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Studies on genetic variability and heritability for quality traits of tomato (*Lycopersicon esculentum* Mill.) under heat stress conditions

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Abstract

The present investigation was aimed to study the variation and heritability of quality characters in tomato genotypes raised under normal and high temperature conditions of Punjab. Fifteen advanced generation breeding lines of tomato along with four checks were evaluated for quality characters under normal and stress (high temperature) conditions. Maximum TSS, pericarp thickness, fruit firmness, acidity, lycopene content and dry matter was recorded in LT-36, LT-10, LT-39, LT-41, LT-16A and LT-36. Both genotypic and phenotypic components of variance were high during February planting for all the characters except for lycopene content and dry matter. High heritability coupled with low genetic advance for all the characters suggested the involvement of non-additive gene action in their inheritance which can be exploited through heterosis breeding.

Keywords: *Lycopersicon esculentum,* tomato, quality, stress, variability, heritability.

Introduction

Tomato has a high nutritive value and is a rich source of vitamins C, A, B_2 and minerals like calcium, phosphorus and iron. Total soluble solids, acidity, lycopene content, dry matter and fruit firmness are important parameters used to measure quality in tomato. It is commercially grown in Punjab during autumn and spring seasons of the year. However, during summer cultivation is comparatively less due to lack of suitable varieties tolerant to heat stress conditions. Therefore, a need of identifying stable genotypes with profitable yields and good quality characters exists for summer growing. Although significant varietal differences in total soluble solids, acid content and vitamin C have been reported by Arora *et al* (1975) and Singh *et al* (1969), but this information is available for normal season tomato only. The present investigation was aimed to study the variation and heritability of quality characters in tomato genotypes raised under normal and high temperature conditions.

Materials and methods

Studies were conducted on fifteen advance generation breeding lines of tomato along with four checks. Lines were planted in a randomized block design with three replications and two planting dates *i.e.* 29 November and 25 February 2002. Each progeny comprised ten plants with plant to plant distance of 30 cm and row to row distance of 135 cm. The observations were recorded on TSS (°Brix), pericarp thickness (mm), fruit firmness (mm), acidity (g citric acid/ 100 ml of juice), lycopene content (mg/100 g of fresh fruit) and dry matter (%).

For pericarp thickness, fruits were cut across the equatorial plane and the average pericarp thickness was measured with common scale in mm. Fruit firmness was measured with a locally designed non-destructive pressure tester. It expresses deformation of pericarp in millimeters (mm) in response to the applied load of 500 g for 10 seconds on horizontal axis of the fruit. The degree of deformation holds inverse relationship with the firmness of the fruit *i.e.* the lower the value firmer is the fruit (Dhatt, 2001). Titrable acidity was measured by titrating two ml fruit juice against 0.1 N sodium hydroxide using phenolphthalein as indicator. For lycopene content, two g fruit sample was taken and pigment was extracted with 10 ml of acetone. The acetone was evaporated to dryness and volume was made to 25 ml with petroleum ether. Then optical density was read at 505 nm (Adsule and Dan,1976). For dry matter, 50 g sample was taken in previously weighed petridish and dried to a constant weight in an oven at 65 ± 2 °C. The per cent dry matter was calculated as Dry matter percentage = (Final dry weight of sample/ Original fresh weight of sample) x 100.

Statistical analysis of data was carried out for coefficient of variation (Burton, 1952), heritability in broad sense (Burton and Devane, 1953) and the expected genetic advance was estimated according to Johnson *et al.* (1955) and Allard (1960).

Results and discussion

Mean performance of the genotypes for different characters has been listed in Table 1. The data reveals that significant differences for TSS were recorded among the genotypes under normal (November planting) environment, whereas differences were non-significant under stress (high temperature *i.e.* February planting) environment. Highest TSS under normal environment was recorded in LT-36 followed by LT-9 and the lowest TSS was observed in LT-16A. Significant varietal differences in total soluble solids have also been reported by Prasad and Rai (1999). Comparison of two planting dates showed that TSS was slightly higher in February planting than in November planting. Hashad *et al.* (1958) reported higher total soluble solids in summer crop than in autumn crop. Under normal environment, maximum pericarp thickness of 8.67 mm was recorded in LT-10 and LT-14

Table 1. Mean performance of tomato genotypes for various quality characters for two planting dates

