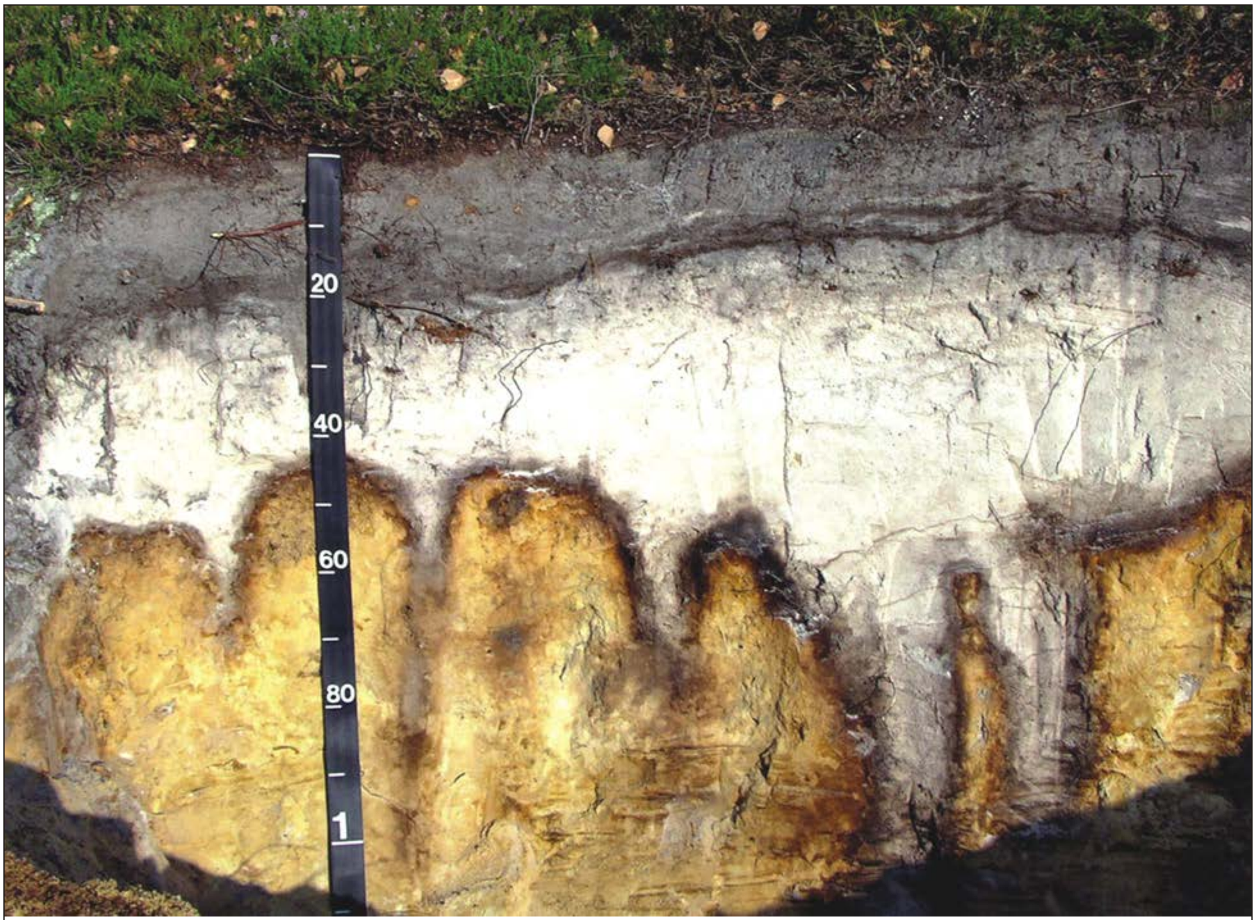

International Journal of Soil Science

ISSN 1816-4978

Academic
Journals Inc.

