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EFFECT OF BIO-FERTILIZER FROM ORGANIC RESIDUES ON THE NUTRIENT-DEFICIENT SOIL OF SOUTHEAST NIGERIA AND TOMATO PRODUCTION

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ABSTRACT: *Sustainable crop yield in nutrient deficient soil under continuous cropping system is a challenge and the use of chemical fertilizer is an unsustainable option as it escalates the soil problems. The present study therefore, was carried out to evaluate the fertilizing value of bio-fertilizer from organic residues its effect on nutrient deficient soil of southeast, Nigeria and tomato production. The study was laid out in completely randomized design (CRD), three (3) treatments and four (4) replication. The bio-fertilizer evaluated were; BA – bio-fertilizer made from Bracharia grass and animal manure, BUA – bio-fertilizer made from Bracharia grass + Eupatorium residues + animal manure and CO- control soil that received no application of bio-fertilizer. The result findings indicated significant ($P < 0.05$) difference in all the parameters assessed except for the result of pH, Na and TEA. All the assessed parameters showed increased value in amended soil relative to the control soil. Aggregate stability showed increased value relative to the control soil, while pH, OM, ECEC, number of fruits, weight of fruit and dry matter weight showed result variation of BA>BUA>CO. From the findings of the study it is evident that bio-fertilizer from organic residues can be an efficient alternative soil ameliorant to chemical fertilizer for soil fertility maintenance and sustainable crop production in nutrient deficient soil of southeast, Nigeria.*

KEYWORDS: Animal manure, Bio-fertilizer, Compost, Organic wastes, Tomato.

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INTRODUCTION

The annual crop production growth rate in Nigeria and southeast in particular has be declining of late while consumer prices for food have been on the upturn. Land a factor of production is becoming extremely a limitation due to increase in population, land degradation, erosion menace just to indicate a few. While increasing the area of land for agriculture is restrictive, the option remaining is to increase the productivity of the available land under cultivation. To do this effectively require the use of fertilizer. But in attempt to increase the fertility status of these soils through the use of inorganic fertilizers escalated the soils problem. After the initial success such as increase crop yield, problem such as soil acidification, structural degradation and reduction in organic matter were observed. This rendered the soil coarser and easily erodible. The application of these chemical fertilizers to the soil cause toxicity to some beneficial soil organisms and pollution of ground water with nitrate (NO_3). Leaching of major nutrients like N, Ca and Mg were also observed and water availability become problematic even when the rainfall was adequate and well distributed. The more the inorganic fertilizer was applied the more the yield declined and brought more frustration. It became obvious therefore, that nutrient imbalance like Ca: Mg ratio, K: Ca ratio which may vary with plant species, the availability and cost of the fertilizer and placement of the fertilizer during application as well as undesirable interactions among inorganic fertilizer components need to be addressed. Inorganic fertilizer also impairs crop quality beside the problem of soil fertility. For instance, it has been observed that the medicinal value of maize silk and mistletoe leaves noted for effective antimalarial and anti- high blood pressure materials according to the local maize farmers in the study area diminished when inorganic fertilizer materials were applied continuously. Further these local farmers reported the disappearance of natural organoleptic (taste flavor) quality of yam, cowpea and pepper when inorganic fertilizer was applied.

Animal manure was tried and it proved successful, but animal production was extensive and therefore could not produce sufficient farmyard manure. Larger scale animal product in southern Nigeria was discouraged due to animal pest tsetse fly. Secondly, animal manure differs widely in their properties and characteristics probably due to their differences in the rate of decomposition, mineralization and management and as such their influence in soil productivity and crop yield varied with type of animal manure. Because of these problems, it becomes necessary to seek for alternative sources of fertilizers instead of inorganic fertilizers. An alternative source of manure is the bio-fertilizer made from compost. This create a good environment for soil microbes to thrive leading to the liberation of plant nutrients. Though the fertilizing value of bio-fertilizer depends on the nutrient content of the materials used in the production of the manure. Further the incorporation of the bio-fertilizer to the soil provides protection against soil borne diseases because it enhances the oxygen-ethylene cycle that is deterrent to disease causing organism in soil. Chime et al. (2019) reported significant reduction in nematode attack on Indian spinach following application of bio-fertilizer from organic residues in soil. These bio-fertilizers are very cheap to obtain and does not constitute any danger to soil or crop plant compared to mineral fertilizers. In this particular study Bracharia sp grass and Chromolaena odorata formerly Eupatorium odoratum and two different animal manure will be used to produce the bio-fertilizer. Agriculturally they enrich the soil through the dead leaves and other organic debris that contain substantial number of nutrient elements needed by plants. Nevertheless, the organic residues will be transformed to bio-fertilizer through decomposition before the contained nutrient are made available. Thus, the objective of this

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present study is to evaluate the effect of bio-fertilizer from organic residues on the nutrient deficient soil of southeast, Nigeria and tomato production.

