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Soil Physical Properties and Yields of Okra (*Abelmoschus esculentus*) as Affected by Locally Manufactured Compost in Nigeria

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Abstract: The superiority of organic fertilizer on crop yield as compared to combination of an inorganic and organic fertilizer (organo-mineral fertilizer) is evident. Experiments were conducted during 2005 and 2006 growing seasons to compare the residual effects of amended compost grade A and unamended compost grade B on the soil physical properties and growth and yields of okra. Eight treatments comprising of compost grade A applied at 80, 100 and 120 kgN ha^{-1} and compost grade B applied at 80, 100 and 120 kgN ha^{-1} and urea at 100 kgNha^{-1} and control (without application). The treatments were replicated four times in a randomized complete block design on an Alfisol in Ibadan. Only compost grade B had significant residual effects on particle size distribution, bulk density, saturated hydraulic conductivity and permeability of the soil after the fourth growing season with 120 kgNha^{-1} being the best among others. Average magnitude of change (%) in the fresh pods weight (FPW) over the four growing seasons with respect to the first growing season in 2005 showed that compost grade A at 80, 100 and 120 kgN ha^{-1} was decreased by 31.2, 37.5 and 50.6%, respectively and compost grade B at 80 100 and 120 kgN ha^{-1} decreased by 22.0, 7.0 and 0.8%, respectively, while urea and control plots decreased by 68.3 and 23.1%, respectively. Residual superiority of compost grade B over compost grade A and urea in improving soil physical conditions was reflected on okra yield as the plots that received compost grade B performed better than others in a continuous cropping system. Compost grade B applied at the rates of 100 and 120 kgN ha^{-1} can be effectively used for tropical soils that were grossly loose (coarse) textured for sustainable agriculture and eradication of poverty.

Key words: Residual effect · Compost · Physical parameters · Okra yield

INTRODUCTION

In recent years, health improvement, increasing rate of enlightenment and other changes led to increasing populations. This has accelerated the demand for food, as well as other agricultural products. Increasing population without commensurable part of the population in food production is the biggest challenge facing farmers, economists, conservationists and soil scientists today. Many attempts to introduce continuous arable cropping systems into the semi-arid, sub-humid and humid tropics have failed [1]. Often, the maintenance of the nutritional status of the soil has not been adequate due to soil degradation caused by physical degradation, erosion, compaction and crusting, associated with nutrient mining and acidification, low organic matter and deterioration of drainage conditions causing water logging or salinization [2]. However, most farmers in the tropics have adopted the use of mineral fertilizers, but the intensive use of this over time could constitute a set back to soil fertility [3, 4]. According to Phicot *et al.* [3], the application of NP and NPK fertilizers increased yields for some years, but in the long run leads to decreasing pH and occurrence of Al toxicity. They postulated that application of organic matter such as green manure, crop residues, compost or animal manure neutralizes the negative effects of these chemical fertilizers.

In Nigeria, the mineral fertilizer has become highly expensive since the Federal Government of Nigeria has removed subsidy on it since 1987. A 50kg bag of fertilizer now sells for as much as N3, 000. Due to the shortage in the supply of inorganic fertilizer and also the increasing cost of getting it, it is now important to look at other resources that may improve vegetable production in Nigeria.

FAO [5] projected that the future of agriculture in fertilizer use will lie on the development of organic based fertilizer which will in turn provide the required nutrients

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as well as enhance the soil organic matter content, water holding capacity and improve physical quality of soils. However, the major constraints with organic inputs are the large amount required to maintain agricultural production at its current level [6]. Therefore an integrated nutrient management (organo-mineral fertilizer) is chosen to combine different technologies in order to help increase fertilizer use efficiencies, as fertilizer nutrients can compliment nutrients released from organic sources. Also, earlier researchers have reported the superiority of combination of inorganic and organic fertilizers (organo-mineral fertilizers) on the crop yield as compared to their use individually [7, 8].

Okra is one of the vegetables commonly eaten by many Nigerians. This is not because it is nutritious but it provides most of the dietary protein, minerals and vitamins in human diet. However, one major constraint to growing this crop is the demand for large quantity of fertilizer on a run down soils. This work was therefore designed to compare residual effects of unamended and amended compost on (i) soil physical conditions and (ii) the growth and yields of okro on a degraded soil.

MATERIALS AND METHODS

Site Description: The field experiment was carried out at the Teaching and Research Farm of the University of Ibadan- Nigeria. Ibadan extends from latitude 7°24'N to longitude 3°54'E. The rainfall pattern is bimodal and averages 1230mm per annum. Rainfall peaks occur in June and September. There are two growing seasons; an early season runs from March/April to August and late season; from mid-August to October/November. Annual temperature ranges from a high of 31.2°C to a low of 21.3°C. Ibadan has a percentage sunshine that ranges between 16% in August to 59% in February and December with an average of 44%. The soil of the area is an Alfisol of the order oxic paleustalf according to the USDA classification. It is classified locally as Iwo series [9].

