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Effect of Composted Poultry Manure on Selected Soil Properties and Organic Carbon Under Tomato Cultivation in Abeokuta, Nigeria

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Abstract
Soil quality improvements provide an environment for plant nutrients uptake that influences the development and yield of the crop. This study evaluated the effect of applied composted poultry manure (CPM) on selected soil physical attributes and soil organic carbon content (SOC) under two tomatoes (UC82B and BESKE) varieties planted in succession. Three rates: 0, 10, and 20 t/ha of CPM was applied to two tomato varieties. The treatments were arranged in a randomized complete block design. The parameters considered are soil physical properties - bulk density, aggregate stability, total porosity, water retention capacity, and SOC. It was observed that the application of CPM increased SOC, total porosity, saturated hydraulic conductivity, aggregate stability and decreased bulk density in the tomato cropped area. Water retention did not show any significant difference ($P<0.05$) between depth at different suctions (0, 30,100 kPa). The SOC was highest in 10 ton/ha of CPM. Application of 10 ton/ha compost is adequate to improve carbon content and soil physical properties for studied soil.

Keywords: Compost, soil physical attributes, soil quality, tomato.

Effet du fumier de volaille composté sur certaines propriétés du sol et du carbone organique dans la culture de la tomate à Abeokuta, Nigéria

Abstrait
L'amélioration de la qualité des sols offre un meilleur environnement pour l'absorption des nutriments des plantes qui influencent le développement et le rendement des cultures. La présente étude a évalué l'effet du fumier de volaille composté appliqué (CPM) sur certaines propriétés physiques du sol et la teneur en carbone organique du sol (SOC) de deux variétés de tomates (UC82B et BESKE) plantées successivement. Trois taux: 0, 10 et 20 t / ha de CPM ont été appliqués à deux variétés de tomates. Les traitements ont été organisés suivant une disposition aléatoire en blocs complets. Les paramètres considérés sont les propriétés physiques du sol - densité apparente, stabilité des agrégats, porosité totale, capacité de rétention d'eau et SOC. Il a été observé que l'application de CPM augmentait le SOC, la porosité totale, la conductivité hydraulique saturée, la stabilité des agrégats et la diminution de la densité apparente dans la zone cultivée de tomates. La rétention d'eau n'a montré aucune différence significative ($P <0,05$) entre la profondeur à

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différentes succions (0, 30,100 kPa). Le SOC était le plus élevé avec 10 tonnes / ha de CPM. L'application de 10 tonnes / ha de compost est suffisante pour améliorer la teneur en carbone et les propriétés physiques du sol pour le sol étudié.

Mots-clés: compost, attributs physiques du sol, qualité du sol, tomate.

Introduction

Soil degradation poses a major threat to sustainable agricultural practices and has become a major environmental threat among others due to excessive soil erosion, nutrient run-off, and loss of soil organic matter. Its ineffective management has resulted in soil quality deterioration, reduced air, nutrient, and water flow, and consequently crop development (Golehin *et al*., 1995; Tejuda *et al*., 2006). Therefore, soil organic matter (SOM) improvement and stability is one major discussion in sustainable agriculture. This is often advantageous for crop production (Arriaga and lowery, 2003) because sustaining soil organic carbon (SOC) is of primary importance in terms of cycling plant nutrients and improving the soil's physical, chemical, and biological properties. SOM enhances water holding capacity and aggregation of the soil inhibits erosion and provides a reservoir of nutrients that can be released into the soil. These provide ease of cultivation, penetration, seedbed preparations, and greater aggregate stability as well as improve water holding capacity at low suction. For this reason, agricultural utilization of organic material with high organic matter such as fresh and composted urban waste (Ron *et al*., 2003) shredded and composted plant material derived from municipal landscape (Walker, 2003) as well as cotton gin compost and poultry manure (Tejada *et al*., 2006) to semi-arid soil has become an environmental practice for soil restoration, maintaining SOM, reclaiming degraded soils and supplying plant nutrients (Ros *et al*., 2003; Walker, 2003). Furthermore, application of organic amendments to the soil can increase SOM content as it enhances the soil carbon level and increases soil organic matter which is associated with the change in the structure and adsorption properties of the soils, and thus their physical properties (Khaleel *et al*., 1985; Edmeades, 2003). Previous studies have consistently found that the application of manure can increase soil aggregation (Paglai *et al*., 2004) and total porosity (Schjonning *et al*., 2002). Miller *et al*., (2002) reported that the manure amendment significantly ($P<0.05$) increased soil water retained compared to the control across the whole range between 0 and 1500kPa. It has also been observed that changes in water retention may depend more on the soil type and its initial carbon content than the addition of organic material i.e., soil porosity (Paglai *et al*., 1987). But little or no information is available on the role of CPM in the improvement of soil physical properties. This study, therefore, compared the residual effect of organic manure i.e., poultry-composted organic manure on the physical properties such as hydraulic conductivity, water retention, soil aggregate stability, soil bulk density and total porosity of soil previously planted with tomato.

