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Effects of Organic and Inorganic Fertilizers on Earthworm (*Lumbricus terrestris*) Population and Soil Properties for Cowpea (*Vigna unguiculata*) Cultivation

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Abstract: *An experiment was conducted at the Rivers State University research farm to investigate the effects of organic and inorganic fertilizers on earthworms (Lumbricus terrestris) population and soil properties under cowpea (Vigna unguiculata) cultivation. Top soil was collected from the research farm and 3 kg of the soils were bagged in perforated bags and a total of 240 earthworms of different species were introduced into the soil at 5 per pot in 12 pots before planting the cowpea and additional 15 earthworms were added to each plot 3 weeks after planting. Four treatments PM (poultry manure) NPK (20:10:10), NPK+ PM and Control) were laid out in a Completely Randomized Design (CRD) and replicated three times. Treatments were applied 14 days before planting. Soil samples were collected from experimental pots after harvest and a total of 12 samples which were analyzed for physical and chemical properties using standard methods of analysis. Bags were also torn at the end of experiment to determine earthworm population. Results showed that the earthworms' population of the poultry manure bag increased to (64) followed by NPK+PM (35), control (31) and the least earthworm count was found in NPK (11). Physical and chemical properties of soil revealed that pH ranged from 4.75 at the control to 5.83 in the pot treated with NPK+ PM, OC ranged from 0.92 g kg-1 in the control and the pot treated with NPK to 20.0 g kg-1 in the pot treated with poultry manure (PM). Organic matter (OM), Available phosphorus (AP) and Total Nitrogen (TN) values were the highest with the application of poultry manure. The textural class of the soil was determined to be loamy soil whose properties reduced with the application of Poultry manure (PM) to an average of (100.1) with clay soil having the lowest percentage increase (8.32), next to silt (11.39) and sand (80.3) had highest percentage, while in the control, particle size increased with sand having the highest percentage increase (81.63), next to clay (9.65) and silt (8.72) having the least percentage increase. Therefore, the study concludes that the use of organic fertilizer by farmers is cost effective, less harmful to soil health and soil dwelling useful organism like earthworm and improved soil nutrient fortification.*

Keywords: Organic and inorganic Fertilizer, Earthworms (*Lumbricus* terrestris) Soil, Cowpea (*Vigna unguiculata*)

INTRODUCTION

Earthworms are often a major component of soil macro fauna in the natural ecosystems of the humid tropics but are absent or rare in cultivated fields (Blanchart *et al*., 2004). In the humid tropical soils, earthworms play a determinant role on soil fertility by their action on soil organic matter turnover. When present and active, influence organic matter decomposition and nutrient cycling as well as affect soil structure and porosity according to Clive and Norman (2022). Earthworms are the major groups of "invertebrate engineers" in the soil because they may be seen to support soil fertility and soil conservation by enhancing the physical, chemical and biological characteristics of soil (Blanchart *et al*., 2004). Earthworms also have some negative traits; introduced species have created competition for native earthworms in certain areas. This makes it very challenging for native species to live productively and even persist since native species habitually exist in small secluded areas (Nature Watch 2014). According to a report made by USDA (2017) the carbon that is consumed by earthworms is processed and then excreted by it, is a key building block in a well-structured soil. Furthermore that earthworms are an important part of maintaining healthy soils by moving the soil around and create tunnels that alter soil in a beneficial way. Soil-dwelling earthworms need more careful culture, but their use in soil enhancement programs, boosting selected agricultural systems and eco toxicological monitoring is now recognized and is becoming more widely established (Lowe *et al*.,2023). However, the impact of soil fauna has not been considered so far. Soil fauna, especially earthworms are may certainly influence plant growth due to, factors like changes in soil structure and water regime, enhancement of soil organic matter and nutrient cycling as well as stimulation and dispersal of useful microorganisms (Chapuis-Lardy *et al.*, 2011; Medina-Sauza *et al.*, 2019). The earthworms are recognized for their important role regarding the improvement of physical and chemical characteristics of soil when compared with other organisms and their activities in the soil, and thus increasing its fertility (Iordache, and Borza, 2010).

