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Field performance and genetic analysis of selected tomato (*Lycopersicon esculentum* Mill.) genotypes

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Abstract

The study was carried out in the field laboratory of the Department of Genetics and Plant Breeding of Bangladesh Agricultural University in order to evaluate varietal performance and genetic variability of fourteen tomato genotypes based on morphological and biochemical characteristics. Tomato genotypes were collected from Genetics and Plant Breeding farm, Bangladesh Agricultural University, Mymensingh. The field experiment was conducted from October 2014 to March 2015 with Randomized Complete Block Design (RCBD) including three replications. Data for genetic analyses were collected on seven traits viz. days to first flowering, pollen grain fertility, days to first fruit maturity, individual fruit weight, plant height, ascorbic acid content and yield per plant. ANOVA showed significant variation among the tomato genotypes for all the traits. Wide range existed between minimum and maximum mean values for all the genotypes whereas genotype World champion had the maximum individual fruit weight with the highest yield. On the other hand, genotype CI-170-0-20-2-0 gave poor performance. Yield exhibited a positive significant correlation with individual fruit weight; and in path coefficient analysis, maximum positive direct effects were found through individual fruit weight followed by plant height, ascorbic acid content and days to first fruit maturity. In principal component analysis, the main three components contributed approximately 79.14% of total variability. Genotypes were classified into five clusters by Ward's method including late maturing and low yielder genotypes in cluster I, early flowering genotypes in cluster II, high yielder with large fruited genotypes in cluster III, genotypes containing low ascorbic acid in cluster IV and genotypes having early maturity with small fruit but minimum pollen grains fertility rate in cluster V. Based on the present findings, World champion and Big cherry were considered as superior varieties among the fourteen genotypes and individual fruit weight might be considered as an important criteria for yield improvement.

Keywords: Genetic variability, Morphological characteristics, Biochemical characteristics, Tomato, *Lycopersicon esculentum*

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most popular vegetables around the world. It belongs to the genus *Lycopersicon* and is a member of the family Solanaceae. Tomato is a diploid crop (with 24 somatic chromosomes, relatively small genome size, 950 Mb per haploid nucleus) plant and can be reproduced by both seed and vegetative propagations. Cultivated tomato is the second most commonly consumed vegetable, just next to potato (FAO, 2008). It is believed that tomato was first grown in South America (Ali *et al*., 2012), in the region of modern day Peru and Ecuador; and due to its crop value it has become a demandable crop throughout the world (Taylor, 1986). Tomato is a very nutritious vegetable and contains a powerful antioxidant called lycopene which acts as an anti-carcinogen (Bhutani and Kallo, 1983). Tomato is a model crop for genetic analysis as it is a source of useful genes which can be used for crop quality improvement, breeding programs to transfer useful gene to the cultivated varieties, and against disease resistance (Bai and Lindhout, 2007; Gur and Zamir, 2004). Tomato is cultivated almost all around the world and the top five tomato producing countries are China, India, United States, Turkey and Egypt, respectively. In Bangladesh, its production is around 9.96 t ha^{-1} (FAOSTAT, 2012), which is very low as compared to other countries. Now-a-days, tomato is very popular not only to the consumers for its health value but also to the farmers for its high market value and as well as to the researchers for its genetic and genomic characters. To meet the increasing demand of tomato, it is important to study the genetic variability of tomato as variability assessment among tomato genotypes helps to maintain and utilize germplasm resources for the improvement of the cultivars (Reddy *et al.,* 2013). Morphological traits play a vital role in determining the important characters, variability and genetic relationship among the genotypes (Osei *et al.,* 2014). Tomato fruit yield is the final result which is associated with other yield contributing traits and theses traits again interrelated among them (Islam and Khan, 1991). So, looking at this complex relationship is useful to obtain better yield.

The objectives of the present study were to compare and study the field performance and genetic variability of tomato genotypes for yield and yield contributing characters and assess Principal Component Analysis of yield and other agronomic traits.