Materials and Methods

The site for the experiment is located behind Fadama area in Alabata, Ogun State which lies on latitude 7^0 15'21" N and longitude 3^0 28'19" E. This area is within the transition zone of the sub-humid forest to the south and derived savannah to the North and West (Keay, 1959). The total plot size is $720m^2$ (36 plots) and each experimental plot is 4m x 5m laid in randomized complete block design. Initial soil samples were collected before and after first and second planting which were analyzed in the laboratory for chemical and physical soil properties. Soil samples were collected at 0-20cm and 20-40cm depth from each experimental plot after first and second harvesting, that is two different soil samples were collected at the two depths. Core samplers were used to take the undisturbed

sample to determine saturated hydraulic conductivity, bulk density and soil auger were used for the disturbed sample. The CPM treatments were applied on the plots at the rate of 0, 10, and 20 ton/ha; where tomato had been cultivated. The Total Organic Matter was determined using the Walkley-Black method (1964). The organic carbon content value derived was multiplied by a standard factor (1.724) to get the corresponding percent organic matter. Aggregate Stability was estimated using wet sieving techniques as described by Emerson (1997) and edited by Udo *et al*. (2009).

Saturated Hydraulic Conductivity was determined using a constant head method (Klute and Dirksen, 1986). This procedure allows water to move through the soil under a steady-state head condition while the quantity (volume) of water flowing through the soil sample is measured over some time. Bulk Density was determined by using the core method (Harte and Horn, 1989). Water Retention was determined by using the pressure plate apparatus. The moisture capacity was determined gravimetrically. Total Porosity was determined in undisturbed water-saturated cores assuming no air was trapped in the pores (Klute and Dirksen, 1986).

Land preparation was done by ploughing and harrowing. Compost was applied at the rate of 0, 10, and 20 t/ha which was thoroughly mixed with the soil before two tomato varieties were transplanted. The experimental design was a randomized complete block; replicated three times. The crop residues of the tomato varieties were left to decay on the plot.

Land preparation for the succeeding crop was carried out by hoeing before transplanting. No compost was applied to the succeeding tomato. The two tomato varieties succeeding in the preceding varieties (UC82B and BESKE) were transplanted accordingly. The spacing was 80 X 30cm with planting a population of 56,000 plants per hectare.

Weed control took place twice in the third and seventh weeks after transplanting using a hand hoe.

Statistical Analysis

Data generated were subjected to analysis of variance using Genstat statistical package release 7.2 DE (2007). Means were separated using Duncan multiple range tests (DMRT) and a significant difference was reported at $P = 0.05$.

Results and Discussion

Pre-planting soil analysis

Soil reaction of the studied site was slightly acidic (6.04 and 5.59) before planting and after first planting (Table 1). The analyzed results also revealed that the soil of the studied site had very low Av. P, TN, K, and OC according to the Federal Department of Agricultural Land Resources' fertility range (1990) before planting. This was however amended reasonably after the first planting of tomato varieties as shown in Table 1. Therefore, there were good responses to soil amendment from the crop and soil.

Table 1: Soil analysis results of the studied sites before and after first planting

Parameters	Value	
	Pre planting soil Analysis	After the first planting Analysis
pH (H_2O)	6.04	5.59
Total Nitrogen, TN (g/Kg)	0.09	0.46
Potassium, K^+ (Cmol/Kg)	0.42	1.01
Available Phosphorus, Av. P (mg/Kg)	1.55	1.25
Sodium, Na^+ (Cmol/Kg)	0.23	0.18
Magnesium, Mg^{2+} (Cmol/Kg)	1.47	1.16
Calcium, Ca^{2+} (Cmol/Kg)	2.35	1.87
Total Exchangeable Acidity, TEA (Cmol/Kg)	0.17	0.14
Cation Exchangeable Capacity, CEC (Cmol/Kg)	4.62	3.47
Organic Carbon, OC (%)	1.01	2.17
Base Saturation, BS (%)	96.1	89.1
Bulk density (g/cm^3)	1.63	1.47
Sand (g/Kg)	805	800
Clay (g/Kg)	80	92
Silt (g/Kg)	105	108
Texture	Loamy Sand	Loamy Sand
Porosity (%)	46	48
Permeability (cm/hr)	4.50	5.15

Soil Organic Carbon

The soil organic carbon (SOC) concentrations within two depths i.e. 0 - 20cm and 20 – 40cm, were significantly higher than the control in both tomato varieties. However, the SOC was higher in the control than in the plot treated with organic manure at 0 - 20cm in okra plot (Table 2). In tomato plot amended with 10 t/ha, CPM showed higher at both depths. The increase in SOC due to the application of organic manure could be due to higher root biomass accumulation (Sharma *et al*., 2002) in the fertilized plot than in the control plot.

