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Effects of Ground Seashells and Rabbit Dung on *Amaranthus* Grown on Degraded Paleudults in South Eastern Nigeria

E.U. Onweremadu
Department of Soil Science and Technology, Federal University of Technology,
PMB, 1526 Owerri, Nigeria

Abstract: Responses of *Amaranthus caudatus* to application of ground seashells (GSS) and Rabbit Dung (RD) on erosion-degraded ultisols were studied. Three experiments were conducted from April to June, 2006 in three locations of Owerri, Southeastern Nigeria for this purpose, using 7 manurial treatments, namely control, 2 t ha^{-1} GSS, 8 t ha^{-1} RD, 2 t ha^{-1} GSS+2 t ha^{-1} RD, 2 t ha^{-1} +4 t ha^{-1} RD, 2 t ha^{-1} GSS+6 t ha^{-1} RD and 2 t ha^{-1} GSS+8 t ha^{-1} RD. These treatments were replicated thrice in a Randomized Complete Block Design (RCBD). Combinations of GSS and RD increased growth and yield parameters of *Amaranthus caudatus* with 8 t ha^{-1} RD, 2 t ha^{-1} GSS+4 t ha^{-1} RD and 2 t ha^{-1} GSS+8 t ha^{-1} RD giving higher fresh matter yield of 55.2, 49.1 and 77.0 t ha^{-1}, respectively.

Key words: Amendment, degradation, eastern Nigeria, refuse, tropics, vegetable, ultisol

INTRODUCTION

Water erosion is the most active erosion process in the ultisols of south eastern Nigeria, which cover more than 67200 km^2 of the total land area (Mbagwu, 1992). Of the erosion forms, sheet erosion predominates in most arable farmlands (Ofomata, 1987). This condition is aggravated due to increasing population resulting from urbanization. Farming in southeastern Nigeria is basically small-holder and continuous in nature and farmers resort to the use of inorganic fertilizers which is hampered by lack of established soil testing programmes, scarcity, adulteration and high cost. Soils of the study area are inherently acidic as they were derived from acidic parent materials. It implies that further application of inorganic fertilizers, most of which are acidic will increase soil acidity (Obi and Akinsola, 1995). Earlier Ano and Asumugha (2000) showed lower benefit-cost ratio for inorganic fertilizer compared with integrated use of chemical and organic fertilizers or non-use of chemical fertilizers. The foregoing stresses the need to explore other sources of soil amendments.

In East Africa, Cameroon and Zambia, ash derived from vegetation is recognized for its liming and fertilizer effects (Ojeniyi, 1998). Oguike and Mbagwu (2001) reported that residues from water hyacinth when mixed with poultry droppings and rice mill wastes improved maize performance in degraded tropical soils. Again, dehydrated pig manure improved the performance of maize grown on a degraded ultisol of southeastern Nigeria (Onweremadu *et al*., 2003). A recent study (Onweremadu *et al*., 2006) showed increased yield of a variety of cowpea cultivated on isohyperthermic Arenic Kandiudults of Owerri, south eastern Nigeria when amended with ground seashells.

Amaranthus (*Amaranthus caudatus*) popularly known as GREEN belongs to the *Amaranthaceae* and is widely used as a vegetable crop. The leaves are used in preparing soup and yam porridges. It is also used to garnish popular foods. It is commonly grown in flat beds near homesteads. It is also a fodder plant. *Amaranthus* has high degree of survivability through its numerous seeds and exhibits high germination percentage. With irrigation it makes a good dry-season crop, supplying vegetable leaf when it is scarciest.

While literature on the use of organic materials as fertilizer are voluminous, there is paucity of information on the use of ground seashells and rabbit dung in the husbandry of *Amaranthus* in the study area. Ground seashells are common wastes of seafood markets. Again the desire to supplement dairy products in southern Nigeria led to increasing rabbit husbandry, which is associated with dung wastes. This study was conducted to determine the performance of degraded Paleudults of Owerri, south eastern Nigeria when treated with different rates of ground seashells and rabbit dung.

