



Variation in Soil Chemical and Microbiological Properties as a Result of Yearly Amendment with Organic Fertilizer

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Authors' contributions

This work was carried out in collaboration between all authors. Authors OAB and MOA designed the study. Author MOA performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors OAB, IOA and MOA managed the analyses of the study. Authors MOA and IOA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Millions of organic fertilizers are produced annually all over the world. Substantial quantities of these were crop residues and the remaining being animal waste based. Meanwhile maintaining and improving soil fertility in the tropic is essential for increasing food production for rapidly expanding the population. This project work, therefore, investigated the variation in soil chemical and microbiological properties as a result of yearly amendment with compost. The experimental site was the Organic Agricultural Farm located within the Federal University of Agriculture, Abeokuta. Soil samples were collected between 0 – 15 cm depth using soil auger and the samples were analyzed for the following soil parameters; total viable counts, total fungal counts, microbial biomass carbon,

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microbial biomass nitrogen, percentage organic carbon, microarthropod counts and earthworm counts. The experiment was a split-plot design using 2 varieties of tomato x 3 levels of compost and two durations of application. The variations include one improved variety (UCB 8) and a local variety (Beske), rate of compost – (0, 10, and 20) kg/ha and years of application (one and two years). Results generally showed that: duration has a significant effect on viable counts, microarthropod counts, microbial biomass P, microbial biomass C and percentage organic carbon but has no significant effect on fungal counts, microbial biomass nitrogen, and earthworm counts. The results indicate that application of compost manure is the preferred option to enhance SOM accumulation, improve soil fertility and quality, and increase tomato yield.

Keywords: Arthropods; chemical fertilizer; earthworms; fungal count; microbial biomass.

1. INTRODUCTION

Millions of tonnes of organic fertilizer are produced annually all over the world. It was reported that almost 400 million metric tonnes of animal waste and crop residues are produced in the United State. It was also reported that in Nigeria Savanna, for 1970-1971 season, about 31.41 million metric tonnes of crop residues and animal waste were obtained [1]. Substantial quantities of these were crop residues like sorghum, millet, cotton, maize, groundnut, soybean and cowpea as well as vegetables and sugar cane. Animal-based fertilizers are usually obtained from cowdung, poultry and swine waste. Soil fertility is a significant factor for the improvement and sustainability of soils productivity [2]. In the tropics, the organic layer is confined to the top few centimeters of the earth surface and this can easily be lost through improper soil management [3]. The implication of this is that tropical soil needs a high amount of organic matter [4].

[3] reported that over the years, cultivation with chemical fertilizers has reduced the soil organic matter leading to adverse effects on crop yield. It is important that a balanced use of both mineral and organic fertilizer be employed for sustaining the soil fertility. Organic fertilizer could contribute to the improvement of soil fertility [5]. Maintaining and improving soil fertility in the tropics is essential for increasing food production for rapidly expanding the population. Soil is a dominant factor determining the distribution and production of a plant community. Consequently, careful and proper management of soil is very essential for efficient and sustainable crop production. Organic fertilizer represents a valuable resource that requires careful management. Organic fertilizer can be used directly for improving the soil productivity [6]. Direct incorporation of organic fertilizer in the soil along with appropriate management practices or

used as a mulching material on the soil surface has proven to be beneficial in improving soil physical properties and increased crop yield. Organic matter is released during the decomposition of organic fertilizer in the soil, this complement the effect of fertilizer. The organic matter helps in the aggregation of soil particles [7,8]. This will also help in determining the quality of the available organic fertilizer. Hence, determine the requirement in a particular soil.

Manure has long been considered a desired soil amendment [9]. They affect to a great extent chemical properties of the soil, this however determines the availability of plant nutrient and sustainability of such soil properties for the optimum, growth, development and yield of plant. The results, obtained from the analysis of poultry manure indicated that it contains principal elements needed for healthy growth and more fruit crop production. [10] reported that the relatively abundant elements in organic manure are Nitrogen, carbon, potassium, phosphorus, iron, copper etc. [11] reported significant increase in organic matter content with application of poultry manure. In the first and second planting seasons, the organic matter levels under the poultry manure treatment showed a 90.5% and 94.1% increase, respectively over the control. Organic matter serves as source for trace elements, thus controlling their uptake by plant. Positive correlation was also observed between organic matter and PO_4 , K^+ , Ca^{2+} , Mg^{2+} [12,1,13].

2. MATERIALS AND METHODS

2.1 Site Description

The experimental site was the Organic Agricultural Farm located within the Federal University of Agriculture, Abeokuta (FUNAAB).

2.2 Treatment

A split-split-pilot design was used with 2 varieties of tomato (UCB 8 and Beske) x 3 levels of compost (0, 10 and 20 kg/ha) x 2 durations of application (2 yrs and 3 yrs).

