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Influence of Poultry Manure and Biochar (Maize husk) on Soil Properties, Microbial Population, Growth and Yield of Tomato (*Lycopersicon esculentum* Mill) in an Alfisol.

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ABSTRACT:
The current global scenario firmly emphasizes the needs to adopt eco-friendly agricultural practices for sustainable use and food production. The cost of inorganic fertilizer is increasing enormously to an extent they are out of reach to small scale and marginal farmers. Therefore, the experiment was conducted to assess the condition of poultry manure and biochar (maize husk) on the growth, soil properties, microbial population and yield of tomato. It was a screenhouse experiment carried out at the Federal College of Forestry Ibadan, using polyethylene bag with 5 kg soil collected at 15-30cm depth at the Botanical garden, Federal College of Forestry Ibadan and sieve with a 2mm sieve. The experiment was a Completely Randomized Design (CRD), replicated four times. The treatments used were poultry manure (5t/ha), biochar (10t/ha) and mixture of poultry manure and biochar (1:1), (2:1) and control (no amendment). The treatments were mixed with the soil and left for 2 weeks. The tomato seeds were sourced from Nihort, Ibadan and raised in a nursery for 2 weeks before transplanting into the polyethylene bags. Data were collected weekly for 6 weeks after transplanting on plant height, collar diameter, number of leaves, flowers and yield of tomato plants. Data analysis was through descriptive statistics and ANOVA means were separated using LSD ($p<0.05$) where applicable. In 15-30 cm soil, there was no significant difference in the number of leaves of tomato among all the amended soil from 2 to 4 WAT, the least tomato leaves were obtained when the soil was not amended and was significantly lower compared to other treatments. Collar diameter was significantly higher at 2 and 3 Weeks After Transplanting (WAT) in the amended soil compared to the unamended. Mixture of poultry manure + biochar (2:1) gave the highest tomato flower and fruits. There was variation in the microbes isolated with different application of compost (Soil amendment) in the post harvested soil as compared with the pre-cropping soil. The application of both amendment (Biochar and Poultry Manure) also boosted the mineralization of the soil after amendment.

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I. INTRODUCTION

Since green revolution, it seems that application of inorganic fertilizer is hardly avoided in increasing crop production. The advantage of inorganic fertilizers, indeed, has been proven widely to have very spectacular results. It is able to make the production doubled, or even tripled compared to world crop production. However, the phenomena of decreasing soil quality, on the other hand to obtain the same yield, the rate of inorganic fertilizer application steadily increases from year to year. The application of chemical fertilizer is not also capable of maintaining yield increase (Islamieset al., 2011). In line with that, it has been widely realized that application of excessive inorganic fertilizer, especially nitrogen, causes soil deterioration and many environmental problems (Haines and Naidu, 1998; Liu et al., 2010; Vitosueket al., 1997). The common technology for increasing fertilizer efficiency is integrated crop management which includes the application of organic manure and other organic materials to soil (Fageria and Baligar, 2005). However, it is known that under wet tropical condition, organic materials put into the soil will be decomposed very rapid. In addition, to make higher cost of organic materials application, it is now realized that the rapid decomposition and mineralization of organic materials have a significant contribution to global warming (Jenkinson et al., 1991).

Biochar is used as a soil amendment to improve soil nutrient status, C storage and/or filtration of percolating soil water (Lehmann and Joseph, 2009). Biochar from pyrolysis and charcoal produced through natural burning share key characteristics including long residence time in soils and a soil conditioning effect (Glaser et al., 2002). Research has claimed that application of biochar can increase soil organic carbon (SOC), improve the supply of nutrients to plants and therefor enhance plant growth and soil's physical, chemical, and biological properties (Glaser et al., 2002; Rondonet al. 2007). Biochar has the potential to increase nutrient availability for plants (Lehmann et al., 2003). Nutrient availability can be affected by increasing cations exchange capacity, altering soil pH, or direct nutrient contributions from biochar.Currently biochar is being used in many different ways both in agriculture and horticulture and in industry at large. The high adsorptive rate of biochar not just for CO_2 in the air but also for smells and liquids has intrigued many members of industry. Biochar is starting to be used in animal farming, in the building industry, in decontamination, textiles and in the treatment of both waste and drinking water. Noticeable experiments include the ability of biochar to reduce carbon in the air. It is of particular interest due to its potential on rectifying the problems of global warming. In the United Kingdom, the research has been focused on whether biochar would be a good replacement for peat moss as a soilless amendment. The drawback to this is that the biochar is an expensive product, although it is produced from by-products the process of pyrolysis is expensive (Jekinsonet al., 1991).

