	32.73	63.14	97.23	180.53
Palm bunch ash	4.0	82.22	14.70	26.03	43.23	87.05	110.72	233.33
Palm bunch ash	6.0	89.44	15.54	23.41	34.42	67.82	92.17	176.67
Wood ash	2.0	91.97	17.99	30.32	49.00	98.01	108.59	209.67
Wood ash	4.0	88.89	16.05	24.15	37.59	72.86	92.80	196.87
Wood ash	6.0	77.78	15.23	28.76	38.40	82.40	112.60	212.00
Control	0.0	58.33	10.42	12.50	29.64	61.69	93.99	149.07
$LSD_{(0.05)}$		21.06	3.50	6.27	10.36	18.31	93.99	149.07

WAP = Weeks after planting

Table 4: Yield and yield parameters

Treatments per pod Lime	Rate of pods per plant ($t\ ha^{-1}$)	Number of seeds weight ($t\ ha^{-1}$)	Number	Pod
Calcium oxide	2.0	2.70	70.09	0.42
Calcium oxide	4.0	3.05	74.62	0.54
Calcium oxide	6.0	2.74	63.32	0.48
Palm bunch ash	2.0	2.09	62.78	0.49
Palm bunch ash	4.0	3.24	87.92	0.57
Palm bunch ash	6.0	2.69	67.51	0.45
Wood ash	2.0	3.41	93.82	0.72
Wood ash	4.0	3.21	72.74	0.63
Wood ash	6.0	2.97	81.74	0.51
Control	0.0	2.02	57.72	0.41
LSD ($_{0.05}$)		0.54	3.95	0.08

WAP = Weeks after planting

Discussion

The results of the pre-planting soil physico-chemical analysis showed that Ultisols have high acidity, low nitrogen content and low exchangeable cations (Onweremadu *et al.,* 2006) and so, resulted in multi-nutrient deficiency (Onwuka *et al.*, 2007). The post-planting physico-chemical analysis revealed an improvement in the soil chemical properties following liming (Brady and Weil, 2004).

The application of calcium oxide at 6 t ha^{-1} and wood ash at 2 t ha^{-1} favored groundnut emergence (91.67%). Non-liming inhibited groundnut emergence in the control plots. This can be attributed to the improved soil conditions due to liming. Growth and yield in groundnut was significantly sustained by wood ash and palm bunch ash probably due to acid neutralization (Ibeawuchi *et al.,* 2008) and multi-nutrient release (calcium and magnesium) (Okoli *et al.,* 2011). The effect of calcium oxide on groundnut growth and yield relative to palm bunch and wood ash was poor, probably because calcium oxide could only supply calcium to the groundnut plants while wood and palm bunch ash nutrient contents were not limited to calcium. Wood ash was consistently superior to palm bunch ash and calcium oxide at the same level and higher levels probably due to higher nutrient contents of wood ash (Table 2).

Conclusion

Generally, liming ultisols with ash is advocated because of the efficiency and local availability. The farmers are familiar with the technology which is also affordable and farmer based. Application of 2 t ha^{-1} of wood ash and 4 t ha^{-1} of palm bunch ash are advocated for liming the Ultisols of the southeastern Nigeria agroecology.

References

Brady, N. C. and Weil, R. R. (2004). Elements of the Nature and Properties of soils. Second edition. Upper Saddle River, New Jersey, USA: Pearson Prentice Hall. 24p.

Bremner, J. M and Mulvaney, C. S. (1982). Nitrogen trial. In: Page A. L, Miller, R. H. and Keeney, R. R. (eds). Methods of soil analysis. Part 2- Chemical and microbiological properties (2nd edtion). American Society of Agronomy. 9: 595-624.

FPDD (Fertilizer Procurement and Distribution Division of the Federal Ministry of Agriculture, Water Resources and Rural Development). (1989). Fertilizer use and management: practices for crops in Nigeria. Series No. 2. Ibadan, Nigeria: Bobma Publishers, 6-7p.

Hendershot, W. H, Lalande, H. and Duquette, M. (1993). Soil reaction and exchangeable acidity. In: Carter, M. R. (ed.). Soil sampling and methods of soil analysis, Canadian Soc. Soil Sci., Lewis Publishers, London, 141- 145.

Ibeawuchi, I. I, Obiefuna, J. C, and Onweremadu, E. U. (2009). Effect of oil palm bunch refuse ash rates on the ultisols of Owerri, Imo State, Southeastern Nigeria. In Proceedings of the 'International Conference on Global Food Crisis'. Publisher, Federal University of Technology, Owerri, Nigeria. 190-193.

Nelson, D. W. and Sommers, L. E. (1982). Total carbon, organic carbon and organic matter. In Page, A. L, Miller, R. H. and Keeney, R. R. (eds). Methods of soil analysis, Part 2- Am. Soc. Agron. Madison WI. 9: 539-579.

Odedina, S. A, Odedina, J. N, Ayeni, S. O, Arowojolu, S. A. A, Adeyeye, S. D. and Ojeniyi, S. O. (2003). Effect of types of ash on soil fertility, nutrient availability and yield of tomato and pepper. Nigerian Journal of Soil Science. 13:61-69.

Olsen, S. R and Sommers, L. E. (1990). Phosphorus. In: Paige, A. L, Millers, R. H. And Keeney, R. R. (eds.) Methods of soil analysis. American Society of Agronomy, Madison, WI. 403-430.

Okoli, N. A, Obiefuna, J. C, Ibeawuchi, I. I, Ihejirika, G. O. and Alagba, R. A. (2011). Assessment of poultry manure fortified with Palm Bunch ash (POASH) for Cassava (Manihot esculenta Crantz) production in Southeastern Nigeria. Acta Agronomica Nigeria. 11, 1 & 2: 88-97.

Onweremadu, E. U, Opara, C. C, Nkwopara, U, Duruigbo, C. I. and Ibeawuchi, I. I. (2006). Yield response of a Cowpea variety on ground seashells on Isohyperthermic Arenic Kandiudult of Owerri, Southeastern Nigeria. Int. J. Soil Sci., 3:251-257.

Onwuka, M. I, Osodeke, V. E and Okolo, N. A. (2007). Amelioration of soil acidity using cocoa husk ash for maize production in Umudike area of southeastern Nigeria, Department of Soil Science and agro-climatology, Michael Opara University of Agriculture. Short note, Tropical and Subtropical Ecosystems. 7: 41-45.

Orajaka, S. O. (1975). Geology. In: Nigeria in Maps: Eastern States, G. E. K. Ofomata (ed.). Benin City, Nigeria: Ethiope Publishing. 5-7p.

Uguru, M. I. (2011). Crop production: tools, techniques and practices. Nsukka, Nigeria: Fulladu Publishing Company, 17p.

Walkey, A. and Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*. 37:29-39.