www.academicjournals.com

International Journal of Soil Science 1 (3): 251-257, 2006
ISSN 1816-4978

Yield Response of a Cowpea Variety on Ground Seashells on Isohyperthermic Arenic Kandiudult of Owerri Southeastern Nigeria

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Abstract: Vital 5 variety of cowpea was cultivated on a very sandy ultisol of Owerri, Southeastern Nigeria-using 3 rates of ground seashells, namely 0 t ha^{-1}, 1 t ha^{-1} and 2 t ha^{-1}. Results showed that soil pH increased from 3.3 (0 t ha^{-1}), 4.2 (1 t ha^{-1} ground seashells) to 4.3 (2 t ha^{-1} ground seashells) Aluminum saturation (ALSAT) decreased from 64% (0 t ha^{-1}), 46% 1 t ha^{-1}) to 38% (2 t ha^{-1}) while base saturation (BSAT) increased from 18% (0 t ha^{-1}), 41% (1 t ha^{-1}) to 52% (2 t ha^{-1}). Available phosphorus distribution was 6.8, 24 and 32 ppm for 0, 1 and 2 t ha^{-1}, respectively. Yield responses varied according to rate of lime (ground seashells) application with 1, 302.0, 1808.0 and 1896.5 kg ha^{-1} for 0, 1 and 2 t ha^{-1}, respectively.

Key words: Yield response, lime, cowpea variety, isohyperthermic-kandiudults, Owerri Southeastern, Nigeria

Introduction

The role of cowpea in soil fertility restoration, livestock and human nutrition cannot be overemphasized. Lucas (1982) reported that indigenous varieties of cowpea contain 22-24% crude protein on dry weight basis while improved varieties contain 23-35% crude protein (FPDD, 1989). In nitrogen fixation, nitrogen fixers associated with cowpea can add nitrogen equivalent of about 200 kg N ha^{-1} of ammonium sulphate (Wrigley, 1981). However, Rao (1993) stressed the capability of bacteria in root nodules of cowpea to convert atmospheric nitrogen to nitrate for plant use.

Several researchers have reported phenomenal land degradation in southeastern Nigeria due mainly to soil erosion (Obi, 1982; Obi and Ebo, 1995; Oti, 2002). The situation calls for cheap methodologies aimed at ameliorating the degraded soils of Southeastern Nigeria, especially in Owerri area with high demographic pressure based on the low-input technological status of the study site. Onweremadu *et al.* (2003) recommended the use of dehydrated pig manure for the growth of maize on degraded ultisols of Owerri. Also, Ibeawuchi *et al.* (2006) recommended the use of poultry manure for vegetable crop production on the degraded ultisols of Owerri Southeastern Nigeria. All these points to the fact that the degraded Owerri ultisols needs serious soil improvement for a sustained cultivation and food production for the ever increasing human population in the area.

The major objective of this study was to investigate the yield response of a cowpea cultivar on a degraded isohyperthermic kandiudult treated with ground seashells.

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Materials and Methods

Location

The research was conducted at the experimental farm of Federal University of Technology Owerri. It is located on latitude 5°27'50.23" North and longitude 7°02'49.33" E, with an elevation of 55 m above mean sea level (Handheld Global Positioning System). It has a rainforest agro ecology characterized with more than 2500 mm annual rainfall and 27-29°C annual temperature. Soils belong to the soil mapping unit number 431, that is, Amakama-Orji-Oguta Soil Association (Federal Department of Agricultural and Land Resources (1985) and derived from coastal plain sands (Lekwa and Whiteside, 1986).

Soil Sampling

Fifteen-soil surface samples were randomly collected on soils of Owerri agricultural area, which has earlier been classified (Federal Department of Agriculture and Land Resources, 1985). These soil samples were oven-dried and sieved using 2 mm aperture in readiness for laboratory analysis. In addition to this, a profile pit was sunk in the site and described for classification purposes using Soil Survey Staff (2003).

