academicJournals

Vol. 8(36), pp. 1720-1724, 25 September, 2013
DOI 10.5897/SRE12.554
ISSN 1992-2248 © 2013 Academic Journals
http://www.academicjournals.org/SRE

Scientific Research and Essays

Full Length Research Paper

Evaluation of the productivity of soil amended with different animal wastes in an acid ultisol at Abakaliki, Southeast Nigeria

Nwite J. N.[1]*, Okolo C. C.[1] and Ezeaku, P. I.[2]

[1]Department of Soil Science and Environmental Management, Ebonyi State University, P. M. B 053, Abakaliki, Ebonyi State.
[2]Department of Soil Science, University of Nigeria, Nsukka, Nigeria.

Accepted 31 May, 2013

An experiment was carried out in order to evaluate the productivity of soil amended with different animal wastes at the Teaching and Research Farm at the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. The field was laid out in randomized complete block design (RCBD) comprising of poultry droppings (PD), swine waste (SW), goat droppings (GD), cow dung (CD) and control (c) replicated four times. Maize variety (Oba Super II) was used as a test crop. The result indicated that bulk density, total porosity, aggregate stability, mean weight diameter and state of aggregation were significantly (P < 0.05) higher in poultry droppings amended plots compared to control. Soil pH, total N, Calcium, Potassium, Sodium, effective cation exchange capacity, percent base saturation and exchangeable acidity were significantly (P < 0.05) higher in plots amended with poultry droppings when compared to control. Plots amended with poultry droppings gave the highest grain yield of maize which was 64% higher than that of the control. Poultry droppings could be recommended for improved soil productivity in Abakaliki location.

Key words: Animal wastes, amended, evaluation, productivity, soil.

INTRODUCTION

Soil is a fundamental resource for agricultural production. Naturally, its continued cultivation leads to loss of nutrients. Consequently, according to Lloyd and Anthony (1999) and Oyentunji et al. (2001), organic resources which act as soil amendments are becoming increasingly utilized as soil fertility improvers over recent years in tropical agriculture. The authors noted that the issue of soil productivity maintenance had remained a knotty one due to poor cultural practices and fragile nature of arable soils.

The use of organic resources such as animal manure has received much attention (Sridhar and Adeoye, 2003). For instance, Moyin and Atoyosoye (2002) reported significant improvements in physicochemical properties of soil and improved crop yields in animal manure treated soil. The use of cow dung and poultry droppings particularly in traditional agricultural system and in most urban areas ensure sustainability in production. They also found animal manure to be effective in supply of N, P, K Ca and Mg to the soil.

Use of animal wastes in productivity restoration is not only important as soil improvement programme but also essential for man's health that derives his sustenance from it (Moyin and Atoyosoye, 2002). Inorganic fertilizer application has been criticized not only as costly and cannot be accessed by local poor farmers but its continued usage is deleterious to soil. Certain types of fertilizers could raise soil pH and capable of causing

*Corresponding author. Email: nwitejamesn@yahoo.com. Tel: +234 8064764659

environmental pollution. This scenario calls for more concerted effort at evolving a proper soil productivity restoration method that would be enduring. The objective of this work was to evaluate the productivity of soil amended with different animal wastes in Abakaliki.

MATERIALS AND METHODS

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 area is located at latitude 06° 4N and longitude 08° 65'E in the derived savannah zone of Nigeria. The rainfall pattern of the area is bimodal (April to July) and (September to November) with a short spell in August popularly called "August break". The minimum annual rainfall is 1700 mm with maximum annual rainfall of 2000 mm. The mean annual temperature ranges from 27 to 31°C throughout the year. The relative humidity is high during rainy season reaching 80% (ODNRI, 1989) and declines to 65% in dry season. The soil is underlain by sedimentary rock derived from successive marine deposit. According to FDALR (1985), Abakaliki agricultural zone lies within Asu River and is associated with brown olive shales, fine grained sandstone and mudstone. The soil is unconsolidated to 1 m depth belonging to the order Ultisol classified as Typic Haplustult (FDALR, 1985).