MATERIALS AND METHODS

Three field experiments were conducted between April and early June, 2006 to compare the effects of no treatment (control), 2 to ha^{-1} ground seashells, 8 ha^{-1} rabbit dung, 2 t ha^{-1} GSS +2 t ha^{-1} RD, 2 t ha^{-1} +4 t ha^{-1} RD, 2 t ha^{-1} GSS+6 t ha^{-1} RD and 2 t ha^{-1} GSS+8 t ha^{-1} RD. The experiments were carried out simultaneously at different sites of Owerri agricultural zone, namely Ihiagwa, Obinze and Eziobodo dominated by ultisols. The 7 manurial treatments as above were replicated three times using a Randomized Complete Block Design (RCBD) was used for the experiments. Seeds of *Amaranthus* were sown in the greenhouse and nursed in trays containing sandy loam soils from the named sites. After 2 weeks, seedlings were transplanted at a spacing of 20×15 cm to each of the 21 plots. The plot area was 4 m^2 (i.e., 2×2 m). A week after transplanting, a ring method of manure application was done on the *Amaranthus*. The treatments were: Control, 2 t ha^{-1} ground seashells, 8 t ha^{-1} rabbit dung, 2 t ha^{-1} ground seashells plus 2 t ha^{-1} rabbit dung, 2 t ha^{-1} ground seashells plus 4 t ha^{-1} rabbit dung, 2 t ha^{-1} ground seashells plus 6 t ha^{-1} rabbit dung and 2 t ha^{-1} ground seashells plus 8 t ha^{-1} rabbit dung.

Performance parameters were determined weekly for 4 weeks after application of treatments. The parameters measured were number of leaves per plant, number of branches per plant and mean plant height. The fresh matter and dry matter yields were determined at harvest and in all determinations, 5 plants were taken per plot.

Soil and Plant Sampling and Analyses

Three auger samples were collected from each treated soil and bulked to produce 7 composite samples representing 7 treatments of the experiments. A profile pit was dug proximal to each experimental site and described in each location for soil classification purposes (Soil Survey Staff, 2003). Collected soil samples were air-dried and sieved using 2 mm sieve in readiness for laboratory analysis.

Particle size analysis was determined by hydrometer method (Gee and Or, 2002). Bulk density was measured by core method (Grossman and Reinsch, 2002). After equilibrating for 30 min, soil pH was measured in 0.1N KCl solutions, with a soil-liquid ratio 1:2.5 in each case, using a Beckman Zeromatic pH-meter (Mclean, 1982). Total nitrogen was estimated by Micro-Kjeldahl (Bremner, 1996). Total soil carbon was obtained by wet digestion (Nelson and Sommers, 1996). Exchangeable basic cations of Ca and Mg were determined using EDTA complexometric titration while exchangeable potassium and sodium were estimated by flame photometry. Exchangeable acidity was measured titrimetrically (Mclean, 1982).

Again, leaf samples were harvested at growth and maturity stages, before they were oven-dried and crushed in preparation for laboratory analyses. Total nitrogen was determined by Micro-Kjeldahl method (Bremner, 1996). Ground samples were digested with nitric-perchloric-sulphuric acid mixture and aliquot used to determine phosphorus, calcium, magnesium and potassium contents (AOAC, 1990). Phosphorus was obtained by Bray 2 method (Olson and Sommers, 1982). Materials used for soil treatments were also prepared and analyzed in the laboratory.

Statistical Analyses

Data were analyzed statistically using analysis of variance (ANOVA). Thereafter, means were separated by least significant difference at $p<0.05$ and Duncan New Multiple Range Test (DNMRT).

RESULTS

Soil morphological properties are shown in Table 1. Soil colour was yellowish red, well-drained and of very fine granular to moderate granular topsoil structure. Generally soils were non-sticky and non-plastic. Soils were very sandy, acidic, of low Effective Cation Exchange Capacity (ECEC) and low organic carbon (Table 2). Bulk density decreased with depth. Based on the soil properties, soils were classified as Typic Paleudult using soil taxonomy (Soil Survey Staff, 2003).

Table 1: Some morphological characteristics of studies profile pits

Horizon	Depth (cm)	Hue	Value	Chroma	Drainage	Root abundance	Structure	Consistence
Ihiagwa								
Ap	0-16	2-5YR	3	2	Excessively drained	Many, mixed	vf gr	ns, np
AB	16-32	2-5YR	3	4	Well-drained	Many fibrous	fsbk	ns, np
Bt_1	32-98	10R	3	2	Well-drained	Few fibrous	cosbk	ns, np
Bt_2	98-185	10R	3	6	Well-drained	Very few woody	vsbsk	ns, np
Obinze								
Ap	0-18	5YR	3	1	Well drained	Abundant	m gr	ns, np
AB	18-25	5YR	3	3	Well drained	Many, mixed	fsbk	ns, np
Bt	25-80	10R	3	4	Well drained	Few	fsbk	ns, np
BC	80-150	10R	3	4	Well drained	Very few	co sbk	ns, np
Eziobodo								
Ap	0-13	2-5YR	3	2	Well drained	Many, mixed	fgr	ns, np
E	13-25	5YR	3	3	Excessively drained	Few, mixed	fsbk	ns, np
Bt_1	25-110	10R	3	3	Well drained	Few fibrous	fsbk	ss, sp
Bt_2	110-190	10R	3	4	Well drained	Very few woody	cosbk	ss, sp