Laboratory Analysis of Soil Samples

Particle size distribution was determined by hydrometer method (Gee and Bauder, 1986). Percent carbon was estimated by wet digestion (Nelson and Sommers, 1982). Total nitrogen was obtained using microkjeldahl (Bremner and Mulvaney, 1982). Exchangeable calcium, magnesium, potassium and sodium were extracted by ammonium acetate at pH 8.0 (Chapman and Pratt, 1965). Calcium and magnesium were measured using atomic absorption spectrophotometry while potassium and sodium were determined by flame emission. Exchangeable acidity was measured using the procedure of McLean (1982). Effective Cation Exchange Capacity (ECEC) was got by summation of exchangeable bases and exchangeable acidic cations. Soil pH was estimated electrometrically (Hendershot *et al*., 1993).

Land Preparation

The site was cleared by hand slashing, followed by tillage using spade. Minor stumping was carried out. Farm size covered 352 m^2 and each plot measured 5×4 m and 0.5 m was allowed within and between plots. A total of 15 plots were marked out. The experimental design was Randomized Complete Block Design (RCBD) using 3 levels of ground sea-shells, namely 0, 1 and 2 t ha^{-1} as treatments and replicated 5 times.

Finally, ground sea-shells were measured using Avery Weighing balance and incorporated immediately after tillage. The treatments were allowed to stay 14 days before planting. Vital 5 variety of cowpea was used since it is adapted to the rainforest belt.

The seed rate was 25-30 kg ha^{-1} and 86% germination (FPDD, 1989) percentage was recorded. Harvesting was done when about 75% of the pods were ripe and this was from 98 Days After Planting (DAP). Harvesting continued for 2 weeks when all pods matured. Dried pods were shelled and packaged for further use. A second set of 15 soil samples were collected and analyzed using the same procedure aforementioned for post-harvest soil analysis.

Results on yield response were analyzed using the Least Significant Difference (LSD) to determine treatment effect.

Results and Discussion

Soil Properties

A profile pit, which was sunk proximal to the experimental plot, had properties shown in Table 1 and 2. Soils were very sandy with coarse sand-sized fraction predominating over fine sand, silt and clay. This could be due to coastal plain sands parent material from which soils are derived. The clay content of the horizon next to the epipedon has 4% clay higher than the clay content of the epipedon. The profile pit shows a kandic horizon with more than 30 cm thickness and an apparent effective cation exchange capacity less than 16 cmol (+) kg^{-1} clay using 1 N NH_4OA_C at pH 8. Organic carbon consistently decreased with depth.

Table 2, shows morphological properties of soils. Soils were excessively to well-drained with root abundance decreasing with depth. Structurally, soils were of very fine granular surface horizons but having fine to coarse sub-angular blocky subsurface horizons. Soils were generally non-sticky and non-plastic to slightly sticky and slightly plastic. Soil colours were more reddish than 2.5 YR hue (Soil Munsell colour chart).

Earlier, soils of the study site have been classified as ultisols at upper category (Federal Department of Agricultural Land Resources, 1985). Based on the above, soils were classified as Isohyperthermic Arenic Kandiudults. The result of soil analysis shows that the soils are extremely acidic (pH 3.6-4.3 in I N KCl), of low base saturation (22-43%) and very low ECEC (2.8-5.0 cmol kg^{-1}). These result point to high status of degradation especially as it relates to soil reaction.

Soil surface sampling was done on the experimental site before liming and results are shown in Table 3. The soils are acidic and of high aluminum saturation (greater than 50%). The implications of these results include the possibility of aluminum toxicity and unavailability of essential plant nutrients in the soil. Gillman *et al.* (1989) observed excessive concentration of hydrogen and aluminum at pH range of 4 to 5 and that such reaction status limits plant growth. Present study revealed a low pH. Implying occupation of the soil exchange site with aluminum cations. Again, such a condition reduces phosphorus availability in soils (Khare *el al.*, 2004), which is a major limiting on soil productivity.

