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Study of genetic variability, heritability and genetic advance for yield and yield parameters in tomato (*Solanum lycopersicum* L.) germplasm

Kavya Eppakayala, Saidaiah Pidigam, Sivaraj Natarajan, Geetha Amarapalli and Ravinder Reddy Komatireddy

Abstract
Forty genotypes of tomato were evaluated for yield and various yield attributing characters at PG student research farm, College of Horticulture, Rajendranagar, Hyderabad during *Kharif*, 2017. The experiment was laid out in Randomized Complete Block Design with three replications. High PCV and GCV were recorded for fruit weight (g), fruit yield per plant (kg), yield per ha (t) and total soluble solids indicating the existence of wider genetic variability for these traits in the genotypes. Low estimates of genotypic and phenotypic coefficient of variations were observed for per cent fruit set, days to first harvest, days to last harvest and ascorbic acid content suggesting narrow range of genetic variability for these traits. High heritability coupled with high genetic advance as per cent of mean indicates operation of additive gene action, which was observed in characters *viz.*, plant height, days to first flowering, days to 50% flowering, number of flower clusters per plant, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, number of marketable fruits per plant, days to first harvest, days to last harvest, fruit length, fruit width, fruit weight, fruit yield per plant, fruit yield per ha, total soluble solids, ascorbic acid content, lycopene content and beta-carotene, which showed high level of genetic advance indicating opportunity for better selection response. The results of genetic parameters from the present study may be helpful to the plant breeder in selection of elite genotypes from diverse genetic populations.

Keywords: Genetic variability, heritability, genetic advance, tomato, *Solanum lycopersicum* L.

Introduction
Tomato (*Solanum lycopersicum* L.) is one of the world's largest grown vegetable crops after potato and sweet potato. It is also popular in India and occupies an area of 0.76 million hectares with a production of 22.34 million tonnes and productivity of 26.22 tonnes per hectare. In Telangana tomato cultivated in an area of 0.053 million hectares with a production of 1.08 million tonnes and productivity of 20.37 tonnes per hectare (NHB database, 2017-18). Tomato belongs to the family Solanaceae and is native of Andean region that includes parts of Colombia, Ecuador, Peru, Bolivia and Chile. All tomato wild relatives are native to this area (Rick, 1973) [21] (Taylor, 1986) [26]. It is a typical day neutral herbaceous annual plant and is mainly self-pollinated, but a certain percentage of cross-pollination also occurs. It is mostly considered as 'Protective food' based on its nutritive value and antioxidant properties due to the presence of lycopene and flavonoids (Sepat *et al*. 2013) [22]. Lycopene has important dietetic properties since it reduces the risk of several types of cancers and heart attacks.

Genetic variability is pre-requisite for initiating any crop improvement programme. The success of genetic improvement in any character depends on the nature of variability present in the gene pool for that character. The importance of genetic variability was perceived for the first time by Vavilov (1951) [27]. Earlier, Fisher (1918) [9] partitioned the continuous variation exhibited by quantitative traits into heritable and non-heritable components.

Heritability refers to the ratio of genotypic variance to the phenotypic variance or total variance. It is a good index of the transmission of characters from parents to offspring. Wright (1921) [29] reported that heritability comprised of additive and non-additive components. However, it is not necessary that a character showing high heritability will also exhibit high genetic advance Johnson *et al.* (1955) [10]. Thus, the estimates of these genetic parameters help the plant breeder in selection of elite genotypes from diverse genetic populations (Singh and Narayanam, 2009) [24]. Investigation on genetic variability was attempted by several investigators earlier (Ravali *et al*., 2017, Somraj *et al*., 2017, Naveen *et al*., 2018, Chandrashekhar *et al*., 2018, Rajashekar Reddy *et al*., 2019, Pidigam *et al.*, 2019, Srivastava *et al*., 2019, Anuradha *et al*., 2020) [30, 31, 36, 35, 37, 33, 8, 3].

Keeping the above in view, the present study was taken up to estimate various genetic variability parameters in tomato germplasm.

Materials and Methods

The experiment has been carried out at PG student research farm, College of Horticulture, Rajendranagar, Hyderabad during *Kharif*, 2017 with forty tomato genotypes consisting of thirty four exotic collections and six varieties *viz*., Pusa Ruby, Arka Vikas, Arka Meghali, Arka Alok, PKM-1, Marutham from India (Table 1). The experiment was laid out in a Randomized Block Design (RBD) with three replications. Each germplasm line was grown in a plot of 1.8 x 3.15 (5.67 Sq. meters) accommodating 21 plants, per plot and 7 plants per row with a spacing of 60 X 45 cm^2.

Analysis of variance was done by the method suggested by Panse and Sukhatme (1985) [17]. The genotypic and phenotypic coefficients of variation were calculated using the formulae of Burton and De Vane (1953) [7]. Heritability and genetic advance were calculated according to Allard (1960) [1] and genetic advance as per cent of mean was estimated using the method of Johnson *et al.* (1955) [10]. Genetic advance in per cent of mean was calculated by the formula of Comstock *et al.* (1952) [20].