Poultry litter is a promising material for organic manure. The majority of poultry litter is disposed of through land application and many regions with intensive poultry production have more phosphorous (P) than local crops require (Maguire et al., 2007). Land application of manure is heavily regulated to control the fate of manure nutrients (DCR, 2005). P based nutrient management is important because it prevents the over application of P and therefore protects freshwater ecosystems from surface runoff as P is a major cause of eutrophication (Steiner et al., 2007) Due to the regulation of land application of P, much of the poultry litter has to be transported off the farm and the distance that the litter can be transported is limited by cost (Harmelet al., 2008).

Tomato is one of the important vegetable crops grown throughout the world and ranks next to potato in terms of the area but ranks first as a processing crop. In India, it occupies an area of 571.70 M ha with a production of 10054 million tones with a productivity of 17.58 Mt/ha. Karnataka is one of the important tomatoes growing states covering an area 47.2 M ha with a production of 1285.10 million tones with a productivity of 27.2 Mt/ha (Anon., 2008).

Since biochar and poultry manure affects the soil properties, influences the microorganisms in the soil and improves crops performances, there is an increasing interest in understanding their potentials synergies in crop production so as to improved agricultural practices that can helpmitigate climate change by reducing emissions from agriculture and other sources and by storing carbon in plant biomass and soils. Therefore, the objective of this study is to evaluates the influences of poultry manure and biochar on the growth, soil properties, microbial population and yield of tomato.

II. MATERIALS AND METHODS

The organic manures (Poultry Manure and Biochar) were analyzed for the nutrient status and microflora present in them following standard methodologies and the results are presented in table A and B respectively. The trial was aimed to study the influence of the manure o the growth, soil properties, microbial population and yield of the tomato. An experiment was carried out at the screenhouse Federal College of Forestry Jericho Hill Ibadan, South West Local Government of Oyo State. It lies within the tropical rain forest region of Nigeria and rainfall pattern ranges between 1000mm-1500mm. The average day temperature of the area is 35^{o}C and relative humidity of is 65% all year round except in January when dry winds blows from the north (Olaniyi, 1997).

The seeds of tomato cultivar (UC82B) was obtained from the National Horticultural Research Institute, Ibadan (NIHORT). The bulk soil samples (15-30cm depth) used for the planting was collected from the Botanical garden site Federal College of Forestry Ibadan. Poultry manure was collected from the poultry farm of The Federal College of Forestry Ibadan, Oyo State (animal section unit).The biomass for biochar (maize husk) was obtained from The Federal College of Forestry Ibadan, Oyo State, dried and then pyrolyzed using a biochar reactor at a starting temperature of 171^{o}C, final temperature at which the biomass got charred at 353^{o}C and atmospheric temperature of 36^{o}C.

Tomato seedlings were raised in a nursery tray for 2 weeks, viable seedlings were selected. Soil was mixed with treatments at a different level at two weeks before transplanting and seedlings were transplanted into the pots at a rate of one (1) seedling per pot.The tomato seedling was selected from the wooden box at random since they had relatively uniform growth as a result of uniform treatment provided in the nursery bed. Control experiment for each tomato was also set up in such a way that no organic manure was applied to the soil prior to planting.Treatments used were: biochar (10t/ha), poultry manure (5.0t/ha), poultry manure+ biochar (1:1) poultry manure+ biochar (2:1) and control. It was a completely randomized design with 4 replicates.

Data Collection: The following parameters were assessed: Plants height (cm) using meter rule, collar diameter (cm) veneer caliper, numbers of leaves, numbers of flowers, fresh weight of yield (g/pot) using sensitive scale, soil samples for post analysis, microbial counts.

Laboratory analysis: Pre-cropping soil and Post soil Analysis: pre cropping soil analysis was done before the experiment and post planting was done after the experiment to determine the nutrient contents of the soil and the treatments.

Soil samples were taken to the laboratory to assess the changes of microbes in the soil before and after the experiment.

Data Analysis:Analysis of Variance (ANOVA) was conducted on all data collected and means were separated using LSD at the 5%. Probability level

III. RESULTS AND DISCUSSIONS

Soil Chemicals and Physical Properties: The chemical properties of the soils (15-30cm) at the experimental sites used in this experiment was shown in table 1. The pH for the soil at 15-30cm was 5.9. The organic carbon content in the soil was 0.11 g kg^{-1}. The total N at the level was 0.25 g kg^{-1}. The level of available P and exchangeable K was modest at the soil depths. Textural class for soil depths is loamy sand.Chemical properties of the compost (Biochar and Poultry manure)The pH for the biochar was 6.4 while that of poultry manure was 6.1. The organic carbon content of biochar is hundred times higher than poultry manure. The total N in biochar is 100% lower than the value of N in poultry manure. The available P and exchangeable K in biochar is 1000times lower than the available P and K in poultry manure.

