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Response of okra (*Abelmoschus esculentus* (L.) Moench) and soil chemical properties to different amendment types in an ultisol

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Abstract

A field experiment was carried out to investigate the effect of different organic manure on the growth and yield of okra (Abelmoschus esculentus (L.) Moench) at the teaching and research farm of the University of Benin, Benin City, Edo State, Nigeria between April to August, 2016. Four treatments; control (T1), cattle dung + poultry manure + pig manure (T2), poultry manure + foliar blend (T3) and bacterial inoculant (T4) were laid out in a randomized complete block design with four replications. Data were collected on growth (plant height, number of leaves, stem girth and leaf area) and yield parameters of okra plant. Results obtained from the research indicated that the growth and yield of okra was lowest in control (T1). These results further suggest that, the organic manure used in the study especially in a combined form (cattle dung + poultry manure + pig manure) positively influenced the agronomic performance of the okra plant. T2 increased okra plant height and, leaf area compared with the control. T3 recorded significantly higher number of leaves (7.188), compared with the control (3.375) whereas, fresh fruit weight from the various treatment plots were in the following order; T2 (79.15g) > T3 (53.58g) > T4 (22.53g) > T1 (20.24g). Although the nitrogen content of the soil was higher (21.33 g/kg) with T4, the highest fruit weight was obtained in T2 treated soils. It was also observed from the microbial analysis carried out on the soil samples obtained from the various plots that, soils with organic amendments (T2, T3 and T4) generally had higher microbial population, relative to control (T1). Based on the findings of this experiment, it could be deduced that cattle dung, poultry manure and pig manure promotes higher performance of okra.

***Keyword:** cow dung, poultry manure, pig manure, foliar blend, microbial population*.

Introduction

Okra, (*Abelmoschus esculentus* (L.) Moench) like any other indigenous vegetable, is widely cultivated, especially for its green tender fruit, and can be found in most local markets in Africa. The crop belongs to the family Malvaceae and the genus *Abelmoschus* (Siemosma, 1982 and Roy *et al.,* 2014). Vegetable crop producers in the tropics are usually bedevilled with the problem of maintaining soil fertility. This is because the native fertility of most agricultural soils in this region is low and cannot support suitable crop production over a long period without the use of fertilizers (Sobulo, 2000; Awodun, 2008). This problem of infertile soil is further compounded by the scarcity and high cost of inorganic fertilizers which has forced farmers to make use of fertilizer rates that are lower than the optimum with its resultant reduction in yield. Mayong*et al.*,(1996) in their survey, discovered that farmers applied less than half of the 120 $kgNha^{-1}$recommended for maize in the Northern Guinea savannah due to the problem of scarcity and high cost of inorganic fertilizer.

Soil fertility degradation has been described as the second most serious constraint to food scarcity in Africa and the maintenance of soil fertility over a long period with inorganic fertilizer application has led to increased soil degradation and nutrient imbalance, resulting in deleterious effects on crop growth, quality, ecosystem, and soil quality (Akiri, 2011). There is therefore the need to explore alternative means of soil amendment in order to improve on the productivity of soil and crop production.

Ultisol of the humid region is one of the major soils that are extensively cultivated for various root, tuber and vegetable crops. Just like most tropical soils, they are derived from the acidic parent materials which are poor in nutrient reserves (Kayode *et al.,* 2012). The need to ensure high soil productivity and increased yield in an ultisol can only be made possible through the use of external inputs from different sources organic and inorganic (Busari*et al.,* 2004; Rameshi *et al.,* 2009).

Application of organic amendment is an environmentally, economically and agronomically sound practice which has already been established by many researchers (Antil and Singh 2007) Therefore, to achieve agricultural sustainability, the use of organic amendment is getting prime importance in recent years, particularly under intensive cropping system. Farmyard manure, vermicompost, poultry manure and green leaf manure are commonly used as organic amendments in agriculture. Organic amendments such as vermicompost also add to growth-influencing substances like plant hormones as observed by Atiyeh *et al*., (1999). Thus, application of organic fertilizer as soil amendment has been proven to have several advantages such as; increased infiltration rate, reduced bulk density, aggregate stability, cation exchange capacity (CEC), and biological activities (Agbede *et al.,* 2008). In addition, organic fertilizer serves as slow-release reservoir for plant macronutrients, aids in plants micronutrient absorption, and facilitates water and air infiltration. It has however been argued that organic manures are usually late in nutrient mineralization. In spite of the numerous advantages of organic fertilizers as soil amendment, not many works have been reported on their effects on growth and quality of vegetables in the tropics (Palm and Sanchez, 1991).

