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Full Length Research Paper

Growth of groundnut (*Arachis hypogaea* L.) on degraded isohyperthermic arenic kandiudult amended with Oyster shell in a university farm, Southeastern, Nigeria

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We studied effect of 6 rates of ground oyster shell (GOS) on the growth characteristics of groundnut (*Arachis hypogaea* L.) in 2007 cropping season. It was a greenhouse experiment arranged in a completely randomized design (CRD) with 6 rates of 0, 250, 500, 750, 1000 and 1250 g/5 kg soil and replicated 4 times. Soil samples were subjected to routine laboratory analyses while growth measurements were also made on root and shoot parts of the test crop. Soil and crop data were analyzed statistically using analysis of variance (ANOVA) and regression analysis. Rates of GOS had significant ($p = 0.05$) effect of root length and root numbers at 14, 21, 28, 35, 42, 49, 56 and 63 days after planting (DAP). There were significant ($p = 0.05$) effects of GOS on some soil properties at post harvest stage of this study. There was significant ($p = 0.05$) positive correlation between GOS and Ca content while it related negatively with total exchangeable acidity ($r = 0.95$; $p = 0.05$).

Key words: Amendment, *Arachis hypogaea,* degradation, growth, tropical soils.

INTRODUCTION

Soils of southeastern Nigeria are highly degraded, resulting from a combination of harsh climate, demographic pressure and land use characteristics and nature of soils. In this study area, soil erosion via the agency of water is predominant and affects ultisols which cover over 67, 200 km^2 of the total land area (Mbagwu, 1992). Soil degradation includes deterioration of physical properties by compaction, increase in bulk density and penetration resistance (Unger and Kaspar, 1994) and diminution of cherished soil chemical quality. South-eastern Nigeria is associated with excessive rainfall, and consequent leaching and runoff losses, needing the use of inorganic of fertilizers which increase soil acidity (Obi and Akinsola, 1995). This calls for alternative sources of improving soils outside inorganic amendments as soils of the area are potentially acidic (Onweremadu et al., 2006), and degradation of soils reflects in its diminished capacity to produce food crops (Brady and Weil, 1999).

Groundnut (*A. hypogaea* L.) is a common leguminous crop in the savanna belt of Nigeria although it grows in virtually all ecological zones of Nigeria. High performance of groundnut in inherently low fertility soils of Guinea and Sudan savanna areas of Nigeria (Enwezor et al., 1988) caused the application of the crop on highly degraded soils of a university research, Federal University of Technology, Owerri Nigeria, Soils of this study area are very low in pH and total nitrogen (FDALR, 1985) but

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groundnut is tolerant to acidity and aluminum toxicity (Mutsaers et al., 1997). Groundnut would fix atmospheric nitrogen to enrich the nitrate, depleted soils as well as cover soils from raindrop impacts. This has resulted to increasing studies on groundnut in the derived savanna and rainforest belts of Nigeria (Nottidge et al., 2008). Similar studies were extended to cowpea (Okpara, 2000; Attah et al., 2005) and soyabean (Onwualu and Ahaneku, 2000) and bambara groundnut (Mbagwu et al., 2000). Studies have been conducted in recent times on the use of soil amendments for restoring degraded soils (Mbagwu, 1988), but this is necessary with increasing population and conflictive land use types (Mbagwu and Auerswald, 1999). Based on the above, the main objective of this study was to investigate the growth and yield characteristics of groundnut if depleted soils are amended with ground oyster shells. Specifically, we evaluated the residual effect on some soil properties.

MATERIALS AND METHODS

Study area

The Centre for Agricultural Research, Federal University of Technology, Owerri is located in southeastern Nigeria (Latitudes 5° 20[1] and 5°401N; and Longitudes 7°101 and 7°301E).It has a relatively gentle sloping topography (Figure 1). Soils are derived form Coastal Plain Sands (Benin Formation) of the Oligocene – Miocene geologic era. This study area has a humid climate with about 2500 mm mean annual rainfall while mean annual temperature ranges from 26 to 29°C. It lies within the rainforest belt, and arable farming is a prominent socio – economic activity of the area.

Experimental materials

Mature seeds of groundnut (*A. hypogaea* L.) were obtained from a Research Institute at Samaru, Northern Nigeria. Soil amendment used was oyster shell, obtained from Ogbete main market, Enugu, Southeastern Nigeria. The shells were gotten empty and dry but were crushed, ground, and passed through 2-mm sieve to achieve a fine texture. Poultry dropping was used to boost crop growth. Poultry droppings were given the same treatment as in oyster shell.

