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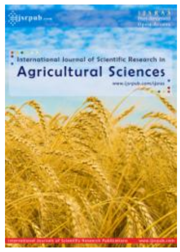

Full Length Research Paper

Effects of Poultry Manure and NPK Fertilizer on Physical Properties of a Sandy Soil in Ghana

Abdul Aziz Khalid[1], Henry Oppong Tuffour[1, 2]*, Mensah Bonsu[1], Bismark Quarku Parker[1, 3]

[1]Department of Crop and Soil Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[2]School of Agriculture and Bio-Resources Engineering, Anglican University College of Technology, Nkoranza Campus, Nkoranza, Ghana
[3]School of Graduate Studies, Research and Innovation, Kumasi Polytechnic, Kumasi, Ghana
*Corresponding Author: hoppongtuffour@gmail.com; (+233) 208 542 308

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Abstract. Field experiment was conducted during the rainy season at the experimental field of the Department of Horticulture, Faculty of Agriculture, Collage of Agriculture and Renewable Natural Resources, Kwame Nkrumah University of Science and Technology to test the effects of poultry manure and NPK fertilizer on the physical properties of a sandy soil. There were five treatments with five replications. The experiment was laid in Randomized Complete Block Design. Data were collected on the following soil physical properties: bulk density, total porosity, aeration porosity, volumetric water content, aggregate stability. The results suggest that the poultry manure decreased the dry bulk density, increased the total porosity and increased the moisture content. However, there were no significant improvement in aggregate stability and aeration porosity. The mineral fertilizer did not show any significant improvement in any of the parameters. In the short term Poultry manure was therefore found to improve some physical properties of the sandy soil.

Keywords: Poultry manure, NPK fertilizer, Sandy soil, Aggregate stability, Aeration Porosity, Physical properties

1. INTRODUCTION

The soil physical properties must be in good condition to enhance free flow of water and nutrients in the soil. In contemporary agriculture, soil must be resistance to various forms of degrading factors and soil properties must meet the requirement of sustainability and input – saving crop cultivation technologies (Balesdent et al., 2000). These days because of high population densities, continuous farming is replacing bush fallowing which used to add a lot of nutrients and organic matter to the soil. This bush fallowing improves not only the nutrient content but also the physical properties of the soil. The improvement of the chemical and physical properties by the bush fallow system is due to the addition of organic matter to the soil. It is therefore important to know the right amendment that may improve physical properties of the soil so as to improve growth and yield of crops in a short term (Palojarvi and Nuuntinen, 2002).

One of the ways of increasing the nutrient status is by boosting the soil nutrient content either with the use of organic materials such as poultry manure, other animal waste and use of compost with or without inorganic fertilizers (Dauda et al., 2008). Poultry manure is relatively resistant to microbial degradation. However, it is essential for establishing and maintaining the optimum soil physical condition for plant growth. Poultry manure is also very cheap and effective as a good source of N for sustainable crop production, but its availability remains an important issue due to its bulky nature, while inorganic fertilizer is no longer within the reach of resource-poor farmers due to its high cost (Rahman, 2004).

However, John et al. (2004) had advocated for an integrated use of organic manure and inorganic fertilizers for the supply of adequate quantities of plant nutrients required to sustain maximum crop productivity and profitability, while minimizing environmental impact from nutrient use. According to Beckman (1973), the use of manure enhances soil productivity, increases the soil organic carbon content, enhances the activities of soil micro-organisms and improves soil crumb structure and the nutrient status of the soil as well as crop yield. The objective of this study was to evaluate the effects of poultry manure on physical properties of a sandy soil.

2. MATERIALS AND METHODS

The work was done at the experimental farm of the Department of Horticulture, Faculty of Agriculture, College of Agriculture and Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

The area is within semi-deciduous forest zone and is subjected to marked wet and dry season with a bimodal rainfall pattern. The two rainfall peaks make two growing seasons possible. There is heavy rainfall from May to July, which is interrupted by a dry period of about four weeks in August; this is followed by another period of heavy rainfall from September to October. Dry season length is between 120 - 130 days. Annual rainfall is about 1375 mm. Annual temperature ranges from 25^oC to 35^oC. The soil has been cultivated for long time. It is sandy loam with little organic matter. The soil is well drained with considerable amount of gravel with a pH of 4.64

The field was prepared by clearing the bush. It was then ploughed and harrowed. The field was then lined and pegged. The field was divided into 25 plots with a plot size of 2 m square. There were five treatments in the experiment. The Randomized Complete Block Design was used in designing the experiment. There were five replications.

