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Evaluation of Tomato (*Solanum lycopersicum* L.) Genotypes for Horticultural Characteristics on the Upland in Southern Sierra Leone

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Abstract

Notwithstanding the importance of tomato in human diet, the average yield of the crop in Africa hardily exceeds 7.5 tha^{-1}. There is continuous unavailability of high yielding cultivars that are adapted to diverse environment and suitable for different purposes. Consequently, evaluation of introduced tomato genotypes for desired horticultural characteristics to identify superior genotypes for additional improvement in yield and yield related traits is indispensible. Hence eight tomato (*Solanum lycopersicum* L.) genotypes including parental were field planted in a randomized complete block design with three replications at the Department of Horticulture Nursery Unit, School of Natural resources Management, Njala University, Njala Campus, Moyamba District, Southern Sierra Leone to evaluate them for good horticultural traits. Data collected include plant height at 50% and 100% flowering, stem girth at 50% and 100% flowering, days to first, 50% and 100% flowering, days to maturity, number of fruits set per plant, number of fruits harvested per plant, average fruit weights, fruit length, fruit diameter, fruit flesh thickness, locule number, marketable and nonmarketable fruits per plant. Results from the study indicated that all genotypes studied are adaptable to the Sierra Leone climatic conditions. P_1 (097) recorded the highest number of fruits set per plant, number of fruits harvested per plant and tallest and largest plant height and stem girth at 100% flowering. BC_2F_2 had the highest locule number while R_3P_9 had the heaviest fruit weight. P_2 (213) had the thickest fruit flesh thickness and longest duration to fruit maturity respectively while P_1 (097), BC_1F_2 and R_3P_9 had the same number of shortest days to maturity. Regarding fruit length and diameter, R_3P_8 and R_6P_6 had the longest and widest. With respects to marketable and nonmarketable fruit per plant, P_1 (097) recorded the highest correspondingly.

Keywords: genotypes, evaluation, horticultural characteristics, tomato, cultivars

1. Introduction

Tomato (2n = 24) (*Solanum lycopersicum* L.) is herbaceous edible fruiting plant and belongs to the Solanaceae family. The crop was introduced by Portuguese in the West African sub-region between the 16th and 17th century (Osei et al., 2013). Universally, it is the second most consumed vegetable after potato (FAOSTAT, 2005; Osei et al., 2010). Present world production is about 100 million tons fresh fruit produced on 3.7 million hectares (Kanneh et al., 2016). Tomato is a good source of minerals, vitamins A, B1, B2, B3, B6, C, E, niacin, folic acid, biotin, and other compounds, including lycopene that has antioxidant activity and is associated with reduced risk of cancer (Soares & Farias, 2012) and development of risk reduction of other chronic diseases (Moritz & Tramonte, 2006). According to Osei et al. (2010), tomato can be grown across varied range of soils as long as drainage and the physical soil structure are good. Nevertheless, it does very well in well-drained sandy loams to loamy soils with optimum pH range of 6.0-6.5. The highest fruit quality and maximum yields are obtainable in the dry season with supplementary water Godia (2014). Tomato is the most important vegetable in the tropics (FAO, 2003). Tomato is promising for improving the earnings and livelihoods of thousands of smallholder farmers in Africa diversifying and increasing agricultural export exchange earnings of many Africa States (CSA, 2006; Lemma, 2001). Because of its physicochemical and biological properties, the crop has attracted attention particularly related to its effects as a natural antioxidant (Shi & Le Maguer, 2004). Tomatoes are the main source of lycopene compounds, and are therefore considered as a major source of carotenoids in the human diet (Willcox et al., 2003). According to Tewodros and Asfaw (2013) the crop is known as an excellence produce for both indigenous and foreign markets and provides a way out of poverty for smallholder growers living in unindustrialized countries. Therefore, tomato is considered as the vegetable of the mainly underprivileged grassroots (Adepetu, 2005). It cultivation provides income generation, economic value and impact the environment (Kanneh et al., 2016).