Materials and Methods

The investigation material comprised of fourteen tomato genotypes (i.e. Marglobe-II, Burpi big, Hekari, World Champion, Florida I, Homeastid, Big cherry, CI-170-0-20-2-0, Derinia, CI-3d-0-99, CI-3d-143-0-13, Hot sent, Okiton no.9, Manik) collected from the Genetics and Plant Breeding farm of Bangladesh Agricultural University; and the field trial was carried out in the experimental farm of the department of Genetics and Plant Breeding of the same university, in a Randomized Complete Block Design (RCBD) with three replications. Thus the total number of plots came to forty two (14×3). Plot size was 6.25 m^2 (2.5m x 2.5m) with fourteen rows and five plants in each row. Row to row distance was 60 cm and plant to plant distance was 40 cm. During the growing period, the average maximum and minimum temperature was 28.77^oC and 18.97^oC, respectively; average relative humidity was 77.90%, and texturally, the soil was sandy loam with pH value of 6.5. The average monthly rainfall of the locality was 2.6 mm. The sowing was conducted on 20 October, 2014 and 30 days old seedlings were transplanted in the main field on 20 November, 2014. When the seedlings were well established, 1st mulching and weeding were done uniformly in all plots. Second weeding was done after 20 days of the first one. Mechanical support was provided to the growing plants by bamboo sticks to keep them erect.

Data were collected on seven parameters namely; days to first flowering (days), pollen grain fertility (%), days to first fruit maturity (days), individual fruit weight (gm), plant height (cm), ascorbic acid content (mg %) and yield per plant (Kg) by individual plant basis. For counting the number of fertile and sterile pollen grains under microscope, four flowers per plant of each variety were taken in the laboratory where IKI (Iodine Potassium Iodide) was used to stain the pollen grains and mean of the fertile pollen grains expressed in percentage was estimated. Ascorbic acid was extracted with 6% metaphosphoric acid from well ripen tomato fruits and estimated by the method of Plummer (1971).

Analysis of variance of the data was performed by PLABSTAT software and then correlation coefficient was estimated by the formula suggested by Weber and Moorthy (1952) and path coefficient was made by Dewey and Lu's (1959) formula. Principal Component Analysis was conducted by Holland (2008) method, and Dendrogram was constructed by Ward's method based on squared Euclidean distance.

Results and Discussion

Significant differences were observed among the genotypes for all the characters (Table 1). The days to first flowering required maximum 74.64 days and minimum 82.50 days and the percentage of pollen grain fertility ranged from 46.00% to 99.09%. In case of days to first fruit maturity, mean value ranged between 128.60 days and 135.10 days. Individual fruit weight varied from 23.75 gm to 47.07 gm, plant height ranged from 41.34 cm to 138.30 cm, ascorbic acid content varied from 15.52 mg% to 31.35 mg % and yield per plant ranged between 0.250 Kg and 0.861 Kg. Among all the genotypes, World Champion had the maximum fruit weight (47.07 gm) as well as maximum yield (0.861 Kg), and Big cherry was early flowering (74.64 days) and high yielder (0.779 Kg) genotype (Table 1). On the other hand, CI-170-0-20-2-0 and Hot sent gave the worst performances. Coefficient of variation ranged between 1.83% for days to first fruit maturity and 8.71% for yield per plant (Table 1). In the correlation coefficient analysis, individual fruit weight showed positive significant correlation with yield per plant (Table 2). Similar result was also reported by Dudi and Kalloo (1982). The path analysis exhibited that individual fruit weight, plant height, ascorbic acid content and days to first fruit maturity had direct positive effect on yield which indicated them as the main contributors for yield (Table 2). Singh *et al.* (2004) and Reddy *et al.* (2013) observed similar results in their investigations. Considering the result of correlation coefficient and path analysis, it can be said that individual fruit weight is the most important factor for improving plant yield.

Table **1.** **Mean performance of various growth parameters and yield components of 14 tomato genotypes**

Genotypes	DFF (days)	PGF (%)	DFFM (days)	IFW (gm)	PH (cm)	AAc (mg %)	Y/P (Kg)
Marglobe-II	79.64abc	99.09a	132.50abc	24.09h	107.20b	31.35a	0.520d
Burpi big	77.78abcd	98.19a	132.90abc	24.59gh	79.50d	22.41ef	0.369fg
Hekari	75.00cd	46.00h	129.70bc	29.09ef	41.34h	18.96gh	0.471de
World Champion	80.08ab	86.00de	133.60ab	47.07a	92.57c	25.86cd	0.861a
Florida I	80.33ab	91.95bc	133.90ab	34.71cd	67.95 e	24.13de	0.691c
Homeastid	78.27abcd	83.33ef	128.60c	29.32e	66.40e	17.24hi	0.479de
Big cherry	74.64d	72.46g	132.40abc	35.91c	96.37c	20.69fg	0.779b
CI-170-0-20-2-0	80.33ab	80.00f	135.10a	25.10gh	62.97ef	27.58bc	0.250h
Derinia	78.69abcd	96.00ab	135.10a	26.93fg	56.60g	20.68fg	0.401ef
CI-3d-0-99	78.07abcd	47.06h	129.50bc	23.75h	138.30a	18.96gh	0.511d
CI-3d-143-0-13	78.15abcd	93.87abc	132.70abc	33.27d	55.96g	15.52i	0.368fg
Hot sent	80.00ab	90.34cd	134.90a	25.39gh	53.57g	25.86cd	0.300gh
Okiton no.9	82.50a	99.01a	132.90abc	40.71b	59.58fg	29.31ab	0.368fg
Manik	76.06bcd	85.71de	133.30ab	30.51e	92.70c	24.13de	0.429ef
SD	2.20	17.46	2.05	6.94	26.17	4.66	0.178
Minimum	74.64	46.00	128.60	23.75	41.34	15.52	0.250
Maximum	82.50	99.09	135.10	47.07	138.29	31.35	0.861
Mean	78.54	83.50	132.65	30.74	76.50	23.05	0.486
CV (%)	3.17	3.47	1.83	4.20	4.50	5.30	8.71
Level of significance	*	**	*	**	**	**	**

