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Genetic Variability, Heritability and Genetic Advance Studies for Yield and Quality Traits among Diverse Genotypes of Tomato (*Lycopersicon esculentum* Mill)

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A B S T R A C T

The present experiment 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 advance at Regional Research Station, Uchani, Karnal, CCS Haryana Agricultural University, Hisar, Haryana during autumn seasons of 2016 and 2017 involving 43 genotypes. The analysis of variance indicated significantly higher difference among the treatments for all the traits studied indicating presence of substantial amount of genetic variability among the materials studied. Analysis of coefficient of variation inferred that, the magnitude of phenotypic coefficient of variation (PCV) was slightly higher over genotypic coefficient of variation (GCV) for all the traits under study except specific gravity referring that they were much influenced by environmental factors. Further, the estimates of heritability and genetic advance were found higher for total fruit yield per plant, early fruit yield per plant, plant height, total number of fruits per plant and total soluble solids indicating scope of direct selection for improvement of these traits.

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is considered as one of the most popular and widely grown vegetable crops throughout the India and world. It is widely grown vegetable crop in the world next only to potato. It also has higher rank among forcing vegetables due to its remunerative price and round the year demand. In many countries it is considered as "Poor man's orange" because of its attractive appearance and nutritional value (Singh *et al.*, 2004). Tomato is considered as 'Protective food' in medicinal dictionary because of its some special nutritional value and antioxidant properties mainly due the pigment lycopene and different flavonoids (Septa *et al.*, 2013).

Present scenario about tomato production and productivity in India is far below than the world. There is need to develop varieties and hybrids superior than available for different agro-ecological conditions with specific end use.

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 and on the expected genetic gain for the character in a population (Golani, *et al.,* 2007). The total variability present in germplasm can be divided into heritable and non-heritable components through genetic parameters like phenotypic and genotypic coefficients of variation, heritability and genetic advance. The heritable portion of phenotypic variation is referred as heritability. It is an important index of characters transmission from parents to offspring (Falconer, 1981). The estimate of heritability helps in the selection of elite genotypes from diverse population. Genetic advance refers amount of improvement made over parents due to selection. Heritability and genetic advance are playing a crucial role in effective selection for a target trait. Estimation of genetic variability and heritability of various yield and quality traits will be helpful in formulating selection strategies for these traits in future breeding programme. Hence, the present study focuses on assessment of available genetic variability, heritability and genetic advance for yield and quality traits in among diverse genotypes of tomato.

Materials and Methods

The experiment was designed in randomized complete block design (RCBD) comprising of 43 genotypes (13 parents and 30 crosses) with three replications (Table 1). The seedlings were planted at spacing of 60 cm from row to row and 45 cm from plant to plant and all the recommended cultural practices and plant protection schedules were adopted for raising the crop successfully. Five plants from each replicated plots were selected randomly and the data was recorded on 13 characters, *viz.*, plant height, number of branches per plant, days to 50% flowering, days to first harvesting, early fruit yield per plant, number of locules per fruit, fruit size (polar and equatorial diameter), total number of fruits per plant, total fruit yield per plant, specific gravity, total soluble solids, ascorbic acid, acidity and the computed mean values of various characters were used for statistical analysis. The analysis of variance was calculated as per Gomez and Gomez (1983). Phenotypic and genotypic coefficient of variation was worked by the formula given by Burton and De Vane (1953). Heritability (broad sense) in per cent was estimated as per the formula given by Burton and De Vane (1953), Johnson *et al.,* (1955) and Hanson *et al.,* (1956). Genetic advance and genetic gain were calculated as per the formula suggested by Lush (1949) and Johnson *et al.,* (1955).

Results and Discussion

Mean performance and range

Analysis of variance showed a wide range of variability among all the 43 genotypes studies for 13 characters (Table 2). The combined mean performance of genotypes for various traits is presented in (Table 3 and 4). The value of plant height varied from 62.67 cm (DVRT-6) to 112.22 (PSH x PNR-7), while the number of branches per plant was recorded highest in P. Upma x PC (10.11) and lowest in DVRT-2 x PC (5.11). Among the parents DVRT-3 (40.0) recorded earliest for days to 50% flowering while DVRT-2 (58.0) most late variety and among crosses the combination DVRT-3 x H-86 (38.0) shown most earliness.