Table 1: Properties of the profile pit

Depth	Clay (%)	Silt (%)	Fine sand	Coarse sand	Total sand	Texture	H_2O	KCl	TEB	TEA	ECEC	BS	C
									--------- cmol kg^{-1} -------			------ % ------	
0-18	11	9	30	60	90	sand	4.1	3.7	1.1	1.1	2.8	39	0.90
18-52	15	9	24	64	86	LS	4.0	3.6	0.8	2.7	3.5	22	0.77
52-96	15	2	3	80	83	SL	4.8	4.3	2.1	2.7	4.8	43	0.50
96-135	17	1	3	79	82	SL	4.9	4.3	2.1	2.8	5.0	42	0.12
135-195	9	2	2	87	89	LS	4.2	3.8	0.8	2.1	2.9	27	0.05

TEB = Total Exchangeable Bases, TEA = Total Exchangeable Acidity, BS = Base Saturation, ECEC = Effective Cation Exchange Capacity, C = Carbon, LS = Loamy Sand, SL = Sandy Loan

Table 2: Some morphological characteristics of the profile pit

Horizon	Depth (cm)	Hue (moist)	Value	Chroma	Drainage abundance	Root	Structure	Consistence
A	0-18	2.5YR	3	2	Excessively drained	Many, mixed	vf gr	ns, np.
AB	18-32	2.5YR	3	4	Well-drained	“ fibrous	f sbk	ns, np
Bt_1	52-96	10 R	3	2	“ “	Few fibrous	Co,sbk	ns, sp
Bt_2	96-135	10R	3	6	“ “	Very few woody	f sbk	ss, sp
Bt_3	135-195	10R	3	6	“ “	“ “ “	f sbk	ns, sp

YR = Yellowish Red, R = Red, vf = very fine, gr = granular, f = fine, Sbk = subangular blocky, Co = Coarse, np = non-plastic, ns = non-sticky, ss = slightly sticky, sp = slightly plastic

Table 3: Pre-liming characterization of soil chemical properties

pH INKU	H^+	Al^{3+}	TEA	ALSAT (%)	Ca^{2+}	Mg^{2+}	K^+	Na^+	ECEC	BSAT	C	OM	TN	Avail P (ppm)
	(cmol kg^{-1})				(cmol kg^{-1})				(%)					
3.6	1.0	2.5	3.50	55	0.6	0.3	0.06	0.06	4.52	22	2.0	3.45	0.140	13
3.6	0.9	2.4	3.3	55	0.7	0.2	0.07	0.05	4.32	23	2.2	3.79	0.160	16
3.3	0.9	2.5	3.4	57	0.5	0.3	0.07	0.06	4.35	22	2.4	4.13	0.165	10
3.5	1.0	2.2	3.2	50	0.6	0.4	0.07	0.05	4.33	26	2.5	4.30	0.170	11
3.8	0.9	2.4	3.3	55	0.6	0.3	0.06	0.06	4.36	24	2.3	3.96	0.150	9
3.9	1.0	2.2	3.2	53	0.5	0.3	0.06	0.06	4.13	22	2.2	3.79	0.165	8
4.0	0.8	2.6	3.4	56	0.6	0.4	0.06	0.07	4.73	26	2.4	4.13	0.160	12
3.7	0.8	2.5	3.3	53	0.6	0.4	0.07	0.06	4.73	25	2.4	4.13	0.165	16
3.6	0.9	2.3	3.2	56	0.7	0.1	0.07	0.04	4.10	22	2.1	3.62	0.118	6
3.5	0.7	2.5	3.2	59	0.5	0.4	0.05	0.05	4.20	23	2.2	3.79	0.158	7
3.6	0.8	2.6	3.4	57	0.7	0.3	0.08	0.02	4.50	24	2.6	4.48	0.250	9
3.7	0.7	2.5	3.2	60	0.6	0.3	0.03	0.02	4.15	22	2.4	4.13	0.150	11
3.9	0.8	2.5	3.3	53	0.5	0.5	0.08	0.05	4.73	25	2.3	3.96	0.150	14
4.1	0.9	2.4	3.3	55	0.6	0.3	0.06	0.06	4.32	23	1.9	3.28	0.120	6
4.0	0.9	2.3	3.2	56	0.6	0.02	0.05	0.05	4.10	22	2.2	3.79	0.146	9