Experimental design

This study was carried out in a greenhouse under natural lighting, temperature and hydrometric conditions. Soil samples were randomly collected from Ap horizons (0 to 20 cm depth) of the research farm. Soil samples were air–dried and passed through 2-mm sieve. These soil samples were bulked to obtain a composite sample. Perforated black polyethylene bags were filled with 5 kg of sieved soils. The polyethylene bags containing soils were laid out in a completely randomized design (CRD) and replicated four times. Treatment (ground oyster shell) rates were 0, 250, 500, 750, 1000 and 1250 g per polyethene bag. Each treatment rate was mixed thoroughly with 5 kg soil. Forty grammes of poultry droppings were applied per polyethylene bag to boost performance of all treatment rates including the control. Planting was done in June 2002. Seeds were packed in holes at 2 seeds per planting hole and 6 holes were made in each polyethene bag. Growth parameters, namely root weight, number of roots, root length and shoot weight were measured at 14, 21, 28, 35, 42, 49, 56 and 63 days after planting.

Soil analysis

Particle size distribution was determined by hydrometer method (Gee and Or, 2002). Soil pH was measured using 1:2.5 soil – solution ratio (Thomas, 1996). Exchangeable basic cations were determined by inductively coupled plasma atomic emission spectrometer (ICP – AES) (Integra XMO, GBC, Arlington Heights, IL USA). Exchangeable acidity was estimated titrimetrically (Mclean, 1982) Effective cation exchange capacity was obtained by summing exchangeable basic cations and exchangeable acidity while total exchangeable base was gotten by summing all basic cations. Total soil carbon was determined by a Leco CS444 analyzer (Leco Corp. ST. Joseph, MI). Soil samples were placed in a furnace overnight at 475°C to estimate inorganic carbon, and organic carbon was measured as a difference between total and inorganic carbon (Yang and Kay, 2001). Total nitrogen was determined by micro–Kjeldahl (Bremner, 1996) analysis. Soil and plant data were subjected to analysis of variance (ANOVA) at 5% probability level using version I0.0 SPSS (SPSS, 1999) while correlation and regression analyses were performed using SAS (SAS Institute, 2001).

RESULTS

Preplanting soil properties and ground oyster shell properties

Results of pre-planting soil analyses are shown in Table 1, indicating that soils were sandy, strongly acidic, of low organic carbon and low effective cation exchange capacity. Low levels of total nitrogen and available phosphorus were recorded. Ground oyster shell (GOS) had highest value of exchangeable calcium, followed by exchangeable magnesium, exchangeable potassium and available phosphorus while least value of attributes was obtained in total nitrogen (Table 2).

Effect of GOS on groundnut growth

Table 3 shows temporal changes in growth parameters of groundnut (*A. hypogaea* L.) following amendment of soils with GOS. Mean root weight did not increase steadily, rather was varying within rates of GOS. There was significant (p=0.05) effect of GOS on root mean weight at 21 DAP while there were non-significant differences on root mean weight at 14 and 25 DAP. Slight differences in values of mean shoot weight were recorded in all rates at 14, 21 and 28 DAP but these differences were not statistically significant. Highest values of mean shoot weight were consistently obtained at 1250 g rate of GOS. Addition of GOS significantly (p=0.05) influenced groundnut root length. Highest values of root length were obtained at 0 and 250 rates of GOS in 28 DAP. There was no clear trend in the distribution of root length at 14, 21 and 28 DAP. Generally, rates of GOS had a significant (p=0.05) effect on root numbers. However, at 35, 42, 49, 56 and 63 DAP, significant (p=0.05) differences in root

