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Evaluation of Tomato (Solanum Lycopersicum L.) Genotypes for Adaptation and Yield Components on the Njala Upland Soil Southern Sierra Leone

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Abstract – **Tomato is one of the most important vegetables consumed in fairly large quantity worldwide. Evaluation of introduced genotypes for adaptation and identification of superior genotypes types for further improvement in yield is necessary. Therefore, experiment was laid out in a randomized complete block design with three replications under field condition was conducted at the Department of Crop Science, School of Agriculture Njala University, Njala Campus, Moyamba District, Southern Sierra Leone to evaluate five tomato (*Solanum Lycopersicum* L.) genotypes for adaptation and yield components. Data collected on growth parameters and yield components, included plant height, stem girth, days to flowering, days to maturity, number of fruits set per plant, number of fruits harvested per plant, fruit weights, fruit length, fruit diameter, fruit flesh thickness, locule number and brix/TSS. Results from the study showed that all genotypes studied are adaptable to the climatic conditions of Sierra Leone. P_1 (097) recorded the highest number of fruits set per plant, number of fruits harvested per plant, locule number, brix/TSS and plant height at 50% and 100% flowering while F_3 had the shortest days to maturity and heaviest fruit weight with P_2 213 recording the longest duration to maturity, longest fruit length and diameter and thickest fruit flesh thickness correspondingly. With regards to yield and yield related components, F_3 was found to be better than the rest of the genotypes for most of the characters. However it measured the shortest plant height at 50% and 100% flowering. Surprisingly, locule number which normally influences fruit weight failed to influence fruit weight in P_1 (097). BC_2F_2 recorded the minimum, Stem girth at 50% flowering, fruit diameter, Fruit flesh thickness and brix/TSS.**

Keywords – **Adaptation, Evaluation, Genotypes, Solanum, Yield Components.**

I. Introduction

Tomato (*Solanum lycopersicum* L) is an edible fruiting plant usually grouped as vegetable [1] and [2]. Tomato belongs to the Solanaceae family comprising of other species, such as potato, tobacco, peppers and eggplant [3]. Tomatoes are believed to have originated in South America nonetheless they are now found all over the world [4]. Between 16th and 17th century tomato was introduced into the West African sub-region by the Portuguese [5]. Being one of the world's largest grown vegetable crops, tomato occupies an important place in the economy of human societies because of its high nutritive values such as Vitamin A and C and minerals which are important ingredients for table purpose; it can also be used for preparation of ketchup, soup, juice pure etc [6]. Moreover, according to [7] the fruit of tomato comprises lycopene which has recently attracted the maximum attention among the carotenoids from the medical research. It is the red carotenoid pigment found primarily in fruits and vegetables, most especially in tomato species [8]. It is one of the most powerful antioxidants that has been found to aid in the prevention of prostate cancer, and also help to improve the skin's ability to protect against harmful UV [9]. Tomato encloses sufficient amount of citric acid, which is alkaline-forming when it gets into our bloodstream. This enhances the alkalinity of the blood and, thereby facilitates in removing toxins, particularly uric acid, from the system [9]. [10] stated that tomatoes contain a great deal of Vitamin A and Vitamin C. This is primarily because these vitamins and beta-carotene work as antioxidants to neutralize harmful free radicals in the blood. Vegetable growers can grow tomato on a small scale in the home garden, where a few plants yield fruits for the whole family and on commercial scale as a cash crop [11]. The existing world production of tomato is about 100 million tons of fresh fruit produced on 3.7 million hectares [2]. In West Africa countries, the average yield of tomato on farm is very low between 7.5-10t/ha which is far below the potential yield of 45-50 Mt/ha obtained from other tomato producing countries [1]. In Sierra Leone, it is consumed as fresh fruit, salads, soup and stew and often used in other dishes. Its cultivation provides source of employment to many and continue to play a key horticultural role in the country in terms of reducing poverty and food insecurity making the crop a very important vegetable. However the local production of tomato is not able to meet the domestic demand as a result, Sierra Leone imports tomatoes from other parts of the world. This is because most tomato growers have no access to improved varieties, adequate and efficient extension services. Hence they have no alternatives but to continue to grow traditional varieties that are characteristically low yielding, susceptible to pest and diseases, poor shelf life, high water content, many seeds, poor colour, and low brix content against the increasing demand at local and international levels. Thus to mitigate this problem, it is imperative to assess introduced tomato genotypes for adaptation in Sierra Leone for further improvement in yield. This would enable tomato breeders and growers to incorporate identified genotypes in their tomato programs for increase productivity and income. The overall objective of the study therefore was to evaluate tomato genotypes for adaptation in Sierra Leone