YR = Yellowish Red, R = Red, vf = very few, f = few, co = coarse, m = moderate gr = granular, sbk = subangular blocky, ns = non sticky, ss = slightly sticky, np = non-plastic, sp = slightly plastic

Table 2: Soil properties of studied profile pits

Horizon	Depth (cm)	Sand	Silt	Clay	SCR	pH H_2O	TEB	TEA	ECEC	OC	TN	BD
		------------- g kg^{-1} ---------------					-------- cmol kg^{-1} ---------			---- g kg^{-1} ----		(mg m^{-3})
Ihiagwa (Arenic paleudults)												
Ap	0-16	900	20	80	0.25	4.9	1.1	1.7	2.8	8	0.3	1.38
AB	16-32	850	30	120	0.25	4.7	1.0	1.9	2.9	4	0.1	1.40
Bt_1	32-98	800	10	190	0.05	5.0	1.8	1.0	2.8	2	0.1	1.56
Bt_2	98-185	790	10	200	0.05	5.1	2.1	0.9	3.0	1	0.1	1.71
Obinze (Typic paleudults)												
Ap	0-18	890	30	80	0.37	5.0	1.2	2.0	3.2	9	0.4	1.36
AB	18-35	860	40	100	0.40	4.8	1.1	1.8	2.9	4	0.2	1.41
Bt	35-80	850	20	130	0.15	5.1	1.6	1.6	3.2	2	0.1	1.57
BC	80-150	910	10	80	0.13	5.3	1.9	2.0	3.9	2	0.1	1.70
Eziobodo (Typic paleudults)												
Ap	0-13	900	20	80	0.25	5.0	1.1	1.8	2.9	10	0.3	1.32
E	13-25	910	10	80	0.13	4.4	0.7	2.5	3.2	4	0.1	1.40
Bt_1	25-110	850	20	130	0.15	5.3	1.4	2.0	3.4	3	0.1	1.55
Bt_2	110-190	820	20	160	0.13	5.5	2.2	2.0	4.2	2	0.1	1.69

SCR = Silt Clay Ratio, TEB = Total Exchangeable Bases, OC = Organic Carbon, TN = Total Nitrogen, TEA = Total Exchangeable Acidity, ECEC = Effective Cation Exchange Capacity

Results on characterization of amendments showed that ground seashells (GSS) contain high amount of exchangeable calcium (320 cmol kg^{-1}) with an appreciable quantity of exchangeable magnesium (115 cmol kg^{-1}) while Rabbit Dung (RD) had high content of organic carbon and total nitrogen (Table 3). However, the Rabbit Dung (RD) had lesser C:N and is expected to mineralize more rapidly than ground seashells.

Application of GSS and RD increased nutrients composition of leaves of *Amaranthus* significantly ($p<0.05$) compared with results of control plot (Table 4). Rabbit dung combined with GSS increased leaf N and P than GSS alone. This result was prominent when GSS was combined with 4 and 6 t ha^{-1} RD. Sole application of GSS and RD increased growth parameters of number of leaves and branches (Table 5). Addition of GSS increased leaf yield compared with GSS alone (Table 6). Generally, leaf yield increased as rate of RD increased.

Post-planting soil analysis (Table 7) shows that GSS and RD improved soil properties. Soil pH and OC which influence most other soil properties were raised to the optimum level for increased and sustained productivity of the highly weathered soils of the study site.

Table 3: Characterization of treatments

Parameters	Ground seashells	Rabbit dung
Total carbon (g kg^{-1})	36	305
Total nitrogen (g kg^{-1})	3	76
Exchangeable calcium (cmol kg^{-1})	320	95
Exchangeable magnesium (cmol kg^{-1})	115	17
Exchangeable potassium (cmol kg^{-1})	85	20
Available phosphorus (mg kg^{-1})	48	8
C:N	12	4

Table 4: Effect of ground seashells (GSS) and Rabbit Dung (RD) on the nutrients content of *Amaranthus* leaves

