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Yield and Processing Quality of Tomato (*Lycopersicon esculentum* Mill) with Fertilizer Type

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Authors' contributions

This work was carried out in collaboration between all authors. All authors designed the study, author BAS performed the statistical analysis and wrote the first draft of the manuscript, author JGB managed the postharvest analysis aspect of the study, and author EAM wrote the protocol. Author VIOO managed the crop nutrition aspect of the study. All authors read and approved the final manuscript.

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ABSTRACT

Sustainable processing of tomato fruits depends on the availability of high yielding varieties, suitable for mechanical harvest and handling. Efforts in addressing the postharvest challenges of handling tomato fruits, have placed great emphasis on cultivating varieties with improved processing qualities. Field experiments were conducted in the early seasons of years 2014 and 2015, to examine the yield and processing qualities of tomato fruits as influenced by fertilizer type, using determinate and indeterminate varieties. The experiment was a Randomized Complete Block Design in a split-plot arrangement, replicated three times. Two tomato varieties (Roma VF and Beske) constituted the main plot while six fertilizer types (poultry manure, cow dung, NPK, poultry manure + NPK, cow dung + NPK and the control) constituted the sub-plot. The sub-plot size was 2.0 m x 3.0 m. Biochemical and proximate analyses were carried out on fruits from each treatment. Data collected on vegetative, reproductive and yield as well as the, proximate and biochemical properties were subjected to analysis of variance. Irrespective of the fertilizer type, tomato varieties differed in number of days to first and 50% flowering, days to maturity, number of fruits and fruit

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yield as well the processing parameters evaluated. These processing qualities are highly determined by the variety of tomato planted as well as fertilizers. Application of poultry manure (5 t/ha) + NPK 15:15:15 (150 kg/ha) enhanced high fruit TSS while sole poultry manure (10 t/ha) enhanced high lycopene content. It is concluded that the processing quality traits of tomato fruits would be mainly affected by the variety, thus it is established that Roma VF is a processing tomato variety. Beske is recommended for high fruit yield targeted at fresh market utilization, while Roma VF is recommended as a processing tomato variety.

Keywords: Tomatoes; organic fertilizer; inorganic fertilizer; proximate composition; Beske and Roma VF.

1. INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is an annual herb belonging to the family *Solanaceae.* It is classified as a functional food, for having good levels of vitamins, minerals, and especially lycopene, a carotenoid pigment that provides red colour and has antioxidant qualities [1]. The quality of a vegetable can be characterized by features such as appearance, texture, safety, flavour and nutritional value. Tomato quality is affected by genetic foundation, growth, environment, used inputs, and aging during postharvest storage. Tomato fruits contain high amount of ascorbic acid and lycopene. Lycopene, an antioxidant, is the pigment that imparts red colour to some fruits, most notably tomato and watermelon. It is also a highly efficient oxygen radical scavenger and has been implicated in human health as providing protection against cardiovascular diseases and some cancers, particularly prostate cancer [2]. The acceptance of crop produced can be influenced by the source of nutrients involved in its production. Many pre- and postharvest factors influence the phytochemical contents of horticultural crops. Large genotypic variation in vitamin content was reported by [3] and [4]. Preharvest factors of relevance include climatic conditions and cultural practices [5,6,7]. Among the cultural practices, fertilizer type can influence the level of functional food components in crops.

In a pot experiment on the effect of poultry manure at 0, 2, 4 and 8 tonnes per hectare on tomato [8] concluded that the optimum growth could be produced with 4 tonnes per hectare of poultry manure. They also reported that application of higher dose had resulted in increased vegetative growth and that poultry manure was excellent for growth and vigour of tomato [8]. [9] observed that chicken manure did not increase tomato yields significantly but it did increased the number of large and medium fruits. [10] reported that application of poultry manure significantly increased tomato fruit yield. [10] reported tomato plants fed with the combination of chicken manure and inorganic fertilizer did not give significant increase in yield of tomato seeds compared with that of chicken manure alone.

Good quality of tomato fruits and their acceptance by consumers describes a high correlation coefficient between the results of sensory assessment and the results of chemical analysis [11,12]. Fruit composition and their desirability are affected by many factors such as growth media, fertilizers, and salinity sources [13,14,15].

Successful processing of tomato products starts from careful field crop management. Despite many investigations in the area of nutrition, knowledge on how organic fertilizers in combination with genotypic variation influences physical and phytochemical contents of tomato fruit is inadequate. The objective of the study was to determine the influence of fertilizer on fruit yield and processing quality of tomato.

