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EFFECTS OF POULTRY MANURE AND PORTLAND CEMENT ADDITIONS ON SOIL PHYSICAL PROPERTIES AND MICROBIAL ACTIVITIES

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ABSTRACT

Top soil sample (0-15 cm) of Apomu series (Inceptisol) was amended with three rates each of poultry manure and cement (0, 5.0, 10.0 g / kg) in a 3 x 3 factorial combination. The experiment was carried out in the laboratory at room temperature. The poultry manure and cement were thoroughly mixed by hand with 100 g portions of air-dried, sieved (2 mm) soil samples and allowed to incubate for 4 and 8 weeks for total heterotrophic microbial counts, and CO_2 evolution, respectively. Bulk density and water-holding capacity were also determined at the end of 16 weeks of incubation.

Poultry manure additions significantly ($p< 0.05$) increased bacterial and fungal numbers over the control while cement addition significantly ($p< 0.05$) increased bacterial numbers only. The interaction effect was significant ($p < 0.05$). While fungal population was significantly ($p < 0.05$) decreased at the highest rate of cement addition, the counts were significantly ($p < 0.05$) increased over the control by the poultry manure additions. The poultry manure, cement and their mixtures significantly ($p < 0.05$) increased CO_2 evolution over the control. While there was no significant ($p < 0.05$) difference with the cement additions, CO_2 evolution was significantly ($p < 0.05$) increased with increase in the rate of poultry manure addition. The interaction effects of poultry manure and cement were not significant on water-holding capacity but was significant ($p < 0.05$) at the highest level of poultry manure on bulk density. However, while bulk density was reduced by poultry manure over the control, cement had no significant ($p < 0.05$) effect on it. The water-holding capacity was significantly ($p <0.05$) increased by poultry manure. While the 5.0 g / kg cement addition increased water-holding capacity over the control, there was no significant difference at the highest level of addition.

INTRODUCTION

The declining food production and increasing population in the sub-Saharan African countries pose a serious challenge to farmers and governments (Ahmed, 2000; Aruleba and Ogunkunle, 2005). Most tropical soils are characterized by relatively low inherent fertility, being highly-weathered, leached and have their parent materials dominated by low activity clay (LAC) minerals (Obatolu and Agboola, 1993). All these constitute a major developmental constraint to crop production

(Kang and Spane, 1986; Adediran *et al*., 1999). In order to restore soil fertility, farmers practiced shifting cultivation (Olufowote and Barnes-Mcconnel, 2000). However, population pressure and the long fallow period required to resuscitate soil fertility led to a decrease or complete disappearance of this system of cultivation (Ano, 2005; Bababe and Kwari, 2005). The use of external inputs like organic and inorganic fertilizers has, therefore, become important options in the tropics to solve these problems (Olayinka and Adebayo, 1983; Olayinka and Adebayo, 1985; Busari *et al.,* 2004).

The application of inorganic fertilizers has been regarded as a key factor in increasing and maintaining crop production as well as the farmer's income (Kang, 1993; Daramola *et al*., 2004). However, because of the removal of government subsidies, resource-poor peasant farmers have found commercial fertilizers too expensive to afford (Babalola and Salako, 2006). Yield increases expected with their application were also not consistent because nutrients such as N are readily leached as a result of the high rainfall regime prevalent in the tropics (Ano and Agwu, 2005). Furthermore, continuous fertilizer applications have also been found to increase soil acidity (Kang, 1993), degrade soil structure, reduce organic matter status as well as cation exchange capacity (Aduayi, 1984; Darusman *et al.,* 1991; Nottidge *et al.,* 2005).