The application of organic manure as fertilizer to agricultural land is a common practice around the world. Livestock and poultry breeding is the pillar industry of agriculture. In order to ensure the effective supply of poultry products, this industry has been developing intensively and on large scale in recent years. (Kumar *et al*., 2018) Therefore, grain legume cropping systems can offer meaningful soil fertility benefits by adding the synergistic impacts of manure and soil beneficial microbes or earthworms (Smith *et al*., 2008, Zhang *et al.*,2016) Nonetheless, fertilizer routines may modify the soil biological communities and functions, which might ultimately affect nutrient cycling and the productivity of arable soils.

Studies have shown that effect of chemical fertilization with NPK on number, biomass and coprolite weight of earthworms revealed positive results when compared to organic fertilization with cattle manure. Other studies have shown that positive results are obtained when chemical and organic are applied (Iordache and Borza 2010)].

Cowpea (*Vigna unguiculata (L.) Walp*) is a major grain legume grown in semi-arid regions of Sub-Saharan Africa. It is a major source of protein and a cheap source of quality protein for both rural and urban dwellers in Africa (Ajeigbe *et al*., 2012). Cowpea leaves and green pods are consumed as vegetable and the dried grain is used in many different food preparations (Dube and Fanadzo, 2013). Protein content of cowpea leaves range from 27 to 43% and protein concentration of the dry grain range from 21 to 33% (Abudulai *et al*., 2016). It is estimated that cowpea can fix up to 200 kg N ha^{-1} (Dakora *et al.*, 1987) and can leave a positive soil N balance of up to 92 kg ha^{-1} (Rusinamhodzi *et al*., 2006). Therefore, this study is focused on evaluating the effects of organic and inorganic fertilizers on soil health and earthworm biodiversity conservation.

MATERIALS AND METHODS

Study Area

The experiment was conducted in the screen house of the Rivers State University, Teaching and Research Farm, Port-Harcourt. It lies between longitude 4° 48' 18.50" N and latitude 6° 58' 39.12" E and on and elevation of 18 m above sea level. The rainfall pattern is bimodal, which begin in March and ends in November, with leaks in June and September and short period of lower precipitation in August which is referred to as August break. The mean annual rainfall ranges from about 3000-4500mm. The annual temperature ranges from an average minimum of 22°C to an average maximum of 31°C. The relative humidity is 69.08% (Dimkpa and Tobin-West 2019).

Experimental Materials and Procedure

Experimental materials used were Poultry manure (PM) gotten from the Rivers State University Teaching and Research Farm, Port-Harcourt, air dried and finely crushed. 0.005 kg (500 g) of poultry manure was weighed and added to perforated bags filled with 10 kg of soil, 2 weeks before transplanting. NPK fertilizer 20:10:10 was also used to fertilize soils 2 weeks before planting.

Beans or cowpea was purchased from a local market (Mile 3 market) in Port-Harcourt Rivers state, which was taking through seed viability test by soaking in cold water and only those that sunk, was planted in perforated bags with 10 kg of soil.

Soil samples without earthworms were collected at the depth of 0-15cm from the Rivers State University Teaching and Research farm. Watering of soil samples was also done for two weeks before introducing earthworms and planting. Different species of earthworms were randomly picked from moist soils where they were in abundance and introduced into experimental pots before planting cowpea. Five (5) earthworms per plot were initially introduced and fifteen (15) more earthworms were added to each pot 2 weeks after planting. Inorganic fertilizers (NPK 20:10) were added to the soils 2 weeks after planting while the poultry manure (PM) was composted applied 14 days before planting. Experiment lasted for three and half months (14 weeks). To harvest the earthworms, the polybags were split open using a razor blade and the remaining soil dispersed on large polythene sheets for visual observation and hand sorting to determine earthworm density. Each treatment was replicated thrice (3 times). Soil samples for physical and chemical analysis were air dried, passed through 2mm mesh size sieve and used for analysis.

Laboratory Analysis

Soil pH was determined in water and in salt (KCl) using pH meter by dipping the glass electrode of pH meter into soil/water and soil/salt suspension, as modified by Mclean (1982).The particle size distributions of the soils were determined by the Hydrometer method (Gee and Or, 2002). Exchangeable bases (Ca, Mg, K and Na) were extracted with 1 N ammonium acetate (NH_40Ac). Exchangeable calcium and magnesium were determined by ethylene diamine-tetra acetic acid (EDTA) titration method while exchangeable potassium and sodium were estimated by flame photometry (Jackson, 1962). Soil organic carbon (SOC) was determined by Walkley and Black digestion method (Olsen and Sommers, 1982). Total nitrogen was estimated by micro-Kjeldahl digestion method (Bremner and Mulvaney, 1982) while available phosphorus was determined by Bray 1 Method (Olsen and Sommers, 1982).

