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Effects of Different Animal Manures on Soil Physical and Microbial Properties

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ABSTRACT

Long term and continuous use of soil for crop production has implication on soil physical and microbial properties and as such there is need to examine ways of protecting the condition of the soil for productive use. Therefore, this study examined the effects of different animal manures on soil physical and microbial properties with the aim of recommending their use in soil management and crop production. The experiment was carried out at the Screen House of Crop, Soil and Pest Management Department of the Federal University of Technology, Akure. Two kilogram of the following animal manure: poultry manure, cow dung and pig manure was mixed with five kilograms of soil and moistened with water until all the pore spaces were filled. Also there was a control experiment where no manure was applied. The topsoil used for this experiment was collected from the Teaching and Research Farm of the Federal University of Technology, Akure. The experiment was arranged in Completely Randomized Design (CRD) with three replicates in the screen house. Soil samples were collected weekly after treatment application (Poultry manure, cow dung, pig manure and control) beginning from the first week to third week for physical and microbial analysis. Result from this study indicates that application of different animal wastes increased certain productivity indicators through positive effect on soil physical and biological properties. Comparatively, pig manure improved soil productivity and the microbial activity of the soil more than cow dung and poultry manure. The decreasing order of general performance of these animal wastes in increasing microbial activity as related to soil microbial biomass and soil basal respiration is Pig manure (PG) (6.55) > Cow dung (CD) (5.42) > Poultry manure (PM) (5.31) > Control (1.25).

Key words: Microbial biomass, organic matter, soil respiration, manure, properties

INTRODUCTION

Soil is a fundamental resource for agricultural production. Naturally, its continued cultivation leads to loss of nutrients. According to Lloyd and Anthony (1999) and Oyetunji *et al*. (2001), organic resources which act as soil amendments are becoming increasingly utilized as soil fertility improvers in tropical agriculture in recent years. However, the issue of soil productivity maintenance had remained a knotty one due to poor cultural practices and fragile nature of arable soils (Oyetunji *et al*., 2001).Use of animal wastes in productivity restoration is not only important in soil improvement programme but also essential for man's health because he derives his sustenance from it (Moyin and Atoyosoye, 2002). Inorganic fertilizer application has been criticized not only because it is costly and usually inaccessible to local poor farmers but because its continued usage is deleterious to soil (Moyin and Atoyosoye, 2002). Studies have shown that adding organic amendments such as manure, results in increased microbial biomass (Soil bacteria and fungi) and higher microbial activity. The carbon and other nutrients in manure can increase microbial biomass and soil respiration rates by two to three times (Jangid *et al.*, 2008). Much of the increase in microbial activity is due to increase in bacterial populations. The accumulation of organic carbon as a result of manure additions not only results in increased microbial biomass but has also been linked to changes in microbial community structure and increased functional diversity. For example, Jangid *et al*. (2008) found that bacterial diversity, in terms of species richness and evenness was higher in soils amended with poultry litter than in those treated with inorganic fertilizers. Certain types of fertilizers could raise soil pH and are capable of causing environmental pollution. The soil microbial population consisting of bacteria, fungi and micro fauna are referred to as soil microbial biomass (SMB). This pool is closely related to the soil organic matter (SOM) pool (Jenkinson and Ladd, 1981, Anderson and Domsch, 1989, Smith and Paul, 1990) and is measured as the amount of C (carbon) and N (nitrogen) in the SMB thus the terms soil microbial biomass carbon (SMB-C) and soil microbial biomass nitrogen (SMB-N).