Although the use of organic manures has been an age-long practice in crop production, it is now receiving renewed attention worldwide (Adediran *et al., 1999).* This renewed attention has been encouraged by the recent clamour for improvement in the organic matter contents of agricultural soils as sink for CO_2 and the high demand for organic foods (Agboola and Fagbenro, 1985). Other amendments have also been applied to the soil in an attempt to improve soil properties and crop production. These include wood ash, gypsum, lime and cement (Prusinki and Bhattacharja, 1999; Nottidge *et al*., 2005). These materials contain macronutrients such as calcium (Ca), magnesium (Mg), phosphorus (P) and potassium (K). They can also act as liming materials and thereby could raise the soil pH (Owolabi *et al.,* 2003). The use of cement as a soil amendment is a new possibility which if successful, can improve soil properties and plant growth. The aim of this research was, therefore, to assess the effects of the complimentary applications of poultry manure and portland cement on soil physical and microbial properties.

MATERIALS AND METHODS

Soil, poultry manure and cement samples:

A bulk sample of Apomu series (Inceptisol), a sandy loam, was collected from 0-15 cm depth of an uncultivated plot at the Obafemi Awolowo University Teaching and Research Farm (OAUTRF), Ile-Ife (Latitude 7^0 32′N and Longitude 4^0 39′E), Osun State of Nigeria. The sample was crushed, air-dried and passed through a 2 mm sieve to remove roots, stones and other debris. Particle size analysis using the hydrometer method (Bouyoucos, 1962) showed that the soil, a loamy sand, contained 79% sand, 12% clay and 9% silt. Chemical analysis of the soil is as follows: pH determined potentiometrically in a soil-solution ratio of 1:2 in 0.01 M $CaCl_2$ using a glass electrode pH meter was 5.3; organic matter, using chromic acid digestion method (Walkey and Black, 1934) was 0.5 g/kg; total nitrogen (N) determined using the microkjeldahl method gave 1.53%; the available P determined using the method of Bray and Kurtz (1945) was 7.68 mg / kg; exchangeable Ca^+, K^+ and Mg^+ extracted with 1 N NH_4OAC at pH 7 were 0.80, 0.55 and 0.05 cmol/kg, respectively. Total heterotrophic bacterial and fungal counts were carried out using the Plate Count method (Wollum, 1982); while microbial respiration was determined by measuring the CO_2 evolved using the double acid titration method (Anderson, 1982).

Composted poultry manure was collected from the Poultry Unit of the OAUTRF. It was air-dried, crushed and passed through a 2 mm sieve. The Portland cement was produced by the West African Portland Cement Company (WAPCO), Shagamu, Ogun State of Nigeria and was purchased from a building materials shop in Ile-Ife, Nigeria. The chemical compositions of the poultry manure and cement are as shown in Table 1.

Laboratory incubations:

The poultry manure and cement were applied at the rates of 0, 5.0 and 10.0 g / kg to 100 g portions of soil on dry weight basis (dwb) in a 3 x 3 factorial design, in the laboratory. The treatments, in triplicates and arranged in completely randomized design (CRD), were as follows:

P_0C_0 Soil only (control)
P_0C_1 Soil + 5.0 g cement/ kg soil
P_0C_2 Soil + 10.0 g cement/ kg soil.
P_1C_0 Soil + 5.0 g poultry manure / kg soil
P_1C_1 Soil + 5.0 g poultry manure + 5.0g cement / kg soil.
P_1C_2 Soil + 5.0 g poultry manure + 10.0g cement / kg soil.
P_2C_0 Soil + 10.0 g poultry manure / kg soil.
P_2C_1 Soil + 10.0 g poultry manure + 5.0g cement / kg soil.
P_2C_2 Soil + 10.0 g poultry manure + 10.0g cement / kg soil.

Soil physical properties:

For the determinations of bulk density and water-holding capacity, a core sampler was inserted into the soil which had been treated and left for 16 weeks. The soil was scooped and scrapped to level using a spatula. One end of the core sampler was covered with gauze and rubber band and the other was dipped into water for 12 hours. The soil was allowed to drain on a sieve under gravity for 48 hours after which it was transferred into cans and weighed to obtain the weight of the wet soil. The soil sample was oven-dried at 105^0 C to constant weight. The water-holding capacity and bulk density were thereafter calculated from the readings.