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for yield and yield components.

II. Materials and Methods

The experiment was conducted at the Department of Crop Science cropping site, School of Agriculture, Njala University, Njala Campus, Moyamba District and Southern Sierra Leone in the first cropping season of 2016. Njala is 54 m above sea level on 8.060 N latitude and 12.060 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 commences from November and ends in April with an average annual rainfall of 2000 to 3000 mm. The average mean monthly maximum and minimum temperatures for greater part of the day and night were 290C to 340C and 210C to 230C and the soil pH of 5.4-6.0 with a dominant grassland vegetation. Tomato genotypes used in this study were generated by the Horticulture Division, Council for Scientific and Industrial Research (CSIR)-Crops Research Institute (CRI) Kwadaso, Kumasi, Ghana through hybridization in 2012. The genotypes include P_1, P_2, BC_1F_2, BC_2 F_2 and F_3.

The experiment was laid out in a randomized complete block design with three replications. The plot size was 150.15 m^2 and a spacing of 0.75 m and 0.60 m between and within rows was used. Seeds were nursed in plastic bag 25’’. 20’’. 15’’ half filled with treated organic manure on the 15th April, 2016. Seedlings were transplanted on 15th May, 2016. Basal application of Palm Kernel Cake at 72g per stand and NPK 15:15:15 at 6g per stand at four weeks after transplanting using side dressing method respectively was done. Standard agronomic practices such as refilling, earthen-up, weed control, fertilizer application, staking, pruning and insecticide application were done [5]. Parameters measured includes; Plant Height (PHT) and Stem Girth (SG) at 50% and 100% flowering, days to 50% and 100% flowering, days to maturity, number of fruit set per plant, number of fruit harvested per plant, Fruit Weight (FW), Fruit Length (FL), Fruit Diameter (FD), Flesh Fruit Thickness (FFT), Locule Number (LN) and brix/TSS. Data collection was based on five randomly tagged plants per plot for vegetative as well as yield parameters were recorded fortnightly Plant height was measured with a calibrated measuring tape from the ground level to the terminal bud of the main stem of the each tagged plant.

Plant stem girth above ground level, fruit flesh thickness, fruit length and fruit diameter was measured using Electronic Vernier caliper. 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. Calibrated manual refractometer was used to estimate brix/TSS content of five fruits of each sampled plant. 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.

III. Results

Growth Characteristics of Five Tomato Genotypes

Mean values of plant height and stem girth at 50% and 100% flowering, days to 50% and 100% flowering and days to maturity for five tomato genotypes are presented in Table 1 and 2 respectively. Significant ($P < 0.05$) differences were observed in PHT at 50% flowering ranging from 47.80 to 78.00 cm with P_1 097 recording the highest PHT (72.40 cm). This was followed by BC_2F_2 (69.67 cm) while F_3 accounted for the shortest PHT (51.94 cm) which falls below parental limits. The range of variation and variance in P_1 097 was higher than the rest of the genotypes. There were statistically no significant differences among tomato genotypes at 100% flowering. However, significant difference was observed between P_1 097 and F_3. The result follows similar trend observed in plant height at 50% flowering with P_1 097 and F_3 again recording the tallest and shortest PHT (108.40 cm and 82.14 cm) respectively. No significant differences were observed in SG with respect to 50% and 100% flowering. The maximum and minimum mean performance for stem girth at 50% flowering were recorded by F_3 (27.05 cm) and BC_2F_2 (22.35 cm) correspondingly. The largest SG at 100% flowering was recorded by F_3 (37.81 cm) which was closely followed by BC_1F_2 (36.14 cm) while P_1 097 had the smallest SG (30.95 cm). Statistically there were no differences among tomato genotypes for SG at 100% flowering, but significant differences exist between F_3 and P_1 097.

