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Effects of inorganic and organic fertilizers application on the growth, fruit yield and quality of tomato (*Lycopersicon lycopersicum*)

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ABSTRACT

Objective: To determine the effects of inorganic and organic fertilizers application on the growth, yield and nutrient content of tomato (*Lycopersicon lycopersicum*).

Methodology and Results: Field experiments were conducted at the Teaching and Research Farm of Faculty of Agricultural Sciences, Ladoke Akintola University of Technology, Nigeria in the cropping seasons of 2004 and 2005. The treatments consisted of two levels of urea (0 and 60 kg.N ha^{-1}) and five levels of poultry manure (Pm) (0, 3.0, 4.5, 6.0, 7.5 t. ha^{-1}). The growth parameters (plant height and number of leaves) showed increasing response as the amount of fertilizer applied increased. The combined application of the two types of fertilizers resulted in the highest marketable fruit yield. The content of essential nutrient elements increased and was also influenced by fertilizer treatments, except K in all the treatments.

Conclusion and application of findings: The yield and nutritional quality of tomato fruits were significantly improved by the application of sole poultry manure and mineral N fertilizer at 6.0 t. pm and 60 kg.N ha^{-1} respectively, or their combined application at 30 kg.N by 6.0 t. Pm ha^{-1}. The yield and quality of tomato fruits produced with poultry manure are comparable with those obtained using mineral N fertilizer. Poultry manure can therefore be a suitable replacement for inorganic fertilizer in tomato production.

Key words: tomato, yield, nutrient contents, poultry manure, mineral N fertilizer.

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INTRODUCTION

Tomato is one of the most important vegetable crops in the world. The tomato belongs to the family Solanaceae, genus Lycopersicon, which is a relatively small genus within the large and diverse family consisting of approximately 90 genera. *Lycopersicon* species are native to Ecuador, Peru, and the Galapagon Island though most evidence suggests that the site of domestication was Mexico (Taylor, 1986). In Nigeria, tomatoes are grown during both the wet and dry seasons but they attract higher profits during the dry season when the demand is higher than supply.

Tomatoes play a vital role in human diet and are a good source of vitamins and minerals (Thompson, 1949; South Pacific Commission, 1992). The fruits are eaten raw or cooked and can be processed into soup, juice, sauce, ketchup, puree, paste and powder. They also serve as an ingredient in stews and vegetable salads. In some cases, especially in Northern Nigeria the fruits are sliced and dried for sale.

Tomatoes require nutrients such as N, P, K, Mg, Ca, Na and S for good production. These nutrients are specific in function and must be supplied to the plant at the right time and in the right quantity (Shukla & Naik, 1993). The use of organic manure, e.g. poultry dropping and ruminant dung has improved agricultural productivity in West African countries. Organic manure helps to improve the physical condition of soil and provides the required plant nutrients. Organic manure also enhances cation exchange capacity and acts as a buffering agent against undesirable soil pH fluctuations (Jones & Wild, 1975; Ngeze, 1998).

Numerous reports (USDA, 1980; Palm *et al.,* 1997) recommend 9-18 tons\acre of manure for good tomato yield. Application of broiler litter at the rate of 15 ton\ha, N at 40 kg/ha, P at 30 kg/ha and K at 30 kg/ha gave higher growth and fruit yield (Brown & James*.,* 1995). Tomato can also be supplied with a combination of compost and mineral N fertilizers to improve fruit yield (Akanbi *et al*., 2005).

As a result of increased popularity of organic vegetable production, more information is needed comparing the yield and quality of vegetable crops produced organically or using mineral fertilizer. The objective of this study was to determine the optimum level of organic and inorganic fertilizers required for maximum growth, fruit yield and quality of tomato.

MATERIALS AND METHODS

The experiments were conducted during 2004 and 2005 cropping seasons at the Teaching and Research Farm of Faculty of Agricultural Sciences, Ladoke Akintola University of Technology, Ogbomoso, Nigeria. Ogbomoso is located at 8°10'N and 4°10'E and the climate is cold and dry from November to March and then warm and moist from April to October. The maximum and minimum temperature is 33 and 28°C, respectively. The humidity of this area is high (about 74%) all year round except in January when dry wind blows from the north. Annual rainfall is over 1000mm (Olaniyi, 1997).

The soil is of a sandy loam texture, moderately well drained and was previously under maize cultivation before fallowing for one cropping season. Nursery beds with good humus content were used and measured 1.2m x 6m with a 1m pathway between the beds. Seeds of tomato variety Roma VF were sown on three beds on the 20th and 13th of April 2004 and 2005 respectively, by broadcasting method then covered with palm fronds and watered. Germination occurred after four days of sowing. Fresh water was supplied every morning to avoid wilting and for normal plant development. Weeding was done by hand after every 10 days. Other seedling management included spraying with neem extracts (20 ml to 10 litres of water) to prevent insect attack.

