



Original Research Article

Studies on genetic variability, heritability and genetic advance for yield and quality traits in Tomato (*Solanum lycopersicum* L.)

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A B S T R A C T

Keywords

Genetic parameters, tomato; PCV; GCV; heritability and genetic advance.

The genetic parameters were studied to elucidate the genetic variability, heritability and genetic advance in tomato (*Solanum lycopersicum* L.). Evaluation of nineteen genotypes of tomato was done in augmented block design due to limited germplasm. The genotypes exhibited a wide range of variability for all the characters studied. Phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the characters studied. High heritability combined with high genetic advance was observed for the characters plant height, number of clusters per plant, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, fruit length, fruit weight, fruit yield per plant, ascorbic acid, acidity, shelf life and TSS. High heritability combined with high genetic advance indicates that additive gene action plays a major role in governing these traits and these traits can be improved by simple selection.

Introduction

Tomato is one of the most economically important vegetables in the world with a production of 152.9 million tonnes with a value of \$74.1 billion (FAOSTAT Database, 2009). In terms of human health, tomato fruit provide significant quantities of betacarotene, a provitamin-A carotenoid and ascorbic acid. Lycopene is the major carotenoid in tomato fruit, is a powerful anti-oxidant and is associated with reduced risk of certain cancers, heart diseases and age-related diseases (Heber and Lu, 2002). Depletion of genetic

reserves is manifest in a reduction to extremely low levels of enzyme variability and consequent difficulties experienced by breeders in finding the genes essential for desired improvements. It is therefore no surprise that special measures were needed to increase the range of genetic variation (Rick, 1987). In India, genetic variation in tomato is collected and maintained by National Bureau of Plant Genetic Resources (NBPGR), New Delhi and Indian Institute of Vegetable Research, Varanasi.

Materials and Methods

The experiment has been carried out at National Bureau of Plant Genetic Resources (NBPGR) Regional Station, Hyderabad with nineteen tomato genotypes consisting of sixteen exotic collections and three varieties *viz.*, Arka Vikas, Marutham and Punjab Chhauhara. The experiment was laid out in augmented block design due to limited germplasm with the three varieties as checks. The field is divided into eight blocks with each block containing two exotic collections and three check varieties. Each genotype is planted in a single row of 4m length at a spacing of 60cm between row-to-row and 50cm between plant-to-plant. The data is recorded based on the NBPGR descriptor for tomato. The analysis is done using the WINDOSTAT software program.

Results and Discussion

The mean performance of all the 19 genotypes of the tomato were recorded (Table 1). Analysis of variance (Table 2) showed significant variation among the genotypes for all the characters studied except days to first fruit harvest and days to last fruit harvest for varieties mean sum of squares (VMSS). Estimates of different statistical and genetic parameters like mean, genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), heritability, genetic advance as percent mean are presented (Table 3).

PCV and GCV were higher (>20) for number of clusters per plant, number of fruits per plant, fruit weight, fruit yield, acidity and shelf life which suggested greater phenotypic and genotypic variability among the accessions and sensitiveness of the attributes for making further improvement by selection. High

PCV (>20) and moderate GCV (10-20) was observed for number of primary branches per plant, ascorbic acid and TSS. PCV and GCV were moderate for plant height, number of flowers per cluster, number of fruits per cluster and fruit length. Moderate PCV and low GCV was observed for fruit width. PCV and GCV were low for days to 50% flowering, days to first fruit set, days to first fruit harvest and days to last fruit harvest. The PCV was higher than GCV for all the characters studied indicating environmental factors influencing their expression. The PCV was higher than the respective GCV for all the traits denoting environmental factors influencing their expression to some degree or other. Narrow difference between PCV and GCV for all the characters suggested their relative resistance to environmental alteration. The results are in accordance with the Ara *et al.* (2009) for plant height, Kumar and Thakur (2007) for number of primary branches per plant, Singh (2005) for days to 50% flowering, Arunkumar and Veeraragavathatham (2005) for number of clusters per plant, Singh *et al.* (2000) for days to first fruit set, Ara *et al.* (2009) for days to first fruit harvest, Kumari *et al.* (2007) for number of fruits per cluster, Ara *et al.* (2009) and Singh (2009) for number of fruits per plant, acidity and TSS, Ara *et al.* (2009), Singh (2009) and Prema *et al.* (2011) for fruit yield.

