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Full Length Research Paper

Comparison of growth, yield performance and profitability of tomato (*Solanum lycopersicon*) under different fertilizer types in humid forest ultisols

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Studies were conducted as an on-farm trial at Uyinwendin, Edo State, Nigeria in 2008 and 2009 to evaluate the effect of different fertilizer types on crop performance in terms of growth, yield and profitability of *Solanum lycopersicom.* The trial involved five treatments viz: control, compost manure, cured poultry manure, inorganic fertilizer (NPK 15:15:15) and combined inorganic and organic fertilizer (organomineral fertilizer) at a combination of 20 t ha^{-1} organic fertilizer (mixture of compost and poultry manures) and 100 kg ha^{-1} NPK laid in a randomized complete block design and replicated three things. Results showed that. Stem girth, plant height, number of branches, number of leaves, and days to 50% flowering and fruit yield indices were influenced positively by fertilizer application. The optimum fruit yield was 27.30 t ha^{-1} produced from organomineral fertilizer treatment based on revenue (₦1, 187,550.00), gross margin (₦1, 090611.50), net farm profit (₦1, 077892.65) and Benefit-cost ratio (10.83) which were the highest among the treatments.

Keywords: Growth, fruit yield quality, soil amendment, soil properties and yield.

INTRODUCTION

About 130 million tons of tomatoes were produced in the world in 2008. China, the largest producer, accounted for about one quarter of the global output, followed by United States and Turkey. For one variety, known as plum or processing tomatoes, California accounts for 90% of U.S. production and 35% of world production. Consumption of tomatoes is on the increase. They are the third most important vegetable crop on the basis of market value; the first is potatoes. Total cultivated area in Nigeria for the production of tomato was 127000 hectares and the production quantity was 889000 tons giving an average of 7 tons per hectare (t ha^{-1}) (FAO, 2009).

According to FAO (2003), tomato productivity in Nigeria is below Africa average which is 20.51t ha^{-1}. The decline in productivity among other factors is due to low native soil fertility resulted from the practice of slash and burn farming system associated with bush fallow and with excessive leaching of the soil. The system is presently unsustainable due to high population pressure and other human activities which have resulted in reduced fallow period (Steiner, 1991).

Maintenance of high crop yields under intensive cultivation is possible only through the use of external fertilizer inputs (organic and inorganic fertilizers). Inorganic fertilizer application is the quickest and easiest way of increasing yield per unit area. The problems associated with inorganic nutrient supplementation in highly weathered soil is that it leads to pollution of ground water after harvest, it does not improved soil structure (Gordon *et al.*, 1993), decline in organic matter content, nutrient imbalance, soil acidification (Ojeniyi, 2000), not readily available to farmers and also costly. Other problems include most inorganic fertilizer does not replace trace nutrients in the soil which become gradually depleted by crop (Lawrence, 2004); fertilizer burn can result from excess application of inorganic fertilizer due to its high solubility and release; the increase in price of natural gas over the past decade resulted in the increased demand for nitrogenous fertilizer which required natural gas overwhelming for the production of ammonia (Sawyer, 2004).

Organic manures can be used as an alternative for the inorganic fertilizers. Consumers have an increasing interest in organic products because they are thought to be environmentally sound or of high quality (Nakano *et al.*2002). They release nutrients rather slowly and steadily over a longer period and also improve the soil fertility status by activating the soil microbial biomass (Ayuso *et al*., 1996; Belay *et al*., 2001). Organic manure application sustains cropping system through better nutrient recycling and improvement of the soil physical attributes (El-Shakweer *et al*., 1998). However, the use of fresh manure should be avoided. Ammonia is released during the decomposition of fresh manures, which can be injurious to plants. Inaddition, fresh manure contains a large quantity of moisture which cause problems in handling and uniformity of distribution in the field. It tends to increase the cost of transportation and handling. Research has confirmed that the human pathogen, *Esehercichia coli* contaminated soil from contaminated manure can be transmitted to produce grown on this soil (Jay, 2000). Therefore, properly composted manure is the most desirable choice for use in crop production and prevent human health problem. The benefits derived from the use of organic fertilizer have however, not be fully utilized in humid tropics due to huge quantities required to satisfy the needs of crops as transportation and handling costs will increase, which constitute major constrains.