Soil samples were collected for analysis before the field was manually cleared. The pH was determined using a digital electronic pH meter using 1:2 (soil: water) suspension. Ammonium acetate (NH_4Ac) was used to leach 10 g of the soil sample. The Calcium content was obtained through titration, Magnesium by atomic absorption spectrophotometer, Potassium and Sodium content by flame photometry and total Nitrogen by the micro-kjeldahl method. The particle size analysis was done by hydrometer method.

Conventional tillage operations including ploughing and preparation of beds were carried out to conserve the soil and its nutrients (Olaniyi, 2007). The land was ploughed two weeks before making the beds for transplanting seedlings. The experimental area measuring 0.0116 ha^{-1} was divided into three portions each containing 10 beds (to give a total of 30 experimental units). Each bed measured 1.2m x1.2 m with 0.5m spacing between beds and 1m apart in each block of rows for easy movement during cultural operations. Seedlings were hardened and transplanted at four weeks after sowing (WAS). Transplanting was carried out in the evening with seedlings transplanted at a spacing of 0.5m x 0.5m to give a total of 40,000 plants ha^{-1}. Plants were watered immediately after transplanting and thereafter daily until rainfall was regular.

Treatments consisted of two fertilizer types and their combinations each at different levels, i.e. urea applied at 0 and 60 kg.N ha^{-1}; poultry manure applied at 0, 3.0, 4.5, 6.0 and 7.5 t.pm ha^{-1}. Combinations consisted of 30 kg.N x 3.0 t.pm ha^{-1}, 30 kg.N x 4.5 t.pm ha^{-1}, 30 kg.N x 6.0 t.pm ha^{-1} and 30 kg.N x 7.5 t.pm ha^{-1}. The treatments were randomly distributed into a complete randomized block design and replicated thrice. The poultry manure was dried and applied at transplanting while urea was applied three weeks after transplanting (WATP). Fertilizers were applied by band placement at 5cm depth and 7cm away from the plants, with proper covering up of the holes to prevent washing away of nutrients (fertilizers) by run-off. Water was applied daily, weeding manually at four week intervals and spraying with neem extract at 10 ml per 5 litres of water at two weeks intervals to control insects.

Data on plant height and number of leaves were collected at four weeks intervals while cumulative fruit yield data and nutrient content assays were done after harvest. Tomato fruit samples were washed, cut into pieces, dried at 80°C for 48h, ground and processed for proximate and nutrient content analysis. Proximate compositions for nutrients were determined as described by AOAC (1984) while fruit tissue N was determined by a semi micro-kjeldahl procedure (Ulger *et al*., 1997). Fruit protein was calculated from the kjeldahl nitrogen using a conversion factor of 6.25. Lipid was estimated by exhaustively extracting a known sample weight with petroleum ether (BP 60°C) using a Tecator Soxhlet apparatus. Fibre content was estimated from the loss in weight of the crucible and its content on ignition. Mineral elements were estimated using the AOAC (1984) method. The atomic absorption spectrometer was used to determine Fe while phosphorus (P) was determined using the colorimetric molybdenum-blue procedure (Murphy & Riley, 1962).

Data were subjected to analysis of variance procedures (Gomez & Gomez, 1984) and means separated using the Least Significant Difference test at 5% probability level.

RESULTS AND DISCUSSION

Pre-treatment analyses showed the soil was slightly fertile and most of the nutrient elements were present in amounts close to the critical level (Table 1). A pH of 6.53 in water was considered suitable for tomato production as it can enhance P availability (Tindall, 1986).

Plant growth was significantly affected by various treatments at 4 and 8 WATP (Table 2). The average plant height and number of leaves increased as the levels of inorganic and organic fertilizers application increased. The best plant height and number of leaves were recorded under combined treatment with 30 kg.N and 6.0 t.pm ha^{-1}.

Plant growth was markedly influenced by application of poultry manure, inorganic N fertilizer and their combinations as observed from the better plant height and number of leaves compared to the control (Brown *et al*., 1995). The low response of tomatoes to mineral N fertilizer in this trial as compared to combined application of poultry manure and N fertilizers is in agreement with the response patterns reported by other researchers on various food crops (Anon, 1989; Akanbi *et* al., 2005). The number of flowers, number of fruits and yield per plant and total fruit yield per hectare were significantly improved by the sole applications of poultry manure and mineral N fertilizers, as well as by their various combinations (Table 3).

