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Genetic variability, heritability and genetic advance for yield and quality in tomato (*Solanum lycopersicum* L.) genotypes

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Abstract
An experiment was conducted for evaluation of genetic variability present in the thirty one genotypes and observations were recorded on various yield and yield contributing characters. Analysis of variance showed the significant variability for all the studied characters. High values of GCV and PCV were observed for characters viz., plant height (31.36, 31.64), number of branches (24.55, 25.22), number of clusters per plant (39.50, 39.87), number of fruits per plant (61.15, 63.90), yield per plant (35.52, 39.40), yield per plot (39.57, 41.52), average weight (64.59, 66.13), TSS (20.14, 20.66) and ascorbic acid (26.72, 27.04) which indicates the presence of high genetic variation. High heritability coupled with high genetic advance observed for the traits viz., plant height, number of fruits per plant and average fruit weight which indicates presence of additive gene action and demands for population improvement by selection.

Keywords: Genetic variability, heritability, genetic advance, tomato, GCV, PCV

Introduction
Tomato (*Solanum lycopersicum* L.) is one of the most important solanaceous vegetable crop having diploid chromosome number 2n = 2x = 24. It is herbaceous, annual to perennial, prostrate and sexually propagated crop plant with bisexual flowers. There are four to eight flowers in each compound inflorescence. Tomato is a typical day neutral plant and is mainly self-pollinated, but a certain per cent of cross-pollination also occurs. It is a warm season crop, reasonably resistant to heat and drought and grows under wide range of soil and climatic conditions. All the species of tomato are native to Western South America. Tomato is used as fresh vegetable and is also very important for processing purposes like soup, ketchups, sauces, concentrates, purees, juices etc. Unripe green fruits are used for preparation of pickles and chutney. Tomatoes are important source of lycopene (an antioxidant) and ascorbic acid and valued for their colour and flavour.

The effectiveness of selection in any crop improvement programme is primarily dependent on the variation present in the population. Information on genetic diversity among available genotypes is necessary for development of a promising variety. Heritability and genetic advance are important selection parameters. Heritability is the heritable portion of phenotypic variation. It is a good index of characters transmission from parents to their off spring. The estimates of heritability help in the selection of elite genotypes from diverse genetic population. Genetic advance measures the amount of progress that could be expected with selection in a character. However, the character showing high heritability needs not exhibit high genetic advance. High heritability coupled with high genetic advance indicates that the improvement could be made for a character by simple selection. Estimation of genetic variability and heritability of various yield attributing traits viz., per cent fruit set, yield per plant, and fruit weight in tomato will be helpful in formulating selection strategies for these traits in future tomato breeding programme. In view of above facts, present investigation was carried out among thirty-one promising genotypes to study the existing genetic variability, heritability and genetic advance for further utilization in genetic/varietal improvement programme.

Material and Methods
The experimental material consists of thirty one genotypes of tomato (Table 1) raised during rabi 2017-18 at SKLTSHU, College of Horticulture, Rajendranagar, Hyderabad.

The seeds were sown on a raised nursery bed and are transplanted after three weeks in main field at a spacing of 60 x 45cm following Randomized Block Design with three replications. Necessary prophylactic measures were taken to raise a healthy crop. Data relating to fourteen qualitative and quantitative traits *viz.*, plant height (cm), number of branches per plant, days to first flowering, days to 50% flowering, number of clusters per plant days to fruit set, days to first fruit harvest, number of fruits per plant, average fruit weight (g), fruit yield per plant (kg), fruit yield per plot (kg), total soluble solids (°Brix), ascorbic acid content (mg/100g of fruit) and lycopene (mg/100g of fruit). The data were analyzed as per methods suggested by Panse and Sukhatme (1967) [10] for analysis of variance, Burton and De Vane (1953) [2] for variability, Allard (1960) [1] for heritability (Broad Sense) and Johnson *et al.* (1955) [5] for genetic advance in per cent of mean.

Table 1: List of thirty one genotypes of tomato

S. No	Accession	Species	Source of Accession
1	EC-914109	*Solanum lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
2	EC-914089	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
3	EC-914088	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
4	EC-917090	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
5	EC-914099	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
6	EC-620378	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
7	EC-164334	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
8	EC-620389	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
9	EC-163605	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
10	EC-538153	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
11	EC-164563	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
12	EC-160885	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
13	EC-631356	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
14	EC-165690	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
15	EC-620395	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
16	EC-620427	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
17	EC-165700	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
18	EC-620406	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
19	EC-249514	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
20	EC-620376	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
21	EC-528368	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
22	EC-249504	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
23	EC-164670	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
24	EC-631374	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
25	EC-631364	*S. lycopersicum*	NBPGR, Research station, Rajendranagar, Hyderabad
26	ArkaVikas (C)	*S. lycopersicum*	IIHR, Banglore
27	ArkaRakshak (CH)	*S. lycopersicum*	IIHR, Banglore
28	Marutham (C)	*S. lycopersicum*	IARI, New Delhi
29	Laxmi (CH)	*S. lycopersicum*	Nunhems India Pvt.Ltd
30	Pusa Ruby (C)	*S. lycopersicum*	IARI, New Delhi
31	Hisar Lalit (C)	*S. lycopersicum*	HAU, Haryana

