Available online at www.elixirpublishers.com (Elixir International Journal)

Agriculture

Elixir Agriculture 71 (2014) 25167-25172

ISSN: 2229-712X

Evaluation of productivity of a degraded ultisol amended with animal wastes in abakaliki, southeastern, Nigeria

Nwite, J.N[1], Okolo, C. C[1] and Okonkwo, G.I[2]

[1]Department of Soil Science and Environmental Management, Faculty of Agriculture and Natural Resources Management, Ebonyi State University, P.M.B 053 Abakaliki.

[2]Department of Agricultural Education, Nwafor Oriuzor College of Education, Nsugbe, Anambra State.

ARTICLE INFO

Article history:
Received: 9 April 2014;
Received in revised form:
12 June 2014;
Accepted: 27 June 2014;

Keywords
Amended,
Animal wastes,
Ultisol,
Degraded,
Evaluation,
Productivity.

ABSTRACT

An experiment was carried out at the Teaching and Research Farm of the Faculty of Agriculture and Natural Resources management, Ebonyi State University, Abakaliki in order to evaluate productivity of a degraded ultisol amended with different animal wastes in Abakaliki. The field was laid out in randomized complete block design (RCBD). There were four treatments viz poultry droppings (PD), Swine Waste (SW), Cow Dung (CD) and Control (C) applied at 12 ha^{-1}, respectively. These treatments were replicated five times. Maize hybrid (Oba super II) and groundnut (*Arachis hypogea*) were used as test crops. Core and auger samples were collected at 0 – 20 cm depth before and after planting for pre and post planting soil properties determination. Data were analyzed using analysis of variance (ANOVA) and means separated with Fisher's least significant difference. Results showed that bulk density, total porosity, moisture content, hydraulic conductivity, aggregate stability and mean weight diameter were significantly ($P<0.05$) higher in poultry droppings amended plots than in control. The texture of soil remained sandy loam. The studied chemical properties showed no significant treatments effect except magnesium that was significantly ($P<0.05$) higher in PD and CD amendments relative to control. Cow dung treatment significantly ($P<0.05$) depressed Na compared to control and other animal wastes amendments. Bulk density was lower by 5 and 7% under poultry droppings compared to cow dung and swine waste treatments. Total porosity and hydraulic conductivity were 9,7,4 and 11% higher in PD relative to cow dung and swine wastes amendments. Available P, total N and organic matter were higher under PD treatment by 8, 17, 18, 12, 17 and 27% compared to SW and CD amended plots, respectively. Maize grain and groundnut yields significantly ($P<0.05$) increased in all animal wastes amended plots relative to control. Animal wastes enhanced physical properties of soil and yields of crops more than chemical ones. Poultry droppings that proved more superior compared to others could be recommended for improving productivity of a degraded soil in the study area.

Introduction

The soils of the tropics are fragile and are easily degraded under intensive farming system. There is also associated torrential and violent rainfall particularly at onset of rains with intense solar radiation and high temperature regime all of which do not favour soil quick recovery rate. These conditions accelerate and exacerbate soil fertility problem in the Abakaliki area (Nwite, 2009).

Consequently, sustainable agricultural practice through mineral fertilizer amendment is unrealistic. Mineral fertilizer overtime has proved to be scarce, cost intensive, capable of causing pollution and toxicity and do not achieve conservation needs of man (Nwite, 2012). There could be initial increase in yield of crops with fertilizer application and subsequent decreases as toxicity builds up. Furthermore, soils in humid tropics are poor in organic matter and suffer low available nutrients. Hence, its productivity and sustainability decline with time when subjected to continuous cultivation (Asadu and Nweke, 1999)

In order to combat soil low fertility problem and sustain increased productivity, interest has been renewed in organic wastes usages as soil amendments. Besides serving as one of the disposal avenues, organic wastes application have numerous positive impacts on soil. Organic wastes release their essential plant nutrients which improve soil physical and chemical properties (Mbagwu and Piccolo, 1990). Organic wastes bind soil particles, increase soil porosity and moisture regime and reduce compactness. Chemical properties such as available P, organic matter, total N and exchangeable bases are enhanced under organic wastes application. Nwite (2013) reported long residual effect of organic wastes amended soil relative to control.