For days to 50% flowering, the parent S-7 (81.44) and cross PSH x PC (83.41) found most early. The parent Pusa Sadabahar (0.7 kg) followed by Punjab Upma (0.64 kg) and cross DVRT-5 x H-86 (0.73 kg) following PSH x PNR-7 (0.72 kg) recorded for highest early fruit yield/plant. Number of locules per fruit varied from 2.08 (DVRT-6) to 4.25 (NT-8 x PNR-7). The parent Punjab Chhuhara (6.63 cm) and cross combination A. Vikas x PC (5.55 cm) exhibited highest fruit polar diameter while maximum fruit equatorial diameter was found in DVRT-3 x PNR-7 (4.91 cm). Total number of fruits/plant was recorded maximum in DVRT-6 x PC (48.03) and minimum in DVRT-3 (19.22). Among the parents, the variety Punjab Chhuhara (1379 g) followed by S-7 (1340 g) and among crosses DVRT-3 x PNR-7 (2314 g) preceded by A. Vikas x PNR-7 (1918 g) recorded the fruit yield/plant. The Specific gravity of fruits recorded maximum value 1.18 g/cm^3 for Pusa Sadabahar and minimum value 0.95 g/cm^3 for A. Vikas x PC. Total Soluble Solids (TSS) content ranged from 3.18 ^{0}Brix (H-86) to 5.24 ^{0}Brix (PNR-7). Ascorbic acid content was found maximum 29.37 mg/100 g juice content (PSH x PC) and minimum 17.67 mg/100 g juice content (Arka Vikas). The genotypes DVRT-2 and DVRT-3 x H-86 recorded minimum (0.52 %) and maximum (0.89 %) acidity content among all the genotypes studied respectively.

Phenotypic and Genotypic Coefficient of Variation

Phenotypic coefficient of variation (PCV) was higher than the corresponding genotypic coefficient of variation (GCV) for all the morphological traits under study except specific gravity (Table 5). High phenotypic and genotypic coefficient of variation was recorded for total fruit yield per plant (29.71 % and 27.42 %), early fruit yield per plant (29.44 % and 26.58 %), total number of fruits per plant (22.7 % and 20.22 %) and plant height (20.01 % and 18.08 %). Moderate coefficient of variability at both phenotypic and genotypic level was observed for number of locules per fruit (18.23 % and 14.15 %), number of branches per plant (17.86 % and 14.14 %), Polar diameter (17.61 % and 14.56 %) and ascorbic acid content (15.92 % and 14.97 %). Acidity (14.08 % and 13.36 %), days to 50 % flowering (14.04 % and 13.24 %), total soluble solids (13.52 5 and 12.52 %) and equatorial diameter (11.75 % and 5.17 %) showed lower values for both phenotypic and genotypic coefficient of variability.

Table.1 List of genotypes studied including parents and crosses

Sr. No.	Parents	Sr. No.	Crosses	Sr. No.	Crosses	Sr. No.	Crosses
1.	Pusa Sadabahar	1.	PSH x PC	14.	DVRT-6 x PNR-7	27.	NT-8 x H-86
2.	Punjab Upma	2.	P. Upma x PC	15.	DVRT-2 x PNR-7	28.	DVRT-3 x H-86
3.	S-12	3.	S-12 x PC	16.	DVRT-5 x PNR-7	29.	S-7 x H-86
4.	DVRT-6	4.	DVRT-6 x PC	17.	NT-8 x PNR-7	30.	A.Vikas x H-86
5.	DVRT-2	5.	DVRT-2 x PC	18.	DVRT-3 x PNR-7		
6.	DVRT-5	6.	DVRT-5 x PC	19.	S-7 x PNR-7		
7.	NT-8	7.	NT-8 x PC	20.	A.Vikas x PNR-7		
8.	DVRT-3	8.	DVRT-3 x PC	21.	PSH x H-86		
9.	S-7	9.	S-7 x PC	22.	P. Upma x H-86		
10.	Arka Vikas	10.	A. Vikas x PC	23.	S-12 x H-86		
11.	Punjab Chhuhara	11.	PSH x PNR-7	24.	DVRT-6 x H-86		
12.	PNR-7	12.	P.Upma x PNR-7	25.	DVRT-2 x H-86		
13.	H-86	13.	S-12 x PNR-7	26.	DVRT-5 x H-86		