Sources of Compost Grades A and B: Various manures were collected from waste dumpsites located in the city of Ibadan. Ibadan is the capital of Oyo State and has an estimated population of over 2.9 million. Ibadan has indigenous culture and people have cultural diversities. An earlier study Sridhar *et al.* [10] and Adeoye *et al.* [11] revealed that municipal solid wastes in Ibadan is composed of 20-30% of recyclable materials like plastics, metals, bottles etc., together with70-80% decomposable organic materials. People collect all the wastes into a common bin or basket without any segregation and dispose at convenient places, which are often illegal. The city has defined areas demarcated for high, medium and low density of population. Most of the illegal dumpsites are located in the high and medium density areas and they are not evacuated regularly. The Ibadan Waste Management Authority, which is charged with the collection and disposal of refuse, has demarcated some final disposal sites for dumping the generated wastes. These designated sites are located at various points in the city. The wastes collected were used in making compost. The compost was prepared at Pace Setter Organic Fertilizer Company's plant located in Ibadan, Oyo State, Nigeria, developed by Oyo State Government using market wastes and cow-dung. In this plant, the waste mixture was allowed to decompose aerobically in windrows for about 60days, cured for further 30 days, sieved, ground and bagged. This is referred to as Compost Grade B. Compost Grade A was prepared by enriching the above compost with urea (nitrogen source) and bone powder (phosphorus source) to increase the N and P to 2.58%N and 1.01%P, respectively, as required by Nigerian farmers.

Treatments Imposed: Eight treatments comprising of locally manufactured compost grade A applied at 80, 100 and 120 $kgNha^{-1}$ were compared with compost grade B applied at 80, 100 and 120 $kgNha^{-1}$ and urea applied at 100 $kgNha^{-1}$ and control. The treatments were replicated four times in a randomized complete block design. The application of compost grades A and B (Table1) was intimately and uniformly mixed with the surface (0-15cm) soil without any intervention. Each plot was 5m x 5m in area. All fertilizers were applied at the beginning of

Table1: Proximate Analysis for compost grade A (amended) and grade B (unamended)

Nutrient Elements	Compost grade A	Compost grade B
N%	4.42	1.68
P%	1.10	1.03
K%	0.68	0.60
Ca%	3.62	1.49
Na%	0.08	0.08
Zn	712.70	57.20
Mn	558.30	30.60
Fe	8153.40	355.30
Cu	257.40	9.60

- Composts were analyzed at the point of application
- Source: Soil Analytical laboratory, Department of Agronomy, University of Ibadan, Nigeria (2005)

experiment in early 2005 and remained throughout the study period without any further application of fertilizers in the subsequent growing seasons.

Planting and Management: Okra seeds were planted at 0.25m within rows and 0.5m between rows and were thinned to one plant per hill two weeks after planting (WAP). Weeding was carried out at 3 WAP using cutlass and hand picking of weeds was done at 6 WAP to maintain weed free plot.

Measurement of Growth and Yield: Ten okra plants heights were measured at the centre of each plot at 8 WAP. The mean of ten plants was used for each plot. Okra fresh pods yield was determined by harvesting all the okra pods in the plot, leaving the first border row on each side of the plot and first two plants at both ends of each plot. Harvesting of pods commenced at 8 WAP. Young pods were harvested 4 days after flowering. The harvesting was carried out over a period of six weeks. The okra pods were weighed fresh in the field. The sub-samples were dried in an oven at 65°C to remove the moisture content. The dry okra pods sub-samples were used to estimate the yield of dry okra pod per hectare.

Soil Sampling and Analysis: Before fields were prepared, bulk soil samples were collected (0-15cm and 15-30cm) from the fields with a 6cm-diameter soil auger. A sub-sample was taken from each bulk sample after this had been thoroughly mixed, air-dried and ground to pass through 2mm sieve for particle size distribution and some chemical analyses to ascertain the base-line properties. At the end of fourth growing season in 2006, some physical properties of the soil on the experimental plot were determined using $100cm^3$ soil cores collected from each plot. Five core samples, 0-15cm and 15-30cm depths, were collected within 5m x 5m plot for physical parameters. Particle size distribution was determined using Day's procedure [12]. Bulk density (Pb) was determined using the core method. $100cm^3$ soil core was used to obtain samples from the plots. The samples were oven-dried at 105°C to constant weight and the bulk density was obtained as follows:

$$Pb = M_s/V_b$$

Where M_s = weight of oven-dry soil+ cylinder-weight of cylinder

V_b = Volume of cylinder

Total porosity (Tp) was calculated from the parameters of bulk density and particle density (Ps) using an assumed value of $2.65g/cm^3$ for particle density in the formula

$$\%TP = 1 - (Pb/Ps) \times 100$$

Saturated hydraulic conductivity (K_Q) was determined by maintaining a constant head of water above undisturbed core [13]. A flask of water was inverted above the core containing water in other to maintain constant head of water. The quantity of water (Q) drained in every 5 minutes was measured until equilibrium (constant through of water) is reached.