Complementary use of organic with inorganic fertilizer is widely known to be reliable fertility management strategy in many countries of the world (Lombion *et al.,* 1991). This emphasized that high and sustained crop yields can be obtained with judicious and balanced NPK fertilizer application combined with organic fertilizer (Makinde *et al*., 2001). Adeniyan and Ojeniyi (2005) have reported a higher yield of maize from a combined use of NPK and poultry manure than from sole NPK or poultry manure application.

This trial was undertaken to determine the effect of fertilizer types on the growth and yield of *S.* lycopersicon in an ultisol humid environment in view to formulate and recommend fertilizer requirement for sustainable production of *S. lycopersicon.*

MATERIALS AND METHODS

Experimental site and design

Field experiments were conducted in 2008 and 2009 as an on-farm trial at Uyinwendin, Edo State (5^0 04' N, 6^0 35' E). The study area lies within rainforest, which degraded to secondary forest as a result of shifting cultivation. The soil used was an ultisol of the Benin formation (Smith and Montgomery, 1962). The organic compost was obtained from Lake Projects PLC, Lagos, cured poultry manure from a commercial poultry nearby and tomato (Roma VF) seeds obtained from Premier Seed Ltd, Benin City.

A randomized complete block design with three replicates was utilized for the trial. Each replicate comprised five plots (treatments). The treatments, consisted of control, cured poultry manure (20 t ha^{-1}), compost manure (20 t ha^{-1}), conventional NPK 15:15:15 (200 kg ha^{-1}) and combined organic fertilizer (cured poultry manure and compost mixture) and NPK 15:15:15 (100 kg ha^{-1}). The organic compost and cured poultry manure were thoroughly mixed with the soil and left for two weeks to allow for mineralization before transplanting. NPK fertilizer was applied one week after transplanting.

Analysis of poultry and compost used

Samples of manures were air-dried at room temperature for three days. Ground compost and poultry manures were digested with nitric-perchloric-sulphuric acid mixture and resulting aliquots were used to chemically characterize the amendments.

Soil analysis

Soil analysis was carried out before and after the experiment. pH was determined at soil + water of 1:1 using glass electrode pH meter. The particle size analysis of the soil was by Hydrometer (Gee and Or, 2002). The total nitrogen was determined by Microkjeldahl procedure as describe by Jackson (1962). The available phosphorus was extracted with Olsen method (Emteryd, 1989).

Exchangeable captions (Ca, Mg and K) were determined by EDTA titration method, while K was determined by flame photometry (Jackson, 1962).

Field trials

Seeds of tomato cultivar “Roma VF” were sown in the nursery in November 20 each year. After three weeks, the seedlings were transplanted to a well prepared beds in the field and spaced 50 cm by 50 cm to achieve a population of 40, 000 plants per hectare (pph). The seedlings were transplanted between 5 and 7 cm in height. Appropriate nursery management practices were carried out as at when due to obtain healthy and uniform seedlings. After transplanting crop, irrigation, weed, in-

Table 1. Initial soil characteristics and chemical properties of compost and poultry manures

Tested item	Chemical Properties							Physical properties (g kg^{-1})		
	pH	Organic C	Total N	Available P	Exchangeable cations (c mol kg^{-1})			Sand	Silt	Clay
		(%)	(%)	(mg kg^{-1})	K	Mg	Ca			
Soil	4.90	1.30	0.08	4.97	0.12	0.18	0.15	860	50	90
Compost manure	7.80	1.02	6.08	0.62%	2.7%	155%	3.60%	nd	nd	nd
Poultry manure	6.00	3.78	6.04	1.36%	90%	205%	6.95%	nd	nd	nd
nd - not determined										

sect pest and disease control were carried out appropriately.