EC: Exotic collection; C: Check Variety; CH: check Hybrid

Results and Discussion

Analysis of variance

The results of analysis of variance for 31 genotypes in tomato are furnished in (Table 2). Highly significant differences among the genotypes were observed for all the characters indicating presence of sufficient amount of variability in all the characters studied. Wide range of variability was observed for plant height, number of clusters per plant, number of fruits per plant, average fruit weight and ascorbic acid indicating the scope for selection of suitable initial breeding material for further improvement.

Mean performances

The mean performance of 31 genotypes of tomato for fourteen characters had been presented in (Table 3). A very wide range of variations in mean performance of genotypes were observed for all the characters. The comparison of mean performance of thirty-one genotypes for fourteen traits using critical differences revealed existence of very high level of variability in the used genotypes. Eleven superior genotypes *viz.*, EC-620378 (2.44kg), EC-917090 (2.01kg), EC-631356 (1.92kg), EC-914109 (1.87kg), EC-62389 (1.85kg), EC-164334 (1.66kg), EC-914099 (1.64kg), EC-620395 (1.60kg), EC-249514 (1.56kg), EC-914089 (1.46kg), and EC-538156 (1.42kg) were superior for yield per plant. Only one genotype EC- 620378 (2.44 kg) produced significantly higher fruit yield per plant than the best check Arka Rakshak (2.10 kg).

Table 2: Analysis of variance for fourteen characters in tomato

S. No	Character	Source of variation		
		Replication	Treatment	Error
	Degrees of freedom (Df)	**2**	**30**	**60**
1	Plant height (cm)	48.94	30	16.57
2	Number of branches	0.41	2772.80**	0.50
3	Days to first flowering	0.68	27.72**	0.98
4	Days to 50% flowering	0.83	28.02**	3.63
5	No. of clusters per plant	1.14	26.74**	0.86
6	Days to first fruit set	10.07	138.53**	4.18
7	Days to first fruit harvest	1.42	34.95**	7.38
8	No. of fruits /plant	12.60	87.66**	30.48
9	Average fruit weight (gm)	21.60	102.36**	68.28
10	Yield per plant (kg)	0.03	4305.12**	0.005
11	Yield per plot (kg)	1.38	0.78**	5.01
12	TSS (°Brix)	0.01	154.18**	0.03
13	Vitamin-c (mg/100g)	0.73	2.01**	0.86
14	Lycopene (mg/100g)	0.01	133.61**	0.01

