Agricultural Journal 7 (2): 135-138, 2012
ISSN: 1816-9155

Effect of Different Rates and Sources of Fertilizer on Yield and Antioxidant Components of Tomato (*Lycopersicon lycopersicum*)

Helen Adeniyi and Olufemi Ademoyegun
National Horticultural Research Institute, P.M.B. 5432, Idi-Ishin, Ibadan, Nigeria

Abstract: Tomato (*Lycopersicon lycopersicum*) is an excellent source of many nutrients and secondary metabolites. Among all the nutrients contained in tomatoes, the most studied and important is lycopene, an antioxidant that has been linked with reduced risk of prostrate and various other forms of cancer. Lycopene can be affected by management practices during period of tomato production. Tomato crop was grown using organic manures and chemical fertilizers and the effect on the major carpometric and antioxidants components of open field grown tomato was investigated. The chicken manure was applied at the rate of 20 and 10 ton ha^{-1} while NPK 15-15-15 was applied at the rate of 120 and 60 kg N ha^{-1}. The control was without any of the fertilizer. The result showed that 120 kg N ha^{-1} of NPK 15-15-15 fertilizer had the highest yield of 32.97 ton ha^{-1} while the lowest yield, 4.07 ton ha^{-1} was recorded in control which was without fertilizer. The titratable acidity and the lycopene content of tomatoes grown with 20 ton ha^{-1} of chicken manure were significantly higher ($p<0.005$) than those grown with other treatments. This result showed that nutrient sources play major roles in determining the levels of titratable acidity and the nutrient antioxidant component of tomatoes.

Key words: Organic, inorganic, chicken manure, NPK, titratable acidity, lycopene, Nigeria

INTRODUCTION

Tomatoes have been reported to be an important source of nutrient antioxidants such as lycopene and vitamin C in human diet (Clinton, 1998; Kanr *et al.*, 2002). Lycopene, the most important antioxidant has been linked with reduced risk of prostrate and various other forms of cancer as well as heat diseases (Barber and Barber, 2002). Tomatoes are grown by both conventional as well as organic fertilizers. Poultry manure properly handled is the most valuable of all manures produced by livestock. Chicken manure is high in nitrogen compared with other livestock manure. Nitrogen supports vigorous growth and is essential in photosynthesis, Nitrogen is equally said to be the motor of plant growth (IFA and FAO, 2000).

Inappropriate uses of fertilizers greatly reduce fertilizer efficiency and negatively affect productivity of the soil (Juang, 1995) also to obtain maximum economic value of plant nutrients in poultry manure and to protect the water supplies from excessive nutrient runoff or leaching, poultry manure should be applied to match nutrient needs of crops (Mitchell and Donald, 1995). Hence, it is important to access the accurate rate of either the organic and inorganic fertilizers to be applied. The nutrient quality of organically and conventionally grown plants has been compared mainly in terms of macronutrients, vitamins and minerals. The results of >150 of these studies were reviewed by Woese *et al.* (1997), they found very inconsistent differences in the nutritional quality of these products. There are very few studies that have compared the eating quality and nutrient antioxidants (lycopene and vitamin C) in conventionally and organically grown foods.

Since, the taste colour and nutrient qualities of tomatoes can also depend on their antioxidant contents, further insights into the factors likely to affect their composition should help to define the quality of tomatoes more clearly (Dumas *et al.*, 2003). The antioxidants components of tomatoes have been reported to be influenced by the cultivars, growing conditions and seasons, harvesting stage and ripening on and off-vine (Toor *et al.*, 2005).

However, there is limited information on the effect of different forms of fertilizers on the antioxidant components of tomatoes; Dumas *et al.* (2003) also reported in a review that there is no information about the effects of different forms and rates of fertilizers on the eating quality and lycopene in tomato. Therefore, the objective of this study was to determine the effects of different forms and rates of fertilizers on the major carpometric characteristics and antioxidant components, especially lycopene and vitamin C.