Data collection

Plant growth and yield characters were evaluated *in-situ* from four randomly selected plants from middle bed through the measurement of the following observations: Stem girth (cm): It was measured using a Vernier-caliber at third node; Plant height (cm): The plant height was measured from the soil surface to the tip of the main stem; Number of branches per plant: The number of reproductive branches of each sample plant was taken as average; Number of leaves per plant: by counting the number of leaves of all sample plants and the average was recorded; Days to 50% flowering: The number of days from transplanting to the time when 50% of the plants at the plot had been commence flowering (at least one flower/plant was considered); Days to first fruit set per plot: The number of days from transplanting to the time when first fruit set in the plot; Number of fruits per plant: The total number of red ripe mature fruits which were harvested from all sample plants and average computed; Average fruit weight (g); and Fruit yield ha^{-1} was obtained through conversion of the net plot yield.

Data analysis

Analysis of variance was carried out on each of the observations recorded for each year of study, followed by combined analysis over two years. The Least Significant Difference (LSD) test was used for detecting significance differences between means at 5% level of probability.

Profitability analysis

Gross margin analysis (Adeniyi, 2001) was used to access the net return of each of the treatment used in the trial. This was based on the formula:

GM = TR - TV

Where GM = Gross margin

TR = Total revenue, and

TV = Total variable cost

Net Profit = TR – TC

Where; TR= Total Revenue

TC = Total Cost

Benefit-cost ratio was calculated as the ratio of crop total value to total cost of production.

RESULTS

Soil Natural fertility

Pre-cropping chemical analysis of the sites is presented in Table 1. The soil is acidic (pH 4.90) and textually sandy loam. The soils were low in organic carbon content (1.30 %). The nutrient status of the soisl showed that they were low in major nutrients. The chemical properties of the compost and poultry manures showed that it contains high amounts of organic carbon and nutrient elements such as N, P, K, Mg and Ca that can boost agricultural productivity on the soil through gradual release of nutrients to crops.

Growth

Soil amendments had a significant effect on stem girth, plant height, number of branches, number of leaves and days to 50% flowering (Table 2). Application of NPK gave the greatest stem girth of 1.20 cm which was at par with organomineral fertilizer and significantly greater than plant treated with poultry manure, compost manure and control in that order.

Plant heights from all the fertilized plots were significantly higher than control, with plants fertilized with organomineral fertilizer (50.15 cm) and NPK (50.00 cm) giving significantly tallest plants, followed by poultry manure, compost manure and untreated control in that order. A reflection of the low nutrient status of the soil was manifested by the untreated tomato plants which were the shortest (37.18 cm).

All fertilized plots had plants comparable in number of branches, but were significantly higher than plants from the untreated plants (Table 2). Greater plant height resulted in an increase in the number of branches as

Table 2. Tomato growth assessment at harvest

Treatment	Stem girth (cm)	Plant height (cm)	Nos of branches (plant^{-1})	Nos of leaves	Days to 50% flowering
Control	0.80	37.18	13.00	59.67	49.33
Compost manure	1.00	47.12	15.00	73.00	45.67
Poultry manure	1.10	49.50	15.33	74.00	43.00
Organomineral fertilizer	1.15	50.15	16.67	75.33	41.00
NPK	1.20	50.00	16.00	77.00	40.67
Mean	1.05	46.79	15.20	71.80	43.93
LSD(0.05)	0.074	0.490	1.898	6.445	1.612

Table 3. Tomato fruit yield and yield components

Treatment	Days to first fruit set	Nos of fruit (plant^{-1})	Fruit girth (cm)	Average fruit (g)	Fruit yield (t ha^{-1})
Control	52.67	17.13	3.50	15.60	10.42
Compost manure	47.50	23.17	4.30	26.50	24.50
Poultry manure	46.47	25.10	4.40	27.30	25.59
Organomineral fertilizer	44.60	24.20	4.50	28.17	27.30
NPK	46.74	25.20	4.40	27.30	26.06
Mean	47.59	22.96	4.22	24.98	22.79
LSD(0.05)	3.087	2.876	0.436	0.628	0.855

there was positive correlation between plant height and number of branches (r = 0.65).

