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Genetic Variability Studies in Tomato (*Solanum lycopersicum* L.) for Yield and Quality Traits

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Abstract

The present study was carried out to investigate yield and quality traits in tomato, in order to generate information regarding the extent of genetic variability, heritability and genetic gain. The experiment was laid out during 2014-2015 in Randomized Complete Block Design (RCBD) at an experimental farm of the Department of Vegetable Science, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan. Genetic variability was estimated among 56 genotypes of tomato which were replicated thrice. Analysis of coefficient of variation revealed that, the magnitude of phenotypic coefficient of variation was slightly higher than the genotypic coefficient of variation for all the studied traits. Further, high estimates of heritability and genetic gain were recorded for number of fruits per plant, average fruit weight, fruit yield per plant, locular wall thickness and lycopene content. Thereby, suggesting that straight selection for these traits may bring worthwhile improvement in identifying superior genotypes in tomato.

Highlights

- The magnitude of phenotypic coefficient of variation was slightly higher than the genotypic coefficient of variation for all the studied traits.
- High estimates of heritability and genetic gain were recorded for number of fruits per plant, average fruit weight, fruit yield per plant, locular wall thickness and lycopene content.

Keywords: Variability, range, heritability, genetic gain, yield, tomato

Tomato is one of the most important, popular and widely grown vegetable in India as well as in the world. In Himachal Pradesh, it is grown during summer and fetches better remunerative price as off season produce. It is considered 'Protective food' as it has some special nutritive value and antioxidant properties due to the presence of lycopene and flavonoids (Sepat *et al*., 2013). But the production and productivity of this crop in India is far below compare to the global scenario. Hence, there is need to develop superior varieties/hybrids for different agro-ecological conditions with specific end use. Success and pace of conventional breeding is primarily conditioned by the availability of desired genetic variability for the target traits (Ara *et al*., 2009). Genetic resources enable plant breeders to create novel plant gene combinations and select crop varieties more suited to the needs of diverse agricultural systems (Glaszmann *et al*., 2010). The importance of genetic variability was perceived for the first time by a Russian scientist, Vavilov (1951), who advocated that wide range of variability provides better scope for selecting a desirable genotype. The efficiency of selection depends on the nature and extent of genetic variability, degree of transmissibility of desirable characters (Golani *et al*., 2007) and on the actual expected genetic gain for the character in a population. So, an insight into the magnitude of variability and the extent of heritability present in the gene pool of a crop

species for desirable traits is of utmost importance to a plant breeder for starting a judicious plant breeding programme. Therefore, an attempt was made to study the genetic variability, heritability and genetic gain among different genotypes of tomato for various horticultural traits.

Materials and Methods

The experimental material consisting of 56 genotypes of tomato collected from various sources (Table 1) were evaluated at an experimental farm of the Department of Vegetable Science, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during 2014- 2015. The experiment was laid out in randomized complete block design with three replications at spacing of 90 cm × 30 cm. The observations were recorded for 14 characters *viz*., days to first picking, plant height, inter-nodal distance, number of fruits per cluster, number of fruits per plant, average fruit weight, fruit yield per plant, number of locules per fruit, locular wall thickness, pericarp thickness, thousand seed weight, total soluble solids, lycopene content and harvest duration in five randomly selected plants from each genotype in each replication. The analysis of variance was calculated as per Gomez and Gomez (1983). Phenotypic and genotypic coefficient of variation was estimated according to Burton and De Vane (1953). Heritability in broad sense and genetic advance as per cent of mean were calculated as per formula given by Allard (1960) and Jhonson *et al*. (1955) respectively.