Permeability was calculated from saturated hydraulic conductivity as follows:

$$K = K_Q \varsigma / e_w g$$

Where:

K = Permeability (cm^2)

e_w = Density of water ($1g\ cm^{-3}$)

g = Acceleration due to gravity ($980\ cm\ sec^{-2}$)

ς = Viscosity at 27°C ($0.00855g\ cm^{-1}\ sec^{-1}$)

K_Q = Saturated hydraulic conductivity ($cm\ sec^{-1}$).

Statistical Analysis: The soil parameters measured and plant data obtained were subjected to analysis of variance and Duncan Multiple Range Test [14] was used to separate the means that were significant at 5% probability level. Correlations were made between the parameters.

RESULTS AND DISCUSSION

Physical Properties of Experimental Site Before Fertilizer Application: The particle size distribution of the experimental site before fertilizer incorporation showed that soil texture 0-15cm and 15-30cm soil depths were loamy sand and sand, respectively (Table 2). Corresponding means soil bulk densities were $1.5gcm^{-3}$ and $1.60gcm^{-3}$, respectively. Soil porosity at 0-15cm and 15-30cm soil depths were 43.30 and 39.62%. The mean saturated hydraulic conductivity and permeability at 0-15cm and 15-30cm soil depths were $98.46cmhr^{-1}$; 2.34 x 10-7 cm^2 and 95.72 cm hr^{-1}; 2.31 x 10^{-7} cm^2; respectively. The low valves of clay content (68 – 102 g kg^{-1}) with higher values of bulk density showed that the site has been degraded and this justified the need for incorporation of fertilizers.

Table 2: Soil physical properties of the experimental site before fertilizer application

Parameters	0-15cm	15-30cm
Sand (gkg^{-1})	801.00	9364.00
Silt (gkg^{-1})	97.00	68.00
Clay (gkg^{-1})	102.00	68.00
Bulk density (gcm^{-3})	1.51	1.60
Total porosity (%)	43.30	39.62
Saturated hydraulic conductivity (cm/hr^{-1})	98.46	95.72
Permeability(cm^2)	2.38×10^{-7}	2.31×10^{-7}

Particle size distribution

Sand (2 - 0.02mm in Diameter): Application of compost to the soil did not significantly influence sand particles at 0-30cm profile depth after the four growing season (Table 3). It is important to note that sand proportion remained the same for both control and urea plots at 0-15cm soil depth, suggesting that urea fertilizer could not alter sand percentage of the soil. However, compost grade B reduced sand percentage than amended compost grade A by 4.48%. The magnitude of change (%) in sand particles at 0-15cm soil depth over four growing seasons with respect to initial soil status before fertilizer application showed that compost grade A at 120 $kgNha^{-1}$, compost grade B applied at 80, 100 and 120 $kgNha^{-1}$, improved soil conditions by decreasing sand percentage. While the plots that received compost grade A at 80 $kgNha^{-1}$, urea at 100 $kgNha^{-1}$ and control plot were degraded by having higher sand particles than before fertilizer application and the plots that received compost A at 100 $kgNha^{-1}$ remained unchanged (Table 4). Unamended compost B is better as soil conditioners for sandy soils which have been found to be impediment to root elongation, root enlargement and root proliferation [15]. Leaching which is a peculiar characteristic of sandy soil could likely be reducing incorporating unamended compost. Beyond 15cm soil depth, unamended compost has no residual effect on sand particles (Table 3). The magnitude of change (Table 4) in sand particles at 15-30cm depth over four growing seasons with respect to initial soil status before fertilizer application showed that both compost grades A and B improved the soil condition but unamended compost B was better in improving the sand condition of the soil.

Silt (0.02 – 0.002mm in Diameter): Amended compost A and urea did not influence silt contents of the soil at both 0-15cm and 15-30cn soil depths (Table 3). On the other hand, compost grade B significantly ($p < 0.05$) influenced silt contents of the soil after the fourth growing season. Unamended compost B applied at 80, 100 and 120 $kgNha^{-1}$ increased the silt content of the soil after the fourth season by 21.81, 11.62 and 13.24%, respectively higher than control at 0-15cm soil depth. On average, compost B increased the silt content of the soil than compost A by 2.22% at 0-15cm soil depth. In term of magnitude of change (Table 5), silt content was higher at the end of the fourth growing season when compared with initial valves of silt at the beginning of experiment by the plots that received compost A and B while urea and control decrease in silt content at 0-15cm soil depth. This indicated that compost could improve the soil physical conditions by mineralizing to increase the silt content which comprises of both primary and secondary minerals while urea fertilizer could not. It is worthy to note that only unamended compost B that significantly ($p<0.05$) influenced silt content of the soil at 15-30cm (Table 4) indicating that unamended compost is better than amended compost in improving the silt content of a degraded soil. When unamended compost B was compared with urea applied at 100 $kgNha^{-1}$ it was observed that compost B applied at 80, 100 and 120 $kgNha^{-1}$ had higher silt content than urea by 51, 22 and 52g kg^{-1}, respectively. Although, there is no significant difference in the values of silt content between urea and control plots, but urea plot was physically degraded than control plot. This is because the surface areas of urea fertilizer particles are smaller than silt particles and could not contribute to physical improvement. When the silt status at the beginning of experiment in 2005 (before fertilizer incorporation) was compared with silt status after the fourth growing season (Table 5), all the treatments improved the silt content of the soil except urea and control. The order of improvement is compost B(120 $kgNha^{-1}$) > compost B (80 $kgNha^{-1}$) > compost A (100 $kgNha^{-1}$) > compost A (120 $kgNha^{-1}$) > compost A (100 $kgNha^{-1}$) > compost A (80 $kgNha^{-1}$). This supports the findings of Babalola *et al.* [16] of the beneficial manorial effect of organomineral fertilizer on soil physical properties. They reported that the addition of organomineral fertilizer to the soil significantly improved the bulk density and the mean weight diameter of aggregate (MWD) than other treatments.