Table 1: Chemical properties of the poultry manure and cement used for the experiments.

Property	Poultry manure	Cement
pH (0.01 M $CaCl_2$)	7.4	11.0
Organic matter (g/ kg)	10.4	-
Total N (%)	3.70	-
Total / Exchangeable cations cmol/kg		
K	6.93	0.93
Ca	6.83	155
Mg	1.58	1.32
Extractable phosphorus (mg / kg)	46	17.6

Heterotrophic bacterial and fungal Numbers:

For the determinations of heterotrophic bacterial and fungal numbers, a second set of treatments were set up. At the end of four weeks, 1 g portions of each treatment were rehydrated with 10 ml of sterile distilled water in test tubes containing some glass chips. Hundred-fold serial dilutions of the suspension were carried out from each test tube by transferring 0.1 ml of the suspension into 9.9 mls sterile distilled water. For bacterial count, one milliliter (1.0 ml) of each dilution was plated in triplicates in sterile nutrient agar medium in sterile Petri dishes. The pour plate method was adopted. Each Petri dish containing nutrient agar and the inoculants were swirled clockwise, anti-clockwise, left and right several times before allowing it to

cool and set. The culture plates were thereafter incubated aerobically at 35^0C for 36 to 48 hours. The plates were observed for growth and plates with colonies ranging from 30 to 300 were selected for counting. The average viable count was multiplied by the dilution factor and expressed as the number of cell-forming units (cfu) per gramme of the original soil sample. To determine the total heterotrophic fungi, the same procedure as for the estimation of total heterotrophic bacteria was repeated except that the medium used was malt extract agar (MEA) and the plates were incubated in inverted position at 30^0C for 5 to 7 days until the colonies showed no further increase in number.

Carbon dioxide evolution

The treatments were placed in 500 ml glass jars and wetted with distilled water to 70% of the soil's moisture holding capacity. Vials containing 10 mls of 1 M NaOH were lowered into each glass jar by means of lengths of thread and the jars were capped tightly. Carbon dioxide (CO_2) evolved, an index of microbial activity, was determined fortnightly over an 8-week period using the double acid titration method (Anderson, 1982).

RESULTS AND DISCUSSION

Effects of poultry manure and cement additions on bulk density:

The bulk densities of the treatments after 16 weeks of incubation are shown in Figure 1. There was no significant difference ($p<0.05$) in bulk densities of the soils treated with different rates of cement. This may be due to the fact that cement has compacting capacity. The bulk density of the control was generally higher than that of the other treatments except the cement-only and poultry manure-only treatments, viz, P_0C_1, P_0C_2, P_1C_0 and P_2C_0. Poultry manure generally lowered the bulk density of the soil compared to the control though there was no significant ($p<0.05$) difference between P_1C_0 and P_2C_0. This is expected since organic materials are known to have low densities and therefore can improve the soil porosity and make it less dense (Mbah *et al.*, 2004). Cement combined with poultry manure namely, P_1C_1, and P_1C_2, however, significantly ($p<0.05$) reduced the soil's bulk density.