TEA = Total Exchangeable Acidity, ECEC = Effective Cation Exchange Capacity, BSAT = Base Saturate, ALSAT = Aluminium Saturation, OM = Organic Matter, TN = Total Nitrogen

Table 4: Changes in selected soil properties at harvest (mean values)

	Rate ($t\ ha^{-1}$)		
Property	0	1	2
pH	3.3	4.2	4.3
ALSAT	64%	46%	38%
BSAT	18%	41%	52%
ECEC	3.6 cmol kg^{-1}	4.6 cmol kg^{-1}	4.9 cmol kg^{-1}
Avail. P	6.8 ppm	2.4 ppm	3.2 ppm

Table 4 shows that liming effect depends on rate of application. At harvest, soil pH in the control plot decreased implying that there was uptake of basic cations during the growth of cowpea, which further acidified control plots. Treated plots had increases in soil pH, base saturation, effective cation exchange capacity and available phosphorous and a reduction in aluminum saturation (Table 4). Phosphorus became more available within a narrow pH range of one unit (that is, 4.2 to 4.3).

Post harvest determinations (Table 5) indicate decreases in total exchangeable acidity, aluminum saturation and organic matter content of the soil while increases were recorded on pH, ECEC, base saturation and available phosphorus. This confirms remedial role played by ground seashells on the soil. Reduced content of organic component is traceable to high mineralization of organic mater on opening soils for cultivation (Eshett *et al*., 1989) as well as consequent utilization during growth. In addition to this, the high rainfall and temperature of the site implies heightened leaching and volatilization, respectively. Low organic matter content means poor ability of soils to reduce aluminum toxicity through complexation (Gillman *et al*., 1989).

Yield

There were significant yield differences between the treated plots and the control plots and between the treated 2.0 t ha^{-1} and treated 1.0 t ha^{-1} at $p>0.05$. Highest yield was recorded on plots treated with 2.0 t ha^{-1} (1896.5 kg ha^{-1}) and least on control plots. Yield performance of cowpea was affected by soil reaction as indicated in the results. Cowpea is acid-tolerant but performs best at pH 5.5 (Isirimah *et al*., 2003). It means that a further application of ground seashells or any other liming material is needed in the site to increase the pH to 5.5. This suggests that the optimum yield of cowpea