Clay Particles (< 0.002mm in Diameter): Compost grades A and B significantly ($p < 0.05$) influenced clay particles at 0-15cm depth after the fourth growing season (Table 3). Among different rates of compost A applied, the plot that received 120$kgNha^{-1}$ was significantly higher

Table 3: Residual effects of fertilizers on some soil properties at 0-15cm and 15-30cm depths after fourth growing seasons as determined in the late season of 2006

Treatments	N rate kg/ha	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Bulk density (g/cm^3)	Total porosity (%)	Saturated hydraulic conductivity (cm/hr)	Permeability (cm^2) x10-7
0 – 15 cm								
Compost grade A	80	813a	124a	63a	1.56a	41.13a	92.0a	2.22
	100	801a	124a	75ab	1.52a	42.64a	94.1a	2.28
	120	786a	125a	89b	1.49a	43.77a	118.2ab	2.86
Compost grade B	80	783a	148c	69ab	1.45ab	45.28ab	114.8ab	2.78
	100	789a	120a	91b	1.50a	43.39a	116.2ab	2.81
	120	725a	124a	151c	1.32b	50.18b	156.8c	3.80
Urea	100	864a	96ab	40d	1.57a	40.75a	91.2a	2.21
Control	0	864a	95ab	41d	1.56a	41.13a	91.0a	2.20
15 - 30 cm								
Compost grade A	80	856a	92a	52a	1.61a	37.73a	91.6a	2.21
	100	831a	105a	64ab	1.54a	41.88a	93.3a	2.26
	120	825a	103a	72b	1.56a	41.13a	109.3ab	2.64
Compost grade B	80	815a	122b	63ab	1.52a	42.64a	112.1ab	2.71
	100	832a	93a	76b	1.53a	42.26a	108.1ab	2.61
	120	756a	123b	121c	1.40ab	47.16ab	148.1b	3.58
Urea	100	890a	71a	39d	1.60a	39.62a	91.4a	2.21
Control	0	864a	97a	39d	1.60a	39.62a	93.3a	2.26

Letters followed by the same letters are not significantly different by DMRT at 5%.

Table 4: Magnitude of change (%) in the soil physical properties at 0-15 cm and 15-30 cm depths with respect to initial soil status before fertilizer application

Treatments	N rate kg/ha	Sand g/kg	Silt g/kg	Clay g/kg	Bulk density g/cm^3	Permeability cm^2
0-15 cm						
Compost	80	+1.5	+27.8	-61.9	+3.3	-7.2
Grade A	100	0.0	+27.8	-36.0	+0.6	-4.3
	120	-1.9	+28.8	-14.6	-1.3	+20.1
Compost	80	-2.2	+52.5	-47.8	-4.1	+16.8
Grade B	100	-1.5	+23.7	-12.0	-0.6	+18.0
	120	-10.4	+27.8	+48.0	-14.3	+59.6
Urea	100	+7.2	-1.04	-155.0	+3.9	-7.6
Control	0	+7.8	-2.1	-148.7	+3.3	-8.1
15-30cm						
Compost	80	-0.9	+35.2	-30.7	+0.6	-4.5
Grade A	100	-3.9	+534.4	-6.2	-3.8	-2.2
	120	-4.7	+51.4	+5.8	-2.5	+14.2
Compost	80	-6.0	+79.4	-7.9	-5.2	+17.3
Grade B	100	-3.9	+36.7	+11.7	-4.5	+12.9
	120	-14.2	+80.8	+77.9	-14.2	+54.7
Urea	100	+3.0	+4.4	-74.3	0.0	-4.5
Control	0	0.0	+42.6	-74.3	0.0	-2.1
Soil condition		(-) better	(-) worse	(-) worse	(+) better	(-) worse
Soil condition		(+) worse	(+) better	(+) better	(-) worse	(+) better