Corresponding Author: Helen Adeniyi, National Horticultural Research Institute, P.M.B. 5432, Idi-Ishin, Ibadan, Nigeria

MATERIALS AND METHODS

Experimental site: The study was carried out at the National Horticultural Research Institute Ibadan, South Western Nigeria (7°30'N.3°4'E altitude and 168 m above mean sea level), a hot humid region with temperature between 16 and 35°C and an average rainfall of between 1100-1250 mm annum^{-1}.

Cultivation and production: Soil samples were collected before the conduct of the experiment at the site were bulked for routine analysis (11TA. 1979). The variety of tomatoes (*Lycopersicon lycopersicum*) was UC82B. The tomato seeds were first raised in the nursery and later transplanted to the field 6 weeks after planting. The tomato was planted at a space of 75×30 cm. The experimental design used was Randomized Block Design (RBD) with 5 treatments and 3 replications.

The chicken manure was fully cured and was applied at the rate of 10 and 20 ton ha^{-1}. NPK 15-15-15 was applied at rate of 60 kg and 120 kg N ha^{-1}, the control was without any fertilizer. The yield data were analyses were conducted using statistical analysis package (SAS, 2000). Routine cultural practices were carried out. After harvesting, the tomato fruits were subjected to carpometric characteristic analysis.

Carpometric characteristics: The tomato samples were reconstituted in distilled water and mixed thoroughly. The total soluble solids were measured using a refractometer and the results were reported as Brix at 201C. The pH and titratable acidity was determined by using 0.1 MNaOH, expressed as percent of citric acid. Lycopene in the samples was extracted by hexane-acetone-ethanol (2:1:1, v:v:v) mixture following the method of Sharma and Le Maguer in 1996 and Davies in 1976. The absorbance of hexane solution containing lycopene was measured at 472 nm on a spectrophotometer using hexane as a blank. The lycopene concentration was calculated using its specific extinction coefficient (E1%, 1 cm) of 3450 in hexane. The ascorbic acid content of the samples was measured by the Method of Association of Official Analytical Chemists (AOAC, 1990).

RESULTS AND DISCUSSION

Table 1 shows data on the pre-treatment soil analysis of the experimental site and the chicken manure used for the experiment. The soils were slightly acidic, deficient in organic matter and nitrogen which are the ultimate determinant of the soil fertility in most tropical soils. The fertility of the soil could therefore be sustained with the addition of fertilizers. The nutrient composition of the poultry manure suggests that it would serve to increase the soil fertility and hence improve the performance of the crop. The chicken manure used contained nitrogen (2.90) that is quite higher than in the one contained in the soil (0.65). Land application rates are generally determined by matching the available nitrogen or phosphorus content of the waste to the nutrient requirements of the crop. In most cases, nitrogen requirements determine the application rate, unless the area is designated nutrient sensitive (Zublena *et al*., 1997). It also contained reasonable quantities of other nutrients; Ca, Mg, P and K.

Based on the present results (Table 2), application of 120 kg N ha^{-1} gave the highest yield of 32.97 ton ha^{-1} and significantly different from all other treatments, especially the control with yield of 4.073 ton ha^{-1}. Among the poultry manure treatments, application of 10 ton ha^{-1} gave higher yield 21.61 ton ha^{-1} and lower number of fruits (332,128) than those with 20 ton ha^{-1} chicken manure with 18.153 ton ha^{-1} and 377,329 fruits ha^{-1}, this implies lager fruit size. Although, the yield produced by application of 60 kg N ha^{-1} of NPK 15-15-15 fertilizer (24.5 ton ha^{-1}) was higher than that of 10 ton ha^{-1} of chicken manure but was not significantly different. All the treatment were significantly different the control. Relative to control and other levels between 10 and 50 ton ha^{-1} of poultry manure.