Therefore, this experiment was undertaken to investigate the response of okra to different types of soil amendments.

Materials and methods

Site of the study

This research was carried out in the Faculty of Agriculture Teaching and Research Farm, University of Benin, Benin City, Nigeria. This area has two major seasons namely; the rainy season (April to October) and dry season (November to March). The peak of the rainy season is usually between July and September with a brief drop in August. The mean annual rain fall is 2500mm (NIMET, 2011) and average daily temperature of about 32^{o}C. The experimental site lies between latitude 6^{0} 31’17.4” and 6^{0} 31’24.6N and Longitude 5^{0} 37’11.5” and 5^{0} 37’13.1”E.

Soil sampling

Soil samples were collected at 0 – 15 cm soil depth before and after sowing using a simple random sampling technique and thereafter, the soil samples obtained were subjected to both physical and chemical analysis in the laboratory.

Chemical Properties of the soil

Organic carbon content of the soil was determined by Walkey Black (1934) wet oxidation method. The total Nitrogen was determined using the micro kjeldahl digestion method (Bremner and Mulvaney, 1982) and the available Phosphorous was determined by the method of Bray and Kurtz (1945). Exchangeable Cations (Ca^{2+}, Na^{2+}, K^{2+}, Mg^{2+}) were extracted with 1 N ammonium acetate solution and the concentration of Ca^{2+} and Mg^{2+} in the soil were determined by Atomic Absorption Spectrophotometer (AAS)as described by Ramirez-Munoz (1968) while potassium (K) sodium (Na) were determined with flame photometer (Thomas, 1982). Exchangeable Acidity was determined by the KCL volumetric procedure by Mclean (1982). The soil pH was determined in 1:1 soil to water ratio using an electrode pH meter as described by Thomas (1982). Electrical Conductivity (EC) was also determined by inserting an electrical conductivity meter into the above suspension and Exchangeable Cation Exchange (ECEC) was determined by summation method (Maclean, 1972)

Source of material used

The bacterial inoculum (*Baccilus thurigenesis*) was obtained from the Department of Soil Science and Land Management, University of Benin and poultry manure was obtained from Ojemai Farm limited, Edo State while the Piggery dung was obtained from the farm project, University of Benin. The Cow dung was obtained from the Cattle farm in University of Benin and the okra (*Abelmoschus esculentus* L.) seeds were obtained from Uselu market in Benin City, and the foliar blend (micro-nutrient fertilizer) was obtained from the Federal Ministry of Agriculture, Abuja.

Plot layout and pre-planting operations

The experimental plot area was 14 m x 5 m. It was manually cleared, prior to planting and divided into two blocks of sixteen sub-plots with each having a dimension of 1.25m by 2m which was laid out in a Randomized Complete Block Design (RCBD) with four replicates. Alley way of 0.5m between plots and blocks was maintained, the experiment consisted of 4 treatment and 4 replicates. The treatments were; Control(T1), Poultry manure + Pig manure + cow dung(T2), Poultry manure + Bacteria + Micronutrient fertilizer (foliar Blend) (T3),Poultry manure + Bacteria (T4), The cow dung, poultry manure and pig manure, were already at the cured state before application to the soil fourteen days before planting at the rates of 0.8 kg (poultry manure), 0.4 kg (cow dung), 0.42 kg (pig dung) which will give an equivalent of 3.2, 1.6 and 1.68 ton ha^{-1} of poultry manure, cow dung and pig dung respectively. While 1.82 ml of foliar blend per plot was used. These treatments were assigned at random to the subplots using the table of random numbers.