2.3 Soil Sample Preparation for Analysis

The soil samples that were collected from the field were taken to the laboratory to test for microbial biomass C, microbial biomass N, microbial P, total viable count, total fungi count, arthropod count and earthworm count with standard techniques as described below. All tests took place at Institute of Agricultural Research and Training (I.A.R & T.), Ibadan.

2.4 Determination of Microbial Biomass C

Composite soil sample thoroughly mixed was taken and sub samples from each plot. The soil was sieved to remove stones, coarse roots and visible litter. Two sub samples of 10 ± 0.01 g of soil was put into 50 ml beaker and a third samples of ± 0.01 g of soil was put in a 125 ml water – tight bottle. The sample in the bottle was extracted and the first sample was fumigated. The % water content of the sample in the beaker was determined. The beaker was then placed in vacuum desiccators containing 30 ml alcohol-free chloroform clearly evaporates. The tap on the desiccators was closed and the soil was stored in the dark for 5 days at 25°C. After days, the soil transferred to a watertight 125ml extraction bottle 50 ml 0.5 M of K_2SO_4 was added to the bottle and it was stored for 30 minutes. The extract was filtered through a No. 42 what man filter paper and the filtrate was retained for analysis.

$$\text{Microbial biomass C} = (\text{Extract } C_{ti} - \text{Extract } C_{t0}) \times 2.64$$

2.5 Determination of Microbial Biomass N

Microbial biomass N can be determined by analyzing for total N in the extract after digestion microbial N = (Extract N_{ti} – Extract N_{t0}) x 1.46.

2.6 Determination of Microbial Biomass P

Microbial biomass P was estimated using a procedure whereby inorganic P was extracted by 0.05 M Sodium bicarbonate at pH 8.5. The extracted P was determined by the Ammonium molybdate – ascorbic acid method.

2.7 Total Fungi Count and Total Viable Count

The method used in the laboratory determination of the total fungi was plate count method and serial dilution techniques which include sterilization of the media and glass ware, inoculation, incubation and counting of the colonies.

2.8 Sterilization of Media and Glass Wares

The agar media included nutrient agar for isolation of bacterial and potato dextrose agar for isolation of fungi were sterilized in an autoclave at 121°C for 15 minutes. The glass ware used i.e. Petri dishes, test tube and pipettes were sterilized at 160° for 2 hours in the oven.

2.9 Inoculation

Ten grammes of the samples for each of the cloth were taken and placed in conical flask, mixed with 90mls of water and shaken for 15 minutes. Nine millimeters of sterilized water placed in 8 test tubes labeled as 10^1 , 10^2 , 10^3 , 10^4 , 10^5 , 10^6 , 10^7 , 10^8 , appropriate series of eight fold dilution were prepared using 1 ml of soil suspension from the conical flask to series of eight test tubes. Aliquot of 1ml were also transferred and place in the series of the eight Petri-dishes before the media were added and swirled to mix. For the bacteria, 28 g/l of nutrient agar medium was used while 39 g/l potato dextrose agar medium was used for fungi. The agar media in the Petri-dished were left to solidify and then they were inverted before placing in the incubator.

2.10 Incubation

The nutrient agar Petri-dishes were incubated at 37°C while dextrose gar Petri-dishes were incubated at 25°C.

2.11 Determination of % Organic Carbon

This was determined using Walkey-Blakey method. One gramme of 0.05mm sieved soil was weighed into a flat bottom flask. Ten millimeters of potassium dichromate ($K_2Cr_2O_7$) was added. This was swirled to mix before 20 mls of concentrated H_2SO_4 was added. After the addition of the concentrated H_2SO_4 , heat was generated to drive reaction to completion. Flask

was allowed to stand for 30 minutes before the solution was diluted with 100 ml of diluted water, two drops of ferroin indicator was added to the whole mixture and titrated against 0.5 N iron sulphate (Fe₂SO₄). The end point was through the development of maroon colour and the percentage organic carbon was determined mathematically.

$$\% \text{ Organic carbon} = \frac{(B-T) \times 0.5N \times 0.03 \times 1.33 \times 100}{\text{Weight of soil (g)}}$$

2.12 Microarthropod Extraction

Soil microarthropods were extracted from each of the undisturbed core samples collected from each plot using a modified high efficiency extractor. The soil cores contained in Aluminium sieves of 2 mm mesh size were placed under a 40-watt light for 72 hours. The fauna were collected through funnels into cials containing 4% formalin solution. The fauna were counted and sorted into their main groups, oribatid, actinadids, gamasids and collembolan using stereomicroscope.

2.13 Earthworm Count

Soil samples between 0-15 cm were extracted within the area of 1 m², earthworms were then counted by physical counting. The number of earthworms per 1 m² then converted to hectare by multiplying the value gotten by 10,000.

2.14 Statistical Analysis

Data collected was subjected to the analysis of variance and treatment using Duncan' Multiple Range Test (DMRT).

3. RESULTS

Duration has significant effect on viable count, micro biomass phosphorus, micro-biomass

carbon but has no significant effect on fungal count and micro biomass Nitrogen as shown in Table 1.

