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Sustainable Food Production

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Contents

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Books and other monographs

Personal author

Sanni, L. O. 1998. Post Harvest Technology. Oxford, UK: Blackwell Scientific Publications. 140p.

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Chapter in a book

Fabusoro, E., George, F. A. O, Idowu, O. M. O, and Adigbo, S. O. 2009. Consumers' Perceptions for Organic Produce. In: Olowe, V. I. O. eds. *Inroduction to Organic Agriculture*. Oxford, UK: Blackwell Scientific Publications, 40-49.

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MARKETABLE YIELD AND FRUIT QUALITY OF TWO TOMATO (*Lycopersicum esculentum* (L.) H. Karst) VARIETIES AS INFLUENCED BY NITROGEN SOURCE AND ORGANIC MULCHING MATERIAL IN THE DRY SEASON

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ABSTRACT

Postharvest losses in tomato can be either quantitative or qualitative. Even though emphasis in crop research nowadays is increasingly shifting from quantity to quality of produce, there is still little improvement in the quality of commercially- produced tomato varieties, hence resulting in high quality losses.Two field trials were conducted in the dry seasons of 2016 and2017 at the Irrigation Research Farm of the Institute for Agricultural Research, Kadawa, Kano State (11°39' N 080' 027'E, 500 m above sea level) in the Sudan Savanna ecological zone of Nigeria. Treatments consisted of two tomato varieties (UC82B and Rio Grande), two organic mulches (Rice straw and Sugar-cane peels) at recommended rates of 5.5 t ha^{-1} and 11.0 t ha^{-1} (4 cm thick),respectively, with a control (No mulch) and three nitrogen sources (Mineral fertilizer, Poultry droppings and Mineral fertilizer + Poultry droppings at recommended rate of 90 kg N ha^{-1} with a control (No application). Varieties and nitrogen sources were assigned to the main plots while sugar-cane peels mulch was assigned to the sub plots and replicated three times. The two varieties did not differ significantly ($P \leq 0.05$) in all the quality traits evaluated. Tomato fruit qualities (appearance, decay, shelf life) as well nutritional qualities and marketable fruit yield were significantly enhanced by nitrogen sourced from organic sources(poultry manure and mineral fertilizer + poultry manure relative to the unfertilized plots (control) while inorganic nitrogen sources was significantly lower. It can be concluded that poultry droppings at recommended rate of 2.88 t^{-1} could be applied for enhanced fruit quality and marketable yield of tomato on sustainable bases. The two organic mulching materials are recommended for increased marketable and fruit quality of tomato. For better fruit quality of tomato any of the variety could be used in the Sudan ecological zone of Nigeria.

Key word: Fruit quality, Nitrogen sources, Organic mulches, Tomato

INTRODUCTION

Postharvest quality status of tomato partly depends on some pre-harvest practices carried out during production. Some of these factors are fertilizer application, pruning, maturity stage, cultivar selection, and irrigation. The fruit potential quality is dependent on the cultivar type. Different cultivars are characterized by different quality parameters, making some more desirable to the producers The choice of a high-yielding tomato cultivar with desired fruit qualities and longer shelf life is therefore a vital decision a producer must take (Hanna, 2009). Failure to select an appropriate cultivar may lead to lower yield, low fruits quality or less market acceptability. Fruits of different cultivars differ in size, colour, texture, and flavor as well as storage potential.

Getinet*et al.*, (2008) reported the influence of tomato cultivar on some postharvest qualities of tomatoes stored under different conditions. Getinet*et al.*, (2011) established that tomato cultivar Roma VF had higher sugar content while maintaining lower weight loss as compared to cultivar Marglobe. Cultivar selection is therefore critical to the postharvest storage life and eating qualities of tomato.

Fertilizer application is a major part of crop production expenses for tomato but it is critical for successful crop yields and high fruit quality. Recommended target nutrient rates are currently 300 Kg NPK (15:15:15) + 45 Kg N ha^{-1} urea (46% N) with phosphorus (P) and potassium (K) rates adjusted downward or eliminated if soils can supply some or all of these nutrients as determined by soil testing (Mylavarapu, 2009; Olson *et al.*, 2010; Isah *et al.*, 2014).