Flower development started at about 5 WATP in all plots receiving fertilizer treatment. The optimum yield and yield components were recorded from plants treated with combined 30 kg.N and 6.0 kg.pm ha^{-1}, which was significantly higher than those obtained from sole application of either of the fertilizers.

Table 1: Chemical and physical properties of the soil of the experimental site.

Parameters	Value
pH in H_20	6.53
Total N (%)	0.63
Available P (mg.kg $^{-1}$)	6.99
Exchangeable cations (c.mol.kg^{-1})	
Ca^{2+}	1.96
Mg^{2+}	7.71
K^+	0.44
Na^+	0.10
Al^{3+}	0.02
Exchangeable acidity (meq/100)	
Organic carbon	2.74
CEC	4.20
Acidity	0.05
Mn	6.41
Fe (ppm)	21.14
Cu (ppm)	1.63
Zn (ppm)	3.47
Physical characteristics	
Sand (%)	79.2
Silt (%)	15.4
Clay (%)	5.4
Textual class	Sandy loam

Table 2: Effect of different levels of inorganic and organic fertilizers and their combinations on the growth parameters of *Lycopersicon lycopersicum*.

Fertilizers (kg.ha^{-1})	Plant Height (cm)		Number of leaves	
	4 WATP	8 WATP	4 WATP	8 WATP
	14.73	19.07	11.27	20.47
P M_1	15.08	19.34	12.42	27.25
P M_2	14.18	21.50	13.75	35.12
P M_3	14.77	22.29	9.10	38.83
P M_4	15.70	23.22	12.93	30.58
N_1	17.33	23.42	15.00	47.25
NP M_1	14.73	20.17	5.00	23.00
NP M_2	13.83	19.63	13.03	26.00
NP M_3	17.79	25.64	15.43	51.08
NP M_4	15.28	13.17	5.97	25.33
SE	1.62	1.85	4.49	6.10

Key: Control = Neither N fertilizer nor poultry manure was applied; P M_1 = 3.0 t.ha^{-1} of poultry manure; P. M_2 = 4.5 t.ha^{-1} of poultry manure; P. M_3 = 6.0 t.ha^{-1} of poultry manure; P. M_4 = 7.5 t.ha^{-1} of poultry manurN_1 = 60 kg.N ha^{-1} mineral N fertilizer; NP M_1 = 30 kg.N x 3.0 t.pm ha$^{-1;}$ NP M_2 = 30 kg.N x 4.5 t.pm ha$^{-1;}$ NP M_3 = 30 kg.N x 6.0 t.pm ha$^{-1;}$ NP M_4 = 30 kg.N x 7.5 t.pm ha^{-1}

In relating plant flowering to the fruiting state, an increase in the number of flowers resulted in an increase in number of fruits and hence in higher total fruit yield, and vice versa. However, the sharp increase in the total fruit yields as compared to the number of flowers and fruits of tomato under inorganic N treatment might be due to the effect of N in increasing the water content of vegetables (Babatola & Olaniyi, 1999; Olaniyi, 2006). The combination of mineral N fertilizer (30 kg.N ha^{-1}) and poultry manure had an interactive effect on flowering and fruit production with a significant increase as compared to single application of either treatment. This may be due to increased N availability to the plants from the organic and inorganic fertilizer combinations. This observation is in agreement with Branley & Warren (1960) who observed a significant increase in number of flowers as N level increased. It also agrees with Penalosa *et al*. (1988) who reported that at the period before fruiting begins, tomato plants should be given K, N, Ca and P. Moreover, the highest marketable yield in tons per hectare of tomato obtained in this study was in agreement with Palm *et al*. (1997). Also, this result is similar to those obtained by Akanbi *et al*. (2005), who observed a great increase in yield of tomato when N fertilizer was combined with compost manure.

Table 3: Effect of different levels of inorganic and organic fertilizers and their combinations on the yield and yield components of *Lycopersicon lycopersicum*.