Soil microbial biomass is a vital soil component, acting as a source and a sink for plant available nutrients, as well as catalyzing the transformations of these nutrients in soil (Jenkinson and Ladd, 1981). During decomposition, the SMB assimilates complex organic substrates for energy and biomass carbon with excess inorganic nutrients being released to the soil. Microbial biomass represents a relatively small standing stock of nutrients, compared to soil organic matter; hence microbial biomass is defined as living component of soil organic matter (Jenkinson and Ladd, 1981) excluding macro fauna and roots of plants. This scenario calls for more concerted effort at evolving a proper soil productivity restoration method that would be enduring. The objective of this research work was to evaluate the productivity of soil amended with different animal wastes (Poultry manure, Swine manure and Cow dung manure) in term of physical properties (bulk density, porosity, moisture content, and organic matter) and microbial properties (microbial biomass, and soil respiration biomass).

MATERIALS AND METHODS

Soil samples were collected from the Teaching and Research Farm, Obanla, FUTA. Ewulo *et al.* (2011) had observed that based on USDA textural classification, the soil is a clay soil, with 63% Clay, 17% Sand, 20% Silt, 1.23 total Carbon, 0.10 total N, and a pH of 6.31 (Table 1). Soil respiration were investigated thrice in order to determine the effects of four treatments (control (no manure), poultry manure at 2.5kg, cow dung manure at 2.5kg, and pig manure at 2.5kg) on soil amendment and productivity restoration.

Table 1: Physical and chemical properties of soil from the study area

Properties	Composition
Sand (%)	16.8
Clay (%)	63.2
Silt (%)	20
Organic carbon (%)	1.23 Moderate
Organic matter (%)	2.11 Moderate
Phosphorus (mg/kg)	2.02 Very low
Magnesium (cmol/kg)	1.30 Moderate
pH (1:2 H_20)	6.31 Slightly acidic
Potassium (cmol/kg)	0.13 very low
Sodium (cmol/kg)	0.16
Nitrogen (%)	0.10 low

Source: Thiagalingam, 2000

Soil samples were collected at 0-10 cm depth at first, second, and third week after adding the treatments (poultry manure, cow dung and pig manure) and was analyzed for physical and microbial properties. Soil samples were collected from three replicate plots of each treatment. Potted moist soil samples were stored in core sampler at 105^{o}C and were used for analysis of soil bulk density, porosity, organic matter.
The microbial biomass of the soil samples was determined using Chloroform- Fumigation Extraction Method (Brookes *et al.,* 1985). Respiration was measured by titration after trapping CO_2 in 0.05M NaOH and adding $BaCl_2$. N mineralization under anaerobic conditions and potential nitrification were measured according to Keeny (1982) and Berg and Rosswall (1985), respectively. The measurements of various soil enzyme activities were based on the release and quantitative determination of the product in the reaction mixture when soil samples were incubated with their respective substrates and aqueous solution. The experiment was laid out in a completely randomized design. Data collected from laboratory were subjected to one-way analysis of variance (ANOVA) using SPSS statistical package. Significant means were separated using Tukey test at $p \leq 0.05$.

RESULTS

Table 2 shows the influence of the organic manures on the soil physical properties at the first week after treatment application. Significance differences were recorded in the properties of various treatments, except microporosity and macroporosity. The control treatment had the lowest organic matter while soil amendment with pig manure had the highest organic matter (Table 2). Compared to other treatments, amendment of soil with cow dung and poultry manures resulted to a low bulk density.

Table 3 shows the influence of organic manures on the soil physical properties at second week after treatment application (i.e. soil amendment). Significance differences were recorded in the properties of the different treatments, except for microporosity and macroporosity. The control treatment had the lowest organic matter while pig manure had the highest organic matter. The results of mean separation revealed that the organic matter of the control treatment was significantly lower than those of the other treatments, which were statistically similar (Table 3). The bulk density of the soil treated with pig manure dropped from 1.30 during the first week of treatment to 1.00 during the second week while those of the other treatments remained virtually unchanged. Table 4 shows the influence of organic manures on the soil physical properties at third week after treatment application. Significance differences were recorded in the properties of the various treatments, except porosity, micro-porosity and macro-porosity. Control had the lowest organic matter while soil amendment with pig manure which had the highest organic matter. There was slight increase in organic matter of the various treatments between week two and three (Tables 3 and 4). For example, the organic matter of the soil treated with pig manure increased from 6.65 at the second week to 7.14 at the third week of treatment while control treatment increased from 0.91 to 1.83 at the end of second and third weeks of treatment, respectively.