Field methods

A land area of 0.02 ha was used for establishing the project. The site was cleared of existing vegetation with matchet and debris removed. Randomized complete block design (RCBD) was used in laying out the field. The plots measured 2 m × 2 m and were separated by 0.5 m space. There were five treatments replicated four times to give a total of twenty experimental plots. The beds were prepared by hoe. The animal wastes, applied at 12 t ha^{-1}, each of poultry droppings, cow dung, swine waste, goat droppings and control were spread on the beds and later raked into the soil. They were allowed to age for two weeks. The animal wastes treatments were collected from Animal Science Department of Ebonyi State University, Abakaliki.

Oba Super II variety of maize (*Zea mays L.*) collected from Ebonyi State Agricultural Development Programme (EBADEP) Onuebonyi, Abakaliki was used as a test crop. The maize seeds were planted two per hole at a planting distance of 25 cm × 75 cm and 5 cm depth. Two weeks after emergence, they were thinned down to one per plant. Weak and those which did not germinate were replaced to give a total of 53,333 plants per hectare. Weeds were removed at 3-weekly interval till harvest.

Soil sampling

A composite soil sample was collected with soil auger at 0 to 30 cm depth while core samples were collected at 0 to 10 cm depth from the site before cultivation and treatment application. The sample was for pre-planting soil analysis. Core and auger samples were further collected from each plot at 0 to 10 cm and 0 to 20 cm depths respectively after planting. These samples were used for post-planting soil analysis.

Laboratory methods

Core samples were used to determine physical properties of soil. Bulk density was determined by Blake and Hartge (1986). Gee and Baudor (1986) method was used to determine particles size distribution. Total porosity was by Obi (2000) method. Hydraulic conductivity determination was by Klute (1986). Mean weight diameter and state of aggregation were determined according to Kemper and Rosenau (1986). Gravimetric moisture content was done using Obi (2000) procedure.

The auger soil samples were dried, ground and passed through 2 mm sieve. Soil pH was determined in soil/water suspension ratio of 1:2..5 and values read with Peech pH meter (1965). Organic determination was by Nelson and Sommers (1982). Nitrogen was determined by semi- macro Kjeldahl method (Bremmer and Mulvancy, 1982). Available phosphorus determination was by using Bray 2 method as described in Page et al. (1982). Exchangeabele K, Ca, Mg and Na were extracted with 1 N ammonium acetate and amount of K, Ca and Na in filtrate determined using coning flame photometer. Magnesium was determined using atomic absorption spectrophotometer. Effective cation exchange capacity was determined by summation method of:

$$ECEC = TEB + TEA$$

where ECEC- effective cation exchange capacity, TEB- total exchangeable bases and TEA- total exchangeable acidity.

$$\text{Percent base saturation by \%BS} = \frac{TEB \times 100}{ECEC}$$

Exchangeable acidity was determined in KCL through displacement method.

Agronomic data

The cobs were harvested when the husks dried. They were dehusked and shelled and further dried.

Data analysis

The data collected from field and laboratory were subjected to ANOVA and significant means were separated using Fishers least significant difference (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Pre-planting soil properties

Table 1 shows result of pre- planting soil analysis. The texture of the soil was sandy loam. The pH was strongly acidic (USDA-SCS, 1974). Available phosphorus was high (Landon, 1991) and nitrogen low (Landon, 1991). Soil organic carbon was low (Metson, 1967). Exchangeable calcium and magnesium dominated the exchange complex of soil. Percent base saturation recorded high value of 85%.

Table 2 shows nutrient composition of animal wastes used as amendments. The nutrient concentration was generally higher in the wastes than in soil. Nutrient composition of poultry droppings was higher relative to other animal wastes. Comparatively, the order of nutrient composition in the amendments was PD > SW > CD > GD. This could be attributed to the nutrients in the feed

Table 1. Mean values of Soil properties prior to planting.