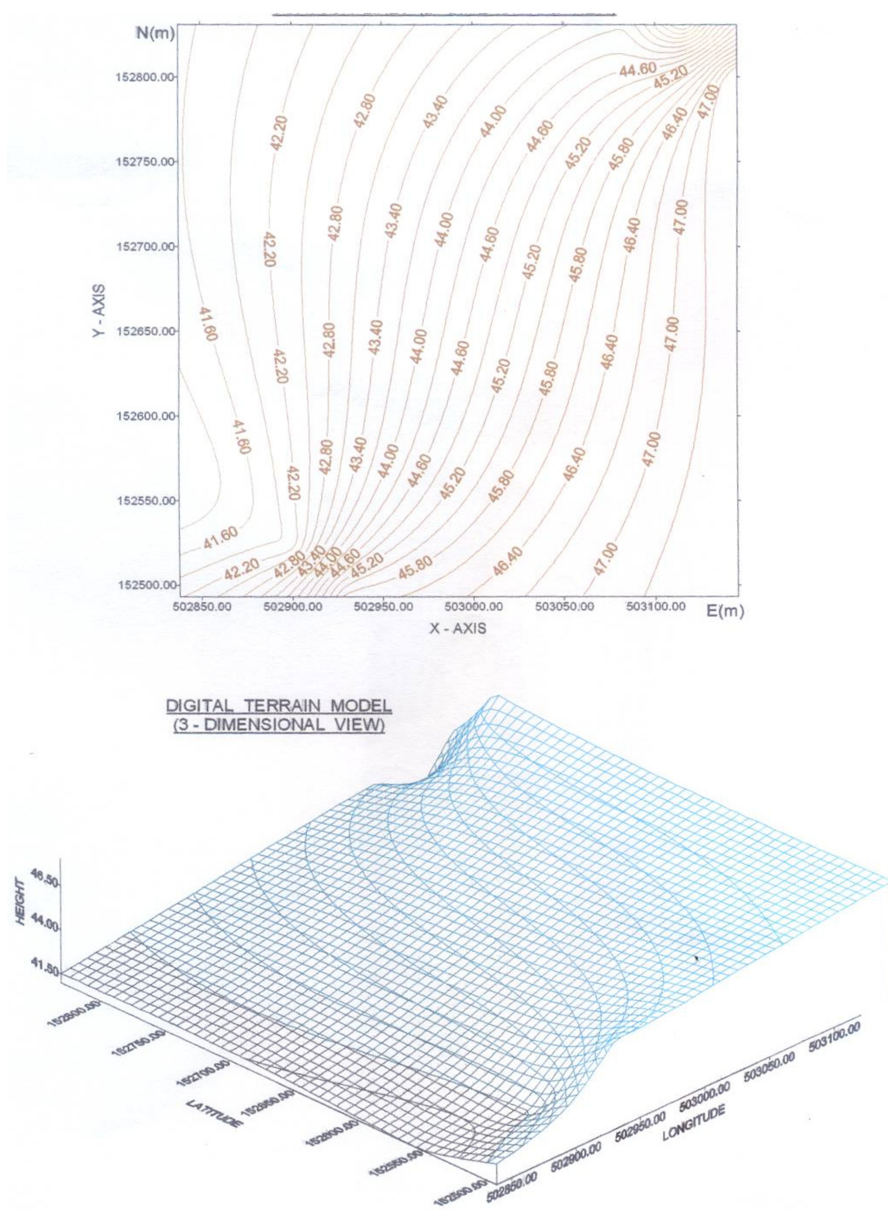

Figure 1. Digital elevation model of the Centre for Agriculture Research Farm Federal University of Technology Owerri, Nigeria.

Table 1. Some soil properties of study site (Pre-planting).

Property	Unit	Value
Sand	g kg^{-1}	914
Silt	g kg^{-1}	58
Clay	g kg^{-1}	38
pH (Water)	-	4.85
Total carbon	g kg^{-1}	15.4
Organic carbon	g kg^{-1}	8.3
Total nitrogen	g kg^{-1}	0.8
Available phosphorus	mg kg^{-1}	5.5
Total exchangeable bases	cmol kg^{-1}	1.5
Effective cation capacity	cmol kg^{-1}	3.8

Table 2. Characterization of ground oyster shell.

Property	Unit	Value
Available phosphorus	mg kg^{-1}	48
Total carbon	g kg^{-1}	36
Total nitrogen	g kg^{-1}	3
Exchangeable calcium	cmol kg^{-1}	320
Exchangeable magnesium	cmol kg^{-1}	115
Exchangeable potassium	cmol kg^{-1}	85

number were recorded. At 1250 g kg^{-1} rate of GOS, highest numerical value of 51.7 was gotten at 63 DAP

Table 3. Effect of ground oyster shell (GOS) on growth of groundnut (mean values).