Numbers of leaves were all comparable among the four fertilizer sources and significantly superior to the control plants (Table 2). Days to 50% flowering in response to different soil amendments are shown in Table 2. The most significant earliness to 50% flowering were plants treated with NPK (40.67 days) and organomineral fertilizer (41.00 days) treated plants were earliness to 50% flowering than other treatments. Poultry manure treated plants flowered in 43.00 days while it took 45.67 and 49.33 days for compost manure treated plants and untreated control to 50% flowering, respectively.

Fruit yield

The effect of fertilizer types on fruit yield of tomato are shown in Table 3. Days to first set were all comparable among the four fertilizer sources and significantly earlier than the untreated control plants. At harvest, Numbers of fruits per plant were significantly lowest with unfertilized, control plots. Number of fruits per plant gave comparative values in all treated plants. The same trend was observed with fruit girth. Average fruit weight was highest from organomineral fertilizer; it was followed by fruits from poultry manure, NPK, compost manure and untreated control in that order. The unfertilized, control plots had fruits with the lowest average. There were significant differences among the treatments. The poultry manure and NPK treated plants were similar.

Profitability

Profitability analysis of tomato production using various soil amendments are shown in Table 4. The highest total cost of ₦109, 657.35 was recorded for the application of organomineral fertilizer, followed by NPK (₦108759.75) and the least was control (₦90, 755.50). Though, the organomineral fertilizer was the most expensive, however, the highest revenue (₦118755.00) was obtained from plants treated with organomineral fertilizer which was 262% higher than control. The highest gross margin was ₦1, 090611.50 obtained from organomineral fertilizer application and the least was control with a value of ₦373515.00. The treated plots produced higher net values than control and ranged from ₦362514.50 to ₦1, 077,892.65 with the highest value obtained from organomineral fertilizer. In terms of viability, organomineral fertilizer was the most viable as indicated through its highest benefit: cost ratio in tomato production (10.83).

Table 4. Profitablity analysis of the effect of fertilizer types on the performance of *S. lycopersicon*

Item of cost and revenue			**₦**		
	Control	**Compost manure**	**Poultry manure**	**Organomineral**	**NPK**
Variable cost					
Land preparation	25861.50	29861.50	29861.50	27861.50	25861.50
Fertilizer/soil amendment	0.00	9000.00	10000.00	12146.50	10293.00
Planting material	1352.50	1352.50	1352.50	1352.50	1352.50
Pesticides	10000.00	10000.00	10000.00	10000.00	10000.00
Stakes	4068.00	4068.00	4068.00	4068.00	4068.00
Sowing	3378.00	3378.00	3378.00	3378.00	3378.00
Staking	2034.00	2034.00	2034.00	2034.00	2034.00
Weeding	25861.50	25861.50	25861.50	25861.00	25861.00
Fertilizer application	0.00	0.00	0.00	3037.50	6075.00
Pesticide application	4000.00	4000.00	4000.00	4000.00	4000.00
Harvesting	1575.00	1575.00	1575.00	1575.00	1575.00
Transportation	1624.50	1624.50	1624.50	1624.50	1624.50
Fixed cost					
Rent	2586.00	2586.00	2586.00	2586.00	2586.00
Depreciation	1839.00	1839.00	1839.00	1839.00	1839.00
Opportunity cost of running capital	6575.50	7875.50	7975.50	8293.85	8212.25
Total cost of Production	90755.50	105055.50	106155.50	109657.35	108759.75
Revenue	453270.00	1065750.00	1113165.00	1187550.00	1133610.00
Gross margin	373515.00	972995.00	1019410.00	1090611.50	1037487.50
Net farm profit	362514.50	960694.50	1007009.50	1077892.65	1024850.25
Benefit: Cost Ratio	4.99	10.14	10.49	10.83	10.42

DISCUSSION

S. lycopersicon performed best in terms of growth and yield with organomineral fertilizer. this was in agreement with Makinde *et al.* (2001) who reported judicious combination of organic and inorganic (NPK) fertilizers as the most satisfactory method of increasing and sustaining crop yield.