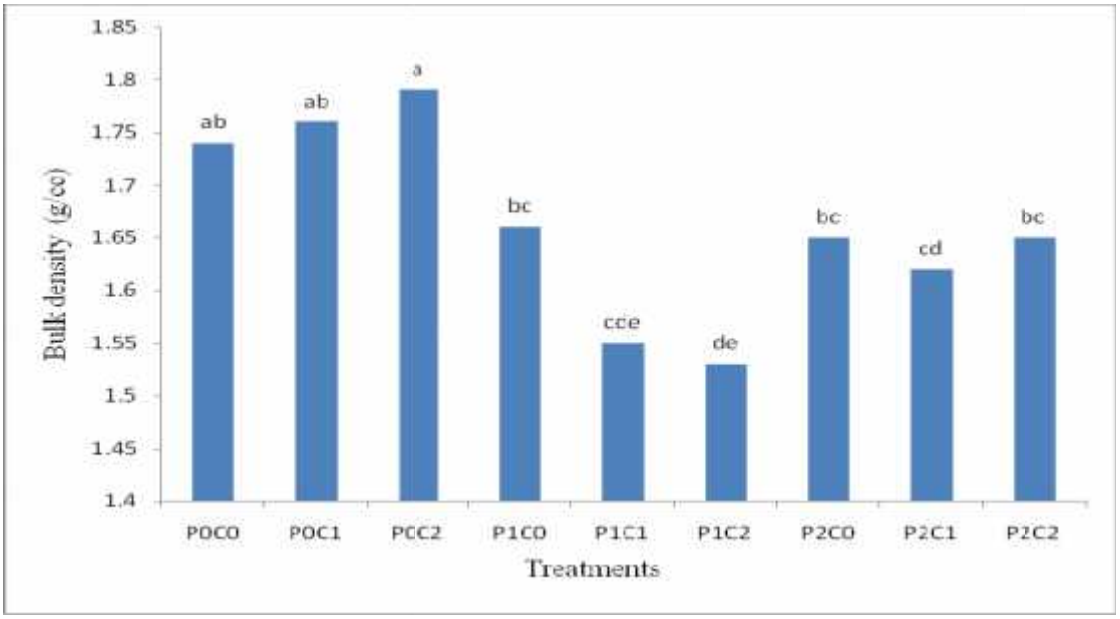


Figure 1: Bulk densities (g/cc) at the end of 16 weeks of incubation of soil amended with poultry manure and portland cement in the laboratory.

Effects of poultry manure and cement additions on water-holding capacity:

The water-holding capacities (WHC) of the treatments after 16 weeks of incubation are presented in Figure 2. The WHC in all treatments were significantly ($p<0.05$) greater than in the control except P_0C_2. This means adding a large amount of cement to the soil might have the same effect as the soil not being treated at all. Generally, the WHC increased significantly ($p<0.05$) with increase in the rate of poultry manure applied. This is in line with the findings of Adeoye (1988) and Anderson *et al*. (1990) where the application of animal manure significantly ($p<0.05$) increased the WHC. Treating the soil with portland cement alone significantly ($p<0.05$) increased the WHC over the control at the first rate (P_0C_1) while no significant ($p<0.05$) difference was observed between the two cement rates (P_0C_1, P_0C_2). However, complimentary applications of the two amendments, showed a significantly ($p<0.05$) higher WHC over the control though they were not significantly ($p<0.05$) different.

Effects of poultry manure and cement additions on total heterotrophic bacterial and fungal counts.

Table 2 shows the total heterotrophic bacterial (THB) and fungal (THF) counts at the end of four weeks of incubation in the laboratory. The total bacterial counts generally doubled the fungal counts. This confirms the fact that bacteria are known to predominate over other microorganisms in the soil (Alexander, 1977; Adebayo, 1997; Olayinka and Babalola, 2001). Isirimah *et al.* (2006) also noticed a similar bacterial-fungal population trend in a similar experiment. The control was significantly ($p<0.05$) lower than all the treatments. This shows that treating the soil with both poultry manure and cement has significant ($p<0.05$) effect on THB. The THB counts were significantly increased ($p<0.05$) as poultry manure rates increased although the highest count was observed at P_2C_0. The interaction effect was also significant.

The poultry manure-only treatments significantly ($p<0.05$) increased fungal counts over the control. This might be attributed to the fact the poultry manure supplied organic C for the fungi which are also chemoheterotrophs. However, the fungal count was significantly ($p<0.05$) reduced with increase in the rate of cement additions. This trend can be attributed to the fact that fungi are more acid tolerant (Alexander, 1977; Adebayo, 1997). Complimentary applications of poultry manure and cement significantly ($p<0.05$) reduced the fungal counts. It was probable that the proliferation of the fungal hyphae were also being hindered as a result of soil compaction with increase in the rate of cement addition.