S. No.	Genotype	Total soluble solids(°Brix)		Pericarp thickness (mm)		Fruit firmness (mm)		Acidity (g citric acid equivalent /100 ml of juice)		Lycopene content (mg 100 g^{-1} of fresh fruit)		Dry matter (%)	
		N	F	N	F	N	F	N	F	N	F	N	F
1.	LT-1	4.80	4.77	7.33	5.33	0.12	0.13	0.52	0.58	4.40	4.37	5.79	5.70
2.	LT-2	4.57	4.60	8.00	6.00	0.07	0.10	0.52	0.52	3.94	3.84	5.51	5.53
3.	LT-2A	4.57	4.27	6.67	7.00	0.14	0.15	0.50	0.49	3.52	3.44	5.81	5.44
4.	LT-9	5.10	4.97	7.33	8.33	0.13	0.15	0.39	0.40	3.13	3.03	5.30	5.23
5.	LT-10	4.60	4.80	8.67	8.33	0.12	0.13	0.47	0.43	4.51	4.36	5.10	5.03
6.	LT-14	5.07	4.93	8.67	7.00	0.08	0.09	0.45	0.44	2.86	2.64	5.75	5.64
7.	LT-16	4.8	4.73	7.00	6.00	0.07	0.09	0.38	0.41	4.44	4.73	5.31	5.13
8.	LT-16A	4.03	4.33	7.67	4.67	0.10	0.12	0.41	0.40	5.26	5.14	4.81	4.94
9.	LT-18	4.83	4.83	8.00	7.67	0.13	0.13	0.41	0.37	3.51	3.41	4.66	5.00
10.	LT-26	4.17	4.50	7.67	6.00	0.09	0.11	0.40	0.41	4.48	4.64	5.10	5.17
11.	LT-34	4.73	4.93	8.33	8.00	0.12	0.12	0.41	0.44	2.91	2.80	6.14	6.17
12.	LT-36	5.3	5.07	7.67	7.00	0.14	0.16	0.41	0.41	3.82	3.66	6.59	6.60
13.	LT-37	4.97	4.93	8.33	8.67	0.09	0.09	0.40	0.43	2.67	2.46	5.38	5.13
14.	LT-39	4.87	4.80	7.00	6.33	0.05	0.08	0.50	0.44	4.48	4.32	5.13	5.13
15.	LT-41	4.97	5.00	7.00	7.33	0.09	0.11	0.54	0.59	3.41	3.34	5.21	5.08
16.	Nagcarlan	5.0	5.33	4.33	5.33	0.17	0.17	0.35	0.36	4.32	4.37	5.71	5.50
17.	S-12	4.53	4.33	5.33	5.00	0.21	0.26	0.38	0.40	3.74	3.68	5.67	5.61
18.	Pb. Chhuhara	4.83	4.73	7.33	5.33	0.13	0.13	0.40	0.39	2.27	2.26	5.07	5.04
19.	Pb. Upma	4.33	4.40	7.33	6.67	0.09	0.11	0.36	0.35	4.29	4.38	5.24	5.07
	Mean	4.74	4.75	7.35	6.63	0.11	0.13	0.43	0.44	3.79	3.73	5.44	5.38
	CD (*P*=0.05)	0.39	NS	1.14	1.33	0.01	0.01	0.06	0.08	1.17	0.75	0.50	0.62

N=November, F=February

Table 2. Components of variance, estimates of heritability and genetic advance

Character	Planting date	Mean	Range	Phenotypic variance	Genotypic variance	Coefficients of variation Phenotypic (PCV)	Genotypic (GCV)	Heritability (broad sense%)	GA	GA as % of mean
Total soluble solids (%)	November	4.74	4.03-5.30	0.14	0.08	7.93	6.18	60.63	0.47	9.91
	February	4.75	4.27-5.33	0.17	0.04	8.61	4.07	22.34	0.19	3.96
Pericarp thickness (mm)	November	7.35	4.33-8.67	1.45	0.98	16.43	13.49	67.45	1.68	22.82
	February	6.63	4.67-8.67	1.91	1.27	20.85	16.95	66.11	1.88	28.40
Fruit firmness	November	0.11	0.05-0.21	0.0014	0.0013	32.94	32.48	97.20	0.08	65.96
	February	0.13	0.08-0.26	0.0017	0.0016	30.67	29.92	95.15	0.08	60.12
Acidity (g citric acid/	November	0.43	0.35-0.54	0.004	0.003	15.50	13.19	72.44	0.10	23.13
100 ml of juice)	February	0.44	0.35-0.59	0.005	0.003	17.91	14.12	62.15	0.10	22.93
Lycopene content(mg/	November	3.79	2.27-5.26	0.94	0.44	25.64	17.56	46.90	0.94	24.77
100 g of fresh fruit)	February	3.73	2.26-5.14	0.83	0.62	24.43	21.16	75.01	1.41	37.75
Dry matter (%)	November	5.44	4.66-6.59	0.28	0.19	9.68	7.93	67.14	0.73	13.39
	February	5.38	4.94-6.60	0.28	0.14	9.89	6.97	49.75	0.55	10.13