Akanni and Ojeniyi (2007) found that 20 ton ha^{-1} performed best in terms of fruit yield of tomato with production of 35 ton ha^{-1}. Ayeni *et al.* (2010) also found that application of 10 ton ha^{-1} poultry manure gave similar values of plant N, P and K and yield components compared with 300 kg ha^{-1} NPK fertilizer. The vitamin C

Table 1: Initial soil analysis and nutrient composition of the chicken manure

Parameters	Soil values	Chicken manure
pH (H_2O)	5.7	-
Organic matter (%)	-	-
Total N (g kg^{-1})	0.65	2.90
Available P mg kg^{-1}	12.5	1.55
Exchangeable K (c mol k g^{-1})	0.13	1.80
Exchangeable Ca	1.23	3.55
Exchangeable Mg	0.48	0.55
Sand (g kg^{-1})	830	-
Silt (g kg^{-1})	110	-
Clay (g kg^{-1})	60	-
Textural class	-	-

Table 2: Effects of different fertilizer sources and rates on tomato yield

Treatments	Yield (ton ha^{-1})	No. of fruits
0 (control)	4.072	14,0362
10 ton of chicken manure	21.607	332,128
20 ton of poultry manure	18.153	377,329
60 kg ha NPK 15-15-15	24.523	624,178
120 kg ha^{-1} NPK 15-15-15	32.970	586,461
SE	4.200	45201

Table 3: Effects of NPK fertilizer and chicken manure on the bioactive components

Fertilizer rate	Lycopene content (mg kg^{-1})	Vitamin C content (mg kg^{-1})	Titratable acidity (g/100 g)	Brix (%)	pH
Control (no fertilizer)	137±2.86	298±1.09	0.243±0.008	5.9±0.68	4.0±0.00
10 ton ha^{-1} of chicken manure	201±3.04	201±0.98	0.543±0.070	7.6±0.54	4.4±0.00
20 ton ha^{-1} chicken manure	286±3.12	180±1.01	0.578±0.080	8.0±0.82	4.4±0.00
60 kg N ha^{-1} NPK 15-15-15	187±2.87	245±1.34	0.313±0.060	6.0±0.56	4.1±0.00
120 kg N ha^{-1} NPK 15-15-15	189±2.67	254±1.45	0.289±0.080	6.2±0.58	4.0±0.01

content ranged from 180-298 mg kg^{-1} (Table 3). The highest content was found in control samples while lowest in organic tomatoes, this result is in contrast to the finding of Shankar and Sumathi (2008) that vitamin C content of tomatoes was found to be significantly higher in organically grown compared to conventionally grown vegetables. The pH and titratable acidity ranged between 4.0-4.4 and 0.243-0.578 g/100 g. The highest levels were found in tomatoes from inorganic fertilizer and lowest in organic fertilizer. Lycopene content varied with treatment but was found more in tomato with chicken manure. Levels of lycopene ranged from 137-286 mg kg^{-1} as shown in Table 3.

The lycopene content of tomato was highest at 20 ton ha^{-1} poultry manure. The organic sources had higher lycopene contents than inorganic (Table 3). Lycopene content of conventionally cultivated tomato was found to be significantly lower compared to all other treatments. Similar increase in lycopene in organically grown tomato was reported by Lumpkin (2005). Organic fertilizer gave the lowest titratable acidity levels. The high tomato solids in excess of 5.5% and acidity in the range 0.35-0.55% showed that this tomato variety (UC82B) has attributes for processing.

CONCLUSION

The significant increases in yield components of tomato due to poultry manure and NPK fertilizer in relative to the control confirm the deficiency of essential nutrients in the soil. Therefore, addition of poultry manure and mineral fertilizer made more nutrients available to tomato plant. Application of 120 kg N of NPK 15-15-15 is the best in term of tomato yield. Organic fertilizer application influenced availability of Lycopene more than inorganic fertilizer.

ACKNOWLEDGEMENTS

The researchers appreciate the assistance given by the management of National Horticultural Research Institute, Ibadan in accepting the research proposal and subsequently financing the research. The contribution of the Agricultural supretendents; Mr. Olumide Odulana and Mr. Seyi Oyeniyi in the field work and data collection is also appreciated.

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