Table 1: Physico-chemical properties of soil, Biochar and Poultry manure used

Properties	15-30cm	biochar	Poultry manure
pH($H_2$0)	5.9	6.4	6.1
Organic carbon (g kg^{-1})	0.11	84.5	15.7
Total nitrogen (g kg^{-1})	0.25	0.5	2.6
Available phosphorus (mg kg^{-1})	11.1	0.2	12.7
Exchangeable cations (cmol kg^{-1})			
Ca	19	6.25	54
Mg	0.89	0.4	6.3
K	0.20	0.2	38
Na	0.36	15	25
Extractable micronutrient (mg kg^{-1})			
Cu	1.40	0.01	1.3
Fe	30.5	0.9	12.6
Zn	32		
Mn	20	0.00	0.03
Particle size distribution (g kg^{-1})			
Sand	820		
Silt	60		
Clay	120		
Textural class	Loamysand		
Microbial counts	$4.3x10^7$		

Plant height was significantly affected by various treatments at 2 weeks after transplanting(WAT) The average plant height increased with different levels of the treatments used .Interaction of poultry manure and biochar (1:1) resulted in highest height of tomato plant at both 3 and 4WAT as compared to the control but was not significantly different from the sole application of Biochar(10t/ha) and Poultry Manure(5t/ha) respectively. At 5, 6, 7 WAT sole application of poultry Manure (5t/ha) gave the highest plant height, the least plant height was obtained when soil was not amended and was significantly lower compared to other treatments. Among the amended soil, tomato plant height was not significantly different irrespective of the amendments used.

Table 2: Plant Height (cm) of Tomato as Influenced by Poultry Manure and biochar in 15-30cm soil under Screenhouse Conditions

Treatments	Weeks after transplanting					
	2	3	4	5	6	7
No amendment	9.05	14.20	19.75	20.15	21.83	24.50
Biochar	11.22	16.77	22.00	22.40	26.50	32.80
Poultry Manure	11.20	16.90	23.00	26.83	29.62	36.50
PM+ Bio (1:1)	12.50	18.40	23.88	26.32	29.30	36.20
PM+ Bio (2:1)	10.05	15.93	20.50	22.95	27.30	32.90
LSD	1.129	NS	NS	NS	NS	NS

Keys: Poultry Manure (PM), Biochar (BIO), Poultry Manure + Biochar (PM+BIO), Control (No amendment).

There was no significant difference in the number of leaves of tomato among all the treatments from 2 to 4 WAT in the 15-30cm soil depth. However, at 5WAT the least tomato leaves was obtained when the soil was not amended and was significantly lower compared to other treatments. Among the amended soil, the number of leaves of tomato was not significantly different irrespective of the amendment applied. At 6WAT, application of poultry manure + biochar (2:1) recorded the highest number of tomato leaves and was significantly higher when compared with the control (no amendment). There was no significant differences in the number of tomato leaves among other treatments. At 7WAT, the highest number of tomato leaves was obtained under the application of poultry manure (5t/ha) and was significantly higher when compared with the control (no amendment). Among the amended soil, the number of leaves of tomato was not significantly different irrespective of the amendment applied.

Table 3.: Number of leaves of Tomato as Influenced by Poultry Manure and biochar in 15-30cm soil underScreenhouse Conditions

Treatments	Weeks after transplanting(WAT)					
	2	3	4	5	6	7
No amendment	16.25	21.50	27.00	26.20	29.11	31.50
Biochar	18.25	24.00	37.00	36.80	39.03	41.75
Poultry Manure	21.25	27.50	38.20	39.80	42.30	45.60
PM+ Bio (1:1)	20.50	31.00	35.80	38.20	39.73	43.50
PM+ Bio (2:1)	21.00	31.20	36.80	43.50	43.53	44.75
LSD	NS	NS	NS	9.36	11.01	6.61

There was no significant difference in the collar diameter of tomato plant among all the treatments from 4 to 7 WAT in the 15-30cm soil depth . However, the highest collar diameter was obtained when the soil was amended with poultry manure + biochar (2:1) and poultry manure (5t/ha) at 4 and 5 WAT respectively while the least collar diameter was observed when the soil was not amended.

At 2WAT, application of poultry manure + biochar (1:1) recorded the highest collar diameter of tomato plant and was significantly higher when compared with the control (no amendment), among the amended soil, collar diameter of tomato was not significantly different irrespective of the amendment applied. At 3WAT, the highest collar diameter was obtained under the application of poultry manure (5t/ha) and was significantly higher when compared with the control (no amendment). Among the amended soil, the collar diameter of tomato was not significantly different irrespective of the amendment applied. At 5 and 6 WAT, the least collar diameter was obtained when the soil was not amended and was significantly lower compared to other treatments.