GA=Genetic advance

while Nagcarlan had the minimum pericarp thickness of 4.33 mm. However, under stress conditions, LT-37 had the maximum pericarp thickness (8.67 mm). Kumar and Tewari (1999) reported marked differences in pericarp thickness among varieties. In general, pericarp thickness was more in November planting than in February planting. The effect of season on pericarp thickness is difficult to explain. LT-39 had the firmest fruits (0.05, 0.08) under normal and stress conditions, respectively and S-12 recorded the least firm fruits (0.21, 0.26) under normal as well as stress conditions, respectively. In general, stress conditions reduced the firmness of the fruits, which confirm the results of Islam and Khan (2000), who studied the effect of different seasons on physical and biochemical characteristics of three tomato cultivars. Fruits of LT-41 had highest acidity of 0.54 and 0.59% under normal and stress conditions, respectively. Nagcarlan had minimum acidity (0.35%) under normal conditions while under stress conditions, fruits of Punjab Upma were minimum in acid content (0.35%). Padmalatha and Reddy (1990) reported low variability in titrable acidity among the progenies of 15 crosses from a diallel set based on Pusa Early Dwarf, Pusa Ruby, Druzhba 1300, Topaz, Svava-VF and Ogosta. The results of the present investigation reveal that acidity was highest under late summer conditions. Similar findings were also reported by Mandy (1966), who recorded 2-4 times more acid content in warmer season than cool weather prevailing during the growing season. The increase in the acidity of fruits during February planting may be due to the adverse effect of high temperature which inhibited the metabolic pathway by inactivating enzyme Aconitase (responsible for

conversion of citric acid into isocitric acid in TCA cycle) resulting in to accumulation of citric acid under stress conditions. As regards lycopene content, LT-16A gave the best performance under both the conditions having lycopene content of 5.26 and 5.14 mg $100g^{-1}$. Minimum lycopene content (2.27 and 2.26 mg $100g^{-1}$) was recorded by Punjab Chhuhara during both plantings. Comparison of two planting dates for lycopene content showed that February planting reduced the lycopene content, whereas it was slightly higher in November planting. These findings are similar to the earlier work of Islam and Khan (2000). Highest dry matter of 6.59 and 6.60% was observed in LT-36 under normal and stress conditions, respectively. LT-18 and LT-16A had minimum dry matter of 4.66 and 4.94% under normal and stress conditions respectively.

General mean, range, genotypic variance, phenotypic variance, heritability and genetic advances are presented in Table 2. The population mean was higher during November planting than February planting for all the characters except acid content and TSS. Among all the characters, pericarp thickness showed the highest phenotypic and genotypic variances under both the conditions. Fruit firmness showed very little difference between phenotypic and genotypic variances indicating less influence of environment. On comparing two seasons, all the characters showed an increasing trend for both the components of variance except for lycopene content which showed low phenotypic variance in February planting and for TSS and dry matter which had low genotypic variance in February planting. Similar trend was also observed for coefficient of variation. Phenotypic coefficient of variation was maximum for fruit firmness followed by lycopene content. Similarly genotypic coefficient of variation, which is the true indicator of the extent of genetic variability in the population was maximum for fruit firmness followed by lycopene content. In general, the phenotypic coefficients of variation were higher than genotypic coefficients of variation indicating that the genotypic influence is lessened under the influence of the given environment. Heritability, which acts as a predictive instrument in expressing the reliability of phenotypic value was maximum for fruit firmness. Among the two seasons, heritability estimates (in broad sense) were high for all the characters for November planting except for lycopene content. The genetic advance is a useful indicator of the progress that can be expected as a result of exercising selection on the pertinent population. In the present study, only fruit firmness showed high genetic advance, while it was low for rest of the characters. The high heritability value for fruit firmness accompanied with high genetic advance showed the presence of additive gene effects, hence selection for this particular trait in the desirable direction could be effective. High heritability estimate associated with low genetic advance for rest of the characters suggested the role of non-additive gene action in their inheritance (Panse, 1957). In order to improve these characters, heterosis breeding followed by selection in desired direction is advocated.

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