Results and Discussion

Range

A wide range of variation was observed among 56 genotypes of tomato, evaluated for 14 characters (Table 2). The *per se* performance of the genotypes revealed a wide range of variation (Table 3) for traits such as days to first picking (72.67 days in 97/754 to 85.33 days in EC- 521038), number of fruits per cluster (1.84 in VRT- 87 to 4.87 in EC- 538146), number of fruits per plant (11.47 in EC- 620398 to 64.78 in EC- 126903), average fruit weight (8.33g in EC- 126903 to 88.13g in Solan Tomato-1), plant height (38.23 cm in KS -7 to 123.27 cm in KS -254), inter-nodal distance (3.60 cm in EC- 531803 to 8.16 cm in Best of All), pericarp thickness (2.01 mm in EC- 126903 to 6.19 mm in Punjab Ratta), locular wall thickness (1.45 mm in EC- 5863 to 4.28 mm in UHF-II), number of locules per fruit (2 in EC -5863 to 5.13 in VRT -87), total soluble solids (3.03^{o}B in DC- 1 to 6.42^{o}B in KS- 254), thousand seed weight (1.84g in Punjab Upma to 3.54g in EC- 5863), lycopene content (1.25mg/100g in EC- 535580 to 13.26mg/100g in Best of All), harvest duration (16.33 days in EC-620410 to 45 days in KS- 254) and yield per plant (261.25g in EC- 620434 to 2033.25g in KS- 254). On the basis of different quantitative and qualitative characters observed, the genotypes *viz*., VL- Tamatar 4, KS- 254, Solan Tomato-1, Solan Tomato-2, EC-620410, Punjab Ratta, Punjab Chhuhara and VTG- 93 were found promising.

Genotypic and Phenotypic Coefficient of Variability

The perusal of the data presented in the Table 3 indicated that phenotypic coefficient of variability was higher in magnitude than their corresponding genotypic coefficient of variability for all the characters. High phenotypic and genotypic coefficient of variability were recorded for number of fruits per plant (42.81% and 42.41%), average fruit weight (47.99% and 47.85%), yield per plant (44.62% and 44.12%) and lycopene content (42% and 40.21%).

Moderate coefficient of variability both at phenotypic and genotypic level were observed for number of fruits per cluster (24.82% and 21.81%), inter-nodal distance (22.08% and 16.34%), pericarp thickness (23.78% and 20.30%), number of locules per fruit (27.36% and 23.56%) and harvest duration (21.98% and 18.46%). Days to first picking (4.39% and 3.57%) showed low values of phenotypic and genotypic coefficient of variability. The characters like total soluble solids (15.92% and 12.83%) and thousand seed weight (15.28% and 13.36%) exhibited moderate and low values for phenotypic and genotypic coefficient of variability, respectively, while for plant height (32.12% and 28.25%) high and moderate values of phenotypic and genotypic coefficient of variability was observed, respectively.

Similar results were reported by Fehmida and Ahmad (2007), Ara *et al*. (2009), Dar *et al*. (2011), Buckseth *et al*. (2012), Rahaman *et al*. (2012), Manna and Paul (2012), Kumar *et al*. (2013), Patel *et al*. (2013), Chadha and Bhusan (2013), Sidhva *et al*.