Table 1. Mean performance of vegetative characters of tomato genotypes

Genotype	Characters			
	Plant height at 50% flowering (cm)	**Plant height at 100% flowering (cm)**	**Stem girth at 50% flowering (cm)**	**Stem girth at 100% flowering (cm)**
P_1 (097)	72.40	108.40	26.72	30.95
P_2 (213)	64.87	90.20	25.31	30.96
F_3	51.94	82.14	27.05	37.81
BC_1F_2	62.87	90.85	24.29	36.14
BC_2F_2	69.67	93.24	22.35	32.79
Lsd P<0.05)	10.00	21.27	9.65	5.50
CV (%)	8.30	12.20	20.40	8.70

Number of days to 50% and 100% flowering after transplanting had no significant differences among tomato genotypes. The maximum and minimum mean values of number of days to 50% flowering were obtained by P_2 213 and P_1 (097) respectively. With respect to number of days to 100% flowering, P_2 213 and F_3 took the same longest number of days to 100% flowering (32.00) which was closely followed by BC_1F_2 (31.00) and that of P_1 097 taking the shortest number of days to 100% flowering. Statistically there were significances differences among tomato genotypes with respect to number of days to

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maturity. P_2 213 (70.00) had the longest days to maturity while F_3 (58.00) had the shortest days to maturity.

Table 2. Mean performance of vegetative characters of tomato genotypes

	Characters		
Genotype	Days to 50% flowering	Days to 100% flowering	Days to maturity
P_1 (097)	16.00	23.00	62.00
P_2 (213)	23.00	32.00	70.00
F_3	22.00	32.00	58.00
BC_1F_2	22.00	31.00	64.00
BC_2F_2	20.00	27.00	60.00
Lsd P<0.05)	5.42	7.15	6.28
CV (%)	14.00	13.10	5.30

The Yield and Yield Attributes of Five Tomato Genotypes

Table 3 and 4 show number of fruit set, number of fruit harvested, FW, FL, FD, FFT, LN and brix per plant for five tomato genotypes respectively. Tomato genotypes were statistically highly different with respect to the number of fruit set per plant with maximum and minimum mean values recorded by parent one P_1 097 (87.00) and BC_2F_2 (49.00) respectively. In terms of number of fruit harvested per plant, tomato genotypes statistically exhibited immense significant differences. The highest and lowest number of fruit harvested per plant was recorded by P_1 097 (62.00) and BC_2F_2 (21.00) correspondingly. There were highly significant variations among tomato genotypes for FW per plant. The average fruit weight per plant varied from 38.58 g to 87.14 g. The heaviest and lightest FW were recorded by F_3 (82.01 g) and BC_2F_2 (40.55 g) respectively. There were no significant differences among genotypes for FL and FD per plant with P_2 213 (46.92 cm) recording the longest FL followed by F_3 (41.52 cm) while P_1 097 (30.46 cm) had the shortest FL. The largest and smallest FD was recorded by P_2 213 (52.53 cm) and BC_2F_2 (30.36 cm) respectively. Although statistically there were no significant differences among tomato genotypes for this trait, there however exist significant difference between P_2 213 and BC_2F_2 (Table 3).