Variety has significance on viable count but has no significant effect on fungal count, micro biomass phosphorus, micro biomass carbon and micro-biomass nitrogen as shown in Table 1.

Duration has significant effect on micro arthropod count and percentage organic carbon but has no significance on earthworm count as shown in Table 2.

Variety has significant effect on micro arthropod but has no significance on earthworm count and percentage organic carbon as shown in Table 2.

Compost rate has no significant effect on viable count, fungal count, microbial biomass Nitrogen, microbial biomass phosphorus and microbial biomass carbon.

Compost rate has no significant effect on micro arthropod count, earthworm count and percentage organic carbon as shown in Table 4.

4. DISCUSSION

Duration has significant effect on the viable counts because a viable count in the second year was more than that in the first year. Duration has no significant effect on fungal counts between the first and second year. Microorganisms assimilated more phosphorus in the first year that in the second year. Therefore duration has significant effect on microbial biomass phosphorus. Duration has no significant effect on microbial biomass Nitrogen. Variety has significant effect on viable counts because there was more viable counts on the field with Beske than the other field with UCB 8. Variety has no significant effect on fungal counts, microbial biomass phosphorus, microbial biomass carbon and microbial biomass Nitrogen.

Table 1. Effect of duration and variety on some soil microbial properties

No. of years	Viable count (CFU x 105)	Fungal count (CFU x 105)	Biomass phosphorus (mg/kg)	Biomass carbon (mg/kg)	Biomass nitrogen (mg/kg)
1.	17.78b	0.37	2.27a	8.67a	0.30
2.	21.63a	0.48	1.70b	6.10b	0.34
Variety					
UCB8	17.40b	0.40	1.73	6.80	0.32
Beske	22.01a	0.46	2.24	7.97	0.32

Means with different alphabet indicate that they are significantly different as p=0.05

Table 2. Effect of duration and variety on soil microarthropods, earthworm and organic carbon

No. of years	Micro arthropod count (no/ha)	Earthworm (no/ha)	Organic carbon (%)
1.	3.89b	45,556ns	3.28a
2.	4.83a	40,000ns	2.31b
Variety			
UCB8	3.72b	40,000ns	2.57b
Beske	5.00a	45,556ns	3.02a

Means with different alphabet indicate that they are significantly different as $p=0.05$.

Table 3. Effect of compost rate on some soil microbial parameters

Compost rate (KG/HA)	Viable count (CFU X 10 ⁵)	Fungal count (CFU X 10 ⁵)	Biomass phosphorus (MG/KG)	Biomass carbon (MG/KG)	Biomass nitrogen (MG/KG)
0	19.63	0.51	0.36	2.23	7.65
10	18.94	0.38	0.30	2.05	7.39
20	20.55	0.39	0.29	1.67	7.12

**ns

Table 4. Effect of compost rate on soil microarthropod, earthworm count and percentage organic carbon

Compost rate (kg/ha)	Micro arthropod count	Earthworm (no/ha)	Organic carbon (%)
0	4.33	46666.83	2.90
10	4.75	40000.17	2.80
20	4.00	41666.83	2.70

**ns

Duration has significant effect on microarthropod counts because micro-arthropods in the first year was greater than that of the second year. Duration has no significant effect on earthworm because there was no difference between the first and second year. Duration has significant effect on percentage organic carbon because the percentage organic carbon was more in the first year than in the second year. Compost rate has no significant effect on the following microbial properties: viable counts, fungal counts, microbial biomass phosphorus, microbial biomass carbon, microbial biomass nitrogen, microarthropod counts, earthworm counts and percentage organic carbon.

This is consistent with the view that organic materials can be an important input for increasing soil quality in rice production systems [14]. Monitoring the changes in soil quality indicators following a specific management strategy is a useful approach to determine the current soil quality status [15]. The soil microbial community responds strongly to both long-term land-use changes and short-term litter additions [16]. After a short period of plant residual addition to soil, net N immobilization and decreased inorganic N pools are often observed [17]. Organic fertilizers are believed to stabilize or

even increase soil pH [18,19] which we did not observe in this experiment. Although no significant correlation was detected between bacterial communities with soil pH under a typical clay loamy anthrosol [20], many studies have reported that environmental factors altered soil microbial community, especially the soil pH, which has been demonstrated in several studies to be the strongest factor shaping microbial community structure [21,22,23,24,25,26,27,28,29].

5. CONCLUSION

Organic fertilizer treatments significantly changed soil microbial biomass C and N, enzyme activities, microbial community composition, and tomato yield after two crop seasons. Organic amendments showed more favorable impacts on nutrient availability and microbial activity and typically increased tomato yield. The compost treatment was characterized by higher levels of available N, P and K, MBC, enzyme and microbial activities. This indicated improved soil fertility and quality. Based on these results, application of chemical fertilizer plus manure is a practical option for enhancing soil labile C and increasing the productivity of soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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