The heritability in broad sense ranged from 36.60 for days to last fruit harvest to 99.70 for number of fruits per cluster. Higher values of heritability (>60) has been observed for plant height, days to 50% flowering, number of clusters per plant, number of flowers per cluster, days to first fruit set, number of fruits per cluster, number of fruits per plant, fruit length, fruit weight, fruit yield, ascorbic acid, acidity and shelf life.

Table.1 Mean performance of the 19 tomato genotypes for studied eighteen characters

Characters	1	2	3	4	5	6	7	8	9
EC677040	85.958	13.146	51.667	14.521	6.846	57.250	97.833	136.667	4.729
EC677079	84.958	10.146	41.667	23.521	7.146	47.250	91.833	136.667	5.029
EC677058	93.625	14.146	42.667	6.287	5.146	48.917	88.167	136.667	3.496
EC677051	85.625	16.646	40.667	15.288	6.446	46.917	80.167	126.667	4.796
EC677063	67.958	18.479	40.000	10.387	4.946	50.917	97.833	145.667	4.696
EC676793	129.958	19.479	39.000	7.187	7.346	40.917	78.833	131.667	5.196
EC676790	74.625	13.813	38.333	27.321	5.512	40.917	82.833	129.000	3.196
EC676816	92.625	16.813	39.333	6.121	6.313	40.917	95.833	135.000	3.796
EC671598	91.125	16.479	45.000	16.788	4.912	52.250	95.500	127.333	6.196
EC677204	138.125	19.979	43.000	6.088	6.412	49.250	95.500	138.333	3.596
EC671593	106.125	13.646	40.000	6.888	4.912	42.583	87.167	141.667	3.196
EC677206	93.125	16.646	41.000	4.888	6.612	45.583	96.167	116.667	2.796
EC671592	66.958	11.146	42.000	7.554	4.912	48.917	91.500	147.333	3.196
EC671599	74.958	10.146	45.000	3.554	5.912	51.917	91.500	137.333	3.996
EC677203	124.625	20.646	44.333	5.454	7.213	48.250	98.167	134.667	4.196
EC677202	132.625	30.146	35.333	8.654	6.912	41.250	96.167	117.667	6.596
Arka Vikas	70.875	14.250	38.000	24.538	5.487	41.125	74.125	139.250	3.613
Marutham	107.125	20.563	34.000	25.463	6.887	39.625	77.625	128.625	4.787
Punjab Chhauhara	100.875	18.625	34.000	25.862	8.363	39.000	79.750	130.125	6.388
Mean	95.888	16.576	40.789	12.966	6.223	45.987	89.289	133.526	4.394
Std. Dev.	22.209	4.690	4.212	8.400	1.008	5.192	8.002	8.126	1.133
Std. Error	5.095	1.076	0.966	1.927	0.231	1.191	1.836	1.864	0.260
C. V. %	23.161	28.297	10.327	64.785	16.205	11.290	8.962	6.085	25.784
Lowest	66.958	10.146	34.000	3.554	4.912	39.000	74.125	116.667	2.796
Highest	138.125	30.146	51.667	27.321	8.363	57.250	98.167	147.333	6.596

Table 1 Contd...