Soil Bulk Density

The soil bulk density (BD) with depth (0 - 20cm, 20 - 40cm) revealed that CPM decreased soil bulk density as compared with the control plot in both crops (Table 3). The BD in surface layer 0 - 20cm was significantly lower than that of the

Table 2: Organic carbon (%) as affected by CPM under tomato cultivation

Tomato varieties	Compost rate (t/ha)	Depth (cm)	
		0 – 20	20 - 40
UC82B	0	1.357	0.883
	10	1.917	1.368
	20	1.765	1.173
BESKE	0	2.207	0.870
	10	2.678	1.082
	20	2.298	1.063

lsd at ($p>0.05$) for treatment[a] x depth is 0.6440
treatment[a]= tomato varieties x compost rate

Table 3: Soil bulk density as affected by CPM under tomato cultivation

Tomato varieties	Compost rate (t/ha)	Depth (cm)	
		0 – 20	20 - 40
UC82B	0	1.357	1.593
	10	1.340	1.487
	20	1.312	1.502
BESKE	0	1.435	1.457
	10	1.252	1.410
	20	1.375	0.883

lsd at ($p>0.05$) for treatment[a] x depth is 0.1244
treatment[a]= tomato varieties x compost rate

subsurface layer (20 - 40cm) (Table 3). This may be due to high soil organic matter content in the top layer and higher compaction with low suction in the sub-surface layer (Ghuram and Sur, 2001). Schjonning *et al*., (2002) reported a reduction in the BD of the soil due to the application of animal manure; while Rose (1991) also found a decrease in BD in plots receiving farmyard manure. Lower bulk density on manure treated plots was due to higher organic matter content in the soil.

Total Porosity

The total porosity (TP) was higher in treated plots compared with the control (Figure 1). The highest TP was recorded in the plots amended with 20 t/ha CPM for both tomato varieties (49.83-UC82B and 49.75-BESKE respectively). Thus, the trend of the TP for the applied soil amendment rate was 20 t/ha > 10 t/ha > 0 t/ha. This is in agreement with Celik *et al*., (2004) report that total porosity with soil organic amendments depends on the amount added. Organic amendment promotes TP of the soil as microbial decomposition products of organic manure such as polysaccharides and bacterial gums are known to act as a soil particle agent. These binding agents decrease the bulk density of the soil by improving soil aggregation and therefore increase the porosity (Bhatia and Shukin, 1982).

