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Full Length Research Paper

Effects of poultry manure on selected soil physical and chemical properties, growth, yield and nutrient status of tomato

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In order to study the effect of poultry manure additions on nutrient availability, soil physical and chemical properties and yield of tomato, five levels of the manure, namely 0, 10, 25, 40 and 50 t ha^{-1} were applied at Akure, Southwest Nigeria. The soil at the two experimental sites were slightly acidic, low in organic matter, N, P, and Ca. Poultry manure increased soil organic matter, N and P. Soil bulk density were reduced and moisture content increased with levels of manure. Manure applications increased leaf N, P, K, Ca and Mg concentrations of tomato, plant height, number of branches, root length, number and weight of fruits. The 25 t ha^{-1} poultry manure gave highest leaf P, K, Ca and Mg and yield relative to control. The 10, 25, 40 and 50 t ha^{-1} manure levels increased average fruit weight by 58, 102, 37 and 31% respectively.

Key words: Poultry manure, nutrient availability, soil physical properties, soil chemical properties, tomato yield.

INTRODUCTION

Tomato is herbaceous, usually sprawling plant in the Solanaceae or nightshade family, grown widely for its edible fruits. China is the leading producer with 32,540,040 metric ton (FAO, 2008). United state, the leading importer of fresh tomato received 25 percent of the global value and volume. Nigeria annual population growth rate exceeds its food production, being 2.7 and 2.9 respectively between 1990 and 1997, which narrowed to 2.6 and 2.7 between 1998 and 2003 (FAO, 2006) necessitating food importation. Total tomato production in Nigeria varies between 889000 and 898000 from year 2004 and 2007 (FAO, 2008) . The average tomato yield (*Lycopersicum esculentus*) in Nigeria is 10 t ha^{-1}, which is lower than 13.5 t ha^{-1} average yield in tropical Africa and world average of 22 t ha^{-1} (FAO, 1993).

Tomato paste market continues to grow resulting in expanded import into the West African countries of Nigeria, Ghana, Togo and Benin. According to Global Trade Atlass (GTA), Nigeria became Italy's second largest export market for paste in year 2003 with shipments value at fifty million dollars. Among the factors that contribute to low tomato yield in Nigeria is low soil fertility and unfavourable soil physical properties such as bulk density (Adekiya and Ojeniyi, 2002). Although studies conducted in the tropics showed significant increase in nutrient status and yield of tomato due to application of inorganic fertilizers (Sobulo et al., 1975; Saxena et al., 1975), high cost and scarcity of inorganic fertilizer pose constraints to its use especially among small-scale farmers in Africa (Ogbalu, 1999). Also attendant soil acidity, nutrient imbalance and soil physical degradation hinder sustainable use of inorganic fertilizers in the tropics. Hence research attention recently shifted to use of animal wastes, which are abundantly produced (Olayinka, 1990; Nwajiuba and Chimezie, 2000) and poses disposal and environmental problems. Efforts should be made to use farm wastes and organic manures in vegetable production in Nigeria.

There are few studies on utilization of poultry manure in tomato production in Nigeria, and information about

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effects on soil physical properties and nutrient uptake, and sustainability of tomato production systems is scarce. Adediran et al. (2003b) compared poultry manure, household, market and farm waste and found that poultry manure at 20 t ha had highest nutrient contents and mostly increased yield of tomato and soil macro and micronutrients content. Akande and Adediran (2004) found that poultry manure at 5 t ha^{-1} significantly increased tomato and dry matter yield, soil pH, N, P, K, Ca and Mg and nutrient uptakes. Aluko and Oyedele (2005) found little information on the effects of organic waste on soil physical properties and they observed that poultry manure incorporation had no significant effect on soil density and porosity. The work being reported studied the effect of different levels of poultry manure on soil bulk density, moisture content, nutrient status, growth and fruit yield of tomato

MATERIALS AND METHODS

Climate of the site

Field experiments were carried out at the Federal College of Agriculture (FECA) and Federal University of Technology (FUTA), Akure, in rainforest zone of Southwest Nigeria, an area subjected to marked wet and dry season with a bimodal rainfall pattern. The two rainfall peak makes two growing season possible. There is heavy rainfall in May-June-July, which is interrupted by a dry period of about two weeks in August; this is followed by another period of heavy rainfall from September to October. Dry season length is between 120 -130 days, its finishing date is (at 0.5 probability) is end of Annual rainfall is between 2.0 to 2.5 m; annual temperature range is about $12^{O}C$, relative humidity is never below 70% at 9.a.m.