Even though, there have been studies on effect of poultry droppings, cow dung and swine waste on soil properties and crop yield, they are not exhaustive. Studies have not been carried out on effect of these wastes on soil properties under mixed cropping system in the study area. Furthermore, the study could add to the existing knowledge. The objective of this experiment was to evaluate productivity of a degraded ultisol amended with poultry droppings, cow dung and swine waste under mixed cropping system in Abakaliki agroecology.

Tele:
E-mail address: nwitejamesn@yahoo.com

Materials and methods

Experimental site

The experiment was carried out at the Teaching and Research Farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. The site is located by Latitude 06°4'N and longitude 08°65'E in the derived savannah of agroecological zone of southeastern, Nigeria. The area is characterized by bimodal pattern of rainfall usually experienced from April – July and September – November. A dry spell is observed in August and this is called "August break". The mean annual rainfall ranges from 1700 – 2000 mm. The mean minimum and maximum daily temperatures are 27°C and 31°C for rainy and dry seasons. Relative humidity is normally high (80%) during rainy seasons but declines to 60% in dry periods (ODNRI, 1989). The soil is derived from successive marine deposits. Abakaliki zone is underlain by sedimentary rocks. The soil is unconsolidated up to 1 m depth and belongs to the order ultisol classified as Typic Haplustult (FDALR, 1985). There was growth of native vegetation, shrubs and herbs in the site. The area has history of previous cultivation of maize (*zea mays*) and cassava (*manihot ultilisma*). It was not under fallow before this experiment.

Field Methods

The field measured 15 x 10 m, approximately 0.14 ha. The existing vegetation was cleared with cutlass and debris removed. Randomized complete block design (RCBD) was used in laying out the field into blocks and plots. The plots measured 2 m x 2 m with 0.5 m alley space between them. The blocks were separated by 1 m distance. The treatments were poultry droppings, cow dung, swine waste and control applied at 12 t ha^{-1} equivalent to 5 kg/plot to each plot in a randomized manner. The animal wastes were collected from Animal Science Department, Ebonyi State University, Abakaliki. The wastes were cured and crushed, spread on the plots and later incorporated into soil with hoe during seedbed preparation. The treatments were replicated five times to give a total of twenty experimental plots.

Maize (*zea mays*) (Oba super II hybrid variety) and groundnut (*Arachis hypogea*) were used as test crops. The maize variety and groundnut were collected from Ebonyi State Agricultural Development Programme, Onuebonyi Izzi, Abakaliki (EBADEP). The maize seeds were planted two per hole and at spacing of 25 x 75 cm two weeks after treatment application. The groundnut seeds were planted at distance of 60 x 60 cm after planting the maize. Two weeks after plant emergence, the maize and groundnut seedlings were thinned down to one seed per hole. Lost stands were replaced by replanting leaving a total of 53,000 maize plants and 27,778 for groundnut population per hectare respectively. Weeds were removed at three weekly interval till harvest.

Soil Sampling

Initial soil composite samples were collected with auger randomly from the field at 0-20cm depth for pre-planting analysis before cultivation and treatment application. Core and auger samples were also collected form each plot at three points for post harvest soil determination.

Agronomic Data

The cobs of maize plants were harvested when the husks had dried, dehusked, shelled and grain yield determined at 14% moisture content. The groundnut was also harvested when the stem and leaves had turned yellow or shrievelled. They were pulled up, nuts removed and further dried before shelling. The seeds were used to determine yield. Yield was taken from twelve maize and six groundnut plants, respectively from each plot.

Laboratory Methods

Core samples were used to determine physical properties of soil. Bulk density determination was carried out according to Gee and Or (2002) methods. Total porosity was calculated as described by Obi (2000). The method of Klute (1986) was used to determine saturated hydraulic conductivity. Gravimetric moisture content determination was determined as described by Obi (2000). Aggregate stability and mean weight diameter determinations were carried out using Kemper and Rosenau (1986) and Van Bavel (1950) methods, respectively.