******significant at 1%

Table 3: Mean performances of 35 genotypes of tomato

S. No	Genotypes	Plant height (cm)	Number of branches	Days to first flowering	Days to 50% flowering	No. of clusters/ plant	Days to first fruit set	Days to first fruit harvest	No. of fruits /plant	Av. fruit weight (g)	Yield/ plant (kg)	Yield/ plot (kg)	TSS (°Brix)	Ascorbic acid (mg/ 100g)	Lycopene (mg/ 100g)
1	EC-914109	68.33	13.00	32.66	37.03	11.33	45.03	61.33	16.60	144.9	1.87	26.17	3.63	22.00	5.17
2	EC-914089	72.66	11.33	38.23	41.23	12.33	48.30	71.96	17.30	116.43	1.43	20.03	2.83	13.20	4.69
3	EC-914088	68.00	9.22	37.66	41.06	15.33	49.23	79.10	13.60	143.66	1.24	17.36	3.66	22.00	4.15
4	EC-917090	129.83	16.33	27.00	30.50	22.66	40.16	68.20	98.66	25.32	2.01	28.15	5.42	42.56	6.24
5	EC-914099	65.00	11.00	38.00	43.26	7.66	50.33	70.36	14.00	102.50	1.64	22.95	3.83	21.86	3.63
6	EC-620378	91.11	12.66	37.66	41.53	19.30	51.26	75.36	26.36	103.30	2.44	34.10	4.44	25.20	3.96
7	EC-164334	117.66	20.83	31.66	36.00	20.66	44.23	82.70	77.50	23.66	1.66	23.25	2.87	22.16	5.48
8	EC-620389	62.00	12.13	32.66	35.00	12.55	45.83	79.00	8.40	122.46	1.85	25.86	2.96	19.70	4.80
9	EC-163605	169.33	7.16	31.16	35.13	36.33	44.26	74.50	37.33	20.36	0.76	10.00	3.15	34.46	3.89
10	EC-538153	111.33	8.90	33.16	37.40	20.00	46.86	81.70	25.00	86.45	1.42	19.88	2.86	23.16	4.63
11	EC-164563	70.33	11.83	31.33	34.16	21.33	43.30	75.83	19.53	39.06	0.74	10.45	3.91	28.76	4.63
12	EC-160885	119.00	11.80	27.66	32.16	19.20	41.80	63.30	26.23	41.23	0.80	11.33	4.22	20.93	4.47
13	EC-631356	82.50	12.83	32.33	36.16	11.33	46.16	69.80	23.33	71.80	1.92	26.92	3.31	19.86	4.39
14	EC-165690	72.83	11.50	28.00	34.00	18.66	43.30	64.23	51.86	20.30	0.99	13.87	4.74	24.13	3.54
15	EC-620395	101.53	12.10	31.66	35.00	13.66	45.40	73.30	21.13	85.63	1.60	22.42	4.35	25.03	4.81
16	EC-620427	92.66	9.10	32.00	35.20	22.20	43.26	72.16	24.60	46.60	1.01	14.18	4.55	19.86	5.57
17	EC-165700	77.33	11.10	28.00	30.30	17.66	38.10	65.16	27.20	25.40	0.49	6.86	3.15	25.40	4.91
18	EC-620406	70.50	11.66	31.33	36.40	10.06	48.10	78.16	17.06	88.66	1.28	18.00	3.86	10.40	4.57
19	EC-249514	94.50	11.90	30.00	35.13	28.23	45.10	72.10	37.66	42.63	1.56	21.93	3.65	34.13	5.42
20	EC-620376	97.50	7.83	29.00	34.50	21.56	41.40	65.00	43.06	13.43	0.45	6.40	3.15	34.13	4.95
21	EC-528368	114.00	9.43	32.66	35.83	13.53	43.53	77.33	17.26	20.33	0.68	9.64	3.20	22.36	4.47
22	EC-249504	185.00	14.23	31.33	36.00	22.40	45.60	77.00	33.06	22.26	0.88	12.33	4.35	27.66	4.27
23	EC-164670	115.03	15.10	29.33	33.73	29.46	42.30	71.26	31.26	36.96	0.98	13.75	4.53	22.50	4.64
24	EC-631374	130.66	16.10	32.33	37.66	12.33	48.10	72.30	15.13	49.20	1.20	16.76	3.91	38.63	4.70
25	EC-631364	123.63	17.53	32.66	37.50	19.33	47.23	69.10	20.53	46.53	1.04	14.68	5.62	27.66	5.67
26	ArkaVikas	70.88	14.43	36.00	39.50	8.90	48.36	74.00	28.00	42.00	1.10	15.40	4.25	25.41	4.47
27	Arka Rakshak	99.00	13.16	29.30	35.00	16.00	44.26	79.00	40.33	47.96	2.13	29.82	5.25	25.76	4.55
28	Marutham	107.10	12.58	31.33	35.00	19.00	41.36	77.62	29.12	36.00	0.9	12.60	5.32	25.00	4.82
29	Laxmi	86.60	15.23	29.33	33.33	14.00	40.16	72.67	34.44	54.00	1.70	23.80	4.34	24.72	4.95
30	Pusa Ruby	65.20	11.10	28.96	34.03	8.50	39.30	70.95	25.24	41.50	0.85	11.90	4.35	17.90	4.71
31	Hisar Lalit	65.10	7.12	31.00	34.83	6.01	39.10	72.00	22.00	42.86	0.82	11.48	5.24	23.16	4.82
Gm		96.65	12.26	31.79	35.92	17.14	44.54	72.79	29.76	58.17	1.27	17.81	4.03	24.83	4.71
SEm±		2.35	0.41	0.57	1.10	0.53	1.18	1.56	3.18	4.77	0.13	1.29	0.10	0.53	0.05
CV (%)		4.21	5.79	3.11	2.30	5.40	4.59	3.73	18.55	14.20	18.32	12.57	4.58	3.74	2.10
CD (0.05)		6.64	1.16	1.16	3.11	1.51	3.34	4.43	9.01	13.49	0.38	3.65	0.30	1.51	0.16

Table 4: Estimates of range, grand mean, phenotypic coefficient of variation (PCV), genotypic coefficient of variation(GCV), heritability in broad sense, genetic advance (Ga) and Ga (in per cent of mean) for fourteen characters in tomato germplasm