Use of mulches in vegetable production is undergoing a radical change away from high input, non-renewable resources, such as plastic, to the use of high-residue organic materials from cover crops. It has been reported that organic mulch also can increase the incidence of diseases such as fruit worm and sun scotch on fruits. According to Rwenzaula *et al.*, (2005), rice straw was the best in enhancing crop performance, followed by grass and finally, saw-dust. All the organic mulch regimes used in their work excelled the control in reducing weed and blossom end rot in tomato. Bender *et al.* (2005) also reported that grass mulch caused significant negative effect on cracking of most of the varieties of tomato used. The use of organic mulching material is recommended as a more viable option for vegetable growers instead of inorganic mulch material in an attempt to reduce chemical inputs for weed control in tomato production (Elaine*et al.*,2011). Plant-based mulch is reported to be more effective in reducing soil temperature and that these improvements of crops growing environment resulted in increased tomato growth and fruit yield (Awodoyin*et al.*, 2007). Bienuenida (2014) evaluated organic mulch sources from dry papaya and dry banana leaves and recommended papaya mulch for enhancing plant growth. Moses and Tuarira (2014) evaluated two different organic mulching materials (trash grass mulch and sawdust mulch) on onion production and reported that trashed grass mulch played a significant role in terms of growth and yield. Mateen-ul-Hassan *et al.*, (2005) on effectiveness of organic and inorganic mulching reported that economic comparison indicated that 4 inch (10.2 cm) thick wheat and grass mulch was more efficient than expensive polythene mulch in tomato production in Pakistan.

According to Ferreira *et al.* (2006), tomato yield was previously the main criterion used to evaluate the efficiency of various farming practices for crops such as tomato, while the fruit quality was not an important criterion. However, due to the emphasis on the importance of healthier foods, attention has recently been focused on the agronomic practices implemented during the production of food in order to develop products with better nutritional qualities. Cultural practices such as nutrient application are presumed to be factors influencing quality of tomato before and after harvest (Watkins and Pritts, 2001).

Acceptance of crop produced can be influenced by the source of nutrients involved in its production. In the recent past, some studies have been conducted to elucidate the beneficial effects of adding crop residue compost into the soil. The practice improves soil physical, chemical and biological activities as well as improving crop yields and nutritional values (Akanbi and Togun, 2002).Aurelice, *et al.* (2013) observed and suggested that tomato fruits from organic farming experienced stressing conditions that resulted in oxidative stress and an accumulation of higher concentrations of soluble solids as sugars and other compounds, contributing to fruit nutritional quality such as vitamin C and phenolic compounds.

MATERIALS AND METHODS

Two field trials were conducted in the dry seasons of 2016 and 2017 at the Irrigation Research Farm of the Institute for Agricultural Research, Kadawa, Kano State, Nigeria (11^0 N 39',08^0 02" E 500 m above sea level) located in the Sudan Savanna ecological zone of Nigeria. Soil samples from 0-15 cm and 15-30 cm depths were randomly collected from the experimental sites, using hand auger. The soil samples in each location were bulked, dried, ground, sieved and subjected to physico-chemical analyses. The poultry dropping was also analyzed for the chemical composition using methods described by Agbenin (1995).

Treatments consisted of two tomato varieties (UC82B and Rio Grande); two organic mulching materials (rice straw and sugar-cane peels) at recommended rates of 5.5 t ha^{-1} and 11.0 t ha^{-1} (4 cm thick) - Owen (2013); Mateen-ul-Hassan *et al.*, (2005), respectively and a control (No mulch) and three nitrogen sources at a recommended rate of 90 kg N ha^{-1} and a control plot (2×4×3). The nitrogen sources included mineral fertilizer (MF), poultry droppings (PD) and mineral fertilizer + poultry droppings. The mineral fertilizer was N.P.K 15:15:15 at 300 kg ha^{-1} to supply 45 kg ha^{-1}of nitrogen, 45 kg ha^{-1}of P_2O_5 and K_2O at two weeks after transplanting and Urea (46% N) at the rate of 97.82 kg ha^{-1} was used to supply 45 kg ha^{-1} of nitrogen as second dose to give a total of 90 kg N ha^{-1} fertilizer recommendation for tomato. The nitrogen content of the poultry droppings (PD) used was determined in the laboratory and the value obtained was used to compute the quantity of poultry dropping needed to supply 90 kg N ha^{-1}. A mixture of mineral fertilizer (N.P.K-15:15:15) and poultry dropping at 45 kg N ha^{-1} each was applied to supply a total of 90 N ha^{-1}. There was a control treatment that was left without any application of mineral fertilizer or PD.Varieties and nitrogen sources were factorially- combined and assigned to the main plots while organic mulches were assigned to the sub-plots at already established recommended rate. The experimental design was hence 2×4×3 factorial in split plot design, and there were three replications.

All the cultural practices were carried outeffectivelyfrom nursery practice to storage.

Data collected were subjected to analysis of variance (ANOVA) as described by Steel and Torrie (1987) and treatment means were separated using Duncan multiple range test as described by Duncan *et al.* (1997) at $p \leq 0.05$ probability level.

RESULTS

The soil was of loam textural classwith mildly alkaline pH. Nitrogen content of the soil was low while organic matter was very high. Potassium content was medium while phosphorus was high. Calcium and magnesium contents were very high. Electrical conductivity of the soil was low, indicating that the soil was non saline at 0-30 cm depth in Table 1.