Soil of the site

Soil at both sites is formed over medium grained granitic gneiss parent material and basement complex parent rock. Soil profile examination by Ewulo et al (2002) reveal pronounced gravel layer between 20 – 40 cm depths and horizon of clay accumulation with depth that satisfied criteria for argillic horizon designation (Soil Survey Staff, 1998).

Experimental layout

The sites had been cultivated to maize and Cassava before being left to fallow for 10 and 8 years respectively. Five levels of poultry manure namely: 0, 10, 20, 40 and 50 t ha^{-1} were tried on tomato plants during early and late 2006 planting season in each site. The treatments were replicated three times using a randomized complete block design.

Tomato seedlings (Roma VF) were raised in the nursery for three weeks and transported to ploughed and harrowed land at 75 x 50 cm spacing. Poultry manure was stacked under a shed and was air-dried for five weeks before application by ring method two weeks after transplanting of seedlings. Each of the plots in each experiment had 66 plants. The early and late crops were planted in May and August respectively. Staking of plants was done and manual weeding was carried out three times.

Growth and yield data

At 6 weeks after treatment application, data on plant height, number of branches, Tap root length, were taken using 10 selected plants per plot. Ripe fruits were harvested two times in a week as from fifth week after treatment application. The number and weight of fruits were taken.

Soil analysis

Surface (0 – 15 cm) soil samples were taken over each site before start of experiment. The samples were bulked and air-dried for analysis. After the experiment, samples were taken again per plot for routine analysis as described by Carter (1993). Organic matter (O.M) was determined by Walkley-Black dichromate digestion method (Nelson and Sommers, 1982) and total soil nitrogen was determined by the kjeldahl method (Bremner and Mulvancy, 1982). Available P was determined by Bray-1 method and colour was developed in soil extracts using the ascorbic and acid blue colour method (Murphy and Riley, 1962). Exchangeable K, Ca and Mg were extracted using ammonium acetate. K was determined on flame photometer and Ca and Mg by EDTA titration. The soil pH in 0.01 M $CaCl_2$ was determined using a glass electrode.

Leaf and manure analysis

At the starting of flowering, leaf samples were collected per plot and oven dried at 80^{O} C for analysis (IITA, 1979). Dried samples were ground in a waley and mill and ignited at $450^{O}C$ for 2 h, the ash was extracted with HCl. The P was determined by ammonium molydate/ammonium vanadate method and K by flame photometry and Ca and Mg by EDTA titration. Determination of N was by the kjeldahl method. Air – dried and ground manure samples were sieved through 2 mm sieve, and N, P, K analyzed using similar methods as for leaf analysis.

Data analysis

Mean soil and plant data covering early and late crops at each site were obtained and subjected to analysis of variance. The Duncan multiple range test was used to compare means for treatment effects.

RESULT

The sandy loam soils at FECA and FUTA sites of (Table 1) experiment were slightly acidic, low in organic matter (O.M), total N, available P and Exchangeable Ca. In the present study (Table 2), it was found that poultry manure additions at 10, 25, 40 and 50 t ha^{-1} increased soil O.M, total N and available P. the values of SOM and P tended to increase with increased level of manure. At FUTA site, soil- N also increased with level of poultry manure. Mean manure properties were 1.7% N, 0.26% P and 2.38 % K.

Poultry manure additions up to 50 t ha^{-1} improved soil physical properties as indicated by reduction in soil bulk density and increased in soil moisture content (Table 3). Bulk density and moisture content reduced and increased with level of manure respectively. The correlation coefficient recorded for relationships between level of manure and soil bulk density and moisture content were – 0.83 and 0.99 respectively. A positive correlation was recorded between organic carbon and the mean weight diameter of soil aggregates.

Table 1. Analysis of soil at FECA and FUTA Sites in Akure.

Soil Property	FECA	FUTA
Sand %	46.0	44.1
Silts %	28.2	25.4
Clay %	25.8	30.5
O.M %	1.47	1.53
Total N %	0.13	0.14
Available P	5.8	10.5
Exch. K cmol/kg	0.44	0.31
Exch. Ca cmol/kg	1.77	1.23
Exch. Mg cmol/kg	0.98	0.50
pH ($CaCl_2$)	6.1	6.3