Auger samples were dried, grinded and passed through a 2 mm sieve. They were used to determine chemical properties of soil. Soil pH determination was carried out in KCL and water in 1:2.5 soil/water ratio. The values were read off using Beckman zeromatic pH meter (Peech, 1965). Total nitrogen was determined using modified method described by Bremmer and Mulvancy (1982). Organic carbon determination was done using Nelson and Sommers (1982) procedure Available phosphorus was determined by Bray-2 method as described by Bray and Kurtz (1945). Exchangeable cations of Ca, Mg, K and Na were extracted using the procedure described by Tel and Rao (1982). Exchangeable acidity was determined using titration method (Juo, 1979). Cation exchange capacity determination was carried out using I N NH_4OAC solution. Percent base saturation was calculated as follows

$$\%BS = \frac{TEB}{CEC} \times \frac{100}{1} \quad \ldots\ldots\ldots 1$$

where

%BS - Percent base saturation
TEB - Total exchangeable bases
CEC - Cation exchange capacity

Data Analysis

Data collected from the study were subjected to analysis of variance (ANOVA) for randomized complete block design (RCBD). Means were separated using Fisher's least significant difference (F-LSD) for those which were significant as recommended by Steel and Torrie (1980).

Results and discussion

Table 1 shows the nutrient composition of the animal wastes used for soil amendment. The pH value is slightly acidic for the wastes (USDA SCS, 1974). Available phosphorus and total N were of low values according to (Landon, 1991). Organic matter (Enwezor *et al.*, 1981) is low. Exchangeable calcium and magnesium though dominated exchange complex was low (Asadu and Nweke, 1999). Generally, the nutrient concentration is higher in poultry droppings compared to cow dung and swine waste.

Pre-planting soil properties

Pre-planting soil properties (Table 2) indicate that sand fraction dominated the Particle Size Distribution (PSD). The textural class was sandy loam. The pH was slightly acidic (USDA SCS, 1974). Available phosphorus, total N and organic matter were low (Landon, 1991). Exchangeable Ca and Mg dominated the exchange complex of soil. The exchangeable acidity was 1.84 $cmolkg^{-1}$ confirming the acidic nature of the soil. Cation exchange capacity is low (Asadu and Nweke, 1999). Percent base saturation is moderate (Asadu and Nweke, 1999).

Particle size distribution after amendment

The particle size distribution (Table 3) did not vary appreciably after planting. The sand fraction dominated other particles in the treatments. The texture still remained sandy loam.

Table 1. Nutrient composition of Animal wastes

Elements			Animal wastes	
	Units	SW	PD	CD
pH in KCL		5.2	5.4	5.3
Available phosphorus	$mgkg^{-1}$	19.20	20.88	17.42
Nitrogen	%	0.09	0.11	0.09
Organic matter	%	1.58	1.80	1.42
Calcium	$cmolkg^{-1}$	3.92	4.00	4.56
Magnesium	$cmolkg^{-1}$	1.52	1.44	2.00
Potassium	$cmolkg^{-1}$	0.22	0.25	0.23
Sodium	$cmolkg^{-1}$	0.16	0.16	0.15

Sw-swine waste, PD-poultry dropping, CD –cow dung.

Table 2. Soil properties at initiation of study

Elements	Units	Values
Sand	%	61
Silt	%	21
Clay	%	18
Texture		Sandy loam
pH in KCL		5.1
Available P	$mgkg^{-1}$	22.40
Nitrogen	%	0.10
Organic matter	%	1.82
Calcium	$cmolkg^{-1}$	4.80
Magnesium	$cmolkg^{-1}$	2.00
Potassium	$cmolkg^{-1}$	0.20
Sodium	$cmolkg^{-1}$	0.14
Exchangeable acidity	$cmolkg^{-1}$	1.84
Cation exchange capacity	$cmolkg^{-1}$	7.04
Base saturation	%	79.50

Table 3. Particle size distribution following amendment of animal wastes

Treatment	Particle sizes			Texture
	% sand	% silt	% clay	
Control	61	23	14	Sandy loam
Swine waste	60	25	15	Sandy loam
Poultry dropping	62	23	16	Sandy loam
Cow dung	62	24	14	Sandy loam