Sand properties	Values
Sand (kg^{-1})	780
Silt (kg^{-1})	130
Clay (kg^{-1})	90
pH (H_20)	4.7
Available phosphorus ($mgkg^{-1}$)	23.6
Nitrogen (%)	0.11
Organic carbon (%)	1.07
Calcium (mol kg^{-1})	4.0
Magnesium (mol kg^{-1})	2.8
Potassium (mol kg^{-1})	0.31
Sodium (mol kg^{-1})	0.29
Base saturation (%)	85
Exchangeable acidity (mol kg^{-1})	1.28

Table 2. Nutrient composition of animal wastes.

Nutrient	PD	CD	SW	GD
Organic carbon (%)	16.0	8.0	13.1	5.2
Nitrogen (%)	2.10	1.60	2.00	1.80
Available phosphorus ($mgkg^{-1}$)	2.18	0.75	0.70	2.10
Organic matter (%)	28.8	13.5	24.2	10.9
Calcium (%)	6.2	4.2	6.1	3.2
Magnesium (%)	2.00	2.00	2.10	1.30
Potassium (%)	3.3	0.65	0.60	0.40
Sodium (%)	0.70	0.32	0.40	0.24
C.N	8.0	4.3	6.8	2.6

PD – Poultry droppings, CD – Cow dung, SW – Swine waste, GD – Goat droppings, C N – Carbon- Nitrogen ratio.

and food of the animals (Mbah, 2004).

Chemical and physical properties of soil following organic amendment

Table 3 shows physical properties of soil after amendment with different animal wastes. The texture remained sandy loam. Obi (2000) noted that texture was a permanent property of soil and did not change after cultivation. The high content of sand could be attributed to parent material. According to FDALR (1987) sand content of the soil in south-eastern region is a characteristics of sand formed on unconsolidated coastal plain and sandstones from Asu River. Texture has good relationship with nutrient storage, water retention and porosity (Foth and Turk, 1972).

Bulk density of control was significantly ($P< 0.05$) higher (1.62) relative to different treatment of animal wastes. This could be due to the low organic carbon recorded in control plots (Table 4) which resulted to increased bulk density and reduced bulk density in animal wastes treated plots. Valpassos et al. (2001) had observed that animal wastes treatment led to reduction in bulk density. The total density, hydraulic conductivity, mean weight diameter and state of aggregation except gravimetric moisture content of control were significantly ($P < 0.05$) lower compared with plots receiving different animal wastes treatment. The increased organic carbon and reduced bulk density (Tables 3 and 4) in animal wastes amended plots could have been responsible for the positive result obtained in these parameters. Mbah and Mbagwu, (2006) observed that animal waste application increased total porosity of soil. Werner (1997) reported increase in total porosity as a result of low bulk density. Many researchers (Adesodun and Ojeniyi, 2005; Edmeades, 2003; Costa et al., 1991; Wagner et al., 2007) have attributed improved hydraulic conductivity, mean weight diameter and state of aggregation to amendment of animal wastes which supplied organic carbon to the soil. Gravimetric moisture content of animal wastes amended plots was not significantly different from control. However, the values were generally higher in different animal wastes treatment relative to control. This improvement could be due to increase in total porosity and low bulk density in animal wastes treatment (Table 3). Poultry droppings amended plots gave significantly ($P < 0.05$) higher (39.10) hydraulic conductivity than other animal wastes amendment. Similarly, poultry droppings treatment showed a significant ($P < 0.05$) higher effect on total porosity, hydraulic conductivity, mean weight diameter, and state of aggregation compared to other animal wastes application.

Chemical properties of the soils following amendment with different animal wastes are shown in Table 4. The pH of different animal wastes amendment was significantly ($P < 0.05$) higher than that of the control. The pH values except poultry droppings amended plots remained strongly acidic (USDA-SCS, 1974) in all the treatments. Poultry droppings and goat droppings amendment significantly ($P < 0.05$) increased total nitrogen relative to control, swine waste and cow dung treatments. Furthermore, total N values in animal wastes amended plots were generally higher (Poultry droppings 0.14%, cow dung 0.12%, swine waste 0.11% and goat droppings 0.11%) than in the control (0.10%). Poultry droppings have high total N (Macrere and Kumbi, 2001) that increased soil productivity than other animal wastes. Percent organic carbon and available phosphorus of different animal wastes were not significantly ($P >0.05$) different from control. However, they were respectively higher when compared with the control plots. This observation is supported by findings of Awodun et al. (2007) and Adesodun et al. (2003) that high percent organic carbon and available phosphorus were obtained from animal wastes amendment. Poultry droppings recorded better pH, percent organic carbon, total nitrogen and available phosphorus in line with Adesodun et al. (2003) report that these parameters were increased by the treatment.