Sowing of okra seeds were done in a spacing of 50 cm by 50 cm. The bacterial inoculum was mixed to form a solution and applied at the rate of 120 ml per ha after two weeks of sowing while the micro nutrient fertilizer (foliar blend) was applied at 2,4,6 weeks after sowing coupled with the collection of data on plant height, number of leaves, stem girth and leaf area.

Isolation and characterization of bacteria

Determination of microbial isolates from soil sample was done using the ‘pour plate method’. All isolates were identified by standard microbial techniques as described by Cowan and Steel (1970), including gram stain. The identification was observed under the high power microscope under oil immersion (Buchanan and Gibbons, 1974) and the isolates of bacteria were characterized based on cultural, morphological and biochemical differences.

Statistical analysis

Data obtained from the experiment were subjected to statistical analysis using a Genstat statistical package using a one way analysis of variance procedure. The treatment means were compared using Duncan Multiple Range Test at 5% level of probability.

Results and Discussion

Table 1 shows the effect of the different treatments on growth parameters of okra. It revealed that the application of organic fertilizers in soil positively affected the fertility status of the soil hence the plant growth varied depending on the quality of raw materials used. T2 which was a combination of poultry manure + cow dung + pig manure had the highest effect on leaf area with a value of 181.7, while the lowest value of 48.6 was recorded in T1. T3 (poultry manure +*bacillus* + foliar blend) had results that was significantly different from theT4 (poultry manure + *bacillus*) results. The use of poultry manure + *bacillus* (T4) showed a higher value (87.0) in leaf area above the control (T1), this findings correlated with the work done by Muhammad *et al*., (2013) whose investigation also showed an increase in vegetable parameters of crops inoculated with microbes.

The highest plant height (19.69 cm,) was observed in T2 plots while the control (T1) had the lowest (6.20 cm.) value. The highest plant height observed in the T2 plant was probably due to the organic amendments (poultry manure + pig manure + cow dung) used. T3 had the highest effect on leaf numbers with a value of 7.0 but was not significantly different (P<0.05) from T1 plants. This results also aligns with the findings of Muhammad *et al*., (2013) who emphasized the positive effect of bacteria on Okra growth. Although the various treatments showed no significant effect on plant girth (P<0.05), however, T2 was recorded with the highest plant girth with a mean value of 2.20.This result agrees with the studies carried out by Banashree and Nirmali (2015) on the effect of organic amendments on germination and seedling growth of okra.

The results of this study also corroborated the finding of Ajari *et al*., (2003) who observed that poultry manure increased plant height of crops when compared with other sources of manures.

Table 1: Influence of the different treatments on some agronomic characters of okra

	Parameters			
Treatment	Leaf area(cm^2)	Plant height(cm)	Number of leaves	Plant girth(cm)
T1	48.6^{c}	6.33^{b}	3.0^{c}	1.531^{a}
T2	181.7^{a}	19.69^{a}	7.0^{a}	2.200^{a}
T3	129.1^{ab}	17.41^{a}	7.0^{a}	1.775^{a}
T4	87.0^{bc}	13.71^{a}	5.0^{b}	1.738^{a}

- T1=Control T2= Poultry manure+ Cow dung+ Pig manure T3=Poultry manure+ Foliar Blend+ *Bacillus*, T4=Poultry manure + *Bacillus*,
- Mean values in column with the same superscript are not significantly different.

Table 2 shows the fresh and dry matter weight of okra harvested from T1, T2, T3 and T4 plots. Although there were no significant difference between T3 and T4, fresh fruit weight (FFW) and dry matter weight (DMW) at P<0.05. However, the FFW increased in the following order: T1 (20.24), T4 (22.53), T3 (53.58) and T2 (79.15).The increase in fresh weight of okra due to manure application could be attributed to easy solubilisation effect of released plant nutrient leading to improved nutrient status in the soil (Tiamiyu, *et al.*, 2012).