MATERIALS AND METHODS

Two biofertilizer made of Bracharia grass plus animal manure (BA), 10kg animal manure (A):10kg Bracharia grass (B), quantity BA = 20kg and Bracharia grass plus Eupatorium (Chromolaena odorata) residues plus animal manure (BUA), 10kg animal maure:8kg Bracharia grass:2kg Eupatorium residues, quantity = 20kg BUA mixed thoroughly respectively were composted following the procedure already described in an earlier study Nweke (2013)

The study involves two stages – greenhouse and laboratory study

Greenhouse study

5kg subsoil sample were collected from the university of Nigeria Nsukka farm land and thoroughly mixed with 100g bio-fertilizer of BA and BUA respectively were potted into 12 ceramic pots of uniform size and diameter. The experiment was laid out in completely randomized design (CRD) and replicated four (4) times. Five (5) seeds were planted per pot in the 12 ceramic pots which later thinned down to two plants after establishment. At the end of the study, plant height, number of fruits, weight of fruit and dry matter were determined by measurement, counting, oven drying and weighing where applicable.

Laboratory study

The following laboratory analysis before and after harvest were analyzed

The pH was determined in water using digital pH meter in soil: liquid ratio of 1:2.5. The exchangeable K and Na was determined by ammonium acetate saturation method using atomic absorption spectrophotometer. Total exchangeable acidity (TEA) was determined using displacement method of Mclean (1965). Base saturation (BS) was calculated using;

% BS = TEB/CEC x100

TEB = total exchangeable base

CEC = cation exchange capacity

Electrical conductivity was determined using soil water ratio 1:2.5 and values read off using digital conductivity meter while total dissolved cation was analyzed using solid digital meter.

Water stable aggregate were expressed as percentage water stable aggregates (WSA) using the formula;

$$\text{WSA} = \frac{Ma+s-Ms}{Mt-Ms}\ x\ 100$$

Where;

Ma+s = mass of the resistant aggregates plus the sand fraction (g)

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Ms = Mass of the sand fraction alone (g)

Mt = Total mass of the sieved soil (g)

Aggregated silt + clay (ASC) was calculated using the formula;

ASC = % silt + clay in water - % silt + clay in calgon

RESULTS AND DISCUSSION

The result presented in Table 1 showed the physicochemical properties of the soil before the beginning of the study the soil is acidic and low in chemical nutrients, while their concentration in the bio-fertilizers were found to be high. Thus, indicating that the soil and tomato plant will benefit from their application.

Table 1. Nutrient content of soil and the bio-fertilizer before mixing with the soil and planting

Parameter	Soil	Poultry	Pig	Biofertilizer BA	Biofertilizer BUA
Sand gkg^{-1}	850				
Silt gkg^{-1}	50				
Clay gkg^{-1}	140				
TC	LS				
pH H2O	4.70	34.5	49.54	6.49	6.59
OC %	0.57			21.96	25.80
TN %	0.073	13.93	7.84	0.56	0.75
Avail. P $mgkg^{-1}$	0.85	2.97	2.10	16.09	18.52
CEC $cmolkg^{-1}$	8.00	22.68	10.99	10.46	13.59
Ca $cmolkg^{-1}$	0.81			5.91	6.41
Mg $cmolkg^{-1}$	0.52	7.85	2.91	2.61	3.95
K$cmolkg^{-1}$	0.15	5.54	1.85	0.85	0.96
Na $cmolkg^{-1}$	0.11	1.53	0.65	0.51	0.45
Water retention	5.403	0.72	0.44	17.89	16.35
Aggregate stability %	57.87			99.14	99.17
BD gcm^{-3}	1.316				

Effect of bio-fertilizer from organic residues on the physicochemical properties of the soil

The result of the physicochemical properties of the studied soil recorded in Table 2 showed that the bio-fertilizer amendment enhanced both the physical and chemical parameters of the studied soil. The result of the physical parameters showed that the recorded values differed significantly ($P < 0.05$) among the treatments. The soil aggregation tested with WSA and ASC showed a variation of BA>BUA>CO. The percentage increase in the aggregate stability over the control were; 37.48%, 145.78% (BA) and 20.84%, 133.58% (BUA) respectively for WSA and ASC. The increased result might be associated with high OM supplied to the soil by the

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amendments which help in binding the soil particles together. Organic matter is a major soil particles binding agent that bind soil particles into aggregates of which is very essential for optimum soil productivity.