Air–dried and ground manure samples were sieved through 2 mm sieve and ignited at 450^oC for 2 hours, the ash was extracted with HCl. The P was determined by ammonium molydate/ammonium vanadate method and K by flame photometry and Ca and Mg by EDTA titration. Determination of N was by the Kjeldahl method.

Moist soil samples were taken from the field two days after a heavy rainfall with the core sampler and sent to the laboratory where they were weighed to find their initial masses. They were then oven-dried at a temperature of 105^oC to a constant mass M_s. The loss of water upon drying constituted the mass of water M_w contained in the sample. The volumetric water content (θ_v) was determined from the formula:

$$\theta_v = \theta_g. \rho_b/\rho_w$$

Assuming ρ_w = 1, θ_g is gravimetric water content ρ_b is bulk density of the soil and ρ_w is the density of water assumed to be unity.

The dry bulk density was determined from soil cores collected from the field with core sampler (Klute, 1987). The cylindrical metal sampler (core sampler) with a diameter of 5 cm and a height of 5 cm was driven into the soil vertically with the aid of wooden plank and a mallet to fill the sampler. The volume of the soil was taken to be the same as the volume of the cylinder. The cylinders were sent to the laboratory and oven dried at 105^oC to constant mass. The oven dried soils were weighed and the dry bulk densities calculated by dividing the oven dried mass (mass of solid component of the soil) by the volume of the soil that is the cylinder.

Total porosity was calculated by the formula; $f = 1-\rho_b/\rho_s$ where f is total porosity, ρ_b is bulk density and ρ_s is particle density (2.65 g cm^{-1}). Air filled porosity was calculated by the formula, $af = f - \theta_v$ where *af* is air filled porosity, *f* is the total porosity and θ_v is volumetric water content.

A modified wet sieving method was used to measure the aggregate stability (ASt). Twenty grams (20 g) of the aggregates were weighed unto a 0.25 mm sieve. The sieve was immersed in water contained in a basin and manually rotated gently for five minutes. The wet sieved aggregates were dried to a constant mass. Another 20 g sub sample was weighed and oven dried to a constant mass. After oven drying, the wet sieved aggregates were divided by the sub sample to give the aggregate stability, which was expressed as a percentage

The data collected on various parameters were subjected to analysis of variance using Genstat software programme 2010. The means were separated using Least Significant Difference (LSD) at 5% probability level.

3. RESULTS

The application of 9 t poultry manure + NPK gave the highest total porosity value of 48.7% while the mineral fertilizer and control recorded 46.8% and 46.4%, respectively. At five per cent probability level there were no significant differences between the treatments with poultry manure application. However they were significantly higher than the control and the NPK Fertilizer treatment.

The aeration porosity for the application of 9 t poultry manure + NPK recorded the lowest value of 28.6% followed by the application of 5 t poultry manure + NPK and 7 t poultry manure + NPK which gave the same value of 28.7%. The NPK fertilizer and the control recorded the 30.1% and 29.0% respectively. However the values of the aeration porosity of all the treatments did not differ significantly.

The application of 9 t ha^{-1} poultry manure + NPK recorded the lowest bulk density value of 1.36 g cm^{-3}, while the control treatment recorded the highest value of 1.42 g cm^{-3}. At five per cent probability level the application of 9 t ha^{-1} poultry manure + NPK gave significantly lower bulk density than all the treatments.