Table 5: Residual effects of fertilizers on okra plant height (cm) at 8 WAP over four growing seasons in 2005 and 2006

Treatments	N rate kg/ha	Early 2005	Late 2005	Early 2006	Late 2006	Mean
Compost grade A	80	61.39a	56.49ab	50.52ab	45.32a	53.43
	100	69.65ab	63.84a	58.39b	45.01a	59.22
	120	88.08c	82.17c	67.68c	49.42ab	71.83
Compost grade B	80	60.20a	56.41ab	54.25ab	44.28a	53.78
	100	59.70a	61.57a	59.62b	53.38ab	58.56
	120	70.92ab	72.43c	71.52c	62.12c	69.24
Urea	100	68.87ab	46.11ab	42.03ab	43.81a	50.15
Control	0	49.82d	47.09ab	46.64ab	46.23a	47.44

Letters followed by the same letters are not significantly different by DMRT at 5%.

in clay content than 80 and 100kgNha^{-1} plots by 41.26 and 18.66%, respectively at 0-15cm depth. Similarly, the plot that received compost B at 120kgNha^{-1} was significantly higher in clay content than plots that received 80 and 100kgNha^{-1} by 118.04 and 65.93%, respectively, at 0-15cm soil depth. Increase in soil clay content is brought about by increasing the rate of application of compost. By comparing compost grades A and B and urea, it was observed that plot that received urea was lower in clay content than compost A and B plots by 84.53 and 152.82%, respectively, suggesting that compost is better than mineral fertilizer in improving the clay condition of a degraded soil. This is in agreement with the reports that the combination of mineral and organic fertilizers termed organomineral fertilizer (OMF) has been found to improve the productivity of tropical soils more than the sole use of mineral fertilizers [17].

Magnitude of change (Table 5) in clay content at 0-15cm depth over four growing seasons with respect to initial soil status before fertilizer application showed that all treated plots resulted in decrease in clay particle with exception of compost B applied at 120kgNha^{-1}. The trend of decrease in clay content at the end of fourth growing season was in order of urea > control > compost A (80kgNha^{-1}) > compost B(80kgNha^{-1}) > compost A (100kgNha^{-1}) >compost A (120kgNha^{-1}) > compost B (100kgNha^{-1}). Compost grade B improved soil physical conditions by mineralizing to increase the clay content than both compost grade A and urea fertilizer. Coefficient of correlation between clay content and saturated hydraulic conductivity was significant (r = 0.82*; p<0.05), indicating that increase in clay content of the soil will also enhance water retention for crop growth. It is also important to note that compost fertilizer imposed significantly (p<0.05) influenced on clay content of the soil at 15-30cm depth (Table 4). Compost grade A applied at 120kgNha^{-1} had higher residual clay content after fourth growing season than plots that received 80 and 100kgNha^{-1} of compost A by 20 and 8g kg^{-1}, respectively. Similarly, plot that received compost B at 120kgNha^{-1} had higher clay content than plots that received 80 and 100kgNha^{-1} of compost B by 58 and 45 g kg^{-1}, respectively. By comparing residual effects of compost grades A and B on clay particles at 15 – 30cm depth, plots that received compost B were higher in clay content than compost A plots by 24 g kg, indicating that unamended compost grade B has greater residual influence in increasing the clay content of the soil beyond 15cm soil depth than amended compost grade A. This is because unamended compost gradually decomposed over a long period of time to produce fine particles which bind the silt and sand particles together to improve the soil condition. With respect to initial status of clay content at 15-30cm soil depth at the end of the fourth growing season (Table 6), compost grade A applied at 80, 100kgNha^{-1} and compost grade B at 80kgNha^{-1} and urea

Table 6: Residual effects of fertilizer application on fresh pods weight and dry pods weight (kg/ha) over four growing seasons of 2005 and 2006

Treatments	N rate kg/ha	Early 2005	Late 2005	Early 2006	Late 2006	Mean
Fresh weight of pods(kg/ha)						
Compost grade A	80	12.37a	10.24a	8.82a	6.47a	9.47
	100	16.30a	13.47a	10.27a	6.82a	11.71
	120	33.84c	25.56c	16.45b	8.04a	20.97
	Mean	20.08	16.42	11.84	7.11	
Compost grade B	80	11.77a	11.97a	9.02a	6.52a	9.82
	100	13.26a	15.66ab	12.63a	8.67a	12.55
	120	17.90ab	22.53c	18.32b	12.38b	7.78
	Mean	14.31	16.72	13.32	9.19	
Urea	100	27.91b	11.34a	8.79a	6.35a	13.59
Control	0	10.91b	9.86a	8.80a	6.50a	9.01
Dry weight of pods(kg/ha)						
Compost grade A	80	3.12a	2.64a	2.26a	1.66a	2.42
	100	4.20a	3.46a	2.70a	1.61a	2.99
	120	8.73b	6.64c	4.29b	2.08ab	5.43
	Mean	5.35	4.24	3.08	1.78	
Compost grade B	80	3.03a	3.08a	2.38a	1.69a	2.53
	100	3.42a	4.05ab	3.46ab	2.23ab	3.29
	120	4.62a	5.86c	4.97b	3.21c	4.65
	Mean	3.69	4.32	3.60	2.37	
Urea	100	6.55ab	2.67a	2.06a	1.49a	3.19
Control	0	2.81c	2.60a	2.28a	1.69a	2.34