Table 2: Fresh fruit weight and Dry matter weight of okra

Treatment	Fresh fruit weight (g)	Dry matter (g)
T1	20.24b	6.20b
T2	79.15a	19.32a
T3	53.58ab	11.77ab
T4	22.53b	6.70b

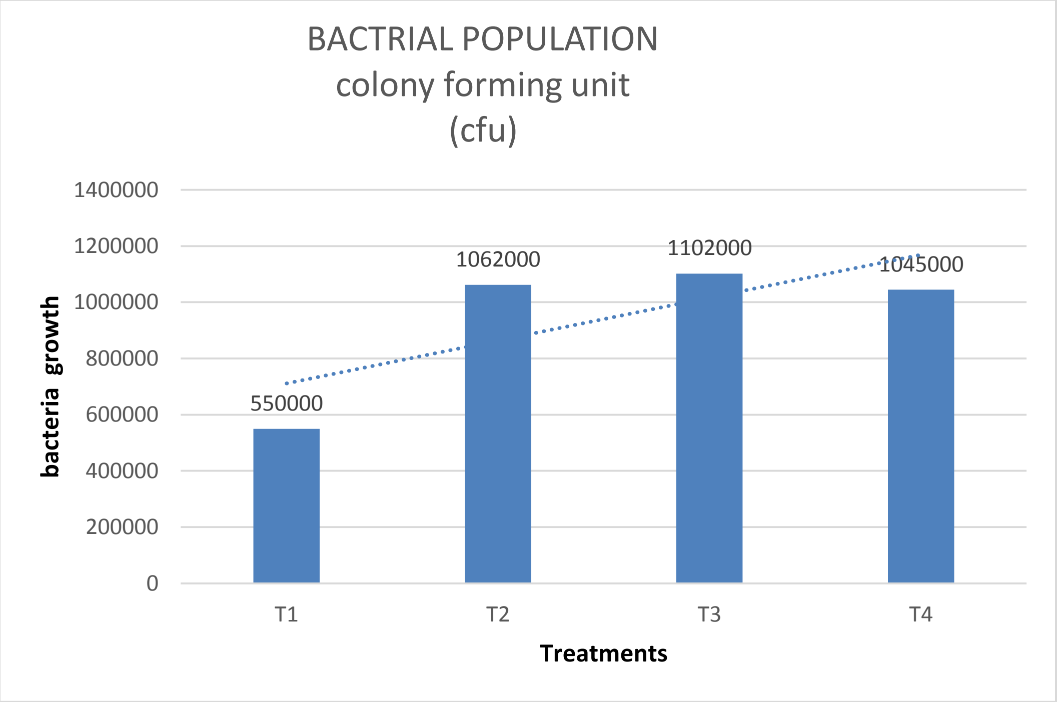
- T1 =Control,T2= Poultry manure+ Cow dung+ Pig manure, T3=Poultry manure+ *Bacillus*+Foliar Blend, T4=Poultrymanure+Bacillus,
- Mean values in column with the same letter are not significantly different.

The results of the post-trial soil properties as influenced by the various treatments are presented in Table 3.The results show that the soil pH, Al, H, PO_4, N, $SO_{4,}$ Mn, Ca, Mg, Na, K, CEC and TOC were not statistically different at $P<0.05$. T2 had the highest pH (5.43) value and this high pH is traceable to the presence of Ca and Mg in the organic material (poultry manure + pig manure + cow dung) used. This finding conforms to the investigation of Whalen *et al.*, (2000) who reported that manure application can cause increases in soil pH values in acid soils. While the decrease in exchangeable acidity agreed with the result of Ewulo (2005) who reported that decrease exchangeable acidity may be due to the presence of Ca and Magnesium in the manures. The phosphorus content was low in T1 (control) whereas, T2 and T3 soils had a higher amount of phosphorus when compared with established critical values of 10-16 mg/kg by Adeoye and Agboola, (1985). The decreased nitrogen content of the soil from T4 to T1 could have been as a result of plant uptake, volatilization and leaching of nitrogen from the soil as reported by Cooperband *et al*., (2002). The highest SO_4 content of the soil was recorded in T1 which justifies the very low pH (4.84) of T1, while T2 recorded the lowest SO_4which explains the reason why T2 had the highest pH (5.64). The Mn content in the treated soils had a mean value between 9.70 – 13.07 cmolkg^{-1} while in the control it was as low as 8.03cmolkg^{-1}.The decrease of Mn in the soil may also be attributed to high uptake of the nutrient by the okra plant. The Ca level of the soil was high when compared with 2.5cmol/kg critical levels recorded by Akirinde and Obigbesan, (2000), also, the Mg content was high (0.61 – 2.69 cmolkg^{-1}) when compared with the critical level of 0.20-0.40cmol/kg established by Adeoye and Agboola (1985). The Na content increased from T1 to T4 with T3 recording the lowest (0.37 cmolkg^{-1}) amount of sodium. Although the Na content was high when compared with 0.02cmol/kg critical levels of Amalu (1997), there was no significant differences in amount between T1, T2, T3 and T4.