Table 2: Influence of different types of organic manures amendments on soil physical properties at first week after treatment application

Treatments	Organic Matter	Porosity (%)	Bulk Density (g/cm3)	Moisture content (%)	Micro-porosity (%)	Macro porosity (%)
Poultry manure	3.12ab	57.67b	1.07a	59.00b	5.00a	61.33a
Cow dung manure	4.23bc	62.00b	1.07a	36.67a	18.67b	40.67a
Pig manure	5.83c	62.00b	1.30a	45.00a	30.33c	56.33a
Control	1.00a	42.00a	1.40b	36.67a	4.00a	50.33a

Means in a column with the same letter (s) are not significantly different ($p \leq 0.05$)

Table 3: Influence of different types of organic manures amendments on soil physical properties at second week after treatment application

Treatments	Organic Matter	Porosity (%)	Bulk Density (g/cm3)	Moisture content (%)	Micro-porosity (%)	Macro porosity (%)
Poultry manure	6.42b	56.00ab	1.17ab	54.00b	15.00a	63.67a
Cow dung manure	5.38b	61.00b	1.03a	53.00b	10.00a	51.00a
Pig manure	6.67b	62.00b	1.00a	60.67b	7.00a	55.00a
Control	0.91a	47.00a	1.40b	38.00a	4.00a	47.67a

Means in a column with the same letter (s) are not significantly different ($p \leq 0.05$)

Table 4: Influence of different types of organic manures amendments on soil physical properties at third week after treatment application

Treatments	Organic Matter	Porosity (%)	Bulk Density (g/cm3)	Moisture content (%)	Micro-porosity (%)	Macro porosity (%)
Poultry manure	6.40b	61.00a	1.13a	50.33b	2.33a	56.00a
Cow dung manure	6.65b	59.33a	1.00a	61.33bc	10.00a	52.00a
Pig manure	7.14b	52.00a	1.00a	72.33c	8.00a	54.00a
Control	1.83a	47.00a	1.53b	35.33a	14.67a	52.00a

Means in a column with the same letter (s) are not significantly different ($p \leq 0.05$)

Table 5: Influence of different animal manures amendments on the soil physical properties

Treatments	Organic Matter	Porosity (%)	Bulk Density (g/cm3)	Moisture content (%)	Micro-porosity (%)	Macro porosity (%)
Poultry manure	5.31b	58.22b	1.12a	54.44bc	7.44a	60.33b
Cow dung manure	5.42b	60.78b	1.03a	50.33b	7.56a	47.89a
Pig manure	6.55b	58.67b	1.10a	59.33c	15.11a	55.11ab
Control	1.25a	45.33a	1.44b	36.67a	7.56a	50.00a

Means in a column with the same letter (s) are not significantly different ($p \leq 0.05$)

Table 6: Influence of organic manures on the soil respiration (mg CO_2-Ckg^{-1} soil)

Treatments	Soil respiration			Cumulative soil respiration		
	Days after treatment			Days after treatment		
	28	**35**	**42**	**28**	**35**	**42**
Poultry manure	5.10c	5.76b	2.94c	5.10c	10.86d	13.8b
Cow dung	6.82a	5.84b	3.26b	6.82a	12.66a	15.92a
Pig manure	5.42b	5.88b	4.14a	5.42b	12.0b	16.14a
Control	5.48b	6.58a	2.14d	5.48b	11.36c	13.5c

Means in a column with the same letter (s) are not significantly different ($p \leq 0.05$)

Table 5 shows the influence of organic manures on the soil mean physical properties for the total experimental weeks after treatment application. Significance differences were recorded in the properties of the treatments, except micro porosity. Controlled soil sample had the lowest organic matter content while soils amended with pig manure had the highest organic matter. The soil treated with the pig manure a moderate bulk density, moderate moisture content which increases its organic matter compared to others.