Carbon dioxide evolution:

The CO_2 evolution from the treatments over a period of 8 weeks is shown in Figure 3. The poultry manure and cement-only treatments significantly ($p<0.05$) increased the CO_2 evolution over the control. The trend in the control might be attributed to the stability of indigenous soil humus (Puig-Gimenez and Chase, 1984; Olayinka, 1990). The significant increase in CO_2 with increase in poultry manure additions can be attributed to the supply

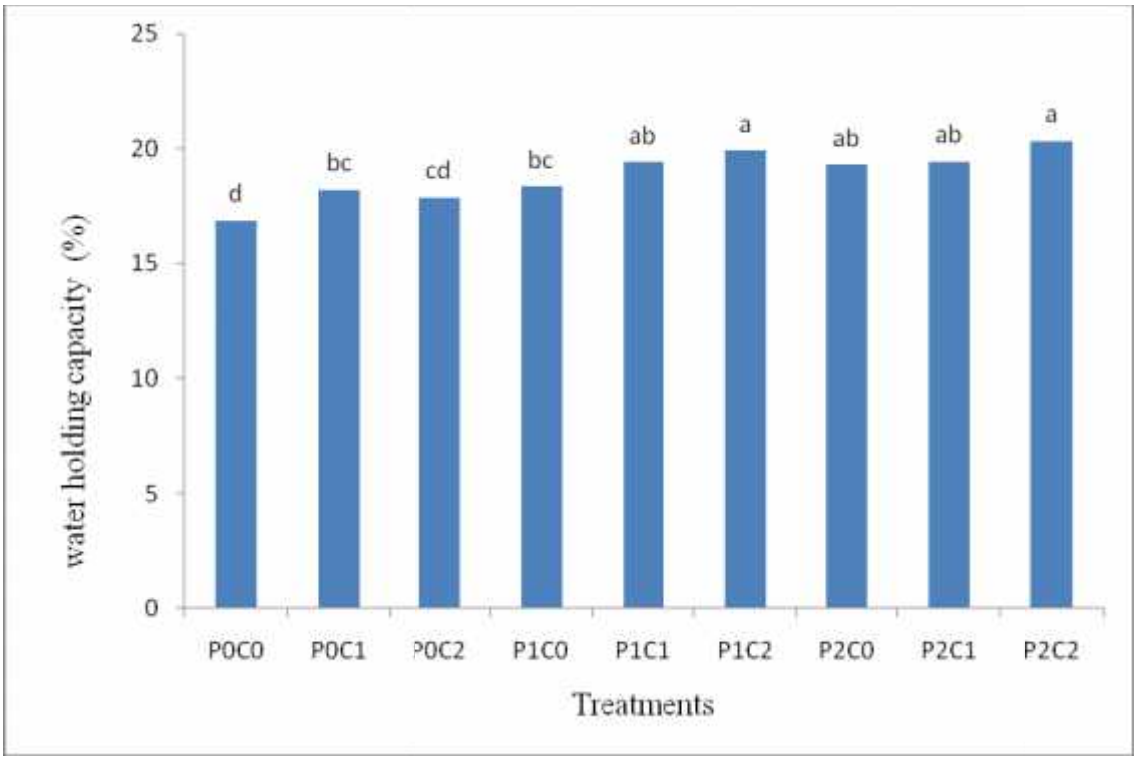


Figure 2: Water Holding Capacity (%) at the end of 16 weeks of incubation of soil amended with poultry manure and portland cement in the laboratory.

Table 2: Total Heterotrophic Bacterial and Fungal counts (log_{10} cfu) in soil amended with poultry manure and cement at the end of 4 weeks of incubation in the laboratory.

Treatments	Bacteria	Fungi*
P_0C_0	8.33h	4.47e
P_0C_1	8.95d	4.37f
P_0C_2	9.25c	4.02g
P_1C_0	8.43g	4.68b
P_1C_1	8.80e	4.61c
P_1C_2	9.18c	4.55d
P_2C_0	8.61f	4.75a
P_2C_1	9.41b	4.51de
P_2C_2	9.64a	3.81h

*Means followed by the same letters within each column are not significantly different $p < 0.05$ (Duncan's New Multiple Range Test).