In Sierra Leone, tomato is now one of the most important vegetables consumed in large amount in most households in urban and peri-urban areas. It is consumed as fresh fruit, salads, soup, stew and other dishes. Virtually, tomato is grown in all regions of Sierra Leone with high production concentrated in the Western and Northern areas. Like other Africa countries, yield of tomato in Sierra Leone continue to be low barely exceeding 6 t ha^{-1}. The low yield of tomato could be ascribed to the poor soil fertility, unavailability of improved planting material (seed) and the incidence of pest and diseases. Despite the significant nutritional, socio-economic and environmental roles of tomato, the right kind and quantity of tomato are not grown in Sierra Leone. This is as a result of unavailability of improved varieties that growers continue to cultivate local cultivars. These local cultivars are characteristically low yielding and susceptible to pest and diseases. Therefore, the need to breed for high yielding tomato genotype for further advancement and enrichment in yield and yield components needs not be overstated. The overall aim of the study was to evaluate tomato genotypes for superior horticultural characteristics of F_3 generation to identify and select promising genotypes for further yield improvement.

2. Method

The experiment was conducted in the first cropping season of 2016 at the Department of Horticulture Nursery, Njala University, Njala Campus, Moyamba District, Southern Sierra Leone. Njala is 54 m above sea level on 8.06°N latitude and 12.06°W longitude. The climatic condition of the research field area falls within humid tropical and it is characterized by distinct mono-modal rainfall pattern (wet and dry) seasons. The rainy season lasts from May to October while the dry season begins from November and ends in April with an average annual rainfall of 2000 to 3000 mm. The mean monthly maximum and minimum temperatures for greater part of the day and night were 29 °C to 34 °C and 21 °C to 23 °C and the soil pH of 5.4-6.0 with a dominant grassland vegetation. Eight tomato genotypes including parental were generated by the Horticulture Division, Council for Scientific and Industrial Research (CSIR)-Crops Research Institute (CRI) Kwadaso, Kumasi, Ghana through hybridization in 2012. They are breeding lines being developed by Kabala Horticultural Crops Research Center (KHCRC-SLARI) for possible release of tomato varieties. The tomato genotypes planted during the experimentation are presented in Table 1 below.

Table 1. Tomato genotypes planted during experimentation

Parental genotypes	**Segregating population**
P_1 097	BC_1F_2
P_2 213	BC_2F_2
	R_1P_7
	R_3P_8
	R_3P_9
	R_6P_6

Source: Salia Milton Kanneh (KHCRC-SLARI).

The experiment was laid out in a randomized complete block design (RCBD) with three replications. Each genotype was planted on a plot size of 3 m × 0.75 m with two rows of six plants spaced at 0.75 and 0.60 m between and within rows. Seeds of the genotypes were nursed on the 15th April, 2016 in a nursery tray filled with treated soil and sufficient organic manure added. Seedlings were transplanted on 15th May, 2016. Poultry manure at the rate of 20g per stand was applied as a basal. NPK 15:15:15 at 6g per stand was applied four Weeks After Transplanting (WAT) using side dressing method. Standard agronomic practices such as weed control, pest and disease management, staking, pruning and tying were appropriately done. Data collected includes **d**ays to first, 50% and 100% flowering, plant height, and stem girth were recorded. Other parameters measured includes days to maturity, Fruit Weight (FW), Locule Number (LN) Fruit Flesh, Thickness (FFT), number of fruits per plant, fruit length, fruit diameter, marketable fruit per plant and nonmarketable fruit per plant. For vegetative parameters, five plants were randomly tagged per plot for data collection of the above ground parts on two weekly intervals. Plant height was measured with a calibrated measuring tape from the ground level to the terminal bud of the main stem. Electronic Vernier caliper was used to measure plant stem girth 20 cm above ground level, fruit flesh thickness, fruit length and fruit diameter. Days to first, 50% and 100% flowering were counted and recorded from the date of transplanting onto the day first flower opened. The number of days to 50% and 100% flowering were recorded when half and all of the plants in the plot had flowered respectively. Days to fruit maturity were counted from the date of transplanting to date fruits were matured and the number of locule per fruit was physically counted after vertically cutting the fruit into two halves. Data recorded were subjected to Analysis of Variance (ANOVA) using the Genstat (12th edition) Statistical package. LSD at 5% was used to separate the significant treatment means.