Although there was no significant difference between the CEC content of T1, T2, T3 and T4, the CEC content increased with the following order T1, T3, T2 and T4, with T4 showing more capacity for the soil to hold more nutrients. The TOC was observed to increase from T1 to T3, with no significant difference observed between them, the level of Organic matter in the control (T1) was however below the critical level of 20 – 30g/kg as established by Enwezor *et al*., (1979).

This investigation further revealed that the micronutrient (foliar-blend) applied had the ability to re-invigorate natural biological process favourable for the proliferation of the indigenous and introduced decomposing microorganisms in the soil. The bacteria population in the controlled (T1) soil (pH of 5.3) was about 550000 count which was only 15% compared to the population in the other treated plots.T4 had a bacteria population of

1045000 (28%) while T3 had the highest bacteria population count of 1102000.Most of the organisms that constituted these population have been reported by several authors to be involved in natural bio-degradation process which allows the earth to recycle itself that results in higher organic matter and the production of humus; a valuable source of plant nutrition (Agrico, 2016).



- T1 = Control T2 = Poultry manure + Cow dung + Pig manure, T3 = Poultry manure + *Bacillus* + Foliar Blend, T4 = Poultry manure + *Bacillus*,

Fig 1. Bacterial population as influenced by different amendment types

Conclusion and Recommendations

This evaluation revealed that the combination of cattle dung, poultry manure and pig manure in the applied rates had a positive and significant effect on plant height, leaf area and stem girth of okra while the number of leaves were more in plants cultivated in plots amended with poultry manure + foliar blend +*bacillus*. Although the nitrogen content was greater in soil treated with bacteria inoculum, the highest crop yield was obtained from the treatment combination of poultry manure + cow dung and pig dung. These treatments were observed also to be environmentally friendly due to the fact that the population of microbes increased in plots with T3 and T4 plots whereas, the lowest soil organism (bacteria) was found in the control plot (T1) suggesting an assurance in the growth of soil microbes that are capable of enhancing a natural bio-degradation process of nutrient cycling in the soil.

Table 3: Effect of different amendments on chemical properties and particle size distribution of soil

							VARIABLES									
Treatment	pH	AL^{3+}	H^{+}	PO_4	N	SO_4	Mn	Ca	Mg	Na	K	CEC	TOC	SAND	SILT	CLAY
		→ (cmol/kg) ←		mg/kg	g/kg		→		(cmol/kg) ←				→ g/kg ←			
T1	4.84a	0.4333a	0.8060a	19.88a	16.00b	14.24a	8.03a	5.30a	0.768a	0.394a	0.215a	6.970a	16.53a	826.4	10.1	162.5
T2	5.43a	0.2333a	0.5667a	35.56a	19.33a	10.91a	13.07a	6.24a	0.612a	0..398a	0.329a	7.583a	19.77a	822.8	10.9	166.3
T3	5.23a	0.2667a	0.5333a	27.91a	20.33a	10.52a	10.64a	5.77a	2.689a	0.650a	0.274a	9.883a	20.30a	828.5	15.97	158.7
T4	5.34a	0.3333a	0.6333a	33.39a	21.33a	12.61a	9.70a	5.665a	1.675a	0.368a	0.332a	8.040a	20.63a	815.9	15.23	168.8

- T1=Control,T2= Poultry Manure+ Cow dung+ Pig manure, T3= Poultry Manure +Foliar Blend+ Bacillus, T4= Poultry Manure +Bacillus, TRT=Treatment, CEC=Cation Exchangeable Capacity, TOC=Total Organic Carbon
- Means with the same letters do not differ significantly ($P < 0.05$)

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