Treatments	N (g kg^{-1})	P (g kg^{-1})	Ca (cmol kg^{-1})	Mg (cmol kg^{-1})	K (cmol kg^{-1})
Control	20	1.4	2.4	0.6	1.1
2 t ha^{-1} GSS	49	3.9	3.9	1.6	2.5
8 t ha^{-1} RD	54	4.3	3.5	1.3	2.1
2 t ha^{-1} GSS+2 t ha^{-1} RD	55	3.7	4.0	1.8	2.3
2 t ha^{-1} GSS+4 t ha^{-1} RD	61	1.4	4.2	1.5	2.6
2 t ha^{-1} GSS+t ha^{-1} RD	55	3.8	3.8	1.0	2.5
2 t ha^{-1} GSS+8 t ha^{-1} RD	66	3.4	4.9	2.9	3.3
LSD (0.05)	24	0.8	0.8	0.6	4.0

LSD = Least Significant Difference

Table 5: Effect of GSS and RD on some growth parameter of *Amaranthus*

Treatments	Mean height (cm)	Mean No. of leaves	Mean No. of branches
Control	31.2	24	6
2 t ha^{-1} GSS	31.1	34	9
8 t ha^{-1} RD	65.9	72	18
2 t ha^{-1} GSS + 2 t ha^{-1} RD	60.4	70	15
2 t ha^{-1}+4 t ha^{-1} RD	48.4	77	16
2 t ha^{-1} GSS+6 t ha^{-1} RD	53.2	80	15
2 t ha^{-1} GSS+8 t ha^{-1} RD	91.2	100	20
LSD (0.05)	38.0	28	7

Table 6: Effect of GSS and RD on leaf yield of *Amaranthus*

Treatments	Fresh matter yield (t ha^{-1})	Dry matter yield (t ha^{-1})
Control	10.3^{d}	2.4^{d}
2 t ha^{-1} GSS	27.6^{ab}	6.4^{ab}
8 t ha^{-1} RD	55.2^{b}	12.7^{b}
2 t ha^{-1} GSS+t ha^{-1} RD	31.0^{ab}	7.1^{ab}
2 t ha^{-1}+4 t ha^{-1} RD	49.1^{b}	11.3^{b}
2 t ha^{-1} GSS+6 t ha^{-1} RD	42.3^{b}	9.7^{b}
2 t ha^{-1} GSS+t ha^{-1} RD	77.0^{c}	17.7^{c}

Means followed by the same letter(s) are not significantly different

Table 7: Residual effect of GSS and RD on some soil properties (Ap horizons)

Treatments	pH (H_2O)	TEB (cmol kg^{-1})	TEA (cmol kg^{-1})	ECEC (cmol kg^{-1})	OC (g kg^{-1})	T.N (g kg^{-1})
Control	3.7	0.7	1.8	2.5	4.3	0.1
2 t ha^{-1} GSS	4.4	1.7	2.2	2.9	7.0	0.1
8 t ha^{-1} RD	5.1	2.8	0.9	3.7	10.0	0.5
2 t ha^{-1} GSS+t ha^{-1} RD	5.5	3.2	0.8	4.0	14.0	0.6
2 t ha^{-1}+4 t ha^{-1} RD	6.8	4.1	0.9	5.0	20.2	0.9
2 t ha^{-1} GSS+6 t ha^{-1} RD	6.6	4.2	0.8	5.0	21.4	0.9
2 t ha^{-1} GSS+t ha^{-1} RD	6.3	4.1	0.8	4.9	20.8	0.9

TEB = Total Exchangeable Bases, TEA = Total Exchangeable Acidity, ECEC = Effective Cation Exchange Capacity, OC = Organic Carbon, TN = Total Nitrogen

DISCUSSION

Soil of the study site are highly weathered (Silt-clay ratio = 0.05-0.25), sandy, granular and acidic. The predominance of granular structures at the top horizons portend structural degradation. Sandiness and acidity could be attributed to both the influence of parent materials and harsh climate of the area. These activities interact to reduce the productive capacity of soils and this condition is aggravated by the increasing farm population without commensurate improvement of soils.

The use of GSS significantly ($p<0.05$) increased performance of *Amaranthus* as it had liming effect on the GSS in soils and this implied reduction in fixation of P and addition of exchangeable basic cations thus playing the double role of de-acidification as well as fertilization. The RD increased the growth and yield parameters of *Amaranthus* when compared with its performance under control plot, showing that RD contains those essential plant nutrients necessary for enhanced growth. Therefore, GSS and RD complemented each other to their effects on general performance of *Amaranthus caudatus*. The improved residual fertility resulting from these treatments is a good development given that area is a feeder farm area to Owerri Municipality. Soil reaction status of treated soils after harvest (pH water = 5.1-6.8) is very desirable as soil acidity is a major limiting factor in this part of the humid agreocology. At this pH range, most soil nutrients are available in studied soils. These results are consistent with the findings of Onweremadu *et al*. (2006) that GSS increased soil pH to an optimal range of 5.5-7.3.

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