Table.2 Analysis of variance (Mean sum of squares) for different characters

Sr. No.	Characters	Mean Squares		
		Replication ($2^{\#}$)	Genotype ($42^{\#}$)	Error ($84^{\#}$)
1.	Plant height (cm)	100.12	647.32*	45.01
2.	Number of branches per plant	1.48	4.35*	0.72
3.	Days to 50% flowering	7.11	136.17*	5.44
4.	Days to first harvesting	16.34	56.85*	5.07
5.	Early fruit yield per plant (kg)	0.00	0.06*	0.00
6.	Number of locules per fruit	0.07	0.80*	0.14
7.	Fruit size (cm)			
a).	Polar diameter	0.16	1.17*	0.16
b).	Equatorial diameter	0.30	0.32*	0.19
8.	Total number of fruits per plant	2.08	131.84*	10.51
9.	Total fruit yield per plant (g)	75270.37	373538.43*	20431.53
10.	Specific gravity (g/cm^3)	0.00	0.01*	0.00
11.	Total soluble solids (^{0}Brix)	0.03	0.90*	0.05
12.	Ascorbic acid (mg/100g fruit juice)	9.49	35.90*	1.50
13.	Acidity (%)	0.00	0.03*	0.00

$^{\#}$degree of freedom, * significant at 5% level of significance

Table.3 Mean performance of parents

Parents / Crosses	Plant height (cm)	No. of branches per plant	Days to 50% flowering	Days to first harvesting	Early fruit yield/plant (kg)	No. of locules	Polar dia. (cm)	Equatorial dia. (cm)	Total no. of fruits/plant	Fruit yield/plant (g)	SG* (g/cm^3)	TSS (^{0}Brix)	Ascorbic acid mg/100gm juice)	Acidity (%)
Punjab Chhuhara	73.44	7.22	53.20	91.98	0.44	2.40	6.63	3.96	29.55	1379	0.97	4.30	24.47	0.60
PNR-7	107.56	8.67	52.30	90.44	0.43	2.82	3.47	4.18	26.69	567	1.03	5.48	21.18	0.70
H-86	66.67	7.00	51.30	85.44	0.49	4.07	3.74	4.30	19.47	1160	0.98	3.18	23.67	0.73
Pusa Sadabahar	70.56	7.67	45.33	83.33	0.70	3.53	3.22	4.13	32.65	1067	1.18	5.13	27.67	0.82
Punjab Upma	64.61	6.55	52.30	84.67	0.64	2.52	4.70	4.31	24.03	1207	0.98	3.84	25.67	0.78
S-12	65.56	6.67	48.10	84.44	0.49	3.84	3.42	4.02	31.72	953	1.03	4.42	27.27	0.77
DVRT-6	62.67	7.56	47.50	85.78	0.53	2.08	3.49	3.38	42.17	1153	1.02	4.48	21.87	0.74
DVRT-2	72.33	7.44	58.00	95.33	0.51	4.23	4.22	4.55	25.05	1082	1.04	4.08	20.00	0.52
DVRT-5	64.89	9.33	50.10	84.78	0.32	2.20	3.64	3.49	43.52	1037	1.05	4.42	20.82	0.83
NT-8	63.00	8.33	48.60	84.67	0.36	3.67	3.44	4.24	35.87	1308	1.03	3.89	19.67	0.76
DVRT-3	69.33	6.78	40.00	83.89	0.22	3.33	3.82	4.49	19.22	564	1.02	3.91	27.13	0.77
S-7	64.67	7.56	42.33	81.44	0.36	3.30	3.68	4.28	31.13	1340	1.09	5.24	23.53	0.80
Arka vikas	66.78	8.66	54.30	93.44	0.28	3.56	3.53	4.38	28.52	900	1.01	3.32	17.67	0.58