Rate of GOS G per 5 kg soil	Root weight (g)	Shoot weight (g)	Root length (cm)	Number of roots
14 DAP				
0	0.79	3.07	9.64	17.25
250	1.03	2.74	8.15	28.00
500	0.90	3.15	8.92	22.25
750	0.73	3.44	7.67	20.50
1000	0.99	3.44	8.72	26.50
1250	0.91	3.87	9.05	31.25
F-LSD $_{(0.05)}$	NS	NS	0.82	6.45
21 DAP				
0	0.87	4.70	18.52	27.75
250	1.08	4.40	16.40	24.75
500	0.97	4.62	22.27	28.00
750	0.90	4.47	20.57	43.50
1000	0.87	4.92	19.60	33.25
1250	1.27	5.72	20.40	34.75
F-LSD $_{(0.05)}$	0.19	NS	2.25	4.36
28 DAP				
0	0.55	5.80	23.15	28.00
250	0.65	4.87	28.22	31.00
500	0.75	5.85	16.77	41.50
750	0.67	4.85	16.77	39.25
1000	0.75	4.92	18.67	44.75
1250	0.57	5.86	17.20	44.75
F-LSD $_{(0.05)}$	NS	NS	1.65	7.84

DAP = days after planting, F-LSD = Fisher's Least Significant Difference.

(Table 4). With the exception of results of 49 DAP, there was significant (p=0.05) difference in the effect of GOS on root length.

Post–harvest changes in soil properties were reported in Table 5. There were significant (p=0.05) improvements on soil pH, available phosphorus, soil organic carbon, effective cation exchangeable capacity and total nitrogen: There was a consistent increase in soil pH, ECEC and TEB with increased GOS application while available phosphorus, organic carbon and total nitrogen did not follow any trend. There were significant (r=0.736; p=0.05) positive correlation between rates of GOS and Ca-content of soils after harvest (Figure 2), while total exchangeable acidity decreased significantly (r=0.95; p=0.05) as exchangeable calcium content of soils increased (Figure 3).

DISCUSSION

Results showed low levels of soil fertility indices especially organic fractions, ECEC and available phosphorus, and these values were consistent with the findings of scholars in this study area (Oguike and Mbagwu, 2001; Igwe, 2003). In southeastern Nigeria, soil erosion has devastated agricultural and non- agricultural landscapes (Igwe, 2003) and the situation is aggravated by increasing demographic pressure with conflicting land use types coupled with nature of parent material and excruciating tropical climate. Strong acidity of studied soils suggests unavailability of essential plant nutrients such as calcium, magnesium, potassium, phosphorus, nitrogen, molybdenum and boron. In contrast, such soils increase toxicity of iron, zinc, aluminium, copper, manganese and cobalt due to their excessiveness. Intermediate pH values are more productive than extreme pH values. Low pH values might have affected soil pH dependent microbes, which are associated with improvement of soil physical and biological properties including aggregation and mineralization of plant nutrients (Adeniyan and Ojeniyi, 2005).

High calcium and magnesium content of ground oyster shell is indicative of its great potential as a liming material. The GOS significantly (p=0.05) improved root length and number of roots (Table 3), and these growth parameters are associated with yield of nuts. Significant (p=0.05)

Table 4. Effect of ground oyster shell (GOS) on some growth parameters of groundnut (mean value).

Rate of GOS G per 5 kg soil	Days after planting				
	35	42	49	56	63
Root number					
0	31.0	33.4	33.0	33.7	34.5
250	34.0	35.7	34.0	36.5	37.0
500	43.0	36.7	37.7	37.2	37.7
750	41.5	47.7	47.5	48.7	49.2
1000	47.7	47.7	46.2	47.2	46.5
1250	47.5	50.5	50.2	47.2	51.7
F-LSD $_{(0.05)}$	6.42	7.09	8.49	8.15	7.52
Root length (cm)					
0	26.15	28.90	21.82	29.20	28.75
250	21.32	24.35	19.00	24.72	24.30
500	19.77	22.77	18.75	22.92	22.67
750	19.47	22.47	19.35	22.52	23.67
1000	21.67	24.42	15.47	24.67	23.87
1250	20.20	23.45	17.40	23.65	23.25
F-LSD $_{(0.05)}$	1.65	1.40	NS	1.31	0.85

F-LSD = Fisher's Least Significant Difference.

Table 5. Post–harvest soil properties.