3. Results

3.1 Presentation of Vegetative Mean Performance of Eight Tomato Genotypes

Vegetative performances of eight tomato genotypes are presented in Tables 2 and 3 respectively. Statistically there were significant differences among tomato genotypes for plant height at 50% flowering of which BC_1F_2 had the tallest plant (77.70 cm) which was followed by P_1 097 (57.30 cm) while R_3 P_8 recorded the shortest plant height (48.20 cm). Though there were no significant differences among tomato genotypes for plant height at 100% flowering, however, P_1 097 and R_6P_6 accounted for the tallest (100.90 cm) and shortest (75.90 cm) plant height respectively. Stem girth at 50% and 100% flowering were highly significant among tomato genotypes. At 50% and 100% flowering, P_1 097 (9.90; 11.58 cm) and BC_2F_2 (6.75; 9.33 cm) accounted for the largest and smallest stem girth respectively (Table 2).

Table 2. Vegetative mean performance of eight tomato genotypes

Genotypes	Plant height (cm) at 50% flowering	Plant height (cm) at 100% flowering	Stem girth (cm) at 50% flowering	Stem girth (cm) at 100% flowering
P_1 097	57.30	100.90	9.90	11.58
P_2 213	56.60	80.90	7.93	9.57
BC_1F_2	77.70	86.70	7.15	9.77
BC_2F_2	53.80	80.90	6.75	9.33
R_1P_7	52.40	77.10	7.94	11.12
R_3 P_8	48.20	80.20	8.08	9.87
R_3P_9	53.10	83.60	7.87	10.13
R_6P_6	49.50	75.90	8.02	10.14
LSD ($P < 0.05$)	**12.31**	**17.14**	**1.26**	**0.65**
CV (%)	**12.50**	**11.80**	**9.10**	**3.70**

From the date of transplanting to days of first and 50% flowering statistically showed no differences among tomato genotypes but days to 100% flowering indicated statistical variances. P_1 097 (12.00; 20.00 and 26.00) took the shortest number of days to first, 50% and 100% flowering respectively. The genotype R_1P_7 (19.00) had the longest days to first flowering while P_2 213 (26.00) and R_3P_8 (26.00) the longest days to 50% flowering. P_2 213 (33.00) accounted for the longest number of days to 100% flowering. The shortest days to fruit maturity were recorded by P_1 097 (56.00), BC_1F_2 (56.00) and R_3P_9 (56.00) which was followed by BC_2F_2, R_1P_7 and R_3 P_8 (59.00) and P_2 213 (69.00) had the longest days to fruit maturity respectively (Table 3).

Table 3. Vegetative mean performance of eight tomato genotypes

Genotypes	Days to first flowering	Days to 50% flowering	Days to 100% flowering	Days to maturity
P_1 097	12.00	20.00	26.00	56.00
P_2 213	18.00	26.00	33.00	69.00
BC_1F_2	16.00	22.00	27.00	56.00
BC_2F_2	15.00	22.00	27.00	59.00
R_1P_7	19.00	24.00	30.00	59.00
R_3 P_8	18.00	26.00	30.00	59.00
R_3P_9	18.00	24.00	29.00	56.00
R_6P_6	17.00	25.00	31.00	60.00
LSD ($P < 0.05$)	**4.41**	**4.83**	**4.15**	**5.25**
CV (%)	**15.20**	**11.70**	**8.10**	**5.10**

3.2 Presentation of Mean Performance of Yield and Yield Components of Eight Tomato Genotypes

Table 4 and 5 display mean performance of eight tomato genotypes on yield and yield related characters. Number of fruit harvested per plant, fruit weight per plant, marketable fruit per plant and nonmarketable fruit per plant exhibited statistical differences among tomato genotypes while fruit diameter, fruit flesh thickness, fruit length and locule number had no statistical differences. P_1 097 (61.00) had highest number of fruit harvested per plant succeeded by P_2 213 (25.00) while R_1P_7 (19.00) recorded the least number of fruit per plant. R_3P_9 had the heaviest average fruit weight of 75.30 g. This was followed by P_2 213 with an average weight of 69.40 g and the least fruit weight was shown by R_1P_7 (44.50 g). The R_3P_8 (42.59 cm) had the longest fruit length while P_2 213 (30.53 cm) recorded the shortest fruit length. Likewise R_6P_6 (43.21 cm) gave the largest fruit diameter which was however, not significantly different among tomato genotypes and R_3P_9 (35.00 cm) had the minimum fruit diameter (Table 4).