Fertilizers (kg ha^{-1})	Number of flowers per plant	Number of fruits per plant (g)	Fruit weight per plant (g)	Total fruit yield (t.ha^{-1})
Control	6.25	1.87	33.33	1.33
P M_1	10.00	3.85	50.35	2.55
P M_2	12.59	5.90	96.25	4.52
P M_3	17.50	6.93	120.57	4.82
P M_4	17.83	7.97	129.00	5.16
N_1	14.50	7.90	166.00	6.64
NP M_1	12.00	6.21	103.63	4.15
NP M_2	15.85	9.27	156.93	6.28
NP M_3	19.17	13.80	311.00	12.44
NP M_4	14.17	7.87	191.23	7.65
SE	5.14	4.15	69.40	2.77

Control = No N fertilizer and no poultry manure; P M_1 = 3.0 t.ha^{-1} of poultry manure; P M_2 = 4.5 t.ha^{-1} of poultry manure; P M_3 = 6.0 t.ha^{-1} of poultry manure; P M_4 = 7.5 t.ha^{-1} of poultry manure; N_1 = 60 kg.N ha^{-1} mineral N fertilizer; NP M_1 = 30 kg.N x 3.0 t.pm ha$^{-1;}$ NP M_2 = 30 kg.N x 4.5 t.pm ha$^{-1;}$ NP M_3 = 30 kg.N x 6.0 t.pm ha$^{-1;}$ NP M_4 = 30 kg.N x 7.5 t.pm ha^{-1}

The results of the fruit proximate analysis showed that the nutrients (Protein, Fibre, Vitamin C, Fat, Mg, Ca, P and Fe) compositions of tomato fruits were significantly influenced by treatments, but K content was not. This result confirms that tomato fruits are very rich in nutrient elements and easily out rank all other vegetables in total contribution to human nutrition (Grubben & Denton, 2004). The nutritional values obtained in this study are higher than those reported by Holland *et al*. (1991) for tomato, probably due to the effects of fertilizer applied in this study.

Nitrogen and phosphorus are the nutrients most limiting the production of vegetable crops, though other nutrients such as K are required. (Anderson, 1974; Friensen, 1991; Smithson & Sanchez, 2000). The ideal anion and cation ratio for tomato has been found to be 58:36:6 for N:S:P and 39:32:29 for K:Ca:Mg (Altunaga, 1988).

This study revealed that organic and inorganic fertilizer applications are very essential for enhancing soil nutrient status and increasing crop yield. Despite the environmental and other yield constraints encountered by the crop during growth, the overall assessment showed that it is essential to consider the main commercial fraction like the marketable fruit yield in choosing the level of organic and inorganic fertilizers, and their combinations suitable for use in tomatoes production. The response of tomato to each fertilizer varied slightly but significant differences were obtained for the growth parameters, yield and yield components considered. Therefore, the optimum marketable fruit yield can be obtained from sole application of poultry manure at 6.0 t.ha^{-1} and N at 60 kg.ha^{-1}, while the combined application at 30 kg N by 6.0 t.ha^{-1} recorded the best yield of all treatments.

Table 4: The nutrient compositions of tomato fruits as affected by the organic and inorganic fertilizers application and their combinations.

Fertilizer (kg ha^{-1})	% Protein	% Fat	% Fibre	Mg/100g Vit. C	% Ca	% Mg	% K	% P	PPm Fe
Control	24.98	3.56	5.75	0.32	0.30	0.16	0.09	0.41	28.14
P M_1	25.00	3.60	5.80	0.33	0.32	0.18	0.09	0.40	29.02
P M_2	25.65	3.72	5.87	0.33	0.33	0.18	0.11	0.45	30.33
P M_3	28.71	3.86	5.90	0.34	0.30	0.19	0.13	0.47	32.52
P M_4	28.75	3.89	6.00	0.35	0.33	0.20	0.13	0.44	32.50
N_1	26.33	5.02	6.48	0.38	0.35	0.22	0.12	0.49	33.84
NP M_1	26.56	3.65	6.15	0.35	0.35	0.20	0.10	0.45	30.66
NP M_2	27.42	3.85	6.35	0.36	0.36	0.22	0.10	0.47	31.82
NP M_3	30.05	4.51	6.57	0.45	0.40	0.25	0.14	0.55	32.25
NP M_4	28.16	3.97	6.45	0.41	0.40	0.22	0.12	0.45	33.75
SE	0.52	0.38	0.39	ns	8.78	1.52	ns	2.91	0.39

Control = Neither N fertilizer nor poultry manure was applied; P M_1 = 3.0 t.ha^{-1} of poultry manure
P M_2 = 4.5 t.ha^{-1} of poultry manure; P M_3 = 6.0 t.ha^{-1} of poultry manure; P M_4 = 7.5 t.ha^{-1} of poultry manure
N_1 = 60 kg.N ha^{-1} mineral N fertilizer ; NP M_1 = 30 kg.N x 3.0 t.pm $ha^{-1;}$ NP M_2 = 30 kg.N x 4.5 t.pm $ha^{-1;}$ NP M_3 = 30 kg.N x 6.0 t.pm $ha^{-1;}$ NP M_4 = 30 kg.N x 7.5 t.pm ha^{-1}

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