Table 4 shows the effect of poultry manure treatments on the leaf macronutrient status of tomato. Compared with the control, application of manure increased leaf N, P, K Ca and Mg concentrations. The 25 t ha^{-1} manure gave highest values of leaf P, Ca and Mg at both sites of study. At FECA site, the treatment also gave highest value of leaf K concentration. Leaf N tended to increase with level of manure up to 50 t ha^{-1}. Hence the correlation coefficient between level of manure and leaf N was the highest. The correlation coefficients for the relationship between level of poultry manure and leaf N, P, Ca and Mg concentrations were 0.99, 0.92, 0.90, 0.92 and 0.89 respectively. Table 4 also shows that 25 t ha^{-1} gave highest leaf P, K, Ca and Mg concentration

Data on growth of tomato plant in response to applications of poultry manure are presented in Table 5. At FECA and FUTA sites, plant height, number of branches and taproot length increased with the level of manure. The effect of manure on the growth parameters was significant according to DMRT (Table 6). The correlation coefficients recorded for the relationships between level of poultry manure, and plant height, number of branches and root length were 0.98, 0.96 and 0.97 respectively.

The correlation coefficients for relationship between soil bulk density and root length, number of branches and plant height were - 0.91, - 0.84 and - 0.90 respectively. In the present study the correlations between soil bulk density and leaf N, P, Ca and Mg were - 0.90, - 0.86, - 0.92, - 0.91 and - 0.78 respectively. The correlations between soil moisture content, and leaf N, P, K, Mg and Ca were 1.00, 0.93, 0.94, 0.89 and 0.95 respectively.

DISCUSSION

The fertility status of the soil is expected to benefit from poultry manure application since the manure is known to improve SOM and macro-nutrient status and micro nutrient qualities of the soil (Maerere et al., 2001; Adeniyan and Ojeniyi, 2003; Adediran et al., 2003b; Akande and Adediran, 2004). The concentration of exchangeable K and Mg were adequate for tomato production (Akinrinde and Obigbesan, 2000).

Increases in soil nutrient contents adduced to poultry manure are consistent with analysis recorded for manure in the present work. Adesodun et al. (2005) had found that application of poultry manure to soil increased soil organic matter, N and P and aggregate stability. The improvement in soil physical properties is attributable to improvement in soil organic matter content. Improved soil moisture associated with poultry manure is attributable to mulching effect of organic matter and improved moisture retention and water acceptance as a result of improved soil structure and macro porosity (Aluko and Oyedele, 2005).

It is ascertained that improved soil nutrient contents caused by poultry manure addition additions led to increased uptake of N, P, K, Ca and Mg by tomato plant. The reduction in P, K, Ca and Mg concentration after 25 t ha^{-1} level of poultry manure could be due to high soil acidity due to production of nitrates (Olayinka, 1990). Hence it was found that the least soil pH was recorded at 40 and 50 t ha^{-1} of manure levels. The relative high soil acidity with application of 40 and 50 t/ha manure should have neutralized availability of cations (K, Ca, Mg) and enhanced fixation of p by Al and Fe ions (Olayinka, 1990). Soil acidity is a factor adversely affecting yield of tomato in Southwest Nigeria (Obi and Akinsola, 1995). 25 t ha^{-1} manure is recommended for maximizing fruit yield.

That increased growth of tomatoes given by 40 and 50 t ha^{-1} manure relative to 25 t ha^{-1} manure did not translate into fruit yield can be adduced to dilution effect of excess organic matter and high availability of N which led to vegetative growth at the expense of fruiting. This is explained by the dilution effect of excess N given by 40 and 50 t ha^{-1} manure. Saxena et al. (1975) had observed that high rates of N reduced leaf Ca in tomato and increased blossom-end-rot of tomato fruits in Guyana. Aside from increasing availability and uptake of N, P, K, Ca and Mg, poultry manure applications at 10 to 50 t ha^{-1} served to improve moisture availability in soil and reduced soil bulk density. These modifications led to improved nutrient availability, growth and yield of tomato.

Adekiya and Ojeniyi (2002) observed that increased in soil bulk density reduced uptake of N, P, K, Ca and Mg by tomato plant in Alfisols of southwestern Nigeria. Therefore improvement in soil physical properties caused by applications of poultry manure led to improved uptake of nutrients.

Conclusion

It is concluded from this work that aside from improving macronutrient availability, poultry manure reduced soil bulk density and enhanced its moisture content. These improvements led to significant increases in growth and yield of tomato. The 25 t ha^{-1} manure is recommended for maximizing nutrient and yield of tomato.

Table 2. Effect of different levels of poultry manure on selected soil chemical properties.