*Specific gravity

Table.4 Mean performance of crosses

Parents/Crosses	Plant height (cm)	No. of branches per plant	Days to 50% flowering	Days to first harvesting	Early fruit yield/plant (kg)	No. of locules	Polar dia. (cm)	Equatorial dia. (cm)	Total no. of fruits/plant	Fruit yield/plant (g)	SG (g/cm^3)	TSS (^{0}Brix)	Ascorbic acid (mg/100gm juice)	Acidity (%)
PSH x PC	77.89	8.78	43.33	83.41	0.61	2.39	5.11	3.98	44.82	1680	0.98	3.94	29.37	0.86
P. Upma x PC	71.44	10.11	55.67	92.83	0.46	2.56	4.66	4.04	32.94	1036	0.96	4.37	21.47	0.62
S-12 x PC	71.67	6.78	55.00	92.33	0.60	3.24	3.98	4.07	35.89	1174	1.03	4.62	28.57	0.66
DVRT-6 x PC	77.56	9.00	55.67	88.87	0.54	2.83	4.33	3.86	48.03	1910	1.01	3.70	21.43	0.63
DVRT-2 x PC	70.89	5.11	58.33	94.70	0.33	3.26	4.11	3.91	25.20	796	1.08	4.29	23.07	0.56
DVRT-5 x PC	67.22	7.00	46.33	93.44	0.40	2.92	3.96	4.04	25.83	1283	0.96	3.56	21.33	0.66
NT-8 x PC	68.67	8.78	44.00	85.20	0.49	3.53	3.67	4.20	29.93	1171	0.99	5.05	19.50	0.74
DVRT-3 x PC	66.22	8.00	46.00	85.56	0.65	3.43	4.33	4.40	26.07	1468	1.09	3.92	26.67	0.70
S-7 x PC	73.44	7.11	55.33	92.47	0.61	3.67	3.93	4.54	34.96	1677	0.97	3.73	23.60	0.62
A. Vikas x PC	85.11	8.55	60.00	94.75	0.47	2.79	5.55	4.27	30.20	932	0.95	4.83	18.40	0.55
PSH x PNR-7	112.22	8.11	47.33	84.67	0.72	3.09	3.96	3.99	41.41	1520	1.02	4.57	26.17	0.76
P. Upma x PNR-7	102.00	7.11	49.67	85.97	0.66	2.96	4.28	4.16	32.28	1021	0.98	4.56	18.03	0.71
S-12 x PNR-7	92.78	9.78	51.67	85.73	0.45	3.33	3.85	4.23	32.04	1154	0.98	3.50	27.90	0.61
DVRT-6 x PNR-7	108.89	8.22	58.00	93.41	0.44	3.47	3.17	3.98	34.34	914	1.14	4.69	22.03	0.58
DVRT-2 x PNR-7	105.78	8.89	58.33	94.88	0.33	3.40	3.87	4.23	22.10	978	1.03	4.35	18.33	0.60
DVRT-5 x PNR-7	97.56	7.33	62.67	95.33	0.38	2.76	4.66	4.46	26.13	1213	0.98	3.67	20.40	0.58
NT-8 x PNR-7	99.44	8.44	44.00	83.95	0.51	4.25	3.69	3.93	33.07	1441	1.05	4.93	18.67	0.78
DVRT-3 x PNR-7	94.56	7.78	44.00	84.91	0.71	3.62	4.15	4.91	37.96	2314	0.98	3.53	27.34	0.79
S-7 x PNR-7	105.67	9.56	52.00	87.34	0.65	2.99	3.51	4.17	32.10	1344	0.98	4.64	20.63	0.74
A. Vikas x PNR-7	91.78	9.78	62.00	96.38	0.68	3.36	3.73	4.71	30.03	1918	1.04	4.87	18.20	0.58
PSH x H-86	65.22	7.78	48.33	86.50	0.41	3.33	3.80	4.05	28.43	959	0.97	3.95	27.40	0.74
P. Upma x H-86	67.22	7.67	44.00	85.47	0.71	3.62	4.20	4.71	30.18	1402	0.98	3.97	20.90	0.78
S-12 x H-86	71.22	9.56	42.00	84.12	0.65	3.38	3.96	4.35	31.93	1314	1.03	4.40	27.07	0.82
DVRT-6 x H-86	77.89	8.22	42.00	85.88	0.39	2.87	3.89	4.44	36.04	1509	1.05	3.50	20.13	0.84
DVRT-2 x H-86	69.11	5.11	53.33	92.75	0.44	3.53	4.26	4.61	20.36	1358	1.08	3.93	18.23	0.59
DVRT-5 x H-86	75.11	7.11	42.00	84.34	0.73	4.02	3.65	4.28	42.46	1913	1.05	4.43	21.00	0.78
NT-8 x H-8 6	70.56	7.00	42.33	84.08	0.52	3.80	3.81	4.02	34.50	1306	1.04	4.87	21.07	0.83
DVRT-3 x H -86	73.78	6.22	38.00	84.16	0.64	3.56	4.04	4.58	28.23	1530	1.10	4.19	26.80	0.89
S-7 x H-86	74.11	5.45	50.67	85.92	0.52	3.44	3.64	4.19	29.89	1016	1.04	5.03	19.93	0.75
A. Vikas x H -86	76.44	7.00	48.00	85.53	0.27	3.20	3.71	4.39	26.87	918	0.98	4.12	20.10	0.65
Mean	78.35	7.78	49.85	88.04	0.50	3.27	4.00	4.20	31.45	1251	1.02	4.26	22.62	0.71
C.D.	10.91	1.37	3.79	3.67	0.11	0.62	0.64	0.7	5.28	232.42	0.05	0.35	1.90	0.04
CV (%)	8.57	10.92	4.84	2.56	2.94	11.63	9.91	10.3	10.3	11.43	3.05	5.11	5.40	3.62
SE (d)	5.48	0.69	1.90	1.84	0.05	0.31	0.32	0.35	2.65	116.71	0.02	0.18	1.0	0.021
SE(m) (+/-)	3.88	0.49	1.35	1.30	0.04	0.22	0.23	0.25	1.88	82.53	0.01	0.13	0.71	0.015