2. MATERIALS AND METHODS

Field experiments were carried out at the Teaching and Research Farm, Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria (7° 15'N, 3^0 25' E) during the early seasons in the years 2014 and 2015. The post field part of the research was carried out in the laboratories of the Departments of Horticulture and Food Science and Technology, FUNAAB. The experiment was laid out in a Randomized Complete Block Design (RCBD) in a split-plots arrangement with three replications. Variety was allotted to the main plot while fertilizer was the sub plot. The sub-plot size was 2m x 3m. Tomato seeds were sown and maintained on a ground nursery. The land was cleared, ploughed and harrowed and beds for planting were prepared manually. Poultry droppings and Cow dung were applied to their allotted plots one week before transplanting according to [16]. Tomato transplanting was done to the field when seedlings were four weeks old. The seedlings

were transplanted at the spacing of 50cm x 50cm (40000 plants/ha and 24 plants/plot). Two seedlings were transplanted per stand and later thinned to one after establishment at two weeks after transplanting. NPK 15:15:15 was applied to the allotted plots following [17], basal fertilizer application was done at one week after transplanting and top-dressing followed at four weeks after transplanting. Weeding was done manually as the need arose. Complimentary fertilizer application was done by the application of half of the recommended rate of the organic fertilizer (5t/ha; 3kg/plot) applied at two weeks before transplanting followed by half of the recommended rate of NPK 15:15:15 (150kg/ha; 0.09 kg/plot) in split doses. Pre-planting soil analysis was carried out on soil sample from the experimental sites. Samples of the cow dung and poultry manure were also analysed for nutrient status. Data collection commenced at 2 weeks after transplanting on vegetative growth and later to reproductive growth and yield as well as the, proximate and biochemical properties. Post-field (Laboratory) analyses were done on randomly selected tomato fruits samples from all the treatments as described below. The parameters measured include;

i. **Firmness of Tomato fruits (10^{th}/mm)** – This was determined with the use of a cone penetrometer (Unified National Inventory Database 020260).
ii. **Moisture Content (%)** – 5g of Edible portion tomato fruit samples was weighed accurately into Petri dishes of a known weight, placed in an oven at 100^0C for 3hours after which the samples were removed and put in a desicator to cool. After cooling, the samples were weighed and returned to the oven for 30minutes, cooled and reweighed until constant weigh was obtained.

The percentage moisture content was estimated as;

$$\% \text{ Moisture Content} = \frac{\text{Weight loss} \times 100}{\text{Original Weight}}$$

iii. **pH** – was estimated with the use of a pH meter (Jenway 3015).
iv. **Ascorbic Acid (Vitamin C) (mg/100 ml)**– This was estimated using Dichlorophenolindophenol (DCPIP) dye
v. **Total Soluble Solids (%)**– The was estimated with the use of a refractometer
vi. **Titrable Acidity** –This was determined by direct titration of 2g of the sample with 0.1M sodium hydroxide using phenolphthalein as indicator.
vii. **Lycopene content (mg/kg)** – This was estimated using a Unicam SP 600 spectrometer (E 1% (1cm) = 2820).

Data collected were subjected to analysis of variance. Duncan's Multiple Range Test and Least Significant Difference at 5% probability level was used as applicable to compare the treatment means.

3. RESULTS AND DISCUSSION

The soil for the experiment in the first year (2014) was sandy loam in texture while the soil for the 2015 experiment was sandy. (Table 1). The soil for both experiments were close to neutral in acidity (between pH 5.99 and 6.85). Soil used for all the experiments was low in both nitrogen and phosphorus.

Table 1. Pre-planting physico-chemical characteristics of soil of the experimental sites

Parameters	2014	2015
pH	6.50	6.19
Total Org C (%)	1.98	0.79
Total Nitrogen (%)	0.07	0.08
Phosphorus (ppm)	6.01	6.65
Potassium (ppm)	0.17	0.28
Sodium (cmol/100 g)	0.75	0.53
Calcium (mg/kg)	0.22	6.03
Magnesium (cmol/100 g)	4.65	1.94
Copper (mg/kg)	0.18	1.1
Manganese (mg/kg)	162.35	38.65
Iron (mg/kg)	11.31	7.95
Zinc (mg/kg)	1.34	5.50
ECEC (mg/100 g)	20.00	8.86
Sand (%)	77	86.2
Clay (%)	20.2	5.0
Silt (%)	1.8	6.8
Textural class	Sandy loam	Sandy

The poultry manure used for the two trials was alkaline (Table 2). Total nitrogen and phosphorus were high to the poultry manure used in the 2015 trial while potassium was high in the poultry manure used for the 2014 trial (Table 2).

Cow dung used for both experiments was alkaline. Total nitrogen was high in the cow dung used for the 2014 trial while potassium and phosphorus were both high in the cow dung used in the second year (Table 2).

Differences were observed in the two tomato varieties on number of days to first and 50%

flowering, days to maturity, number of fruits and fruit yield. These observed differences in yield attributes in both years may be due to different environmental conditions in these years.