The application of 9 t poultry manure + NPK gave the highest value 20.4% field volumetric wetness. The application of 5 t poultry manure + NPK and 7 t poultry manure + NPK gave the same volumetric wetness of 19.3%. The NPK fertilizer and the control also recorded the same volumetric wetness of 17.0%. At five per cent probability level the treatments with poultry manure application did not differ significantly. However they were significantly higher than the NPK fertilizer treatments and the control. The application of 9 t poultry manure + NPK gave the highest aggregate stability value of 55.8%. The application of 7 t poultry manure + NPK, 5 t poultry manure + NPK, NPK fertilizer and control treatments also gave 53%, 50%, 49.3%, and 49.8%, respectively. There was no significant difference among the treatments.

Table 1: The effects poultry manure on total porosity, aeration porosity and bulk density

Treatments t ha^{-1}	***f* (%)**	***af* (%)**	**ρ_b (g cm^{-3})**
5 t poultry manure + N.P.K fertilizer	47.9 (3.5)	28.7 (2.6)	1.38 (0.04)
7 t poultry manure + N.P.K fertilizer	47.9 (3.0)	28.7 (2.4)	1.38 (0.03)
9 t poultry manure + N.P.K fertilizer	48.7 (3.4)	28.6 (2.0)	1.36 (0.04)
N.P.K Fertilizer 225 kg ha^{-1}	46.8 (3.2)	30.1 (2.5)	1.41 (0.05)
Control	46.4 (3.8)	29.0 (2.2)	1.42 (0.04)
LSD	1.2	4.4	0.02
CV%	4.2	8.0	3.4

Values in brackets represent standard deviation

Table 2: The effects of poultry manure on moisture content and aggregate stability

Treatments t/ha	**θ_v (%)**	**ASt (%)**
5 t poultry manure + N.P.K fertilizer	19.3 (2.5)	50.8 (4.5)
7 t poultry manure + N.P.K fertilizer	19.3 (2.0)	53.0 (5.2)
9 t poultry manure + N.P.K fertilizer	20.4 (2.2)	55.8 (4.0)
N.P.K Fertilizer 225 kg ha^{-1}	16.9 (2.6)	49.3 (5.0)
Control	17.0 (2.3)	49.9 (4.8)
LSD	2.6	9.4
CV%	4.3	4.3

Values in brackets represent standard deviation

4. DISCUSSION

The results indicated that poultry manure + NPK has the ability to decrease soil bulk density. It was also observed that increased rate of poultry manure applications resulted in decreasing bulk density because the 9 t application of poultry manure + NPK was significantly lower than other poultry manure applications. This is consistent with the earlier studies by Agbede et al (2008) who observed that poultry manure improved soil physical properties significantly by reducing soil bulk density in 2004, 2005 and 2006. They further noted that yearly application of poultry manure had cumulative positive effects on soil physical properties. The reduced bulk density due to the application of poultry manure resulted in higher porosity. It has earlier been reported that poultry manure significantly increased total porosity (Ewulo et al., 2008; Agbede et al., 2008.). It was also observed in the present study that increased poultry manure application up to 9 t ha^{-1} significantly gave higher porosity than the 5 t ha^{-1} and 7 t ha^{-1}. This suggests that addition of poultry manure to soils has cumulative positive effect on porosity.

The aeration porosity for the treatments with poultry manure applications was lower than the control and the fertilizer treatment. However the differences were not significant. This could be attributable to the fact that the treatments with poultry manure retained more water hence the low aeration porosity or air field porosity.

The treatments with poultry manure significantly retained higher moisture than the control and the NPK fertilizer treatments. This suggests that poultry manure has the ability to increase soil moisture content. The improvement in soil moisture content could be attributed to increase in organic matter content as a result of poultry manure application. This observation is in line with the work of Adesodun et al., (2005) who found that application of poultry manure to soil increased soil organic matter content. Also improvement in soil moisture associated with poultry manure could be due to the mulching effects of the manure which improved moisture absorption and retention as a result of improved soil structure and porosity (Aluko and Oyedele, 2005).