DFF – Days to first flowering; PGF – Pollen grain fertility, DFFM – Days to first fruit maturity; IFW – Individual fruit weight; PH – Plant height; AAc – Ascorbic Acid content; Y/P – Yield per plant

Table **2**. Path co-efficient analysis showing the direct and indirect effect of different yield contributing traits on fruit yield

Characters	DFF (days)	PGF (%)	DFFM (days)	IFW (gm)	PH (cm)	AAc (mg %)	Correlation with Y/P (Kg)
DFF (days)	**-0.287**	-0.0191	0.0010	0.144	-0.0574	0.0188	-0.200
PGF (%)	-0.159	**-0.0345**	0.0015	0.117	-0.107	0.0136	-0.168
DFFM (days)	-0.121	-0.021	**0.0025**	0.074	-0.113	0.0164	-0.162
IFW (gm)	-0.0574	-0.0056	0.00025	**0.719**	-0.0369	0.0031	0.622*
PH (cm)	0.0378	0.0085	-0.00064	-0.0611	**0.435**	0.0035	0.423
AAc (mg %)	-0.1725	-0.0151	0.00128	0.0719	0.0491	**0.031**	-0.034

Residual effect: 0.307

DFF – Days to first flowering; PGF – Pollen grain fertility, DFFM – Days to first fruit maturity; IFW – Individual fruit weight; PH – Plant height; AAc – Ascorbic Acid content; Y/P – Yield per plant

In the present investigation, after analyzing principal component, three main principal components were found which explained 79.14% of total variability (Table 3). First principal component accounted 38.68% of total variability and consisted of days to first flowering, pollen grains fertility and days to first fruit maturity Individual fruit weight and yield per plant were the traits of second main component and plant height and ascorbic acid content were the important characters of third principal component. The second and third principal components contributed 24.59% and 15.87% of total variability, respectively (Table 3). Henareh *et al.* (2015) conducted an experiment on 97 tomato land races where they found three main components which explained 71.6% of total variability in principal component analysis. In another study, Chernet *et al.* (2014) tested 36 tomato genotypes where they obtained six principal components explaining 83.03% of total variability.

Table 3. Major three principal components of seven tomato traits

Variables	PC1	PC2	PC3
Days to first flowering	0.485	0.074	0.127
Pollen grain fertility	0.499	0.021	-0.098
Days to first fruit maturity	0.487	-0.004	-0.041
Individual fruit weight	0.107	0.607	-0.481
Plant height	-0.201	0.341	0.736
Ascorbic acid content	0.444	0.176	0.442
Yield per plant	-0.171	0.692	-0.064
Eigen values	2.71	1.72	1.11
% Total Variance	38.68	24.59	15.87
Cumulative (%)	38.7	63.3	79.2

Dendrogram was constructed using Ward's method, in which 14 tomato genotypes were grouped into five clusters (Fig. 1 & Table 4). Reddy *et al.* (2013) also worked on 19 tomato genotypes and found five clusters by cluster analysis. In the present study, cluster I had maximum number of genotypes. It had six genotypes named; Marglobe-II, Burpi big, CI-170-0-20-2-0, Derinia, Hot sent, and Manik. On the other hand, cluster III had three genotypes and both cluster II and IV had two genotypes and cluster V had only one genotype (Fig. 1).