Beske had higher number of fruits and total fruit yield than Roma VF in both years (Table 3). This is supported with the view of [18] who suggested that indeterminate varieties continuously produce flowers and fruits, and consequently higher number, though of small fruit sizes. Fertilizer type also differed significantly on fruit yield although the observed difference was not significant. Yield was significantly higher with the application of organic fertilizers (both poultry manure and cow dung) in the first year, while in the second year yield was significantly higher with the application of sole NPK although not significantly different from the inorganic fertilizers (Table 4).

There was a significant varietal difference on the firmness of tomato fruits in both years, it was observed that variety Beske fruits were not as firm as Roma VF (Tale 5). This could be attributed to the inherent genetic differences in the two varieties. Variety Beske also had fruits with high moisture content in both years (Table 5), suggesting that firm fruits are low in moisture content. It was observed that variety Beske fruits had low TSS when compared with Roma in both years (Table 5). This suggests that the TSS in tomato fruits could be determined by the fruit moisture content as well as firmness. It was observed that the pH, titrable acidity and vitamin C contents of tomato fruits would not be determined by the variety as tomato varieties were not significantly different in these parameters (Table 5).

Table 2. Characteristics and composition of poultry manure and cow dung

Parameters	Poultry manure		Cow dung	
	2014	2015	2014	2015
pH	9.40	7.76	9.3	9.19
Org C (%)	2.41	5.15	2.59	2 89
Total Nitrogen (%)	0.18	0.21	0.20	0.15
Phosphorus (mg/kg)	9.86	9.13	6.32	7.10
Potassium (cmol/100 g)	0.40	0.54	0.72	1.03
Sodium (cmol/100 g)	25.00	0.54	1.65	1.02
Calcium (mg/kg)	53.59	3.05	5.83	8.55
Magnesium (cmol/100 g)	12.26	1.65	1.16	2.77
Copper (mg/kg)	0.33	350	11	14
Manganese (mg/kg)	3.55	724	512	491
Iron (mg/kg)	23.25	4026	4837	6923
Zinc (mg/kg)	3.80	4.12	119	128

Table 3. Effect of variety on number of fruit and yield (t/ha) of tomato

Variety	Number of fruits/plant		Fruit yield (t/ha)	
	2014	2015	2014	2015
Beske	158.35	115.14	6.76	2.14
Roma VF	125.97	79.47	4.58	1.63
LSD, 5%	30.68	18.08	1.39	0.43

Table 4. Effect of fertilizer type on number of fruit and yield (t/ha) of tomato

Fertilizer type	Number of fruits/plant		Fruit yield (t/ha)	
	2014	2015	2014	2015
Poultry droppings	299.830[a]	126.420[a]	9.169[a]	2.573[ab]
Cow dung	300.000[a]	138.500[a]	9.346a	2.386[ab]
NPK	53.670[bc]	151.000[a]	2.721[b]	2.691[a]
Poultry droppings + NPK	78.830[b]	39.170[c]	3.057[b]	0.879[d]
Cow dung + NPK	15.420[c]	89.400[b]	0.283[c]	1.760[bc]
Control	4.930[c]	46.500[c]	0.121[c]	1.124[cd]

Note: -Means followed by the same alphabet in the same column are not significantly different at 5% probability level of DMRT

Table 5. Effect of variety on processing quality traits of tomato fruit

Variety	Firmness (10^{th}/mm)		MC (%)		TSS (%)		pH		TTA		Lycopene (mg/kg)		Vitamin C (mg/100 ml)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Beske	29.78	48.19	74.99	89.01	3.46	4.99	113.81	166.16	2290.57	3003.75	26.31	61.88	28.23	49.14
Roma VF	17.44	41.12	70.42	82.55	3.52	5.20	114.72	165.54	2233.67	2884.75	27.13	58.08	28.09	39.92
LSD, 5%	0.84	0.36	0.92	0.68	0.93	0.39	0.98	0.49	0.93	0.23	0.89	0.27	0.99	0.16