Nitrogen content of poultry droppings used was 2.57 % in 2016 and 3.67 % in 2017and these values were used to determine the quantity of poultry dropping that supplied the recommended nitrogen need for the plants. However phosphorus was low in 2016 and high in 2017 while potassium was high in both years in Table 2.

Variety did not affect t all the fruit qualities (appearance, fruit decay, shelf life and marketable fruit yield) studied in both years (Table 3).

In 2016, PD and MF+PD significantly resulted to very good fruit appearance which was comparable than the control while in 2017, nitrogen sources did not affect fruit appearance. Application of PD as well as MF+PD resulted to significantly lower cases of fruit decay which are comparable than the control in both years. However, similar trend was observed for fruit shelf life with PD and MF+PD resulting to a significant and comparable longer shelf life than the control plots in both years. Similar trend was also observed with marketable fruit yield in the mean result.

Apart from in 2016 that organic mulching materials did not affect fruit appearance, mulching materials enhanced all the fruit qualities studied in both years where the two organic mulching schedules produced significantly better fruit appearance, less cases of decay, longer shelf life as well as higher marketable fruit yield that were comparable than fruits from un-mulched plots.

Variety did not affect fruit vitamin A, E and C content (Table 4).

Nitrogen sources enhanced vitamins A, E and C. PD and MF+PD significantly produced fruit with statistically higher and comparablevitamin A concentration than fruits from MF and unfertilized plots. Vitamin E content of fruit was significantly increased with MF+PD than the other nitrogen schedules. However, any of the nitrogen sources significantly produced fruits with statistically comparable and lower vitamin C concentrationthan fruits from the unfertilized plots.

Organic mulching materials did not differ significantly on vitamin concentration of tomato fruit.

DISCUSSION

Results from this study showed that tomato varieties did not significantly affect any of the fruit qualities assessed (Tables 3 and 4). However, fruit qualities such as fruit appearance, fruit decay, fruit shelf life as well as vitamin (A, E and C) concentrations were significantly enhanced by nitrogen sources.

There were observed variations and significant differences between varying nitrogen sources on fruit appearance and fruit shelf life with poultry droppings (PD) and mineral fertilizer (MF) + poultry dropping (PD) producing significantly longer shelf life and good fruit appearance than MF and unfertilized plots (Table 3). The performance trends of the organic nitrogen fertilizer source which showed superiority over application of mineral fertilizer might be due to the fact that organic N source have the ability to enhance soil physical properties (water holding capacity, aeration etc) and greater and gradual release of nutrients. Similar findings by Rajiasree and Pillai (2009) reported that more frequent split application of nutrient N or greater proportion of organic source enhanced the shelf life of fruits. The observed significant differences between the applied nitrogen source treatments with regard to fruit decay (Table 3) with poultry droppings and mineral fertilizer + poultry droppings which produced significantly lower cases of fruit decay might partly be due to the origin of the nitrogen source which was from organic materials and hence enhanced marketable fruit yield.

Significant difference was observed in mean vitamins A, E and C concentrations, between the varying sources of nitrogen, with PD and MF + PD which were statistically comparable being significantly higher than from application of MF and the unfertilized plots which had the lowest vitamin A concentration (Table 4) while application of MF + PD had significantly higher vitamin E concentration than other nitrogen sources. The superiority in vitamins A and E concentrations recorded under PD and MF + PD treatment which are both of organic origin could be attributed to oxidative stress which most have exerted some pressure on the crops, thereby enhancing nutritional quality such as vitamin A and E concentration. This result corroborate with Aurelice, *et al.*, (2013) who suggested that tomato fruits from organic farming experienced stressing conditions that resulted in oxidative stress and the accumulation of higher concentrations of soluble solids as sugars and other compounds contributing to fruit nutritional quality such as vitamins and phenolic compounds. Also, Poiroux-Gonord*et al.*, (2010) reported that environmental stress (biotic or abiotic) is a major factor that can increase the concentrations in photochemical in fruit and vegetables. However, organic N-sources (PD and MF + PD) were found to have reduced vitamin C concentration (Table 4). Similar findings were reported by Anon (2018) that nitrogen fertilizers, especially at high rates, seem to decrease the concentration of vitamin C in many different fruits and vegetables.

Significant ($P \leq 0.05$)difference was observed between the varying organic mulching treatments with the two organic mulching materials showing significantly higher and comparable fruit qualities such as good fruit appearance, less fruit decay, longer shelf life and higher fruit N concentration. Sugar cane peels mulch which was observed to be significantly similar but higher than rice straw mulch offered additional advantage of providing protection in additional to its role of moisture conservation for tomato fruit against direct contact with the soil which subsequently might have prevented infestation from soil born deceases and hence good fruit qualities thus further prolonged storage life of tomato fruit.