Rate of GOS g per 5 kg soil	pH (Water)	Average P (mg kg^{-1})	OC (g kg-^{1})	ECEC (cmol kg^{-1})	TEB	TN (g kg^{-1})
0	4.84	5.45	8.4	3.90	1.52	0.92
250	5.01	9.88	9.1	4.89	3.93	1.20
500	5.61	9.76	9.0	6.01	5.45	1.60
750	5.53	14.22	12.5	6.50	5.97	2.61
1000	5.79	17.06	14.4	6.55	5.98	1.93
1250	6.23	15.26	15.6	7.06	6.50	2.96
F-LSD $_{(0.05)}$	1.02	2.17	1.09	1.86	2.22	0.81

Average= P = available phosphorus, 0C = organic carbon, ECEC = effective cation exchange capacity, TEB = total exchangeable bases, TN= total nitrogen, F-LSD = Fisher's Least Significant Difference.

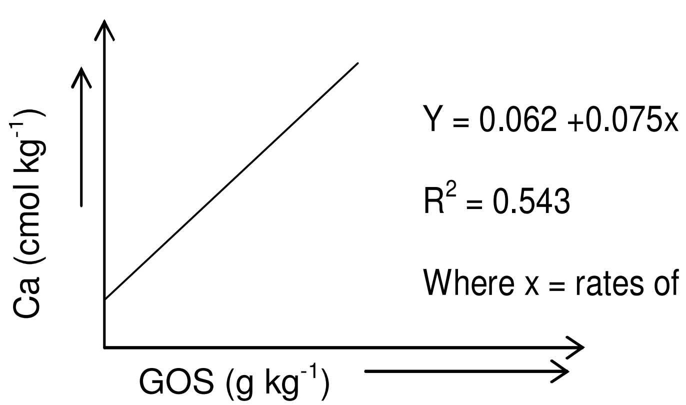

Figure 2. Linear relationship between rates of GOS and exchangeable calcium.

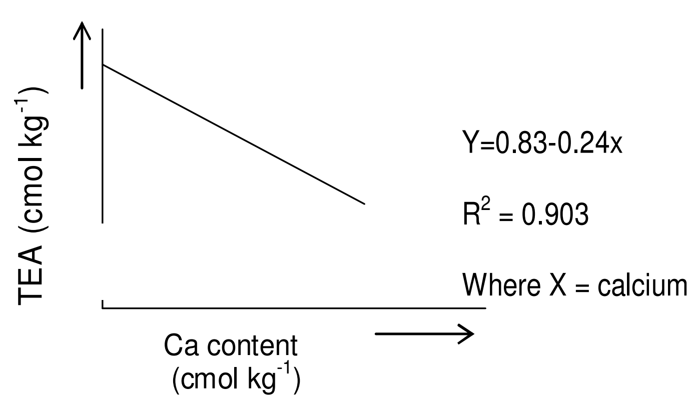

Figure 3. Linear relation between total exchangeable acidity and exchangeable calcium in studied soils.

changes in root length and number could be due to variation in rhizo-deposition (Allmaras et al., 2004), presence of other living roots (Cheng and Coleman, 1990), soil temperature and water regimes (Goss and Watson, 2003), crop residue contact with soil and soil nitrogen content. Values of shoot weight were higher than root weight but did not vary significantly in all temporal measurements, suggesting that edaphic properties varied more than aerial properties of groundnut in this study area. In another sub-Saharan study site, Murata et al. (2002) reported that calcium–containing materials influenced the soil pH, nutrient availability and productivity of groundnut (*A. hypogaea* L.) on acid sandy soils.

The GOS relative to the control had significant (p=0.05) improvement on soil properties especially soil pH where it increased its value, thereby reducing possibility of aluminum toxicity in soils. In highly weathered soils of the humid tropics, soils consist of low activity clay minerals such as kaolinite, Al and Fe oxides resulting to the preponderance of Al in the exchange sites (Gillman et al., 1989). High Al levels in the soil prevent healthy root penetration, and lack of Ca greatly reduces root proliferation (Bangerth, 1979). The application of GOS increased total exchangeable cations (Figure 2), implying higher base saturation and reduced aluminium occupation of the soil micelle; consequently, increasing Ca content led to a corresponding decrease in total exchangeable acidity (Figure 3), and this could also increase soil moisture content (Logsdon and Laird, 2004) and electrical properties (Logsdon, 2000).

Conclusion

Applications of GOS on degraded soils of a university farm have a major effect on root characteristics of groundnut (*A. hypogaea* L.) compared with growth parameters. It is suggested that researchers should try to increase the number of edaphic and crop attributes in future studies, in addition to evaluating its adaptability in a weedy environment.

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