Table 6 shows the results summarizing the influence of the various organic manures on soil respiration and cumulative soil respiration. At 28 Days After Treatment (DAT), only PM and CD significantly altered soil respiration compared to the un-amended soil. Amendment with CD significantly raised soil respiration, this parameter was lowered by the application of PM. Amendment with PG also reduced CO_2 evolution, but the effect was not significant. At 35 DAT, all the manures significantly reduced CO_2 evolution compared to the control. At the end, there was high variability among the various treatments, the treatments all raised CO_2 compared to the control and CO_2 was significantly lower in PM compared to soil amendments. Also, at this time of sampling, soil amendment with all the manures significantly raised the cumulative soil respiration compared to the control.

Table 7: Influence of organic manures on the Soil Microbial Biomass and Organic carbon at 42 days after treatment application

Treatments	Microbial biomass C (Mg/kg)	Organic carbon
	42 days after treatment	
Poultry manure	0.7368a	4.322a
Cow dung manure	0.7515a	4.389a
Pig manure	0.7315a	4.322a
Control	0.6796a	1.330b

Means in a column with the same letter (s) are not significantly different ($p \leq 0.05$).

Table 7 shows the results of the effects of the various manure treatments on both organic and microbial biomass carbon at the termination of the experiment. At the end of the incubation period, it was observed that each of the treatments caused an increase in soil MBC.

However, the soil MBC of the different treatments was not significantly different (Table 7). However, all manure treatments significantly increased organic carbon compared to the control. The organic carbon of the control treatment was significantly lower than those of the treatments, which were statistically similar.

Table 8: Influence of organic manures on soil eco-physiological parameters

Treatments	qCO2	qM
Poultry manure	18.737b	0.68b
Cow dung manure	21.19ab	0.74b
Pig manure	22.15a	0.91b
Control	19.88b	1.74a

Means in a column with the same letter (s) are not significantly different ($p \leq 0.05$).

Table 8 shows the effects of the various treatments on qCO_2 and mineralization quotient (qM). The qCO_2 was higher in the cow dung and pig manure treated soil compared with the control. This increase was however significant only with the application of pig manure. The qCO_2 was not affected by the application of poultry manure to the soil. The application of each of the manure significantly lowered qM. The results indicated that qM of the sample were in the order 0.68<0.74<0.91 for soil amended with poultry manure, cow dung and pig manure, respectively.

DISCUSSION

It is commonly acknowledged that soils with organic fertilization can maintain soil sustainability and enhance more accumulation of organic carbon than arable soil relying on only chemical fertilizer (Deng *et al.,* 2006). The result of this study showed that compared to the non-treated soil (with no organic manure), the organic manures influenced the soil physical and microbial properties. The soil treated with different organic content varies in term of the organic matter for the period of this research while the soil treated with pig manure was consistent in its increase in organic matter. The results obtained from the laboratory incubation study are in tune with the findings of several authors regarding the effects of various organic manures on soil microbial parameters. The increase in CO_2 caused by cow dung and pig manure indicates that the two manures promoted soil microbial activity (Martens *et al*., 1992). This is probably because they serve as suitable substrate that can support microbial growth (Ellen and Gerfried, 1993). The reduction in the microbial activity in the soil treated with poultry manure indicated probably the presence of toxic metals e.g. heavy metals.

Application of pig manure was found to stimulate the key soil microbial activity indicators measured in this study. This suggests that organic manure was able to release nutrients to the soil which were used by the micro-organisms for their metabolic activity. Incorporation of organic manures into soil promotes the microbial growth with attendant increase in microbial activities (Zantua and Bremner, 1976). At the end of the incubation period, it was observed that each of the treatments caused a statistically similar increase in MBC. However, all manure treatments significantly increased organic carbon compared to the control but the soil treated with pig manure showed the highest non-significant inputs of easily degradable organic carbon that promptly stimulates the microbial activity (Dinesh *et al*., 2003).