The chemical parameter results showed significant ($P < 0.05$) difference among the treatments except for the result of pH, Na and TEA. The pH showed higher value in treated soil compared to the value obtained from the untreated soil. The increased value probably may be due to release of Ca and Mg from decomposed bio-fertilizer and removal of Al ion from the exchange site of the soil. All the values recorded from amended soils when compared with the control values showed remarkable increases in all parameters tested. This probably may be that bio-fertilizer contains high levels of these nutrients and in available form. Increases in these nutrients appeared to be linked directly to their higher contents and values as recorded in Table 1. The result of pH, OM and ECEC showed variation of BA>BUA>CO, while the result of K, Na, EC, BS and dissolved soluble cation showed result variation of BUA>BA>CO. The observed increased soil properties were due to mineralization of the applied bio-fertilizer with the consequent release of nutrients. In the amended soils increases in the tested parameters varied with the treatment type and the highest increment in the recorded value were specific with the treatment type. The decrease in the total exchangeable acidity (TEA) in amended soil with respect to control soil may possibly be as a result of removal of Al from soil exchange site following neutralization reaction of Al by Ca and Mg by bio-fertilizer addition. This observation corroborates similar results of Datta et al. (2009), Nnabude et al. (2015) and Nweke and Chukwuma (2023).

Table 2. Effect of bio-fertilizer from organic residues on the physicochemical properties of the soil

Treatment	WSA%	Agg. Silt+ clay%	pH H_2O	OM	ECEC	K	Na	TEA	Dissolve cation	EC $uscm^{-1}$	BS %
					$cmolkg^{-1}$						
BA	11.74	22.46	6.95	2.72	8.71	0.76	0.47	0.73	0.68	275	89.97
BUA	10.32	21.35	6.94	2.59	7.93	0.96	0.54	0.89	0.89	284	92.72
CO (soil)	8.54	9.14	5.96	0.96	3.58	0.57	0.37	1.12	0.25	106	68.51
LSD0.05	1.65	1.53	NS	0.39	0.68	0.18	NS	NS	0.05	17.33	3.88

Germination, growth and yield

A total of 60 seeds were planted in the 12 ceramic pots during the planting period. Total germination count taken on the 7th day after germination recorded 97.5% germination for BA, 87.5% germination for BUA and 60% for the control soil respectively. The result showed relatively an excellent result. Germination rate and early growth were influenced by the bio-fertilizer addition because by the 3rd day after planting germination of rate 2-4 have been recorded in each pot of the amended soil relative to 0 (zero) plants observed in the control soil.

The growth rate monitored in terms of increase in plant height as influenced by the bio-fertilizer are shown in Table 3. Average plant height increased in the amended soils relative to the control soil. Similar findings were reported by Nsoanya and Nweke (2015). The trend in the result of

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number of fruits, weight of fruit and dry matter weight is similar to that of plant height in the sense that the values recorded are significantly ($P < 0.05$) different among the treatments and higher values were recorded in the amended soils relative to the control soil. In most of the parameters the differences in value between BA and BUA treatments were not high but the differences in value between the amendments and control soil were very high in most parameters. Number of fruits, weight of fruit and dry matter showed a result variation of BA >BUA>CO. The percentage increase in weight of fruit and dry matter relative to the control were; 145.80%, 283.83% (BA) and 133.71%, 245.36% (BUA) respectively. The observed increases and differences in the values of the parameters tested could be attributed to higher content of nutrients and differences in plant nutrients in the rate of amendment applied. Crop yield improvement on treatments with organic wastes materials were likely due to enhanced nutrient status of the soil following bio-fertilizer addition. Similar results were reported in the studies of Mikhailouskaya and Bogdevitch (2009), Nnabude et al. (2015, 2020) and Nweke and Chukwuma (2023).

Table 3. Effect of bio-fertilizer from organic residues on the growth and yield of tomato

Treatment	Plant height cm	No. of fruits	Weight of fruits g	Dry matter weight g
BA	49.30	9.75	62.85	50.09
BUA	52.08	8.79	59.76	45.07
CO (soil)	30.02	6.0	25.57	13.05
LSD0.05	3,09	1.89	3.78	2.79

CONCLUSION

The result findings of the study are of evidence that bio-fertilizer made from Bracharia grass, Eupatorium odoratum in combination with animal wastes are an efficient organic manure. Through their nutrient content and mineralization have been able to effectively restore the fertility of the nutrient deficient soil. The physicochemical properties, tomato growth and yield parameters were adequately improved, indicating the potentiality of bio-fertilizer application in increasing yield along with sustainable soil productivity. The farmers are advised therefore, to embrace this technology as the data generated from the study have shown the capability of bio-fertilizer in nutrient release and mineralization hence an element of nutrient management to be considered in organic agriculture and greenhouse farming.

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AUTHOR CONTRIBUTIONS

Nweke Ikechukwu Aloysius: The head of the team, initiator of the research work and the author of the paper.

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Igili Daniel Nnaemeka: Field data collection and literature review

Ngonadi Emmanuel N: Statistical analysis of the data generated

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