Results and Discussions

Estimates of different statistical and genetic parameters like mean, genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), heritability, genetic advance as per cent mean are presented (Table 2). High PCV and GCV were recorded for plant height, days to first flowering, days to 50% flowering, number of flowers per cluster, number of fruits per plant, per cent fruit set, number of marketable fruits per plant, days to first harvest, days to last harvest and fruit weight indicating the existence of wider genetic variability for these traits in the genotypes under study. The PCV was higher than GCV for all the characters studied indicating 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 Mahesha *et al*. (2006) [14] for plant height, Suarma *et al*. (2009) [25] for number of primary branches per plant, Patel *et al.* (2013) [18] for days to 50% flowering, Kumar *et al.* (2010) [11] for days to first fruit harvest, Eswara Reddy *et al.* (2015) [8] for number of fruits per cluster, Vyas *et al.* (2011) [28], Ara *et al.* (2009) [2] and Singh (2009) [23] for number of fruits per plant, acidity and TSS, Ara *et al.* (2009) [2], Singh (2009) [23], Prema *et al.* (2011) [19] for fruit yield, Triveni *et al*., 2017 [39] in tomato, Rajasekhar Reddy *et al*., 2017, 2019 in cluster bean and Anuradha *et al*., 2020 [3] in tomato.

The heritability in broad sense ranged from 32 for per cent fruit set to 99.5 for fruit weight (g). Higher values of heritability (>60) has been observed for Plant height, days to first flowering, days to 50% flowering, number of flower clusters per plant, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, number of marketable fruits per plant, days to first harvest, days to last harvest, fruit length, fruit width, fruit weight, fruit yield per plant, fruit yield per ha, total soluble solids, ascorbic acid content, lycopene content and beta-carotene. Moderate values of heritability (30-60) have been observed for number of primary branches per plant and per cent fruit set. 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. Ravali *et al*., 2017, Somraj *et al*., 2017, Rajashekar Reddy *et al*., 2019, Pidigam *et al.*, 2019, Naveen *et al*., 2018, Chandrashekhar *et al*., 2018, Srivastava *et al*., 2019, Anuradha *et al*., 2020 [30, 31, 36, 35, 37, 33, 8, 3] in tomato also reported similar kind of results in vegetable crops.

Genetic advance as per cent mean (GAM) *i.e.*, genetic gain ranged from 3.84 to 96.98. High genetic gain (>20%) was observed for plant height, number of primary branches per plant, days to first flowering, days to 50% flowering, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, number of marketable fruits per plant, fruit length, fruit width, fruit weight, fruit yield per plant, fruit yield per ha, total soluble solids, lycopene content and beta-carotene. Moderate genetic gain (10-20%) was observed for number of flower clusters per plant, days to first harvest, days to last harvest and ascorbic acid content. Low genetic gain (<10%) was observed for per cent fruit set.

High heritability along with high genetic gain were noticed for plant height, fruit weight and fruit yield per ha 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 first flowering, days to 50% flowering, number of flower clusters per plant, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, number of marketable fruits per plant, days to first harvest, days to last harvest, fruit length, fruit width, fruit yield per plant, total soluble solids, ascorbic acid content, lycopene content and beta-carotene 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 Mohanty *et al.* (2002) [15] for plant height, Asati *et al.* (2008) [4] for number of primary branches per plant, Kumar *et al.* (2010) [11] for days to 50% flowering, Aysh- Al *et al.* (2012) [5] for number of flowers per cluster and number of fruits per cluster, Buckseth *et al.* (2012) [6] for number of fruits per plant and fruit yield, Kumari *et al.* (2007) [13] for acidity, ascorbic acid and TSS, Anuradha *et al*., 2020 [3] in tomato. The results of genetic parameters from the present study may be helpful to the plant breeder in selection of elite genotypes from diverse genetic populations. They should be given weight age in selection of new varieties or in crop improvement.