Table 4: Collar diameter (cm) of Tomato as Influenced by Poultry manure and Biochar in 15-30cm soil under Screenhouse Conditions

Treatments	WEEKS AFTER TRANSPLANTING					
	2	3	4	5	6	7
No amendment	1.10	1.41	1.61	1.75	1.88	1.90
Biochar	1.33	1.75	1.84	1.95	2.00	2.15
Poultry Manure	1.39	1.80	1.93	2.01	2.11	2.18
PM+ Bio (1:1)	1.58	1.73	1.88	1.93	1.91	2.00
PM+ Bio (2:1)	1.33	1.70	1.93	1.99	2.01	2.13
LSD	0.09	0.07	NS	NS	NS	NS

Table 5 shows that flower developments started about 6 weeks after transplanting in all plots that received treatments at the soil depth 15-30cm. Combined application of poultry manure+ biochar (2:1) gave the highest number of tomato flowers among other treatments used at 8 & 9 weeks after transplanting. The highest fruit yield was obtained under the application of PM+BIO (2:1), the least fruit yield was observed from plots treated with biochar (10t/ha) and PM+BIO (1:1) and poultry manure (5t/ha) respectively at 8 weeks after transplanting while the control plot produced no fruit. There was variation in the microbes isolated with the different applications (Amendment) used in Table 6.

Table 5: flowering &Fruits of Tomato as Influenced by Poultry Manure and biochar in 15-30cm soil under Screenhouse Conditions

	flowering				fruits		
Treatments	6	7	8	9	7	8	9
Control	0.00	0.00	0.25	0.25	0.00	0.00.	0.00
Biochar	0.25	1.25	1.00	0.75	0.00	0.25	0.00
PM	0.50	1.00	1.25	1.00	0.25	0.10	0.00
PM+BIO(1:1)	0.25	1.00	0.25	0.75	0.00	0.25	0.00
PM+BIO(2:1)	0.50	1.75	2.52	2.25	0.00	0.50	0.50
LSD	NS	NS	NS	NS	NS	NS	NS

Table 6: Microbial population isolates and identification from soil (post analysis)

Total viable count (cfus/ml)	15 – 30 cm soil
Control	$4.8x10^7$
Organisms Isolated	bacillus, pseudomonas sp and staphyloccocuss
Biochar	$5.7x10^7$
Organisms isolated	Bacillus spp; pseudomonas sp; Staphylococcus sp; flavobacterium sp
Poultry Manure	$6.3x10^6$
Organisms isolated	Bacillus spp; pseudomonas sp; Staphylococcus sp;flavobacterium sp
PM+BIO(1:1)	$6.9X10^6$
Organisms isolated	Bacillus spp; pseudomonas sp; Staphylococcus sp; flavobacterium sp
PM+BIO(2:1)	$4.9X10^6$
Organisms isolated	Bacillus spp; pseudomonas sp; Staphylococcus sp; flavobacterium sp

0-15cm depth shows that the increase in the growth of tomato plant in 0-15cm depth of soil was as a result of Nitrogen(N) ,Phosphorus(P) and potassium (K) availability to the medium. This is in line with the report of Fried and Bache E.T and F.DHelathcote (1969) that low availability of N,P,K in soil reduces crop productivity and yield. They also pointed out that low availability of K distorts N metabolism in plants tissue. Obviously, soil amended with poultry manure and biochar favor early growth and fruiting considering the reduction in Days of 50% flowering (Table 7)

Table 7. Soil Chemical Properties as Influenced by Poultry Manure, Biochar and itsCombinations after Harvesting

Treatments	pH	Total N g/kg	P Mg/kg	K Cmol/kg	O.Carbon g/kg
Control	6.4	0.9	16.1	0.88	51
Biochar	6.3	1.1	20.1	1.00	73
P.M	6.6	1.3	22.1	0.99	29
PM+BIO(1:1)	7.1	1.5	19.1	1.1	61
PM+BIO(2:1)	7.1	1.2	21.7	1.O	58

Conclusion

The study was carried out in the screen house of Federal College of Forestry, Ibadan, Nigeria to evaluate the influence of poultry manure and biochar on selected morphological growth and yield of tomato plants as well as the microbial counts. In 15-30cm soil, number of leaves showed increased response to combined application of poultry manure PM+BIO (2:1) and poultry manure (5t/ha). Plant height also showed increase response to combined application of PM+BIO (1:1) andpoultry manure (5t/ha).Combined application of PM+BIO (2:1) at 15-30cm soil depth gave the highest fruit yield of tomato. There was variation in the microbes isolated with different applications of amendment in the post harvested soil as compared with the pre cropping soil.

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