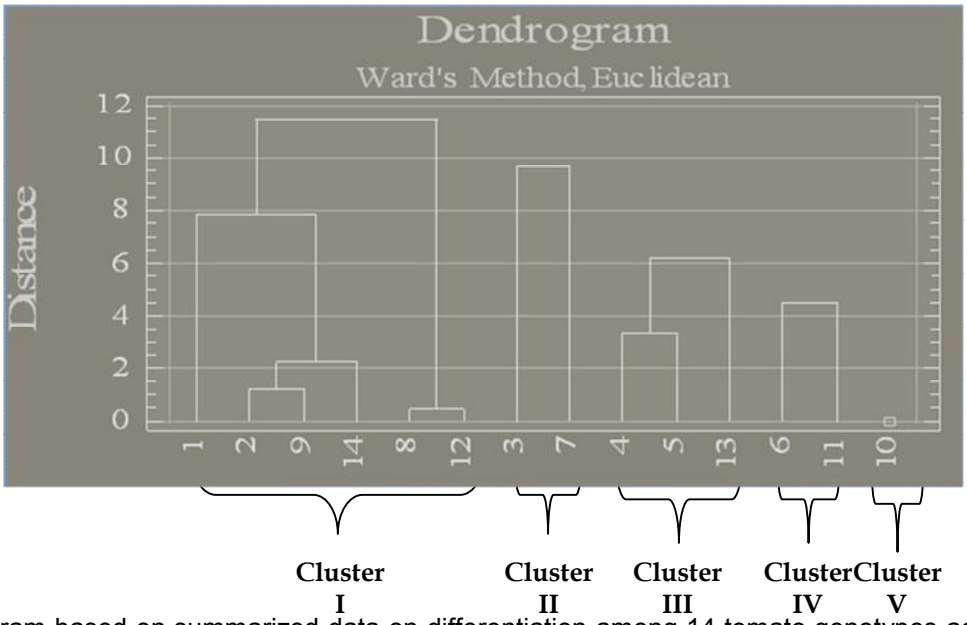

Fig. 1. Dendrogram based on summarized data on differentiation among 14 tomato genotypes according to Ward's method.

Cluster I mainly consist majority of genotypes (42.86%) which took maximum days (133.97 days) for fruit maturity and gave moderate performance in case of first flowering, fruit weight, pollen grain fertility and ascorbic acid content, with lowest yield (0.378 Kg/plant). Cluster II contained genotypes (14.29%) having the characteristics of lowest flowering period (74.82 days) as compared to cluster I, III, IV and V. This cluster also showed intermediate results in other parameters (Table 4 & 5).

Table 4. Distribution of 14 tomato genotypes in different clusters based on Euclidian distance following Ward's method

Cluster number	Number of genotypes	Percentage (%)	Name of genotypes
I	6	42.86	Marglobe-II , Burpi big, CI-170-0-20-2-0, Derinia, Hot sent, and Manik
II	2	14.29	Hekari and Big cherry
III	3	21.43	World Champion, Florida I and Okiton no.9
IV	2	14.29	Homeastid and CI-3d-143-0-13
V	1	7.14	CI-3d-0-99

As compared to other clusters, genotypes (21.43%) belonged to cluster III gave the best performance, as it showed relatively highest value in case of fruit weight, pollen grain fertility, ascorbic acid content and yield per plant. Cluster IV comprised genotypes (14.29%) with lowest ascorbic acid content whether cluster V contained only one genotype which showed poor results in individual fruit weight, pollen grain fertility and ascorbic acid content (Table 5). Henareh *et al.* (2015) classified 97 tomato genotypes into five clusters by Ward method where early maturing, high yielder, large fruited, late maturing and genotypes with high acidity were fell in cluster I, II, III, IV and V, respectively.

Table 5. Cluster mean values of 7 different characters of 14 genotypes of tomato

Characters	I	II	III	IV	V
Plant Height	75.42	68.86	73.37	61.18	138.30
	I	I	I	L	H
Days to first flowering	78.75	74.82	80.97	78.21	78.07
	I	L	H	I	I
Days to fruit maturity	133.97	131.05	133.47	130.65	129.50
	H	I	I	I	L
Individual fruit weight	26.10	32.5	40.83	31.29	23.75
	I	I	H	I	L
Pollen grain fertility	91.56	59.23	92.32	88.6	47.06
	I	I	H	I	L
Ascorbic acid content	25.33	19.83	26.43	16.38	18.96
	I	I	H	L	I
Yield per plant	0.378	0.625	0.640	0.424	0.511
	L	I	H	I	I

Here, H = High, I = Intermediate, L = Low

Conclusion

The present experiment was conducted on seven characters of 14 genotypes of tomato for studying field performance and genetic diversity where the presence of wide diversity among the characters was found. Based on the present findings, World champion and Big cherry may be considered as superior varieties among the fourteen genotypes and individual fruit weight may be considered as an important criterion for yield improvement. This analysis could be beneficial for the further breeding program for utilizing the genotypes and for effective selection for boosting yield in tomato.

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