Table 1: List of tomato genotypes studied along with their sources

Sl. No.	Genotypes	Sources	Sl. No.	Genotypes	Sources
1	EC-5205	IIVR, Varanasi	29	Solan Tomato-3	UHF, Nauni, Solan
2	EC-521079	IIVR, Varanasi	30	Solan Lalima	UHF, Nauni, Solan
3	EC-5863	IIVR, Varanasi	31	97/754	UHF, Nauni, Solan
4	EC-538146	IIVR, Varanasi	32	Arka Abha	IIHR, Bangalore
5	EC-521038	IIVR, Varanasi	33	Arka Alok	IIHR, Bangalore
6	EC-526146	IIVR, Varanasi	34	Arka Saurabh	IIHR, Bangalore
7	EC-531804	IIVR, Varanasi	35	Arka Meghali	IIHR, Bangalore
8	EC-129604	IIVR, Varanasi	36	Arka Vikas	IIHR, Bangalore
9	EC-531803	IIVR, Varanasi	37	VRT-87	VPKAS, Almora
10	EC-620398	IIVR, Varanasi	38	VL-Tamatar 4	VPKAS, Almora
11	EC-620378	IIVR, Varanasi	39	VTG-93	VPKAS, Almora
12	EC-126903	IIVR, Varanasi	40	Punjab Varkha Bahar-2	PAU, Ludhiana
13	EC-620424	IIVR, Varanasi	41	Punjab Ratta	PAU, Ludhiana
14	EC-620383	IIVR, Varanasi	42	Punjab Tropic	PAU, Ludhiana
15	EC-392693	IIVR, Varanasi	43	Punjab Upma	PAU, Ludhiana
16	EC-620396	IIVR, Varanasi	44	Castle Rock	PAU, Ludhiana
17	EC-620434	IIVR, Varanasi	45	Punjab Kesri	PAU, Ludhiana
18	EC-620410	IIVR, Varanasi	46	Punjab Chhuhara	PAU, Ludhiana
19	EC-535580	IIVR, Varanasi	47	Rodade	RHRS, Bajjura
20	Palam Pride	HPKV, Palampur	48	EC-2491	RHRS, Bajjura
21	BT-12	OUAT, Bhubneshwar	49	EC-164660	RHRS, Bajjura
22	BT-18	OUAT, Bhubneshwar	50	Best of All	IARI, Katrain
23	BC-333-1	UHF, Nauni, Solan	51	Roma	IARI, Katrain
24	DC-1	UHF, Nauni, Solan	52	Marglobe	IARI, Katrain
25	S-208	UHF, Nauni, Solan	53	S-12	PAU, Ludhiana
26	UHF-II	UHF, Nauni, Solan	54	HADT-294	CHES, Ranchi
27	Solan Tomato-1	UHF, Nauni, Solan	55	KS-254	CSAUAT, Research station, Kalyanpur
28	Solan Tomato-2	UHF, Nauni, Solan	56	KS-7	CSAUAT, Research station, Kalyanpur

(2014), Khapte and Jansirani (2014) and Kumar (2014).

Heritability and Genetic gain

Heritability (broad sense) estimates ranged from (54.73%) to (99.43%). High heritability estimates were recorded for number of fruits per plant (98.12%), average fruit weight (99.43%), locular wall thickness (80.63%), lycopene content (91.69%) and yield per plant (97.77%), while days to first picking (66.23%), number of fruits per cluster (77.21%), plant height (77.36%), inter-nodal distance (54.73%), pericarp thickness (72.86%), number of locules per fruit (74.13%), total soluble solids (64.98%), thousand seed weight (76.39%) and harvest duration (70.57%) revealed moderate heritability. Genetic gain is the genetic advance expressed as percent of population mean. In the present studies, genetic gain was high for number of fruits per plant (86.53%), average fruit weight (98.30%), plant height (51.18%), locular wall thickness (55.42%), lycopene content (79.32%) and yield per plant (89.87%), while it was moderate for number of fruits per cluster (39.47%), pericarp thickness (35.70%), number of locules per fruit (41.78%) and harvest duration (31.95%).

However, low genetic gain was observed for days to first picking (5.98%), inter-nodal distance (24.90%), total soluble solids (21.31%) and thousand seed weight (24.05%). High heritability with high estimates of genetic gain were observed for number of fruits per plant (98.12% and 86.53%), average fruit weight (99.43% and 98.30%), locular wall thickness (80.63% and 55.42%), lycopene content (91.69% and 79.32%) and yield per plant (97.77% and 89.87%)

Table 2: Analysis of variance (Mean Sum of Squares) for different characters

Character	Abbreviation	Replication	Genotype	Error
	DF	2	55	110
Days to first picking	**DFP**	78	27.91**	4.055
Number of fruits per cluster	**NFPC**	0.007	1.47**	0.132
Number of fruits per plant	**NFPP**	20.956	514.73**	3.267
Average fruit weight (g)	**AFW**	0.501	1077.09**	2.049
Plant height (cm)	**PH**	437.032	1688.58**	150.089
Inter-nodal distance (cm)	**ID**	1.391	2.878**	0.622
Pericarp thickness (mm)	**PT**	1.242	2.094**	0.231
Locular wall thickness (mm)	**LWT**	0.023	1.684**	0.125
Number of locules per fruit	**NFLP**	0.446	2.043**	0.213
Total soluble solids (°B)	**TSS**	0.60	1.111**	0.169
Thousand seed weight (g)	**TSW**	0.018	0.461**	0.043
Lycopene content (mg/100g)	**LC**	1.322	13.593**	0.353
Harvest duration (days)	**HD**	27.810	85.603**	10.446
Yield per plant (g)	**YPP**	31680.59	734931.30**	5543.22