Letters followed by the same letters are not significantly different by DMRT at 5%.

at 100kgNha^{-1} decrease by 31, 6, 8 and 7%, respectively, indicating soil degradation while compost A at 120kgNha^{-1} and compost B at 100 and 120kgNha^{-} increased by 6, 12 and 78%, respectively, indicating soil improvement. Any practice that increases clay particles of the soil will enhance water retention of the soil [18] because clay is characterized by preponderance of micro-pores (capillary pores) which are responsible for holding water for plant use. Therefore, unamended compost B applied between 100 and 120kgNha^{-1} likely to improve the soil moisture status of a degraded soil to alleviate water stress especially during reproductive stage of plant cycle (critical stage).

Bulk Density and Total Porosity: Bulk density (a measure of weight of the soil) was only significantly ($p<0.05$) influenced by unamended compost B at 0-15cm soil depth after the fourth growing season in 2006 (Tables 3 and 4). Mean soil bulk densities for unamended compost B and amended compost A of furrow slice were 1.42 and 1.52gcm^{-3}, respectively; bearing in mind that initial soil bulk density at the beginning of experiment was 1.51 gcm^{-3}. This showed that unamended compost B could reduce the bulk density by reducing the coarseness of a degraded soil leading to higher total porosity on unamended compost B plots. Correlation coefficient between bulk density and soil moisture content was significant (r = -67*; $p<0.05$), indicating that a soil with higher bulk density value will have lower soil moisture retention ability. Therefore, unamended compost B is not only reducing the soil bulk density but also improving the soil moisture regime within the 0-15cm profile depth, referred to as 'root zone water storage' and it has been proven that almost all of the roots of the arable crops were within these [19]. Although, unamended compost B did not significantly influence the bulk density of the treated soils at 15-30cm depth, but higher rates (100-120kgNha^{-1}) gave the lowest values of bulk density among the treatments imposed.

Saturated Hydraulic Conductivity (Ks) and Permeability (K^1): Compost applied at higher rates significantly ($p < 0.05$) influenced saturated hydraulic conductivity (Ks) of soil within 0-30cm profile depth. However, plot treated with compost grade A applied at 80 and 100kgNha^{-1} and urea (100kgNha^{-1}) were not different in Ks valves at 0-15cm soil depth. Soil permeability (K^1) followed the same trend as saturated hydraulic conductivity after the fourth growing season. The valves of soil permeability for soils treated with compost A at 80, 100 and 120kgNha^{-1} compost B at 80, 100 and 120kgNha^{-1} and urea (100kgNha^{-1}) and control were 2.22×10^{-7}, 2.28×10^{-7}, 2.86×10^{-7}, 2.78×10^{-7}, 2.81×10^{-7}, 3.80×10^{-7}, 2.21×10^{-7}, and 2.20×10^{-7}cm^2, respectively at 0-15cm soil depth. Residual effect on soil showed that only plot treated with compost B at 120Nha^{-1} that significantly influenced saturated hydraulic conductivity and permeability valves at 15-30cm. The ability of unamended organic fertilizer to increase Ks and K^1 values shows that (silted pores) crusting has been improved, allowing the free flow of water. Increased rate of water movement in the soil will enhance infiltration rate which in turn reduces soil erosion. Compost grade B applied at 100-120kgNha^{-1} is better for soil amendment on a degraded Alfisol because it will not only supply nutrients but it has potential for soil physical amendment.

Plant Height: Okra plant height was significantly ($p < 0.05$) influenced by the treatments imposed during the early growing season in 2005 when the fertilizers were applied (Table 5). Mean plant height under compost grades A and B, urea and control were 73.04, 70.20, 68.67 and 49.82cm, respectively. The superiority of compost grade B over other fertilizers became evident during the third growing season because only the plants from plots treated with compost B at 100-120kgNha^{-1} that had significant residual effect on plant height. It is worthy of note that the residual superiority of compost B over others is becoming clearer with years of continuous cropping on a degraded soils. The best vegetative growth observed on plot that received compost B at 120kgNha^{-1} suggests a definite ameliorative effect on the properties of the soil. This is due to ability of compost B to mineralize gradually to release fine particles over a long period of time to improve soil physical properties by increasing soil aggregation. Coefficient of correlation between clay and plant height is significantly high (r = 0.82**, *$p<0.05$, **$p<0.01$, Y = 42.12X + 0.2), indicating that increase in clay content of the soil will also bring about increase in plant height. Plots that received compost grade B were characterized with high percentage of clay content. This accounted for highest plant height on plots that received compost B at 120kgNha^{-1} because clay particles are characterized by preponderance of micro-pores which are responsible for holding water for plant use. On the other hand, coefficient of correlation between plant height and bulk density is negatively significant (r = -0.67*, *$p<0.05$, Y = 164.83X-71) and (r = -0.64*, *$p<0.05$, Y=183X-81),