Table 3. Physical properties of soil following amendment.

Treatment	Sand ($mg\ kg^{-1}$)	Silt ($mg\ kg^{-1}$)	Clay ($mg\ kg^{-1}$)	Texture	BD (mgm^{-3})	TP (%)	GMC (%)	HC (Cmh^{-1})	MWD (%)	SA %
C	750	150	100	SL	1.62	39	11.4	19.03	1.84	2.47
PD	730	170	100	SL	1.45	45	14.1	39.10	2.50	3.98
CD	760	140	100	SL	1.47	44	14.0	30.94	2.36	3.46
SW	700	170	130	SL	1.51	43	13.1	34.08	2.39	3.61
GD	730	170	100	SL	1.52	43	12.4	27.26	2.26	3.29
FLSD (0.05)					0.08	3.2	NS	5.75	0.16	0.33

C-control, PD – Poultry droppings, CD- Cow dung, SW- Swine waste, GD- Goat droppings, Bd-bulk density, TP-total porosity, GMC-gravimetric moisture content, HC– hydraulic conductivity, MWD- mean weight diameter, SA- state of aggregation.

Table 4. Chemical properties of soil following amendment with different animal wastes.

Treatment	pH (H_20)	OC (%)	TN (%)	P ($mgkg^{-1}$)	Ca	Mg	K	Na ($Cmolkg^{-1}$)	ECEC	EA	%BS
C	5.1	1.05	0.10	25.60	4.2	2.5	0.31	0.29	8.51	1.20	85
PD	6.0	1.76	0.14	29.65	6.1	3.5	0.40	0.35	11.13	0.90	92
CD	5.7	1.40	0.12	28.24	5.1	2.9	0.31	0.30	9.78	0.90	90
SW	5.6	1.62	0.11	28.30	4.7	2.9	0.36	0.32	9.45	0.88	91
GD	5.5	1.52	0.11	27.79	5.1	3.0	0.34	0.31	10.06	1.01	90
FLSD (0.05)	0.1	NS	0.02	NS	0.8	0.3	0.04	NS	0.91	0.11	2.0

C- Control, PD – Poultry droppings, CD – Cow-dung, SW – Swine waste, GD – Goat droppings, OC- percent organic carbon, TN- percent total nitrogen, P- available phosphorus, EA- exchangeable acidity, ECEC – effective cation exchange capacity BS- percent base saturation.

Table 5. Grain yield of maize.

Treatment	Grain yield of maize (tha^{-1})
Control	0.61
Poultry droppings	1.66
Cow dung	0.74
Swine waste	1.07
Goat droppings	0.66
FLSD (0.05)	NS

The exchangeable cations of calcium, magnesium and potassium, effective cation exchange capacity and percent base saturation were significantly ($P < 0.05$) higher in different animal wastes amendment, respectively. Calcium (6.1 $Cmolkg^{-1}$), magnesium (3.5 $Cmolkg^{-1}$), potassium (0.40 $Cmolkg^{-1}$), ECEC (11.3 $Cmolkg^{-1}$) and BS% (92) were significantly ($P < 0.05$) higher in poultry droppings treatment than in other animal wastes treated plots. Significantly ($P < 0.05$) higher exchangeable acidity was obtained in control (1.20 $Cmolkg^{-1}$), and goat droppings (1.01 $Cmolkg^{-1}$) amended plots relative to amendments of other animal wastes.