CONCLUSION

Results of this study indicate that application of different animal wastes increased certain soil productivity indicators. This was through positive effect on soil physical and biological properties. Comparatively, pig manure improved soil productivity and the microbial activity more than the other animal wastes investigated in this study. There is a decreasing order of general performance of these animal wastes in increasing microbial activity as related to soil microbial biomass and soil basal respiration is PG > CD > PM > Control. However, if pig manure can be used and applied to a degraded soil, it can restore the soil health and increase microbial activity of the soil which helps in improving the soil structure and better growth of crops.

REFERENCES

Anderson, J.P.E. and Domsch, K.H., (1989). Ratios of microbial biomass carbon to total organic carbon in arable soils. *Soil Biology and Biochemistry*. 21: 471–479.

Berg, P. and Rosswall, T. (1985). Ammonium Oxidizer Numbers, Potential and Actual Oxidation Rates In Two Swedish Arable Soils. *Biology and Fertility of Soils*, 1; 131-140

Brookes, P. C., Landman, A., Pruden, G. and Jenkinson, D. S. (1985). Chloroform fumigation and the release of soil nitrogen: a rapid direct extraction method to measure microbial biomass nitrogen in soil. *Soil Biology and Biochemistry.* 17:837-842.

Deng, S.P., Parham, J.A., Hattey, J.A. and Babu, D. (2006). Animal manure and anhydrous ammonia amendment alter microbial carbon use efficiency, microbial biomass, and activities of dehydrogenase and amidohydrolases in semiarid agroecosystems. *Applied Soil Ecology*, 33: 258–268.

Dinesh, R. Chaudhuri, S.G., Ganeshamurthy, A.N. and Dey, C. (2003). Changes in soil microbial indices and their relationships following deforestation and cultivation in wet tropical forests. *Applied Soil Ecology,* 24: 12-26.

Kandeler, E. and Eder, G. (1993). Effects of cattle slurry in grassland on microbial biomass and on activities of various enzymes. *Biology and Fertility of Soils*, 16: 249-254.

Jenkinson, D. S. and Ladd, J. N. (1981). Microbial biomass in soil: measurement and turnover. In: Paul, E.A. and Ladd. J.N. (eds) Soil Biochemistry, Vol. 5 Marcel Dekker, Inc, New York and Basel, pp. 415-471.

Keeny D.R. (1992). Nitrogen – availability indices. In; Page AL, Miller RH, Keeny DR (eds) Methods of soil analysis, Part 2. Am Soc Agron, Maison, Wisconsin, pp 711- 733

Lloyd, R.H. and Anthony, S.R., (1999). Soil nutrient management for sustained food crop production in upland farming systems in the tropics. *Journal of Soil Crop Science,* 7*:*78-84.

Martens, R., (1995). Current methods for measuring microbial biomass C in soil: potentials and limitations. *Biology and Fertility of Soils*, 19: 87–99.

Moyin, J.E.I. and Atoyosoye, B. (2002). Utilization of agriculture wastes for the growth of leaf and soil chemical composition of Accia seedling in the nursery*. Pertanika Journal of Tropical Agricultural Science* 25:53-62.

Oyentunji, O.I, Ekanakaya, I.N. and Sonubi, O.O., (2001). Influence of Yam fungi on cassava system. Influence of yam fungi on cassava-maize intercrop in an alley cropping system. Proceeding of African Crop Science Conference, Uganda

Smith, J.L. and Paul, E.A., (1990). The significance of soil microbial biomass estimation*. Publication of Soil Biology and Soil Biochemistry,* 6: 357-396.

Zantua, M.I. and Bremner, J.M. (1976). Production and persistence of urease activity in soils. *Soil Biology and Biochemistry* 8: 369-374.

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