S. No	Characters	Range		Mean	Variance		PCV (%)	GCV (%)	h2 (%)	Genetic Advance	GA as per cent of mean
		Minimum	Maximum		Phenotypic	Genotypic					
1	Plant height (cm)	62.00	185.00	96.65	935.31	918.74	31.64	31.36	98	61.88	64.02
2	Number of branches	7.12	20.83	12.26	9.57	9.07	25.22	24.55	94	6.03	49.22
3	Days to first flowering	27.00	38.23	31.79	9.99	9.01	9.94	9.44	90	5.87	18.47
4	Days to 50% flowering	30.30	43.26	35.92	11.34	7.70	9.37	7.27	67	4.71	13.11
5	No. of clusters per plant	6.01	36.33	17.14	46.75	45.89	39.87	39.50	98	13.82	80.62
6	Days to first fruit set	38.10	51.26	44.54	14.44	10.25	8.53	7.19	71	5.56	12.48
7	Days to first fruit harvest	61.33	82.70	72.79	34.14	26.76	8.02	7.10	78	9.43	12.96
8	No. of fruits /plant	8.40	98.60	32.06	361.77	331.29	63.90	61.15	91	35.88	120.55
9	Average fruit weight (g)	13.43	144.96	58.17	1480.56	1412.28	66.13	64.59	95	75.60	129.96
10	Yield per plant (kg)	0.45	2.44	1.37	0.29	0.24	39.40	35.52	81	0.91	72.63
11	Yield per plot (kg)	6.40	34.10	19.14	54.73	49.72	41.52	39.57	90	13.84	77.7
12	TSS (°Brix)	2.83	5.62	4.03	0.69	0.66	20.66	20.14	95	1.63	40.46
13	Vitamin-c (mg/100g)	10.40	42.56	24.83	45.11	44.24	27.04	26.78	98	13.57	54.65
14	Lycopene (mg/100g)	3.54	6.24	4.71	0.34	0.33	12.42	12.24	97	1.17	24.86

Coefficient of variation, Heritability (h^2_b) and Genetic advance

The genetic variability is the raw material in the plant breeding industry on which selection act to evolve superior genotypes. Thus, higher the amount of variation presents for a character in the breeding materials, greater the scope for its improvement through selection. The genotypic and phenotypic coefficients of variation were computed to assess the exiting variability in the germplasm (Table 4). High magnitude of phenotypic as well as genotypic coefficients of variation were observed in case of plant height, number of branches, number of fruits per plant, yield per plant, yield per plot, average weight, TSS and ascorbic acid. This indicates possibility of obtaining higher selection response in respect of above traits. The high estimates of PCV and GCV for these characters were also reported by Dar and Sharma (2011) and Rani and Anitha (2011) [3, 12]. Moderate variation was noted in case of lycopene. While, low GCV and PCV were observed for days to first flowering, days to 50 per cent flowering, days to first fruit set, days to first fruit harvest. Moderate and low variability for these traits in tomato were also reported by Sahanur *et al.* (2012) and Madhurina and Paul (2012) [14, 7].

Heritability estimates the information which helps the breeders for selecting the genotypes for further use. Higher magnitude of heritability suggests the measure of genotypic factors in the expression of the characters. The highest estimates of heritability were observed in case of plant height. High heritability and high genetic advance in per cent of means were observed for plant height, number of branches per plant, number of clusters per plant, number of fruits per plant, average fruit weight, yield per plant, yield per plot, TSS and lycopene. Similar findings are also reported by various workers such as Joshi and Singh (2003) [4], Singh *et al.* (2006) [15], Maurya *et al.* (2011) [9] and Tasisa *et al.* (2011) [16].

The degree of success in selection depends upon the magnitude of the heritability. Furthermore, the progress in the selection is also directly proportional to the amount of genetic advance. Therefore, the effect of selection is realized more quickly in those characters, which have high heritability as well as high genetic advance.

Perusal of data (Table 4) on heritability and genetic advance revealed that high heritability coupled with high genetic advance were recorded for all the traits (>20%) plant height, number of fruits per plant and average fruit weight. Thus, these traits which exhibited high heritability in broad sense and high expected genetic advance as per cent of mean may be considered to be largely governed by additive gene action and therefore, could be effectively improved through selection. High heritability along with high genetic advance have also been reported for most of the yield and yield attributing traits by Mahesha *et al.* (2006) [8], Kumari *et al.* (2007) [6], Saeed *et al.* (2007) [13], Prema *et al.* (2011) [11], Tasisa *et al.* (2011) [16], Madhurina and Paul (2012) [7] and Sahanur *et al.* (2012) [14].

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