Table 1: List of genotypes used for evaluation along with their sources

S. No	EC No.	Source	S. No	EC No.	Source
1	EC-914085	NBPGR Regional station, Rajendranagar Hyd-30	21	EC-914105	NBPGR Regional station, Rajendranagar Hyd-30
2	EC-914086	NBPGR Regional station, Rajendranagar Hyd-30	22	EC-914106	NBPGR Regional station, Rajendranagar Hyd-30
3	EC-914087	NBPGR Regional station, Rajendranagar Hyd-30	23	EC-914107	NBPGR Regional station, Rajendranagar Hyd-30
4	EC-914088	NBPGR Regional station, Rajendranagar Hyd-30	24	EC-914108	NBPGR Regional station, Rajendranagar Hyd-30
5	EC-914089	NBPGR Regional station, Rajendranagar Hyd-30	25	EC-914109	NBPGR Regional station, Rajendranagar Hyd-30
6	EC-914090	NBPGR Regional station, Rajendranagar Hyd-30	26	EC-914110	NBPGR Regional station, Rajendranagar Hyd-30
7	EC-914091	NBPGR Regional station, Rajendranagar Hyd-30	27	EC-914111	NBPGR Regional station, Rajendranagar Hyd-30
8	EC-914092	NBPGR Regional station, Rajendranagar Hyd-30	28	EC-914112	NBPGR Regional station, Rajendranagar Hyd-30
9	EC-914093	NBPGR Regional station, Rajendranagar Hyd-30	29	EC-914113	NBPGR Regional station, Rajendranagar Hyd-30
10	EC-914094	NBPGR Regional station, Rajendranagar Hyd-30	30	EC-914114	NBPGR Regional station, Rajendranagar Hyd-30
11	EC-914095	NBPGR Regional station, Rajendranagar Hyd-30	31	EC-914115	NBPGR Regional station, Rajendranagar Hyd-30
12	EC-914096	NBPGR Regional station, Rajendranagar Hyd-30	32	Pusa Ruby©	IARI, New Delhi
13	EC-914097	NBPGR Regional station, Rajendranagar Hyd-30	33	AVTO-1219	WVC,Taiwan,China
14	EC-914098	NBPGR Regional station, Rajendranagar Hyd-30	34	AVTO-1314	WVC,Taiwan,China
15	EC-914099	NBPGR Regional station, Rajendranagar Hyd-30	35	LA-3667	UC, Davis,California,USA
16	EC-914100	NBPGR Regional station, Rajendranagar Hyd-30	36	Arka Vikas ©	IIHR, Bangaluru
17	EC-914101	NBPGR Regional station, Rajendranagar Hyd-30	37	Arka Meghali©	IIHR, Bangaluru
18	EC-914102	NBPGR Regional station, Rajendranagar Hyd-30	38	Arka Alok©	IIHR, Bangaluru
19	EC-914103	NBPGR Regional station, Rajendranagar Hyd-30	39	PKM-1©	Periyakulum,TNAU
20	EC-914104	NBPGR Regional station, Rajendranagar Hyd-30	40	Marutham©	TNAU, Tamilnadu

Table 2: Estimates of variability, heritability and genetic advance as percent of mean for twenty one characters in forty genotypes of tomato

S. No.	Character	Range		Mean	Variance		PCV (%)	GCV (%)	$h^2_{(bs)}$(%)	Genetic Advance	GA as per cent of mean
		Minimum	Maximum		Phenotypic	Genotypic					
1	Plant height (cm)	50.57	90.63	70.52	130.76	117.02	16.21	15.34	89.5	21.08	29.89
2	Number of primary branches per plant	3.56	7.10	5.17	0.89	0.81	18.31	17.46	91.0	1.77	34.32
3	Days to first flowering	29.20	49.30	35.13	25.32	21.29	14.32	13.13	84.1	8.71	24.80
4	Days to 50% flowering	28.07	52.73	37.30	26.24	22.32	13.73	12.66	85.1	8.97	24.06
5	Number of flower clusters per plant	4.56	6.63	5.93	0.27	0.17	9.02	7.24	64.4	0.68	11.97
6	Number of flowers per cluster	4.03	6.10	5.22	0.45	0.41	12.86	12.25	90.7	1.25	24.03
7	Number of fruits per cluster	4.00	6.66	4.98	0.45	0.35	13.06	11.53	77.9	1.08	20.97
8	Number of fruits per plant	18.53	40.40	28.77	29.36	26.03	18.83	17.73	88.7	9.89	34.40
9	Per cent fruit set	75.27	92.97	85.47	24.84	7.94	5.83	3.29	32.0	3.28	3.84
10	Number of marketable fruits per plant	19.03	37.07	26.11	24.49	20.90	18.95	17.51	85.4	8.70	33.33
11	Days to first harvest	61.43	79.17	70.54	25.80	21.72	7.20	6.60	84.2	8.80	12.48
12	Days to last harvest	104.20	149.10	117.24	103.69	97.08	8.68	8.40	93.6	19.64	16.75
13	Fruit length (cm)	3.30	7.16	4.90	0.72	0.66	17.38	16.55	90.7	1.59	32.47
14	Fruit width (cm)	3.53	7.46	5.22	0.92	0.84	18.44	17.62	91.3	1.81	34.70
15	Fruit weight (g)	53.83	307.77	117.50	3089.61	3074.84	47.30	47.19	99.5	113.95	96.98
16	Fruit yield/plant (kg)	2.00	7.00	3.21	1.28	1.22	35.15	34.44	96.0	2.23	69.51
17	Yield/ha (t)	27.07	111.10	51.17	323.86	310.54	35.16	34.43	95.9	35.54	69.46
18	Total soluble solids (ºBrix)	2.96	6.73	4.77	0.97	0.93	20.71	20.25	95.7	1.94	40.82
19	Ascorbic acid (mg/100g)	17.67	28.40	22.41	7.88	5.39	12.52	10.36	68.5	3.96	17.66
20	Lycopene content (mg/100g)	2.40	6.90	4.99	1.36	1.31	23.42	23.00	96.5	2.32	46.54
21	Beta-carotene (mg/100g)	1.10	2.63	1.71	0.14	0.13	22.00	21.32	93.9	0.72	42.58

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