CONCLUSION AND RECOMMENDATION

It is recommended from this study that poultry droppings at recommended rate of 2.88 t ha^{-1} could be applied for fruit quality and marketable yield of tomato on sustainable basis. Sugar-cane peels mulch is recommended as a suitable replacement to rice straw mulch due to high cost of obtaining rice straw mulch. Any of the tomato varieties (Rio Grande or UC82B) are recommended for increased yield and quality of tomato in the Sudan ecological zone of Nigeria.

Table 1: Initial soil properties of the experimental site

Soil properties	2016	
	0-15 cm	15-30 cm
Sand (g kg^{-1})	420	400
Silt (g kg^{-1})	450	480
Clay (g kg^{-1})	130	120
Textural class	Loam	Loam
pH in H_2O 1:2.5	7.90	7.80
pH ($CaCl_2$)	6.80	6.90
Organic matter (mg kg^{-1})	7.89	4.99
Available phosphorus (g kg^{-1})	10.92	10.38
Total nitrogen (g kg^{-1})	0.63	0.41
Ca^{++} (cmolkg^{-1})	4.60	3.60
Mg^{++} (meg/100g)	1.58	0.97
K^{+} (meg/100g)	0.15	0.16
Na^{+} (meg/100g)	6.54	4.95
H^{+}+Al^{3+} (meg/100g)	0.05	0.05
ECEC (meg/100g)	6.59	5.00
EC (dS/m)	0.013	0.110

Table 2: Nutrient levels of the poultry droppings used

Chemical properties	2016	2017
N (g kg^{-1})	25.7	36.7
P (mg kg^{-1})	2.5	10
K(mg kg^{-1})	100	30
Ca (mg kg^{-1})	40	20
Mg(mg kg^{-1})	40	10
Na (mg kg^{-1})	50	30

Table 3: Main effects and interactions of variety, nitrogen source and organic mulch on tomato fruit qualities in 2016 and 2017 dry seasons

	Fruit appearance		Fruit decay		Fruit shelf life (days)		Marketable fruit yield (t ha^{-1})
Factor levels/interactions	2016	2017	2016	2017	2016	2017	Mean
Variety (V)							
UC82B	3.47	3.31	5.86	5.93	9.69	7.75	14.02
Rio-Grande	3.53	3.44	5.78	6.08	9.53	7.67	13.16
SE±	0.12	0.05	0.25	0.15	0.32	0.29	0.46
Nitrogen source (N)							
No application	2.11c	3.22	6.78a	6.39a	6.39c	5.11c	11.33c
Mineral fertilizer (MF)	3.28b	3.11	6.28ab	6.28a	8.11b	6.83b	13.50b
Poultry droppings (PD)	4.39a	3.83	4.83c	5.50b	11.89a	9.39a	13.89ab
MF.+ PD	4.22a	3.33	5.39bc	5.83ab	12.06a	9.50a	15.64a
SE±	0.41	0.22	0.36	0.21	0.45	0.42	0.65
Organic mulch (M)							
No mulch	3.33	2.50b	7.04a	7.58a	8.38b	7.00b	12.05b
Rice straw	3.50	3.72a	5.08b	6.67b	9.92a	7.58ab	14.78a
Sugarcane peels	3.67	3.92a	5.33b	3.75c	10.54a	8.54a	13.93a
SE±	0.152	0.206	0.326	0.172	0.37	0.35	0.56
CV (%)	29.94	29.94	14.03	14.03	18.94	18.92	34.94
Interaction							
N×V×M	ns	ns	ns	ns	ns	ns	ns

All means within a column/factor followed by same letters are not different at 5% level of significance using Duncan Multiple Range Test DMRT; ns=Not significant.

Table 4: Main effects and interactions of variety, nitrogen source and organic Mulch on Vitamins A, C and E concentrations of irrigated tomato fruit in the combined season

Factor levels/interactions	Vitamin A (mg/kg)	Vitamin E (mg/kg)	Vitamin C (g/kg)
Variety (V)			
UC82B	6.24	7.73	1.53
Rio-Grande	6.57	7.62	1.58
SE±	0.17	0.13	0.11
Nitrogen source (N)			
No application	3.14c	3.92c	1.98a
Mineral fertilizer (MF)	5.42b	5.48c	1.54ab
Poultry droppings (PD)	7.83a	8.41b	1.39b
MF.+ PD	9.23a	12.88a	1.29b
SE±	0.34	0.35	0.15
Organic mulch (M)			
No mulch	6.53	7.87	1.63
Rice straw	6.66	7.59	1.57
Sugarcane peels	6.03	7.56	1.45
SE±	0.26	0.51	0.13
CV (%)	22.43	18.98	24.27
Interaction			
N×V×M	ns	ns	ns

All means within a column/factor followed by same letters are not different at 5% level of significance using Duncan Multiple Range Test DMRT; ns=Not significant.

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