** Significant at 5% level of probability. DF- Degree of freedom

Table 3: Estimates of parameters of variability in tomato for different traits

Traits	Mean	Range	Coefficient of variability (%)		Heritability (%)	Genetic Advance	Genetic Gain (%)
			Phenotypic	Genotypic			
DFP (days)	79.02	72.67 - 85.33	4.39	3.57	66.23	4.73	5.98
NFPC	3.06	1.84 - 4.87	24.82	21.81	77.21	1.21	39.47
NFPP	30.79	11.47 - 64.78	42.81	42.41	98.12	26.64	86.53
AFW (g)	39.56	8.33 - 88.13	47.99	47.85	99.43	38.89	98.30
PH (cm)	80.17	38.23 - 123.27	32.12	28.25	77.36	41.03	51.18
ID (cm)	5.31	3.60 - 8.16	22.08	16.34	54.73	1.32	24.90
PT (mm)	3.88	2.01- 6.19	23.78	20.30	72.86	1.39	35.70
LWT (mm)	2.41	1.45 - 4.28	33.37	29.96	80.63	1.33	55.42
NLPF	3.32	2.00 - 5.13	27.36	23.56	74.13	1.39	41.78
TSS (°B)	4.37	3.03 - 6.42	15.92	12.83	64.98	0.93	21.31
TSW (g)	2.80	1.84 - 3.54	15.28	13.36	76.39	0.67	24.05
LC (mg/100g)	5.34	1.25 - 13.26	42.00	40.21	91.69	4.23	79.32
HD (days)	27.11	16.33 - 45.00	21.98	18.46	70.57	8.66	31.95
YPP (g)	1117.57	261.25 - 2033.25	44.62	44.12	97.77	1004.37	89.87

*Abbreviations are given in Table 2.

respectively. The results are in line with Fehmida and Ahmad (2007), Ara *et al*. (2009), Kumar (2010), Kumar *et al*. (2012), Buckseth *et al*. (2012), Rahaman *et al*. (2012), Manna and Paul (2012), Kumar *et al*. (2013), Patel *et al*. (2013), Chadha and Bhusan (2013), Sidhva *et al*. (2014), Khapte and Jansirani (2014), Kumar (2014), Kumar *et al*. (2014) and Prajapati *et al.* (2015).

Among various parameters of variability, high coefficient of variation (phenotypic and genotypic) were found for number of fruits per plant, fruit yield per plant, average fruit weight and lycopene content. The differences between phenotypic and genotypic coefficient of variation were very less but phenotypic coefficient of variation were slightly higher than the genotypic coefficient of variation for all the traits studied. Further, high estimates of heritability and genetic gain were recorded for

number of fruits per plant, average fruit weight, fruit yield per plant, locular wall thickness and lycopene content, thereby suggesting that straight selection for these traits may bring worthwhile improvement in identifying superior genotypes in tomato.

Moderate heritability coupled with moderate genetic gain was observed for number of fruits per cluster, harvest duration, plant height, pericarp thickness and number of locules per fruit. Therefore, these characters also show some scope for improvement through selection. Moderate heritability with low genetic gain was recorded for days to first picking, total soluble solids and thousand seed weight which indicated that these characters are under the control of non-additive gene action, therefore, the improvement in these traits can be achieved by partitioning the genetic variance further and making selection for suitable types in segregating generations.

Conclusion

Thus, the evaluation of 56 genotypes of tomato indicated a wide range of variability for different yield and quality traits. From above study it can be concluded that number of fruits per plant, average fruit weight, fruit yield per plant, locular wall thickness and lycopene content followed by number of fruits per cluster, harvest duration, plant height, pericarp thickness and number of locules per fruit are the most important traits for which straight selection may bring worthwhile improvement in identifying superior genotypes of tomato.

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