Manure (t/ha)	pH ($CaCl_2$)		OM(%)		Total N (%)		P (mg/kg)	
	FECA	FUTA	FECA	FUTA	FECA	FUTA	FECA	FUTA
0	7.0^{a}	6.7^{a}	1.40^{a}	1.76^{a}	0.09^{a}	0.12^{a}	10.6^{a}	9.0^{a}
10	6.7^{b}	6.3^{b}	2.30^{b}	2.56^{b}	0.17^{b}	0.35^{b}	18.2^{b}	18.9^{b}
25	6.4^{c}	6.1^{c}	2.50^{b}	3.66^{c}	0.51^{e}	0.48^{c}	30.9^{c}	37.1^{c}
40	6.4^{c}	6.0^{d}	2.45^{b}	4.15^{d}	0.28^{c}	0.52^{d}	33.0^{c}	44.3^{d}
50	6.2^{d}	5.9^{d}	2.77^{c}	4.29^{d}	0.31^{d}	0.56^{e}	32.6^{c}	45.6^{d}

*Mean in same column followed by same letters are not significantly different by DMRT.

Table 3. Effect of poultry manure on soil bulk density and moisture content.

Manure (t/ha)	Bulk density (g/cc)		Moisture Content (%)	
	FECA	FUTA	FECA	FUTA
0	1.43^{a}	1.13^{a}	11.9^{a}	22.0^{a}
10	1.29^{b}	0.99^{a}	12.7^{a}	25.4^{b}
25	1.25^{b}	0.94^{a}	14.6^{b}	25.9^{b}
40	1.15^{c}	0.92^{a}	16.4^{c}	28.1^{bc}
50	1.11^{c}	0.92^{a}	17.2^{c}	29.1^{c}

*Mean in same column followed by same letters are not significantly different by DMRT.

Table 4. Effect of poultry manure on leaf nutrient concentration of tomato.

Manure t/ha	N %		P%		K %		Ca %		Mg %	
	FECA	FUTA	FECA	FUTA	FECA	FUTA	FECA	FUTA	FECA	FUTA
0	3.95^{a}	1.76^{a}	0.12^{a}	0.37^{a}	2.32^{a}	3.24^{a}	0.16^{a}	0.66^{a}	0.09^{a}	0.14^{a}
10	4.25^{ab}	2.72^{b}	0.15^{b}	0.57^{bc}	3.78^{d}	4.18^{b}	0.36^{c}	0.73^{b}	0.13^{b}	0.16^{a}
25	4.41^{b}	3.43^{c}	0.50^{c}	0.57^{bc}	4.16^{c}	5.35^{c}	0.39^{c}	0.94^{c}	0.23^{c}	0.36^{b}
40	4.16^{ab}	4.68^{d}	0.16^{b}	0.53^{b}	2.86^{b}	5.98	0.32^{b}	0.91^{c}	0.21^{c}	0.30^{c}
50	4.89^{c}	4.67^{d}	0.14^{ab}	0.50^{d}	3.16^{c}	5.95^{d}	0.37^{c}	0.89^{c}	0.20^{c}	0.27

*Mean in same column followed by same letters are not significantly different by DMRT.

Table 5. Effect of poultry manure on growth of tomato at FECA and FUTA sites Akure.

Manure t/ha	Plant height (cm)		No of branches		Tap root length (cm)	
	FECA	FUTA	FECA	FUTA	FECA	FUTA
0	612^{a}	56.2^{a}	10.5^{a}	6.2^{a}	22.9^{a}	21.9^{a}
10	73.9^{b}	55.4^{a}	14.0^{b}	8.3^{b}	25.7^{b}	28.9^{b}
25	78.1^{b}	60.9^{ab}	13.9^{b}	9.1^{c}	30.9^{c}	30.7^{b}
40	85.6^{c}	59.3^{ab}	16.2^{c}	9.4^{c}	34.9^{d}	33.2^{c}
50	88.6^{c}	62.7^{b}	17.2^{c}	12.4^{d}	35.8^{d}	34.9^{c}

*Mean in same column followed by same letters are not significantly different by DMRT

Table 6. Effect of poultry manure on yield of tomato.

Manure t/ha	No of fruits /plant		Fruits yield t/ha	
	FECA	FUTA	FECA	FUTA
0	22.0^{a}	20.6^{ab}	16.4^{a}	18.9^{a}
10	24.4^{b}	20.3^{a}	27.1^{c}	28.7^{c}
25	30.6^{c}	33.4^{c}	31.6^{d}	39.7^{d}
40	23.4^{ab}	33.4^{c}	22.7^{b}	25.9^{b}
50	22.3^{ab}	21.5^{b}	21.3^{b}	24.8^{b}

*Mean in same column followed by same letters are not significantly different by DMRT.

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