As reported by Ewulo et al., (2008), poultry manure additions up to fifty tons per hectare improved soil physical properties by increasing soil moisture content. It can therefore be said that poultry manure is a good source of organic amendment for improving soil moisture content of sandy soils. The aggregate stability increased with poultry manure application but the differences were not significant. This may be due to the short period of the experiment which could not allow enough time for the poultry manure to homogenize with the soil to form stable aggregates. Also the sandy nature of the soil could not favour inter-particle bonding to enable the poultry manure bind the soil particles to form stable aggregates. Wanas (2002) reported that addition of compost led to significant effects of physical properties of soil such as pore size distribution, aggregate stability and soil moisture retention. This was possible because the study was carried out continuously for about three years. Since there has been some increase in aggregate stability as a result of poultry manure application, allowing this experiment to continue for longer period may result in significant increase in the aggregate stability due to poultry manure application.

5. CONCLUSIONS AND RECOMMENDATIONS

The addition of poultry manure serves as good source of organic amendment for the improvement of soil physical properties of a sandy soil. The highest poultry manure application results in the highest improvement in the physical properties of the sandy soil. The NPK fertilizer alone did not show any significant improvement. Poultry manure can therefore be used as amendment for the improvement of soil physical properties of a sandy soil either alone or in combination with mineral fertilizers.

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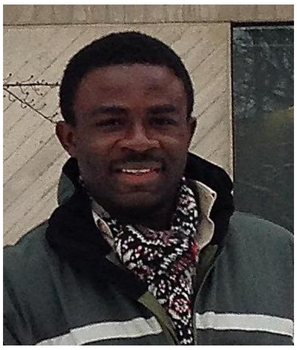
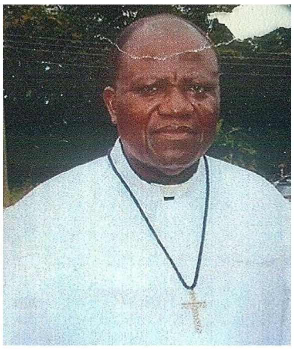
Abdul Aziz Khalid obtained his first degree from the University of Cape Coast, Cape Coast, Ghana in General Agriculture in 2007. He later obtained his Master's degree in Soil Science with focus on soil conservation and management from the Kwame Nkrumah University of Science and Technology (KNUST) in 2010. He is currently studying for a Ph.D. in Soil Science at KNUST. His current research is focused on the impact of crop residue management on soil organic carbon, hydrology and agronomic production in a tropical forest zone.



Henry Oppong Tuffour is a Ph.D. candidate in Soil Physics / Soil Hydrology at the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana and Soil Science lecturer at the Anglican University College of Technology, Nkoranza Campus, Ghana. He received his first degree in 2008 with the award of a Bachelor of Science in Agriculture and a Master of Science in Soil Science in 2012 with major in Soil Physics and Geostatistics from the Kwame Nkrumah University of Science and Technology, Ghana. His current research focuses on hydrological modelling of infiltration involving the soil particle phase and groundwater quality.



Rev. Fr. Professor Mensah Bonsu is a Visiting Professor (Post-retirement from the University of Cape Coast, Ghana) in Soil Science at the Department of Crop and Soil Sciences of the Kwame University of Science and Technology, Kumasi, Ghana. He obtained his first degree in Agricultural Mechanization in 1972 and a Master's degree in Soil Science with Soil Physics major in 1978 from the University of Ghana. He later pursued another Master's degree in Soil Science (Soil Physics / Soil Hydrology Major) in 1984 and Ph.D. in Soil Science with major in Soil Physics / Soil Hydrology Major in 1987 at the University of British Columbia, Vancouver, Canada. He has published numerous refereed articles covering soil physics, soil hydrology, soil conservation and management, climate change and agronomy in professional journals.

Bismark Quarku Parker is presently investigating the synergistic effect of combined farming systems practise on soil fertility in Ghana. His interest is to identify farming systems strategies that can best improve the low fertility of soils in Ghana. His previous studies focused on emissions of Greenhouse gases from farm residue burning in the Coastal Savanna ecosystems of Ghana. He was awarded Master of Philosophy degree by the University of Cape Coast, Ghana for this particular work. He obtained his bachelor's from the same institution. He has also undertaken academic studies with other international institutions including the Technical University in Denmark, Wageningen University in The Netherlands and the Institute of Commercial Management in the United Kingdom.