Table 6. Effect of fertilizer type on processing quality traits of tomato fruit

	Firmness (10^{th}/mm)		MC (%)		TSS (%)		pH		TTA		Lycopene (mg/kg)		Vitamin C (mg/100 ml)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
PD	41.390^{a}	56.942^{ab}	84.373^{a}	88.893^{ab}	6.843^{a}	5.462^{b}	4.822^{a}	5.794^{a}	0.257^{a}	1.595^{b}	0.313^{a}	0.306^{a}	151.163^{a}	165.968^{b}
CD	44.970^{a}	69.367^{a}	84.330^{a}	87.268^{b}	6.744^{a}	5.782^{ab}	4.798^{a}	5.738^{a}	0.305^{ab}	1.593^{b}	0.299^{ab}	0.300^{ab}	152.298^{a}	165.667^{b}
NPK	15.450^{b}	60.083^{ab}	85.220^{a}	88.784^{ab}	6.862^{a}	5.704^{ab}	4.869^{a}	5.750^{a}	0.244^{ab}	1.595^{b}	0.319^{a}	0.300^{ab}	155.288^{a}	165.822^{b}
PD+NPK	12.280^{b}	45.033^{b}	84.617^{a}	88.838^{ab}	6.884^{a}	5.978^{a}	4.795^{a}	5.709^{a}	0.243^{bc}	1.595^{b}	0.312^{a}	0.289^{b}	156.871^{a}	166.024^{b}
CD+NPK	8.140^{b}	48.610^{b}	42.318^{b}	88.254^{b}	6.335^{b}	5.499^{b}	2.613^{b}	5.803^{a}	0.186^{bc}	1.854^{a}	0.188^{b}	0.303^{a}	88.772^{b}	166.585^{a}
Control	10.320^{b}	45.379^{b}	86.305^{a}	90.289^{a}	3.612^{c}	5.324^{b}	1.921^{c}	5.574^{b}	0.167^{c}	1.415^{c}	0.131^{b}	0.206^{b}	68.359^{c}	165.891^{b}

Note: -Means followed by the same alphabet in the same column are not significantly different at 5% probability level of DMRT
-PD – Poultry manure; -TSS – Total Soluble Solid; -TTA – Titatable Acidity; -MC – Moisture content; -CD – Cow dung

It was observed that the combination of poultry manure and NPK favoured fruit firmness (Table 6). Tomato fruits from this fertilizer combination were very firm compared with other fertilizer types that were not different in fruit firmness. This agrees with the result of a study by [19], that tomato fruit quality determinants are not affected by organic farming.

The high moisture content, pH, titrable acidity and vitamin C content observed in all the organic tomatoes as seen in Table 6 agrees with the result of a study by [20] reporting that fruits from organic farming have higher levels in all the quality parameters analysed. It also supports other studies demonstrating that tomatoes from organic farming accumulates higher levels of vitamin C (+55%) and phenolic compounds (+139%) than those from conventional farms [21]; [22]. The organic tomatoes having higher levels of these compounds agrees with the discoveries of [23].

Fertilizer types were not significantly different in lycopene content (Table 6). The observed similarities in the lycopene content of the tomato fruits from all the fertilizer types agrees with a work by [24] that the levels of vitamin C, total acidity, Lycopene and carbohydrate among the fruits of tomatoes from the organic and the conventional systems may not have significant differences.

In the first year, application of fertilizer reduced the moisture content of tomato fruits (Table 6), fruits from the control plot had high moisture content, while in the second year 2015, although, moisture content was low in the control plot but it did not differ from fruit with applied fertilizer (Table 6).

Fertilizer types differed in fruit total soluble solids (TSS), in both years (Table 6), the observed low TSS in tomato fruits suggest that application of a fertilizer type would increase the tomato fruit TSS which contradicts the work of [19] that high nitrogen supply of about 250kg/ha can impair some important quality traits of fruits such as total soluble solids.

Fruits from the control plots were observed to be highly acidic, implying that application of fertilizer could reduce the acidity of tomato fruits. This observation on pH was similar with titrable acidity and vitamin C content of tomato fruits in that fruit from the control plots were low in these three parameters (Table 6). This could be attributed to added potassium fertilizer through the different fertilizer types which agrees with Passam *et al.* 2007 that potassium fertilizer in tomato production improves fruit color and enhances titratable acidity of the fruit.

It was observed that in the first year, the different fertilizer types were not different in the lycopene content of tomato fruits except for the application of cow dung + NPK, although the application of fertilizer had resulted in fruits with high lycopene content (Table 6). In the second year it was observed that fruits from plot with the application of cow dung + NPK were high in lycopene while the other fertilizer types were low and similar with the control.

4. CONCLUSION

From this experiment, it is concluded that indeterminate tomato variety (Beske) attained first and 50% flowering and maturity earlier than Roma VF and also had more fruits as well as higher fruit yield. It was observed that fruit yield could be influenced by the yield variables such that variety that is early in flower production and maturity results in higher number of fruits as well as fruit yield. Irrespective of the type of fertilizer, fertilizer application gives higher level of processing quality parameters of tomato, although, there could be no significant difference among the tomato fruits from the organic and the inorganic fertilizer types. Processing qualities of tomato would be influenced mainly by varieties.

Thus processing qualities of tomato fruits would be influenced more by the variety and not the type of fertilizer applied or the growing method. It is established that Roma VF is a processing tomato variety.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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