Table 3. Mean performance of yield and yield components of tomato genotypes

	Characters				
Genotype	Number of fruit set per plant	Number of fruit harvested per plant	Fresh Fruit weight per plant (g)	Fruit length per plant (cm)	Fruit diameter per plant (cm)
P_1 (097)	87.00	62.00	54.24	30.46	38.65
P_2 (213)	63.00	24.00	63.41	46.92	52.53
F_3	69.00	25.00	82.01	41.52	41.59
BC_1F_2	63.00	27.00	47.15	37.08	37.42
BC_2F_2	49.00	21.00	40.55	31.20	30.36
Lsd P<0.05)	18.30	9.61	12.33	17.63	19.78
CV (%)	14.60	16.00	11.40	25.00	26.20

The FFT, LN and brix per plant had significant differences ($P < 0.05$) (Table 4). The thickest and thinnest mean values for FFT per plant were recorded by P_2 213 (7.51 mm) and BC_2F_2 (2.63 mm) respectively. The highest and lowest LN was observed in P_1 097 (8.00) and F_3 (3.33). Furthermore, with respect to the brix content, the highest and lowest was between 8.68 and 3.88 recorded by P_1 097 and BC_2F_2 respectively.

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

	Characters		
Genotype	Fruit flesh thickness (mm)	Locule number	Brix
P_1 (097)	3.14	8.00	8.68
P_2 (213)	7.51	4.00	3.95
F_3	4.44	3.33	5.93
BC_1F_2	3.29	4.67	4.27
BC_2F_2	2.63	4.00	3.88
Lsd P<0.05)	2.55	2.39	2.38
CV (%)	32.30	26.50	23.70

IV. Discussion

Growth Characteristics of Five Tomato Genotypes

Among the most important objectives of any breeding programme is the development of high yielding, better environmental adaptation, and better quality lines for release as varieties to farmers. To attain this goal the availability of sufficient amount of variability among genotypes from which desired lines are selected for further improvement is necessary. Hence, growing parameters are of great significance for evaluating introduced breeding genotypes of tomato for environmental adaptability. The current study was carried out to evaluate the performance of five tomato genotypes with respect to growth characteristics, yield and yield components. The significant differences observed among tomato genotypes with respect to PHT and number of days to maturity could be attributed to dissimilarities in genetic make-up of tomato genotypes as well as the environmental conditions such as temperature, rainfall, and soil nutrients under which the experiment was conducted. The result conforms to the findings of [12] and [13] reported that different genotypes perform in a different way in the same environment. Differences in the climatic conditions especially the soil nutrient status during the experiments perhaps might have substantially contributed to the variations observed in the performance of the genotypes. Additionally, genetic constitution of crop genotypes can influence growth characters such as plant height [14] and [15]. Moreover, [16] also ascribed the differences of crop varieties to right choice of suitable agro-ecological zone. One of the most critical components in tomato production is the number of days to flowering. It is significant because it is a transition for the initiation of reproductive stage in the life cycle of the plant and it indicates earliness to maturity. Generally no statistically differences were observed in the number of days to flowering among tomato genotypes. However, the differences observed between individuals could be attributed to differences in genetic structure between genotypes which strongly influenced development and growth of plants. The result is in agreement with [17] who indicated that flowering in tomato usually starts 50 to 65 days after sowing. Conversely, [18] and [19] indicated a lower number of days to flowering ranging between 40 to 49 days after transplanting.

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Number of days to fruit maturity is another very important factor in crop production because it determines when harvesting starts and subsequently generation of proceeds from cultivated crops. The variations observed in number of days to maturity among tomato genotypes might be attributed to genetic differences in addition to environmental conditions prevailed at the time of experimentation. These conditions might have influenced growth and development of tomato genotypes with respect to fruit maturity. This might have accounted for the differences in the number of days to harvesting. The result obtained from this study is in harmony with [17] and [20] that made similar observation in the differences of number of days to maturity in their study of hybrid tomato and attributed it to the genetic factors of the hybrids and the environmental conditions. Earliness in tomato genotypes is envisaged as important parameter for rainy and off-season tomato production. Furthermore, it may also determine genotypes adaptation to a specific environment.