Table 4. Mean performance of yield and yield components of eight tomato genotypes

Genotypes	Number of fruit harvested per plant	Fruit weight per plant (g)	Fruit length (cm)	Fruit diameter (cm)
P_1 097	61.00	52.60	33.57	41.15
P_2 213	25.00	69.40	30.53	36.32
BC_1F_2	20.00	50.60	35.11	38.90
BC_2F_2	21.00	46.60	36.46	40.78
R_1P_7	19.00	44.50	38.97	35.54
R_3 P_8	22.00	53.10	42.59	42.70
R_3P_9	22.00	75.30	34.51	35.00
R_6P_6	22.00	47.20	37.09	43.21
LSD ($P < 0.05$)	**4.25**	**16.02**	**7.78**	**8.54**
CV (%)	**9.20**	**16.70**	**12.30**	**12.40**

The maximum FFT among tomato genotypes was recorded by P_2 213 (0.77 mm) followed by R_3P_8 (0.63 mm) with R_6P_6 (0.41 mm) exhibiting the least fruit flesh thickness. With respect to LN, BC_2F_2 had the highest number of locule per fruit. P_1 097, P_2 213, Bc_1F_2 and R_1P_7 had the same number of locule (5.00) correspondingly while R_3P_9 and R_6P_6 accounted for the least LN (3.00). The highest number of marketable fruit per plant was recorded by P_1 097 (54) and the minimum was recorded by R_1P_7 (15.00). For the nonmarketable fruit per plant P_1 097 (11.00) also had the highest with BC_1F_2, R_1P_7 and R_3P_8 recording the least number of nonmarketable fruit per plant (Table 5).

Table 5. Mean performance of yield and yield components of eight tomato genotypes

Genotypes	Fruit flesh thickness (mm)	Locule number per fruit	Marketable fruit per plant	Non-marketable fruit per plant
P_1 097	0.49	5.00	54.00	11.00
P_2 213	0.77	5.00	22.00	6.00
BC_1F_2	0.50	5.00	17.00	3.00
BC_2F_2	0.55	6.00	17.00	4.00
R_1P_7	0.56	5.00	15.00	3.00
R_3 P_8	0.63	4.00	18.00	3.00
R_3P_9	0.54	3.00	17.00	4.00
R_6P_6	0.41	3.00	17.00	4.00
LSD ($P < 0.05$)	**0.30**	**2.40**	**8.25**	**3.55**
CV (%)	**31.20**	**30.80**	**21.10**	**40.50**

4. Discussion

4.1 Vegetative Mean Performance of Eight Tomato Genotypes

The morphological variations observed in contrast to the tomato genotypes could be attributed to differences in genetic and environmental conditions among tomato genotypes. Climatic conditions primarily the soil nutrient status during the experimentation might have significantly contributed to the variances existed in the performance of these genotypes. The result of this finding corroborate with the findings of Kanneh et al. (2016) and Gongolee et al. (2015) who reported that different tomato genotypes perform differently when exposed to the same environment as a result of their differences in genetic constitution.

Furthermore, it is essential and imperative to understand the performance of plant genotypes for not only breeding purpose but also for prediction of their performances. Iken and Anusa (2004) had reported analogous results and indicated that growth and yield differences of crop varieties could be attributed to right choice of suitable agro-ecological zone. The wider variations observed in stem girth among tomato genotypes could not be unconnected to variant in soil nutrients compositions of the locations and the effective uptake and efficient utilization of available nutrients for growth and development of the crop. The finding concord with Kanneh et al. (2016) and Ogundare et al. (2015) who reported similar situations in the evaluation of early tomato genotypes and the effect of different spacing and urea application rates on fruit nutrient composition, growth and yield of tomato respectively. The dissimilarities acknowledged in the number of days to first, 50% and 100% flowering might be ascribed to the differences in genetic constitution among tomato genotypes evaluated. Earliness is an essential component in tomato breeding as it provides and or enhances early fruit maturity. The result is in line with Sinnadurai (1992) who observed variations among tomato genotypes evaluated with respect days to flowering.