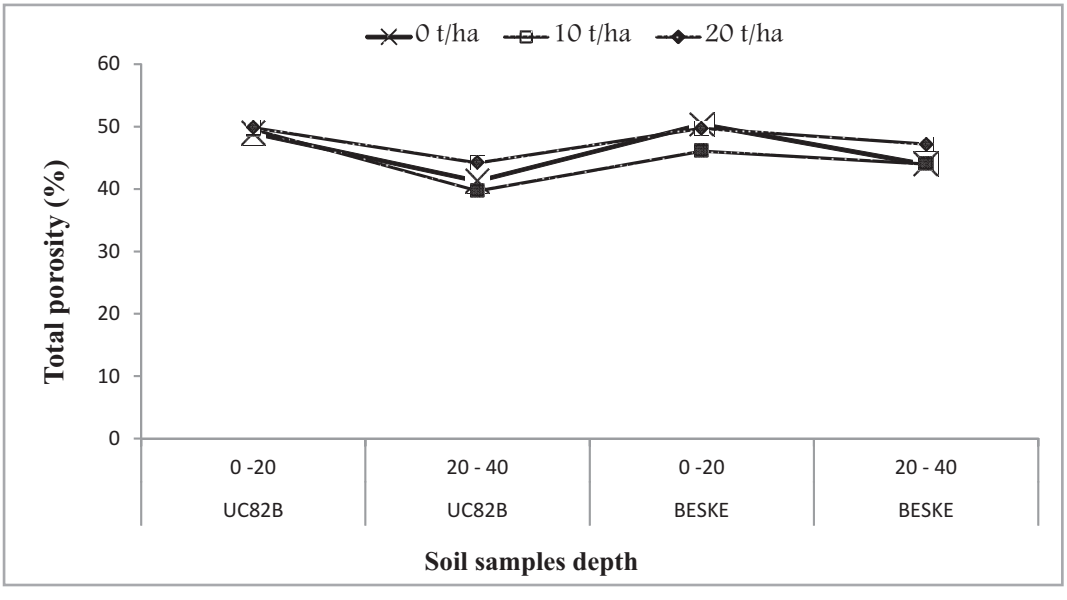


Figure 1: Total porosity as affected by poultry manure under tomato cultivation

Aggregate Stability

The aggregate stability expressed in terms of mean weight diameter (MWD) increased with an increase in the application rate of CPM. Plot amended with 20ton/ha showed a decrease in the trend in both tomato varieties plots (Figure 2). The MWD was highest in the plot treated with 10t/ha. The OM stabilizes the aggregates by forming and strengthening bonds between the clay domain and between quartz particles and clay domain (Emerson, 1997).

The MWD at the subsurface (20-40cm) was higher as compared with the surface (0 - 20cm) (Figure 2). This was due to the absence of tillage practice which induces disruption of soil aggregate in deeper soil layer and compaction of soil due to over-burden pressure, which induced close contact of soil particles and consequently, better adhesions of soil particle to form stable aggregate (Ghuram and Sur, 2001).

Conclusion and Recommendation

This study showed that the application of CPM to soils increased soil organic carbon and decreased soil bulk density thereby causing an increase in total porosity of the soil. The increase in porosity in the topsoil may be due to the increase in the frequency of very small pores. Generally, high soil organic matter (composted poultry manure) increased soil physical properties e.g. saturated hydraulic conductivity, total porosity, water retention, and so on.

Furthermore, the plot amended with 10ton/ha has the highest organic carbon content and shows an increase in soil physical properties than either the control or plot amended with 20 t/ha.

In conclusion, the application of organic manures at 10 t/ha is adequate to improve carbon content and other soil physical properties for fragile soil characteristics of the area.

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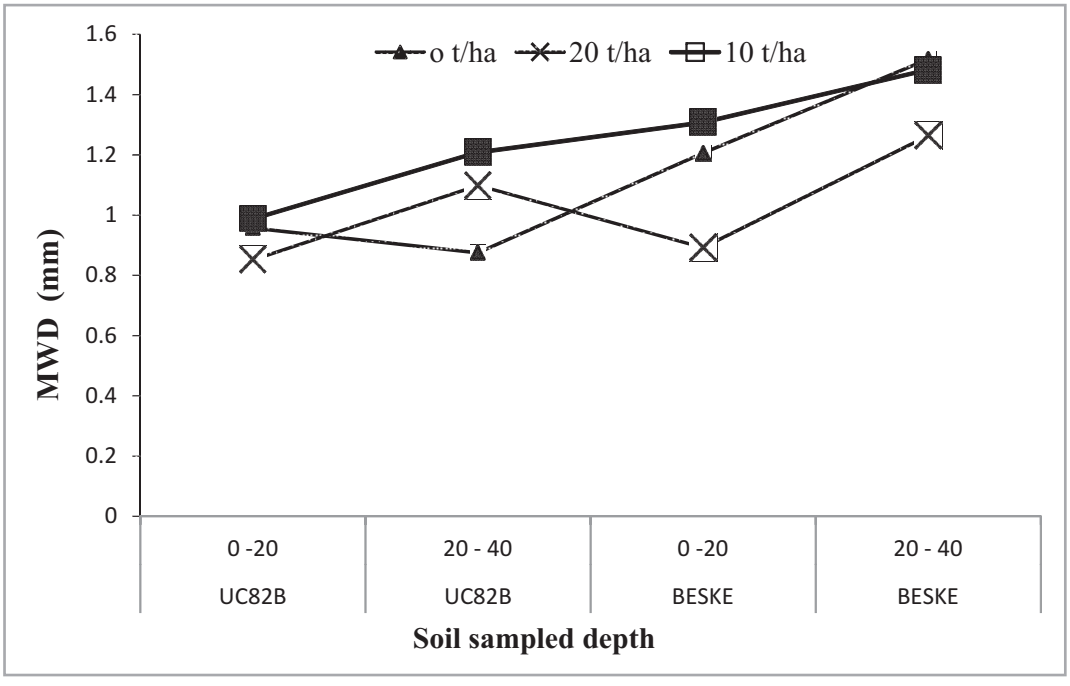


Figure 2: Mean weight diameter (MWD) as affected by poultry manure under tomato cultivation

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