Table 7: Magnitude of change (%) in the fresh pods weight and dry pods weight seasons with respect to early 2005

Treatments	N rate kg/ha	Late 2005	Early 2006	Late 2006	Mean
Fresh pods weight					
Compost grade A	80	-17.23	-28.69	-47.69	-31.20
	100	-17.36	-46.99	-58.15	-37.50
	120	-24.46	-51.38	-76.24	-50.69
Compost grade B	80	+1.69	-23.36	-44.60	-22.09
	100	+18.09	-4.75	-34.61	-7.09
	120	+25.86	+2.34	-30.82	-0.87
Urea	100	-59.36	-68.50	-77.24	-68.36
Control	0	-9.62	-19.34	-40.42	-23.12
Dry pods weight					
Compost grade A	80	-15.38	-27.56	-46.79	-29.78
	100	-17.61	-35.71	-61.66	-38.32
	120	-23.94	-50.85	-76.17	-50.32
Compost grade A	80	+1.65	-21.45	-44.22	-21.34
	100	+18.42	+1.16	-34.79	-5.07
	120	+26.19	+7.57	-30.51	+1.08
Urea	100	-59.23	-68.54	-77.25	-68.34
Control	0	-7.47	-18.86	-39.85	-22.06

+ and – mean increase and decrease, respectively; (+) better and (-) worse conditions with respect to early 2005.

respectively, at 0-15 and 15-30cm soil profile, suggesting that increase in soil bulk density will hindrance the plant heights. Addition of compost B reduces the coarseness of soil, consequently reduces the soil bulk density leading to increase in plant growth. This showed that compost B has ameliorative effect on the soil properties which reflected on plant height [20].

Okra Pod Yield: Okra yield differences were due to a combination of water availability and fertility status of the soil as induced by the treatments. Table 6 demonstrates the definite beneficial and significant residual effect of compost on weight fresh pods compared with other treatments. In the early season of 2005, plots that received amended compost A at 120kgNha^{-1} and urea at 100kgNha^{-1} were significantly higher in the fresh weight of pods than control by 210 and 155%, respectively. The significant beneficial effect of urea fertilizer in producing higher fresh pod yield during first growing season was dwarfed in the second growing season when there was no significant difference between fresh pod yield obtained from urea treated plot and the control. This is because of loss of nutrients through leaching, runoff and volatilization which responsible for lower pod yield from urea treated plot. It is worthy to note that the plots that received unamended compost B at 120kgNha^{-1} had significant residual effects on fresh weight of pods during second and third growing seasons. Indeed, the plots that received unamended compost B at 120kgNha^{-1} had higher weight of fresh pod than urea and control plots by 86 and 108%, respectively, during the third growing seasons. This is in agreement with the reports that organic fertilizers performed better on crop growth and yield than mineral fertilizers. [11, 20, 21], During the fourth growing season, only unamended compost B applied at 120kgNha^{-1} that had significant residual effect on fresh weight of okra pod. This result is an indication that organic manure is a store house for nutrients essential for crop yields. [11] Confirmed the agronomic value and potential use of organic manure in soil fertilizer amendment. The dry weight of pod is an indication of dry matter content of the okra (Table 6). In comparing the dry pod yield of the first season with the second season (Table 7), highest reduction in dry pod yield was found on urea treated plot followed by amended compost treated plots. This suggests that urea and N-P fortifiers mineralized completely within a short period leading to high leaching on a grossly coarse textured (highly porous medium aggravates leaching) soil, a characteristics of the experimental site. Compost B (a waste mixture that was allowed to decompose aerobically in windows for about 60 days and cured for further 30 days) residual effect became prominent among others treatments on dry weight of pods from second growing season to the fourth growing. Indeed, compost B treated plots were consistently higher in dry pod weights than plots treated with compost A during the second, third and fourth seasons by 2, 17 and 33%, respectively. This result showed that the compost grade B takes longer period to decompose and mineralize for plants' use. This gradual decomposition and mineralization of nutrients tend to reduce leaching in a degraded soil.

CONCLUSION

Residual superiority of long-term application of compost grade B over grade A on a coarse textured soil produced markedly different particle size distribution, bulk density and permeability. Soil physical conditions were the best under compost grade B and the least under urea treated plots. This indicates that unamended compost has higher potential manorial values and can be used as soil amendments for loose coarse textured soil, characteristics of the tropical soils. Compost grade B was more effective in producing higher values of both fresh and dry weight of okra pods consistently for the three residual growing seasons. This result is an indication that compost grade B is a storehouse for nutrients which decompose and mineralize gradually over a long period of time for sustainable crop production. For maximum benefits, compost grade B should be applied at 100-120kgNha^{-1} to a physically degraded Afisol as soil amendment.