Statistical Analysis

All data collected were subjected to Analysis of variance using ASSISTAT software version 7.7 beta. The means were separated using LSD at 5% level of probability to determine the treatment effects.

RESULTS

Effects of Organic, Inorganic Fertilizers and mixture of both Fertilizers on Earthworms (*Lumbricus terrestris*) Population

The effects of organic and inorganic and mixture of both fertilizers on earthworms (Lumbricus terrestris) population are presented on fig 1. At the end of the experiment, the pot with the poultry manure had the highest value for earthworm population. (64) Followed by NPK+PM (35), control (31) while the least earthworm count was found in the pot containing NPK (11).

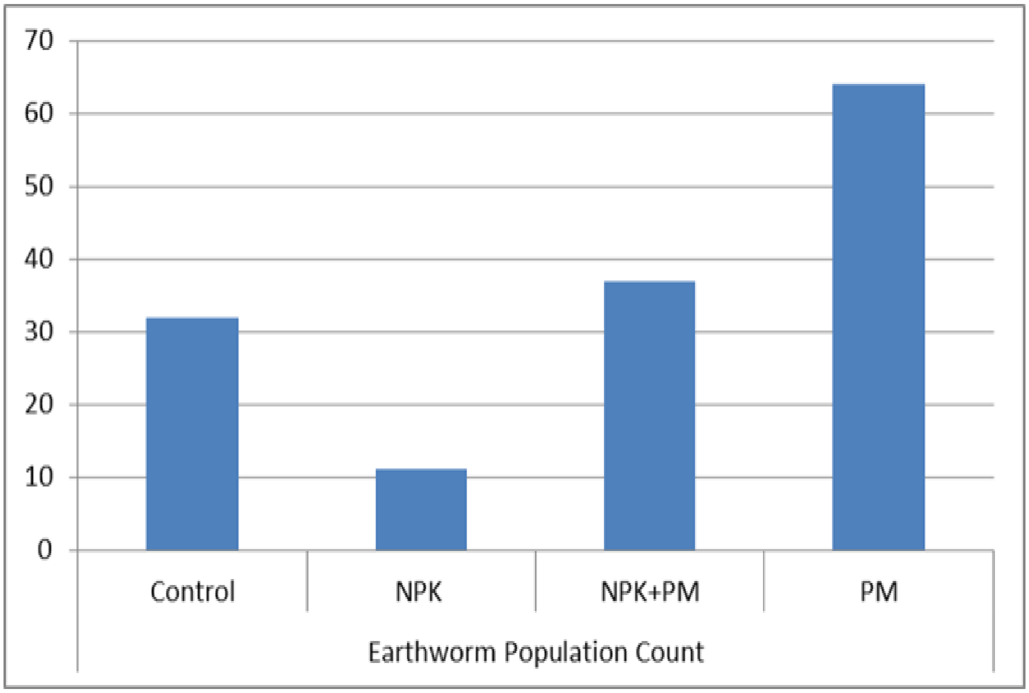

Fig: 1 Effects of Organic, Inorganic Fertilizers and mixture of both Fertilizers on Earthworms (Lumbricus terrestris) Population.

Effect of Organic, Inorganic Fertilizers and Mixture of both Fertilizers on Physical and Chemical Properties of Soil.

The effects of organic and inorganic fertilizer and on soil properties are shown in table 1. pH ranged from 4.75 at the control to 5.83 at the plot with the mixture of organic and inorganic fertilizer. Organic Carbon (OC) ranged from 09.2 g kg-1 at the control (no treatment) and the pot with the inorganic fertilizer (NPK) to 20.0 g kg-1 at the pot with the organic fertilizer (PM). Treatment effect was significantly higher with organic fertilizer (PM). Organic Matter (OM) ranged from 15.8 g kg-1 at the control and the pot treated with inorganic fertilizer (NPK) to 34.4 g kg-1 at the pot treated with the organic fertilizer (PM). Total Nitrogen ranged from 0.19 g kg-1 at the control to 0.29 at the plot treated with PM. Available Phosphorous ranged from 12.42 g kg-1 at the control to 29.46 g kg-1 at the plot treated with PM. Calcium content ranged from the 1.27 g kg-1 at the pot with the inorganic fertilizer (NPK) to 3.70 g kg-1 at the pot with the organic (PM), Magnesium content ranged from 0.48 g kg-1 at the pot with (NPK) to 2.11 g kg-1 at the pot with (PM) Potassium (K) ranged from 0.03 g kg-1 at the control to 0.09 g kg-1 at the other treatment pots. There was a significant difference in the K content between the control pot and the other treatment pots.