Table 4. Effect of animal wastes amendment on soil physical properties

Treatments	Soil physical properties					
	BD (gcm^{-3})	TP(%)	AS(%)	MWD(mm)	HC($Cmhr^{-1}$)	GMC(%)
Control	1.61	39.2	42.2	1.9	59.03	20.37
Swine waste	1.51	43.0	46.4	2.5	69.00	25.87
Poultry dropping	1.44	46.0	50.8	2.6	71.62	27.75
Cowdung	1.54	42.0	43.4	2.3	66.37	24.75
FLSD (0.0)	0.03	8.0	3.7	0.2	2.24	1.20

BD- Bulk density, TP – total porosity, AS – aggregate stability, MWD-mean weight diameter, HC-hydraulic conductivity, GMC-gravimetric moisture content.

Table 5. Effect of animal wastes amendment soil chemical properties

Treatment	Chemical properties									
					$cmolkg^{-1}$					
	pH(KCL)	$Pmgkg^{-1}$	N%	OM%	Ca	Mg	K	Na	Ea	CEC	%BS
Control	4.8	14.88	0.08	1.24	3.92	1.44	0.21	0.17	2.48	5.81	70.17
Swine waste	5.2	19.20	0.09	1.54	4.32	2.00	0.22	0.16	2.06	6.68	76.51
Poultry dropping	5.3	20.88	0.11	1.80	4.00	2.05	0.25	0.16	1.84	6.91	78.32
Cow dung	5.0	17.42	0.09	1.42	4.56	1.52	0.23	0.14	1.88	5.85	76.45
FSLD (0.05)	NS	NS	NS	NS	NS	0.34	NS	NS	NS	NS	NS

Table 6. Effect of animal wastes amendment on crop yield

Treatment	Yield of crops (tha^{-1})	
	Maize	groundnut
Control	1.9	1.0
Swine waste	2.3	1.3
Poultry dropping	2.4	1.6
Cow dung	2.2	1.3
FSLD (0.05)	0.2	0.3

This agrees with the report of Obi (2000) that texture was immutable and did not change after cultivation or planting. The texture of soil is of primary importance especially as it is a determinant of nutrient, water retention and supply. It is also associated with soil compactibility and compressibility. Generally, texture influences soil productivity.

Effect of animal wastes amendment on physical properties of soil

Table 4 shows effect of animal wastes amendment on soil physical properties. The results show that bulk density of animal wastes amended soil was significantly ($P<0.05$) lower than control. Similarly, significantly ($P<0.05$) lower bulk density was obtained under poultry droppings treated plots compared to cow dung and swine waste amended ones. This bulk density in PD was lower by 5 % and 7 % when compared to cow dung and swine wastes treatments. Mbagwu and Piccolo (1990) observed that animal wastes amendment of soil significantly reduced bulk density. This could be attributed to effect of nutrients contained in animal wastes, particularly organic matter released to the soil on decomposition (Table 1). The lower bulk density in poultry droppings amended plots would be due to higher organic matter released to soil compared to other animal wastes.

Total porosity had inverse relationship with bulk density. Generally, the total porosity of plots treated with animal wastes were significantly ($P<0.05$) higher relative to control. The total porosity of poultry droppings amended plots increased by 9 and 7% over cow dung and swine waste amendments. Gou (1987) and Pauletto *et al.* (1990) noted that total porosity increased in soil amended with animal wastes relative to control. Furthermore, Akanni and Ojenyi (2008) observed that organic matter supplied by animal wastes application stabilized soil structure and that increased soil porosity. The high total porosity and lower bulk density under poultry droppings (PD) treatment could be attributed to higher organic matter content that helped to stabilize the soil (Table5)