4.2 Mean Performance of Yield and Yield Components of Eight Tomato Genotypes

From crop production point of view the yield and yield parameters of tomato is the principal concern of the plant breeder which is very important and contribute more to gardeners' income. The differences observed among tomato genotypes with respect to number of fruit harvested per plant could be ascribed to the genetic differences in capacity to produce and retained greater quantity of flowers that developed into fruit. Tomato genotypes with high numbers of fruits may have initiated and developed more flowers that were successfully developed into fruit as a result of better genetic components. The result conformed to the findings of Olaniyi et al. (2010) who reported that only 50% of flowers produced developed into fruits, thus sink size (genetically controlled) influences fruit production in tomato. Additionally, the findings further suport what had been reported by several other authors including Turhan et al. (2011); Abrar et al. (2011) and Eshteshabul et al. (2010) that the mean number of fruits per plant lay between 4.46 and 98.30. However, a value between 9.70 and 158.90 had been reported by Agong et al. (2001) although Lemma (2002) indicated a range between 26 and 62. Yields obtain from crops might be attributed to better genetic structure variations among them and the possibility of possession of higher stomata conductance, better partitioning of photosynthetic materials towards economic yield, and higher potential to transport photosynthetic materials within plants. The result concords with the finding of Clark et al. (1997) who ascribed differences in crop yield and its components among crop genotypes to variations in genetic structure, mineral concentration and absorption in addition to the abilities of carrying photosynthetic materials within plants.

The variability exhibited among tomato genotypes for average fruit weight per plant might be associated with genetic differences among tomato genotypes in higher number of fruit set, big fruit size and higher retaining ability of matured fruits/plant. Moreover, additive and non-additive gene type action might have influenced this character. The result is analogous to Kanneh et al. (2016) and Sultana (2013) who reported variability in fruit weight among tomato genotypes studied and attributed variation in individual fruit weight among tomato genotypes as a result of plant's general combine ability (GCA) and specific combine ability (SCA) for that character. Fruit size influences fruit weight and thus determines the consumer preference in tomato crop Resh (2003). The differences expressed among tomato genotypes with respect to fruit length and fruit diameter might be as a consequence of a combination of factors including plant health, fruit shape (spherical, elongated, flat or pear-like) and ability of plant to absorb and utilize existing moisture (water) and nutrients. The finding is in conformity with several authors including Kanneh et al. (2016) and Regassa et al. (2012) who reported significant statistical variability among tomato genotypes for these characters. The variations observed among tomato genotypes with respect to fruit length might be associated with genetic differences. The result agrees with Hozhbryan (2013) and Muhammad and Singh (2007) who indicated differences in fruit length among tomato genotypes studied. Even though there were non-statistical variability existed among tomato genotypes with regards to FFT, dissimilarity between individual genotypes was however shown. This could be ascribed to fruit firmness and possibly genetic variance in addition to gene action for this character. The result does not conform to the results obtained by Kanneh et al. (2016), Gongolee et al. (2015), and Dar et al. (2012) who reported significant statistical differences among tomato genotypes with respect to FFT in the tomato genotypes evaluated. The individual differences in relation to LN among genotypes might not be unconnected to that of genetic variations in progenies and genes actions responsible for LN which is expressed in the differences in individual LN. The finding corroborates to Dar et al. (2012); Durvesh and Singh (2006) who observed considerable variations in tomato genotypes regarding number of locule. Locule number is very important in tomato production in that fruit size and fruit weight are influenced by number of locule with fewer locule numbers having small fruit sizes and less fruit weight and vice versa (Barrero & Tanksley, 2004). A marketable fruit refers to fruits without blemishes, cracks, deformation, reduced size and weight, sunburn, diseased and pest and or change in normal fruit colours when matured while nonmarketable fruits are associated with the aforementioned characters. The variations exhibited by tomato genotypes with respect to marketable and nonmarketable fruits could be ascribed to the number of flowers set that developed into fruits and retained by the plants onto harvest for marketable fruits. The finding is analogous to the finding of Rida et al. (2002) and Gongolee et al. (2015) who indicated similar noticeable differences in fruit yield of tomato varieties.

5. Conclusion

In order to identify, select and develop tomato (*Solanum lycopersicum* L.) genotypes with desired horticultural characteristics for breeding purpose, it is critical that plant materials are field tested. Selection for further improvement would be based on vividly identified variability that existed among genotypes with respect to characters of interest helps in the development of preferred plant material in tomato. However, a continuous study for the genetic basis of variation is important. The type of tomato genotypes used and the environmental conditions of the study area might have accounted for the major variations based on their agronomic and morphological characters and yield. Conclusively, all the tomato genotypes evaluated are adaptable to Sierra Leone climatic conditions with reference to Njala upland soil. Tomato genotype R_3P_9 was identified and selected for its fruit size and weight and therefore should be incorporated in tomato breeding programme. Further evaluations should consider TSS content of genotypes.

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