Table.5 Mean, Range, PCV, GCV, Heritability and Genetic advance of 13 morphological traits of 43 different tomato genotypes

Sr. No.	Characters	Mean	Range		PCV (%)	GCV (%)	Heritability h^2_{bs} (%)	Genetic advance (as % of mean)
			Min.	Max.				
1.	Plant height (cm)	78.35	62.67	112.22	20.01	18.08	81.69	16.94
2.	Number of branches per plant	7.78	6.55	10.11	17.86	14.14	62.69	2.48
3.	Days to 50% flowering	49.85	38.0	62.67	14.04	13.24	88.90	1.00
4.	Days to first harvesting	88.04	81.44	96.38	5.37	4.72	77.30	1.80
5.	Early fruit yield per plant (kg)	0.5	0.22	0.73	29.44	26.58	81.54	20.45
6.	Number of locules per fruit	3.27	2.08	4.25	18.23	14.15	60.22	3.10
7.	Fruit size (cm)							
a)	Polar diameter	4.0	3.22	6.63	17.61	14.56	68.35	2.80
b)	Equatorial diameter	4.2	3.38	4.91	11.75	5.17	19.40	2.17
8.	Total number of fruits per plant	31.45	19.22	48.03	22.70	20.22	79.37	7.04
9.	Total fruit yield per plant (g)	1251	564	2314	29.71	27.42	85.21	26.35
10.	Specific gravity (g/cm^3)	1.02	0.95	1.14	5.06	5.06	99.96	0.97
11.	Total soluble solids (^{0}Brix)	4.26	3.32	5.24	13.52	12.52	85.83	4.16
12.	Ascorbic acid (mg/100g fruit juice)	22.62	17.67	29.37	15.92	14.97	88.41	2.89
13.	Acidity (%)	0.71	0.52	0.86	14.08	13.36	90.00	2.77

A critical perusal of data showed that days to first harvesting had very less difference between PCV and GCV (5.37 % and 4.72 respectively) indicating that the variation present was mainly due to genotype. One of the 13 characters, specific gravity showed similar value for both PCV and GCV (5.06 and 5.06) indicating that the character was fully governed by the genotype.

Heritability and genetic advance

Higher value for heritability along with high genetic advance as per cent of mean was recorded for total fruit yield per plant (85.21 % and 26.35 % respectively), plant height (81.69 % and 16.94 % respectively) and early fruit yield per plant (81.54 % and 20.45 % respectively).

This indicated that selection for these traits may be highly effective as these traits are less influenced by environmental factors. Similarly, a joint consideration of heritability, GCV and genetic advance revealed high value for total fruit yield per plant, early fruit yield per plant and plant height.

Based upon the results recorded in this experiment of 43 genotypes of tomato, it could be concluded that total fruit yield per plant, early fruit yield per plant, total number of fruits per plant, days to first harvesting, ascorbic acid content, Total Soluble Solids (TSS) and plant height are the most important characters for which straight selection may bring worthwhile improvement in identifying superior genotypes of tomato.

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