Significantly ($P<0.05$) higher aggregate stability was obtained in plots amended with poultry droppings (PD) and swine waste amendments relative to cow dung and control. The aggregate stability in PD amended plots was higher by 9 and 15 % than swine waste and cow dung amendments. The amendment of animal wastes significantly ($P<0.05$) increased mean weight diameter over the control. The values of mean weight diameter did not significantly vary among the animal wastes treatments. The significant improvement in aggregate stability under poultry droppings amendment could be attributed to higher nutrient content that helped to bind the soil particles into aggregates. The pronounced positive effect on aggregate stability and mean weight diameter of animal wastes in plots where they were amended suggest that animal wastes application could improve these soil properties. The hydraulic conductivity and moisture content were significantly ($P<0.05$) higher under animal wastes treatment relative to control. The hydraulic conductivity and moisture content were 4 and 11 % higher under PD treatment when compared with swine waste and cow dung, respectively. Anikwe (2000) attributed higher hydraulic conductivity obtained under animal wastes amendment to high total porosity and reduced bulk density. Weil and Kroontje (1979) had earlier reported that organic wastes application on soil increased hydraulic conductivity. The findings in moisture content is in line with Obi and Ebo (1995) observation which noted that increase in moisture content was due to colloidal nature of organic matter which increased the soil moisture retention capacity.

Effect of animal wastes amendment on soil chemical properties

Effect of animal wastes amendment on soil chemical properties (Table 5) shows that available P, percent total N and organic matter (OM) were not significantly ($P<0.05$) different from control. The result indicated that the values of available P, N and organic matter were higher under poultry droppings application relative to swine waste and cow dung treatments, respectively. These soil parameters were higher by 8, 17, 18, 18, 12and,21 % in PD amended plots compared to swine waste and cow dung amendments, respectively. The higher available total N and organic matter obtained in plots amended with animal wastes agree with the findings of Sharply *et al.* (1994) that organic wastes amendment of soil increased available P relative to control. Jekinson (1990) and Bernston and Aber (2002) observed that organic wastes incorporation in soil gave higher values of total N and organic matter. The values of available P, organic matter and total N were low to very low (Landon, 19991) in all the treatments.

The exchangeable Ca, K and Na were not significantly ($P<0.05$) different from control. However, Mg under poultry droppings and swine waste treated plots were significantly ($P<0.05$) higher than control. Poultry droppings amended plots yielded higher exchangeable Ca, Mg, K and Na relative to swine waste and cow dung treated ones. The values of these exchangeable cations in all the treatments were low (Asadu and Nweke, 1999). Organic wastes amendment of soil increase exchangeable cations particularly Mg and Ca due to materials they add to soil (Hue and Licudine, 1999; Perucci, 1992). Adeniyi and Ojeniyi (2005) reported that organic wastes application increased K content in soil compared to control. The increase in K content in soil due to organic wastes amendment was reported by Andrews *et al.* (2002). Increase in Na content of soil amended with organic wastes had been reported by (Chang and Tiguo, 1990).

Exchangeable acidity (EA), cation exchange capacity and percent base saturation (%BS) were not significantly ($P<0.05$) different from control. The exchangeable acidity of control was higher relative to animal wastes amendment. Clark *et al.* (1998) as corroborated by Mbah (2004) observed that animal wastes treatment precipitates exchangeable Al^{3+} and H^{+} that constitute exchangeable acidity (EA) due to their organic matter content which was added to the soil. Exchangeable cations increase with incorporation of organic wastes and this in turn increases cation exchange capacity (Pool *et al.*, 2002). Jokova *et al.* (1997) further noted that cation exchange capacity increased with addition of organic wastes into soil. Percent base saturation of poultry droppings amended soil was slightly higher compared to swine waste and cow dung treated ones. Agboola and Fagbenro (1985) in their findings reported that animal wastes application in soil increased base saturation. Cation exchange capacity and percent base saturation were of low (Asadu and Nweke, 1999) to medium (Asadu and Nweke, 1999) values in the treatments.

Effect of animal wastes amendment on grain yields of maize and groundnut.

Effect of animal wastes amendment on grain yields of maize and groundnut is shown in Table 6. Significantly ($P<0.05$) higher grain yields of maize and groundnut were obtained under animal wastes treatment relative to control. Crop yields were higher under poultry droppings amendment by 4, 8 % and 19, 19 % respectively for maize and groundnut when compared to swine waste and cow dung treatments. The higher grain yields in plots treated with animal wastes compared to control could be attributed to nutrient composition in these wastes which were released to the soil on application (Table 1). Furthermore, animal wastes have properties that improve soil properties and increase maize and groundnut yields. Similarly, the higher yields obtained under poultry droppings amendment relative to swine waste and cow dung treatments could be as result of better nutrient composition (Table 1) observed in the treatment. Higher grain yield of maize under poultry droppings amended plots relative to other animal wastes had been noted by Agbim (1985).