Result showed that particle size distribution decreased significantly at the pot with the organic fertilizer (PM) and increased significantly at the control and textural class is sandy loam

Table 1.2 Effect of Treatment on Soil Chemical Properties

TREATMENTS	pH	O.C g kg-1	O.M g kg-1	T.N g kg-1	Av.P mg/kg	TEA Cmol/kg	Ca Cmol/kg	Mg Cmol/kg	K Cmol/kg	%Sa
Poultry manure	5.56[a]	2.00[a]	3.44[a]	0.29[a]	29.46[a]	0.72[a]	3.70[a]	2.11[a]	0.09[a]	80.2
Npk + poultry manure	5.83[b]	1.70[b]	2.92[b]	0.26[b]	27.88[b]	0.28[b]	2.80[b]	1.82[b]	0.09[b]	81.2
Npk	4.95[c]	0.92[c]	1.58[c]	0.25[b]	26.82[c]	0.78[ac]	1.27[c]	0.48[c]	0.09[b]	81.6
Control	4.75[d]	0.92[c]	1.58[c]	0.19[c]	12.42[c]	1.09[a]	1.30[c]	0.58[c]	0.03[c]	81.6

Keys: O.C=Organic carbon, O.M= Organic matter, T.N= Total nitrogen, A.P= Available P
Means with the same superscript are not significantly different at 5% level of probability

DISCUSSIONS

This study revealed a higher earthworm population density which differed significantly among the various treatments with the highest value found in the pot with the poultry manure. This is similar to the findings of Ngosong, *et al*., 2020; Yahyaabadi *et al*.,2018 where earthworm biomass and abundance increased significantly in the plot containing organic manure and the plot that has a combination of organic manure and inorganic (OM + NPK). They further reported that the effect of organic matter on all species maybe due to increasing food supply, as a result of direct feeding on organic matter or on microorganisms growing upon it. Boyle *et al*., 2019 stated that earthworm cocoons usually remain in a state of diapause in the soil for an extended period of time until conditions are favorable and the poultry manure treatment may have provided this condition. Environmental factors such as temperature, moisture and others such as food quality and quantity can also affect cocoon production, hatching and growth of earthworms Ali and Kashem 2018. The low earthworm density in the inorganic fertilizer treatments is in contrast with the findings of Lalthanzara, 2010 where inorganic fertilizer (NPK) caused significant increases in earth-worm numbers, biomass, and casts. They opined that this may be due to long-term application of inorganic fertilizers which may have adversely affected earthworm population as a result of soil acidification or other changes in the soil environment that may have increased.

Soils treated with poultry manure were observed to be more conducive environment for the earthworms to thrive and also the physical and chemical parameters were increased when compared to other treatments. The findings of Butenschoen *et al*., 2009 revealed that physico-chemical properties of the soils such as pH, organic matter, nitrogen (N), phosphorus (P), etc. are affected by earthworms due to their contribution in the involvement of the soil particles, as well as in organic matter transfer. Stating further that earthworm hastens nitrogen (N) mineralization from organic matter, depending on the specific species and their interaction with soil characteristics, environment where the organic matter is found. This may also be the reason for the decrease or low values in the physical and chemical properties at control plots. Furthermore, total nitrogen increased with Poultry Manure as revealed in a study by Miheretu and Sarkodie-Addo 2017 which conforms to the current study. The integrated treatment of inorganic and organic (PM+NPK) fertilizer application in soil also had values for the soil properties that were next to the Poultry Manure. Adugna,2022 reported that since the application of inorganic fertilizers may not only improve nutrients but also either positively or negatively affect soil health, in order to maintain soil health and foster crop productivity, the organic matter should be maintained and an integrated use of organic and inorganic fertilizer should be adopted.

CONCLUSION

Soils fertilized with poultry manure was a more conducive environment for the earthworm's reproduction and abundance therefore earthworm population increased with the application of poultry manure and reduced at the pot with inorganic fertilizer (NPK) which is as a result of reduced organic matter and source energy for the earthworm. Soil properties are affected by earthworms due their activities in hastening mineralization processes,

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