The results of organic fertilizers (compost and poultry manures) analysis showed that the organic fertilizers were high in some plant nutrients and organic matter. The high organic matter improves the soil structure leading to improvement of soil physical conditions. This was in agreement with FAO (1983) who highlighted the role of organic matter in sustaining the fertility of the soil for good production of vegetables by binding the soil to form good soil structure. The pre-cropping analysis of the soil before fertilizer application revealed that the soil is low in organic content. Deficiency of organic matter is an indicative of poor water and nutrient retentivity. The soils were classified as ultisols derived from coastal plain sand. The soil contain less than 0.15 – 0.20 % N, 25.00 mg kg^{-1} available P, exchangeable Ca of 0.20 – 0.40 cmol kg^{-1} and exchangeable Mg of 0.40 cmol kg-1. Soils below these critical levels are regarded as being low in these nutrients (ibude let al. 1988). This revealed that the soils in the area are largely deficient in major essential nutrients. This observation re-affirmed Akanbi and Togun (2002) who reported that most of our agricultural soils are improvised due to intense weathering, leaching and extensive cultivation. Consequently, optimum growth and yield cannot be achieved without supplementary nutrients through organic manures and/or inorganic fertilizer.

Uptakes and utilization of applied fertilizers significantly enhanced the stem girth, plant height, number of branches and leaves. Increase in stem girth with fertilizer application treatment resulted in retention of appreciable amount of assimilates in the stem for node and leaf production (law-Ogbomo and Remison, 2008). This accounted for higher number of leaves in the treated plants. The enhancement in the number of leaves by fertilizer application was a precursor to greater amount of assimilate and thus allowing more translocation to the berry. Changes in number of leaves are bound to affect the overall performance of the plant as the leaves serves as the photosynthetic organ of the plant. Increase in number of increase leads to better utilization of solar radiation (Law-Ogbomo and Remison, 2008).

The earlier number of days to 50% flowering observable with fertilizer treated plants could be attributed to acceleration of the vegetative phase through the stimulating effect of the absorbed nutrients on photosynthetic process which reflected on both vegetative growth and flowering initiation (Kawthar *et al.,* 2005).

The application of organomineral fertilizer resulted in significantly highest fruit yield per hectare among treatments. This was mainly attributed to increased uptake of available nutrients present in the soil. The test crop used for the trial showed a huge potential of fertilizer usage as the fruit yield was reduced where fertilizer was not applied (Saeed, 2005). This finding was in agreement with the view of Chung *et al.* (2000) who reported the application of organic manures fortified with adequate amount of chemical fertilizer produced the greatest biological yield of maize.This finding also confirmed the view of Ayoola and Makinde, 2007) who reported the organic fertilizer can be enriched with inorganic fertilizer to obtained optimum maize grain yield.

The profitability analysis of this study showed that there was positive relationship between fruit yield enhancement and viability in tomato production. The application of organomineral fertilizer was the most expensive. However, it is the most profitable and viable with reference to net profit and benefit-cost ratio.

CONCLUSION

The soil amendment materials used for the soil fertilization had great potentials in improving degraded ultisol. This investigation revealed that all treatments have a profound effect on the overall performance of *S. lycopersicon*. Organomineral fertilizer application is most effective for the optimum growth yield and profitability of tomato. It is therefore recommended to be used to improve infertile soils and increase productivity of vegetable production for a sustain soil and excellent crop yield.

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