Table 5: Post harvest characterization of soil chemical properties

pH 1N KU	H^+ (cmol kg^{-1})	Al^{3+}	TEA	ALSAT (%)	CA^{2+} (cmol kg^{-1})	Mg^{2+}	K^+	Na^+	ECEC (%)	BSAT	C	OM	TN	Avail P (ppm)
4.6	0.8	2.1	2.9	38	1.6	0.8	0.06	0.07	5.43	46	1.17	2.02	0.110	25
4.6	0.6	2.1	2.7	41	1.3	0.9	0.06	0.06	5.02	46	1.60	2.76	0.090	30
4.4	0.8	2.1	2.9	39	1.4	0.9	0.08	0.08	5.36	45	1.63	2.81	0.090	22
4.6	0.7	2.0	2.7	38	1.4	0.9	0.06	0.08	5.14	47	1.16	2.00	0.100	30
4.7	0.6	2.0	2.6	4.4	1.0	0.08	0.06	0.08	4.54	42	1.90	3.28	0.090	31
4.9	0.8	2.1	2.9	37	1.6	0.9	0.08	0.09	5.61	47	2.00	3.45	0.080	28
4.9	0.6	2.2	2.8	40	1.8	0.9	0.08	0.07	5.45	48	2.10	3.62	0.100	29
4.9	0.6	2.1	2.7	41	1.3	0.9	0.06	0.06	5.04	46	2.20	3.79	0.100	25
4.8	0.6	2.0	2.6	39	1.3	1.0	0.07	0.08	5.05	48	2.30	3.96	0.110	38
3.7	0.5	2.1	2.6	40	1.4	1.0	0.08	0.07	5.15	49	2.10	3.62	0.100	40
4.7	0.6	2.2	2.8	45	1.1	0.8	0.05	0.06	4.81	41	2.00	3.45	0.100	29
4.6	0.6	2.4	3.0	45	1.5	0.7	0.05	0.05	5.30	43	2.40	4.13	0.150	26
4.3	0.4	2.2	2.6	4.6	1.0	0.9	0.06	0.18	4.74	45	1.90	3.28	0.090	24
4.6	0.5	2.4	2.9	41	1.5	0.9	0.07	0.10	5.47	46	2.40	4.13	0.160	36
4.8	0.6	2.2	2.8	4.2	1.4	0.8	0.06	0.08	5.14	45	2.02	3.37	0.100	22

Table 6: Yield responses (kg ha^{-1})

Rate (t ha^{-1})	Net grain yield (kg ha^{-1})	Dry matter (kg ha^{-1})
Control	1302.0	303.0
1	1808.0	495.1
2	1896.5	689.8
LSD 0.05	52.3	89.7

in the site has not been attained. The dry matter yield also indicated that at 2.0 t ha^{-1} there were higher dry-matter obtained than in other treatments. It is of note that dry matter accumulation is a measure of relative yield. This shows that as pH is increased from 5.5 to 7.3 there may be higher yields both in grain and dry matter. Therefore ground seashells when added to soil helps to improve its productivity by increasing the base saturation, soil pH, phosphorus availability etc (Table 6).

Relating results to microbial activity vis-à-vis nitrogen fixation, one aptly concludes that the ability of nitrogen fixers associated with *Vigna unguiculata* L. Walp, has not been exhausted. Isirimah *et al*. (2003) reported that N-fixation activities of beneficial organisms are inhibited in strongly acidic soils. Therefore the ameliorating effects of the ground seashells must have influenced the soil pH to enable the N-fixers act positively in the cowpea roots. Yield responses in control plots may have been affected by some observed results above-shoot symptoms. Generally, there were retarded growths in most plants growing on control plots plus occurrence of pate to yellowish green colouration of young plants. These are possible nutrient deficiency diseases induced by high acidity in the control plots and these symptoms were minimal in treated plots. All these may have interacted to cause variability in the yield of Vital 5 variety of cowpea used for the study.

Conclusions

Soils of the study site are highly degraded, acidic and needs remediation for optimum productivity. Sand-sized fractions predominated over other particle size fractions. Soils were classified as Isohyperthermic Arenic Kandiudults (USDA-Soil Taxonomy).

Soils have high aluminum toxicity but species of say polymeric or monomeric species were not investigated in this study. Such investigations in future would be necessary as aluminum toxicity depends on the species type.

Treatment of soils of study site with ground seashells improved soil properties like base saturation, soil pH and effective cation exchange capacity and consequently increased phosphorus availability. These improvements in soil properties may have increased the activity of soil nitrogen fixers.

Finally, there were higher yields in plots treated with ground seashells. These high yields in the experiment do not represent optimum cowpea yields in the study site since optimum pH range of cowpea (pH = 5.5) was not attained in the liming experiment. Based on this, we recommend more trials with increased levels of ground seashelland.

Acknowledgement

We appreciate the assistance we enjoyed from Staff, Department of Soil Science, University of Nigeria, Nsukka.

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