Characters	10	11	12	13	14	15	16	17	18
EC677040	69.188	5.238	4.558	101.833	1.154	24.267	0.379	6.287	27.167
EC677079	49.188	4.438	3.458	49.333	1.554	18.667	0.179	5.287	26.167
EC677058	39.521	3.604	2.425	23.500	0.521	24.667	0.313	6.387	32.833
EC677051	65.521	3.704	2.225	27.500	0.821	34.467	0.213	8.587	25.833
EC677063	55.021	6.704	3.325	69.167	1.021	27.200	0.213	3.787	29.500
EC676793	37.021	6.204	4.025	95.667	1.421	13.200	0.213	3.387	20.500
EC676790	35.854	5.938	3.458	72.000	2.087	34.467	0.313	4.921	7.167
EC676816	34.854	5.438	3.458	79.000	1.487	28.867	0.313	5.321	34.167
EC671598	74.188	4.638	3.625	59.667	1.154	14.733	0.279	6.354	34.500
EC677204	11.188	3.537	2.825	34.667	0.154	25.933	0.879	10.354	27.500
EC671593	27.521	4.671	2.358	31.333	0.521	10.867	0.313	5.154	24.500
EC677206	66.521	5.871	4.458	102.333	2.721	24.067	0.313	5.254	18.500
EC671592	18.688	3.771	4.325	77.000	0.188	16.133	0.412	5.987	25.167
EC671599	19.688	5.371	3.225	77.000	0.013	24.133	0.412	5.787	34.167
EC677203	39.521	4.838	4.225	81.000	2.254	29.067	0.379	6.021	23.167
EC677202	35.521	4.338	3.625	54.000	1.154	37.467	0.279	7.221	12.167
Arka Vikas	55.313	3.463	3.725	52.000	1.712	22.975	0.300	5.200	14.000
Marutham	66.375	3.387	3.162	35.750	1.813	24.900	0.450	5.513	17.875
Punjab Chhauhara	52.875	4.363	3.487	60.250	1.337	27.125	0.388	5.650	14.625
Mean	44.924	4.711	3.472	62.263	1.214	24.379	0.344	5.919	23.658
Std. Dev.	18.628	1.013	0.681	24.697	0.738	7.221	0.150	1.555	7.982
Std. Error	4.274	0.232	0.156	5.666	0.169	1.657	0.034	0.357	1.831
C. V. %	41.466	21.496	19.619	39.666	60.837	29.619	43.634	26.279	33.741
Lowest	11.188	3.387	2.225	23.500	0.013	10.867	0.179	3.387	7.167
Highest	74.188	6.704	4.558	102.333	2.721	37.467	0.879	10.354	34.500

Note: 1. Plant height; 2. Number of primary branches per plant; 3. Days to 50% flowering; 4. Number of clusters per plant; 5. Number of flowers per cluster; 6. Days to first fruit set; 7. Days to first fruit harvest; 8. Days to last fruit harvest; 9. Number of fruits per cluster; 10. Number of fruits per plant; 11. Fruit length (cm); 12. Fruit width (cm); 13. Fruit weight (g); 14. Fruit yield (Kg/plant); 15. Ascorbic acid (mg/100g); 16. Acidity (%); 17. TSS (°Brix); 18. Shelf life (days)

Table.2 Analysis of variance (ANOVA) for yield and quality traits in tomato

Character	Block MSS	Check MSS	Varieties MSS	EMSS
Plant height (cm)	648.8800	3004.1700***	685.4600***	84.0700
Number of primary branches	25.1100	83.6600***	26.8600**	6.9200
Days to 50% flowering	3.4200	42.6700***	12.0300***	0.7600
Number of clusters per plant	19.0200	3.7000	46.5800***	2.8000
Number of flowers per cluster	0.2900	16.5400***	0.8000***	0.0036
Days to first fruit set	2.0000	9.5400***	16.2500***	1.4000
Days to first fruit harvest	32.1700	64.5400*	39.4600	16.3000
Days to last fruit harvest	25.9400	264.5400**	61.9600	27.7800
Number of fruits per cluster	0.5800	15.5200***	1.2100***	0.0017
Number of fruits per plant	83.1800	414.0900**	338.0300***	47.3000
Fruit length (cm)	0.7500	2.3600***	0.7600***	0.0900
Fruit width (cm)	0.0800	0.6400*	0.4100*	0.1600
Fruit weight (g)	195.9200	1243.1700***	615.3300***	27.5500
Fruit yield (Kg/plant)	0.1900	0.5000**	0.5100***	0.0700
Ascorbic acid (mg/100g)	17.2400	34.5000**	50.0600***	4.9100
Acidity (%)	0.0200	0.0400***	0.0300***	0.0016
TSS (Brix)	2.2200	0.4200	2.9500***	0.4100
Shelf life (days)	17.5700	34.6200**	57.6300***	3.0100