Animal manure contain substantial amount of calcium, magnesium and potassium (Moyin and Atoyosoye, 2002; Hue and Licudine, 1999). Adeniyi and Ojeniyi (2005) stated that poultry dropping increased potassium content of soil compared to inorganic manures. The high exchangeable acidity in control (1.20 $Cmolkg^{-1}$) and goat droppings treatment (1.01 $Cmolkg^{-1}$) could be attributed to high presence of Al^{3+} in soil in those plots receiving the treatment relative to other animal wastes amendment. Lavelle et al. (1993) as corroborated by Adeniran (2003) noted that animal wastes decreased exchangeable acidity by removal of Al^{3+} from soil exchange site. Nonga (2001) reported that application of poultry droppings significantly increased effective cation exchange capacity and percent base saturation, respectively.

Grain yield of maize

Grain yield of maize was not significantly ($P > 0.05$) affected by different animal wastes treatment. Nevertheless, higher grain yield of maize was obtained in poultry droppings amendment than in other animal wastes amended plots. The decreasing order of grain yield was PD > SW > CD > GD > C corresponding to 1.66, 1.07, 0.74, 0.66 and 0.61 (Table 5). This result is a reflection of higher nutrient in poultry droppings released to the soil to increase its productivity. Moyin (2002) and Olayinka (1990) reported increased grain yield of maize in poultry droppings treatment relative to other animal wastes amendment.

Conclusion

Results of this study indicates that application of different animal wastes increased soil productivity. This was through positive effect on soil physiochemical properties. Comparatively, poultry droppings more than other animal wastes improved soil productivity and increased phenomenal grain yield of maize.

The decreasing order of general performance of these animal wastes in increasing soil productivity as related to crop yield is PD > SW > CD > GD > C. Poultry droppings could be recommended for increasing soil productivity in Abakaliki, southeastern Nigeria.

REFERENCES

Adesodun JJ, Ojeniyi SO (2005). Effects of poultry manure, NPK 15:15:15 and combination of their reduced levels on maize growth and soil chemical properties. Nig. J. Soil Sci. 15:34-41.

Adesodum JJ, Mbagwu JSC, Oti N (2003). Distribution of Carbon-nitrogen and phosphorous in water stable aggregate of an organic wastes amended ultisol in southeastern Nigeria. Bioresour. Technol. 96:509-516.

Awodun MA, Omonijo LI, Ojeniyi SO (2007). Effect of goat dung and NPK fertilizers on soil and leaf nutrient content and yield of pepper. Int. J. Soil *2:*142-146.

Blake GR, Hartge KH (1986). Bulk density. *In* Klute, A. (ed) methods of Soil Analysis. Part 1.Physical and Mineralogical methods. Am. Soc. Agron. 1:365-375.

Bremmer JH, Mulvancy CS (1982). Total Nitrogen. In: Methods of Soil Analysis. Part 1. Par et al. (ed). Am. Soc. Agron. pp. 596-624.

Costa F, Garcia C, Hemandez T, Polo A (1991). Residue Organic wastes. *In:* Manejo Utilization ed. Sci. Murica pp. 1-18.

Edmeades DC (2003). The Long term effect of manures and fertilizers on soil productivity and quality. A review of nutrient cycling. Agroecosystem 66:165-180.

Federal Department of Agriculture and Land Resources (FDALR, 1985). Reconnaissance Soil Survey of Anambra State, Nigeria. Soil Report, Kaduna.

FDALR (1987). Reconnaissance Soil map of Nigeria. Federal Ministry of Agriculture and Rural Development, Abuja.

Foth HD, Turk C (1972). Fundamentals of Soil Science. New York, John Wiley and Son Ltd, p. 25.

Gee GW, Baucher JW (1986). In: Particle Size analysis. Part 1. Physical and Microbiological method 2nd (ed). Agronomy series No. 9 ASA, Wisconsin, Madison.

Hue NV, Licudien DI (1999). Amelioration of Sub soil acidity through surface application of organic manures. J. Environ. Qual. 20:623-632.

Klute A (1986). Water retention. Laboratory methods *In*: Klute A. (ed). Methods of soil physical analysis. Part 1: Physical and Mineralogy. Method 2nd (ed) ASA, ASSa Madison, USA.

Kemper A, Roseanau K (1986). Size distribution of aggregate. *In:* Klute, A. (ed). Methods of Soil Analysis Part 1, ASA, Madison, WI. pp. 425-442.