Conclusion

The results have shown that animal wastes amendment could improve physico-chemical properties of degraded ultisol and enhance crop yields. Of all the treatments, poultry droppings was superior in improvement of soil physico-chemical properties and yields of crops at the same rate of application. The performance of the treatments in enhancement of soil properties and crop yields could be rated as poultry droppings > swine waste > cow dung > control. Alternatively, poultry droppings could be recommended for treatment of degraded ultisoil.

References

Adeniyan, O. N. and Ojeniyi, S.O. (2005). Effects of poultry manure, NPK 15:15:1:15 and combination of their reduced levels on maize growth and soil chemical properties. Nig. J. soil Sci., 15:34-41.

Agboola, A.A. and Fagbenro, J. A. (1985). Soil organic matter and its management in humid tropics with particular reference to degradation in the humid tropics. Proceedings ISS$/SSSN, Ibadan, 215-283.

Akanni, D.I. and Ojeniyi, S.O. (2008). Residual effects of goat are poultry manures on soil properties, nutrient content and yield of amaranthus in south West, Nigeria. Nig. Journ. of Agron. 2(2):44-47.

Andrews, S.S., Karlen, D.L. and Mitchel J.P. (2002). A comparison of soil quality indexing methods for vegetable production in Northern California, USA.

Anikwe, M.A.N. (2000). Amelioration of heavy clay loam soil with rice husk dust and its effect on soil physical properties and maize yield Bioresource Technology 74:169-173.

Asadu, C.L.A. and Nweke, F.I. (1999). Soils of Arable Crop Fields in sub-Saharan Africa. Focus on cassava – growing areas. Collaborative study of cassava in Africa. Working paper No. 18. Resources and crop management Division, IITA, Ibadan Nigeria, 182p.

Bernstom, G. M. and Aber, J.D. (2002). Fest nitrate immobilization in N-saturation in Temperate forest soils. Soil Bio and Biochemi. 32:151-156.

Bray, R.H. and Kurtz, L.T. (1945). Determination of total organic carbon. In: page, A *et al.* (ed). Method of soil Analysis. Part 2. American Soc. Of Agron., Wisconsin, Madison, 595-624.

Chang, N. and Tiguo, H. (1990). The role of straw covering in crop production and soil management in better cropping, 6(2):6-7).

Clark, S.W.R., Howath, C. and Scow, K. M. (1998). Changes in soil chemical properties resulting from organic and low-in put farming practices. Journ. of Agronomy 90:662-671.

Enwezor, W.O., Udo F.J. and Sobulo, R.I. (1981). Fertility status and productivity of acid sands. In: Acid sands of southeastern Nigeria. Monograph No 1. Soil Sci. Soc. of Nigeria 56 – 73pp.

Federal Department of agriculture and Land Resources (1981). Reconnaissance soil survey of Anambra State, Nigeria. Soil Report, Kaduna 3p.

Gee, G.W. and Or, D. (2002). Particle size Analysis. In: Dane, J.H. and Topp, G.C. (eds) Methods of Soil Analysis. Part 4, physical methods. Soil Sci. Soc. Am. 5:255-293.

Guo, J. (1987). The effect of consciously Returning Plant straw back to paddy field in improving soil fertility. Bueji Agric. Soil Tech 5:28-30.

Hue, N.V. and Licudine, D.L. (1999). Amelioration of sub soil acidity through surface application of organic manures. J. Environmental quality 28:623-632.

Jekinson, D.S. (1990). An introduction to the global nitrogen cycle soil use and management 6:56-61.

Jokova, M., Kostov, O. and Van Clean Put, O. (1997). Cation exchange and reducing capacities and criteria for compost quality. Biol. Agric Hort. 14:187-197.