REFERENCES

1. Adeoye, G.O., 2005. Organic Agriculture: for food security in Nigeria. 1st National Conference on Organic Agriculture in Nigeria. Held from 25-28th October, 2005 at university of Agriculture Abeokuta, pp: 3-14.
2. FAO, 1994. Soil Management for Sustenance Agriculture and Environmental Protection in the Tropics. Land and Water Development Division Food and Agriculture organization of the United Nations Viable delle Terme di Caracalla Rome 00100 Italy. Design, editing and production by Words and publication, Oxford United Kingdown.
3. Phicot, J., M. P. Sedogo and H.F. Arrivers, 1981. Evaluation De La Fertilite Dun sol ferrugineux tropical sous L influence De Femures Milnerales et Oganiques. L'Agronomic Tropicale, 36(2): 122-133.
4. Isherwood, K.F., 2000. Fertilizer use and the Environment INternation Fertilizer Industry Association, Revised edition, Paris, FRANCE, February, 2000.
5. FAO, 2000. Report From Food and Agriculture Organization. Handbook on Fertilizer Use and Management, pp: 88.
6. De. Ridder, N. and H. van Keulen, 1990. Some aspects of the role of organic matter in sustain intensified arable farming system in the West African semi-arid tropics. Fertilizer Rresearch, (26): 299-310.
7. Sridhar, M.K.C, G.O. Adeoye and O.O. AdeOluwa, 2001. Alternate to nitrogen amendments for organic fertilizers. In optimizing Nitrogen Management in Food and Energy Production and Environment Protection. Proceedings of the 2nd International Nitrogen Conference on Science and Policy. The Scientific World, l(2): 142-147.
8. Omueti, J.A.I., M.K.C. Sridhar, G.O. Adeoye, O. Bamiro and D.A. Fadare, 2000. Organic fertilizer use in Nigeria: Our Experience, In M. O. Akoroda (Ed.). *Agronomy in Nigeria,* University of Ibadan, Ibadan, Nigeria, September, pp: 208-215.
9. Soil Survey Staff, **200).** Keys to soil Taxonomy. Tenth Edition. USDA National Resources Conservation Service, 331pp. http:// soilsusda.gow/ technical/ classification/ tax-keys/keyspdf
10. Sridhar, M.K.C., A.O. Bammeke and M.A. Omishakin, 1985. A study on the characteristics of refuse in Ibadan, Nigeria. Waste and Management Res., 3: 191-201.
11. Adeoye, G.O., O.O. Adeoluwa, M. Oyekunle, M.K.C. Sridhar, E.A. Makinde and A.A. Olowoake, 2008. Comparative evaluation of organomineral fertilizer (OMF) and mineral fertilizer (NPK) on yield and quality of maize (*Zea mays* (L) Moench). Nigerian J. Soil Sci., 18: 132-137.
12. Day, P.R., 1965. Particle size analysis. In: Black, C.A. (Ed.), Methods of soil analysis. America Society of Agronomy. Madison, Wisc., 1: 545-566.
13. Soil Science Society of America, 2002. Methods of Soil Analysis, Physical Methods. Part 4. Editor, Warren, A. D., Madison, Wisconsin, USA, pp: 3692.
14. Wagner, S.F., 1992. Introduction to Statistics. Harper Perennial, New York, pp: 369.
15. Babalola, O., 1977. Field calibration and use of the neutron moisture meter on some Nigerian soils. Soil Sci., 126(2): 118-124.
16. Babalola, O., S.O. Oshunsanya and K. Are, 2007. Effects of vetiver grain (*Vetireria nigritana*) srips, vetiver grain mulch and organomineral fertilizer on soil, water and nutrient losses and maize (*Zea mays*, L.) yields. Soil and Tillage Res., (96): 6-18.

17. Akanbi, W.B., J.A. Adediran, A.B. Olaniyan and A.O. Togun, 2004. An economic analysis of split application of organomineral fertilizer on okro in humid forest zone of Nigeria. Dentscher Trpentag, October 5-7, 2004, Berlin, pp: 56-61.
18. Aiyelari, E.A. and S.O. Oshunsanya, 2008. Preliminary studies of soil erosion in a valley bottom in Ibadan under some tillage practices. Global J. Agricultural Sci., 7(2): 221-228.
19. Oluwasemire, K.O., C.J. Stigte, J.J. Owonubi and S.S. Jagtap, 2002. Seasonal water use and water productivity of millet-based cropping systems in the Nigerian Sudan savanna near Kano. Agricultural Water Management, (56): 207-227.
20. Sikora, L.J. and N.K. Enkiri, 2000. Efficiency of compost fertilizer blends compared with fertilizer alone. Soil Sci., 165(5): 444-451.
21. Sridhar, M.K. C.and G.O. Adeoye, 2003. Organomineral fertilizers from urban wastes: The Nigerian Field, 68: 91-111.