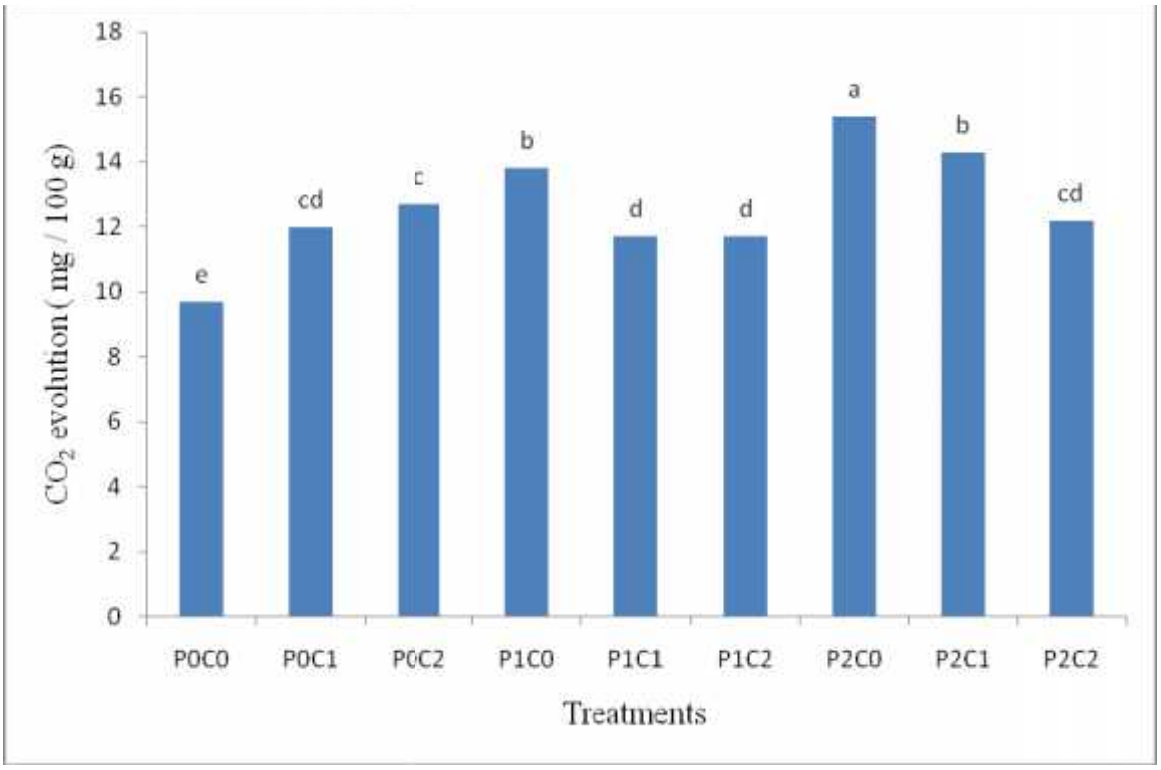


Figure 3: Mean amounts of C evolution (mg/100 g) from soil amended with poultry manure and cement over a 8-week period of incubation in the laboratory.

of nutrients including organic C for the heterotrophic microorganisms. No significant ($p<0.05$) increase was observed with increase in cement additions in the cement-only treatments as the cement did not add substrate C for the heterotrophic microorganisms.

Generally, the CO_2 evolution significantly ($p<0.05$) decreased as the rate of cement increased in the complimentary additions. This trend could be due to the fact that the soil was compacted with increase in the rate of cement additions as earlier pointed out (Figure 1).

CONCLUSION

It was concluded that additions of poultry manure and only moderate additions of portland cement would have beneficial effects on soil physical and microbiological properties.

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