Juo, N.S.R. (1979). Selected method for soil and plant analysis. IITA manual series, Ibadan, Nigeria 1:97-98.

Kemper, W.D. and Rose Nauu, R.C. (1986). Aggregate stability and size distribution. In: Klute, A. (ed). Methods of Soil analysis. Part 1. Am. Soc. Agron. 9:425-440.

Klute, A. (1986). Water retention. Laboratory methods. In: Klute, A. (ed). Methods of soil physical property. Physical and mineralogical methods 2nd (ed), ASA, ASSA, Madison, 635 – 660.

Landon, J.R. Booker, (1991). Tropical Soil manual. A handbook for soil survey and Agricultural land Evaluation in Tropics and sub-tropics. New York, USA. John Wiley and Sons, Inc. Third Avenue.

Mbah, C. N. (2004). Evaluation of Agricultural use and pollution potential of four animal wastes in an ultisol at Abakaliki; southeastern, Nigeria. Ph.D, Thesis university of Nigeria, Nsukka, 189.

Nelson, D.W. and Sommers, L.W. (1982). Total P organic carbon and organic matter. In: Page *et al.* (ed). Methods of soil Analysis, Part II. Chemical and Mineralogical properties. Agron. Monograph, Madison, USA..

Nwite, J. N. (2008). Strategies for soil conservation and management. Journal of Ebonyi Technology and Vocational education, 1:65-68.

Nwite, J. N. (2012). Effect of different rates of poultry droppings on soil properties and grain yield of maize proceeding soil Sci. Soc. of Nigeria, UNN, Nsukka, March, 2012,In Press.

Nwite, J. N. (2013). Evaluation of the productivity of a spent lubricant oil-contaminated soil amended with organic wastes in Abakaliki, Southeastern Nigeria, Ph.D, Thesis, Univ. of Nig. Nsukka, 140-145.pp.

Obi, M.E. (2000). Soil physics. A compendium of lectures. Atlanto Publishers, Nsukka, Nigeria, 28p.

Obi, M.E. and Ebo, P. O. (1995). The effects of organic amendments on soil physical properties and maize production in severely degraded sandy soil in southern, Nigeria. Bioresources Tech. 52:117-123.

Overseas Development of Natural Resources Institute (ODNRI, 1989). Nigeria Profile of Agricultural potential, ODA, United Kingdom.

Pauletto, E.A., Wachtigall, G.R. and Guard grin, C. (1990). Addition of rice husk ash unto soil of the district of petotes states of Riogradedoul Brazil Revists de cunia do soli 14(2):225-227.

Perucli, P. (1992). Enzyme activity and Microbial biomass in a field amended with municipal refuse in biofertility of soil. Macmillan, London 54-60pp.

Peech, M. (1965). Hydrogen ion activity. IN: Black, C.A. (ed). Methods of soil Analysis. Part 2. Am. Soc. Agron 9:914-926.

Pool, N.L., Trinidal, S.A., Etchevers, B.J.D., Perez, M. J. and Martinez, G.A. (2002). Improvement of soil fertility in hill side agriculture of Los Altosde Choapa, Mexico. Agrocienia 34(3):251-259.

Sharpley, A.N., Smith, S.J. and Bain, W.R. (1994). Nitrogen and phosphorus fate from long-term poultry litter application to Oklahoma soils. J. Soil Sci. Soc. Am. 57:1131-1137.

Steel, R.G.D. and Torrie, J. H. (1980). Principles and procedures of statistics. A bio metric approach. 2nd edition, McGraw Hill book Co. Inc. New York, 1-3.

Tel, D. and Rao, F. (1982). Automated and Semi-automated methods for soil and pant analysis, 201-270pp.

USDA – SCS (1974). Soil classification system. Definition and Abbreviations for soil description. West Technical service center, Portland, Oregon, USA.

Van Bavel, C. H.M. (1950). Mean weight diameter of soil aggregates as a statistical index of aggregation. Soil Sci. Soc. Am. 14:20-23.

Weil, R. R. and Kroontje, W. (1979). Physical condition of a Davison clay loam after five years of heavy poultry manure applications. J. Environ. Quah 8:387-392.