Note:BMSS: Block mean sum of squares; CMSS: Checks mean sum of squares; VMSS: Varieties mean sum of squares; EMSS: Error mean sum of squares

Table.3 Estimates of genetic parameters in tomato

Character	Grand mean	GCV	PCV	Heritability	GA	GAM
Plant height (cm)	95.89	17.41	19.84	77.00	30.36	31.48
Number of primary branches	16.58	18.71	24.68	57.50	4.77	29.21
Days to 50% flowering	40.79	5.50	5.88	87.40	4.43	10.58
Number of clusters per plant	12.97	42.51	45.32	88.00	8.75	82.15
Number of flowers per cluster	6.22	10.06	10.10	99.10	1.26	20.62
Days to first fruit set	45.99	5.60	6.14	83.30	4.96	10.52
Days to first fruit harvest	89.29	3.60	5.69	40.00	4.29	4.69
Days to last fruit harvest	133.53	2.99	4.95	36.60	4.99	3.73
Number of fruits per cluster	4.39	17.52	17.54	99.70	1.55	36.03
Number of fruits per plant	44.92	27.51	31.93	74.20	20.72	48.82
Fruit length (cm)	4.71	11.48	12.99	78.10	1.02	20.91
Fruit width (cm)	3.47	9.96	15.18	43.10	0.47	13.47
Fruit weight (g)	62.26	25.66	26.91	90.90	32.6	50.4
Fruit yield (Kg/plant)	1.21	40.04	46.13	75.40	0.82	71.61
Ascorbic acid (mg/100g)	24.38	18.96	21.04	81.20	8.54	35.19
Acidity (%)	0.34	32.85	34.93	88.40	0.22	63.64
TSS (Brix)	5.92	18.19	21.06	74.60	1.94	32.36
Shelf life (days)	23.66	20.09	21.24	89.50	9.86	39.15

Moderate values of heritability (30-60) has been observed for number of primary branches per plant, days to first fruit harvest, days to last fruit harvest and fruit width. High values of heritability for the traits clarified that they were least affected by environmental modification and selection based on phenotypic performance would be reliable.

Genetic advance as percent mean (GAM) *i.e.*, genetic gain ranged from 3.73 to 82.15. High genetic gain (>20%) was observed for plant height, number of primary branches per plant, number of clusters per plant, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, fruit length, fruit weight, fruit yield, ascorbic acid, acidity, TSS and shelf life. Moderate genetic gain (10-20%) was observed for days to 50% flowering, days to first fruit set, and fruit width. Low genetic gain (<10%) was observed for days to first fruit harvest and days to last fruit harvest.

High heritability along with high genetic gain were noticed for plant height, number of clusters per plant, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, fruit length, fruit weight, fruit yield per plant, ascorbic acid, acidity, TSS and shelf life which might be assigned to additive gene effect governing their inheritance and phenotypic selection for their improvement could be achieved by simple method like pure line or mass selection or bulk or SSD method following hybridization and selection in early generations. High estimates of heritability coupled with low genetic gain were observed for days to 50% flowering and days to first fruit set which might be attributed to non additive gene action controlling their expression and simple selection would not be rewarding.

Nevertheless, they could be improved by development of hybrid varieties or utilization of transgressive segregants in heterosis breeding programme. The results are in accordance with Singh (2009) for plant height, Aradhana and Singh (2003) for number of primary branches per plant, Singh (2005) for days to 50% flowering, Arunkumar and Veeraragavathatham (2005) for number of clusters per plant, Mayavel *et al.* (2005) for number of flowers per cluster and number of fruits per cluster, Singh (2009) for number of fruits per plant and fruit yield, Kumari *et al.* (2007) for acidity, ascorbic acid and TSS.

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