Landon JR (eds) (1991). Booker, Tropical Soil Manual: A Handbook for survery and Agricultural Land Evaluation in tropics and subtropics. John Wiley and Sons. Inc. Third Avenue, New York, USA, p. 474.

Lloyd RH, Anthony SR (1999). Soil nutrient management for sustained food crop production in upland farming systems in the tropics. J. Soil Crop Sci. *7:*78-84.

Lavelle PE, Blanchart A, Martin A, Spain F, Toutain I, Schaefer R (1993). A hierarchical model for decomposition in terrestrial ecosystem. Application to soils of the humid tropics. Biotropica *25(2*):130-150.

Macrere AP, Kumbi GG (2001). Comparative effectiveness of animal manures on soil chemical properties and yield and root growth of amaranthus (*Amaranthus cruentus L*.) AJST 1:14-21.

Mbah CN (2004). Evaluation of Agricultural use and pollution potential of four Animal wastes in an ultisol at Abakaliki, South eastern, Nigeria. Ph.D. thesis, University of Nigeria, Nsukka, p. 189.

Mbah CN, Mbagwu JSC (2006). Effect of animal wastes on physico chemical properties of a dystric leptosol and maize yield on South Eastern Nigeria. J. Soil Sci.11:98-193.

Metson A (1967). Methods of Chemical analysis for soil survey samples. New Zealand DSK. Soil Bull. 12. Government printer, Washington, New Zealand.

Moyin JEI, Atoyosoye B (2002). Utilization of agriculture wastes for the growth of leaf and soil chemical composition of Accia seedling in the nurser*y.* Partmark J. Trop. Agric*.* Sci. 25:53-62.

Nelson DW, Sommers LW (1982). Total Organic carbon and organic matter. *In:* Page et al. (ed). Methods of soil analysis. Part 2 Chemical and Microbiological properties. Agronomy monograph, No. 7 Madison, USA.

Nonga DLM (2001). Comparative effectiveness of animal manure on soil chemical properties, yield and growth of (*Amaranthus cruntus L.)* Agric. J. Soil Technol. 1:14-21.

Obi ME (2000). Soil Physics. A Compendium of lecturers. Atlanto Publishers, Nsukka Nigeria pp. 28-40.

Overseas Department of Natural Resources Institute ODNRI (1989). Nigeria profile of agricultural potentials. Chanthan, UK.

Olayinka A (1990). Effects of poultry manure, corn straw and saw dust on plant growth and chemical properties of soil. Ife J. Agric. 12:12-44.

Oyentunji OI, Ekanakaya IJ, Sonubi OO (2001). Influence of Yam fungi on cassava system. Influence of yam fungi on cassava/- mazi intercrop in an alley cropping system. Proceeding of African Crop Science Conference, Uganda.

Page AL, Miller RH, Keeney DR (1982). Methods of Soil Analysis. Part 2 American Society of Agronomy, Madison, pp. 539-579.

Peech M (1965). Hydrogen ion activity. *In:* Black , C.E(eds) Methods of Soil analysis part II. Am. Soc. Agron. 9:914-926.

Steel RGD, Torrie JH (1980). Principles and proceedures of statistics. A biometric approach. 2nd edition, McGraw-Hill Book and Co. Inc. New York. pp. 1-3.

Sridhar MKC, Adeoye GO (2003). Organic Mineral fertilizers from urban waste Development in Nigeria. Nig. Field 681*:*91-111.

USDA-SCS (1974). Soil Classification system, Definition and abbreviations for soil description. West Technical Service Centre, Portland, Oregon, USA.

Valpassos MA, Cante R, Cassioloto EGS, Alves AMJ (2001). Effects of soil management systems on soil microbial activity, bulk density and chemical properties. Agro. Pec. 36:153-1545.

Wagner S, Cattle SR, Scholten T (2007). Soil aggregate formation as influenced by clay content and organic matter amendment. J. Plant Nutr. Soil Sci. 170*:*173-180.

Werner MR (1997). Soil Quality Characteristics during conversion to organic orchard management. Appl. Soil Ecol. 5:151-167.