Yield and Yield Components of Five Tomato Genotypes

Generally, yield and yield components of cultivated tomato fruits are most complex and important characters from production point of view. For plant breeder it is one of the core concerns and is the critical factor on which selection programs are mostly envisaged. The variations exhibited by tomato genotypes evaluated in the number of fruits set per plant and the number of fruits harvested per plant could be attributed to genetic differences with the ability to produce and retained greater number of flowers that developed into fruits. Genotypes with the minimum number of fruit set per plant and number of fruit harvested per plant possibly might have had about 50% of its flowers dried up and fell off or its flowers failed to further develop into fruits.

Conversely, genotypes with high numbers of fruits harvested might have successfully developed more flowers into fruits possibly as a result of better genetic components. The result of finding corroborates with [17] and [21] who indicated that only 50% of flowers produced developed into fruits, therefore sink size (genetically controlled) influences fruit production in tomato and perhaps higher capacities to convey photosynthetic materials towards economic yield. Moreover, the results further agree with [18] and [19] that the mean values of number of fruits per plant range between 4.46 and 98.30.

The variation observed among tomato genotypes evaluated for FW per plant might be attributed to the possession of higher stomata conductance, better partitioning of photosynthetic materials towards economic yield, better genetic structure and higher potential to transport photosynthetic materials within plants. The result is in harmony with the finding of [17] and [22] that ascribed yield variations in crop cultivars to stomata conductance value and differences in partitioning of photosynthetic materials towards economic yield. The results further concord with [23] that evaluated tomato genotypes and reported variations in individual FW.

The variations in FFT among genotypes might be associated with fruit firmness and perhaps differences in genetic structure for that character. The result is in line with [24] and [25] that reported minimum and maximum FFT for tomato to range between 3.7 mm to 9.0 mm. Furthermore, several authors including [26] and [27] ascribed FFT to gene actions which may contribute to long fruit shelf-life. Increasing shelf-life of cultivated tomato is a critical component in tomato breeding. This allows for appreciable storage period without considerable impairment of value.

Variation observed in LN per fruit among genotypes could be genetic, in addition to the effective uptake and efficient utilization of available nutrients. The result is in conformity with [28] that reported a range of LN per fruit of tomato to be between 2.0 to 6.0 during evaluation of 48 tomato genotypes. Also, [17]; [24] and [25] observed significant variations in tomato genotypes with respect to locule number. The LN is an important horticultural characteristic in tomato breeding in that it immensely contributes to final fruit weight. Fewer LN results in small fruit sizes and less fruit weight while more LN results in large fruit sizes and hence much heavier fruit weight [29].

The observed variations in respect to Total Soluble Solids (TSS/°Brix) among genotypes could not be unrelated with the genetic makeup that influences genotypes performance for the trait. The variations corroborates with those found by [24] and [25]. They reported that quality attributes for tomato TSS fruit ranged from 4.0 to 5.0%. Furthermore, the total sugar content and acidity of cultivated tomato taste are considered to be one of the most important characteristics in its breeding for commercial and industrial utilization [30]. High sugars are required for best flavor [31]. However, [32] stated minimum value of TSS around 4.5%, is considered low for industrial tomatoes. Therefore, based on the result tomato genotype F_3 could be considered suitable candidate for industrial utilization. BC_1F_2 and BC_2F_2 require further improvement for this trait.

V. Conclusion

Evaluation for adaptation of any introduced breeding lines is a prerequisite of any breeding programme. Therefore, tomato genotypes (P_1 097, P_2 213, BC_1F_2, BC_2F_2 and F_3) were field evaluated. Based on the results obtained in the present study, the following conclusion can be drawn: that genotypes evaluated are adaptable to Sierra Leone climatic conditions and have the potential to increase yield. It is recommended that future work on these tomato genotypes incorporate major disease assessment especially for molecular analysis for TYLCV.

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