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Studies on genetic variability, heritability and genetic advance in tomato (*Solanum lycopersicum* L.) genotypes

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Abstract
The present investigation was conducted to generate the information regarding genetic variability, heritability and genetic advance among 23 genotypes. The experiment was laid out during *kharif*, 2018 in the Randomized Block Design with three replications at P.G research farm, SKLTSHU, Rajendranagar. High analysis of variance (Mean sum of squares for genotype) was recorded for some characters *viz.*, average fruit weight (1236.44), plant height (776.81), number of fruits per plant (360.07), and days to last fruit harvest (208.24) indicated very wide range for these characters. The present study revealed that the phenotypic coefficient of variation was slightly higher than the genotypic coefficient of variation for all the traits. Further, high heritability along with high genetic advance as percent of mean was recorded for number of fruits per plant followed by average fruit weight, fruit yield per plant, number of primary branches per plant, TSS, beta-carotene content, lycopene content, ascorbic acid content, plant height, fruit length and fruit width. These traits are used for direct selection in crop improvement program.

Keywords: Tomato, GCV, PCV, heritability, genetic advance

Introduction
Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable among solanaceous group. It is native of Peru in South America (Rick, 1969) [18]. It is a good source of vitamins and minerals. Tomato is a typical day neutral plant and is mainly self-pollinated, but a certain percentage 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.
The genetic variability is the raw material of vegetable breeding industry on which selection acts to evolve superior genotypes. The higher amount of variation present for a character in the breeding materials, greater is the scope for its improvement through selection. Phenotypic and genotypic coefficients of variation are useful in detecting amounts of variability present in genotypes. Heritability and genetic advance help in determining the influence of environment in expression of characters and the extent to which improvement is possible after selection (Robinson *et al.*, 1949) [19]. Heritable variation can be effectively studied in conjunction with genetic advance. High heritability alone is not enough to make efficient selection in segregating generation and needs to be accompanied by a substantial amount of genetic advance (Johnson *et al.*, 1955) [7].

Material and Methods
The experimental materials for the present investigation comprised to twenty three germplasm of tomato (Table 1) was carried out during *kharif*, 2018 at P.G research farm, SKLTSHU, Rajendranagar, Hyderabad, Telangana. The experiment was conducted in the Randomized Block Design (RBD) with three replications at spacing of 60 x 45cm per replication. The observations were recorded on *viz.*, plant height (cm), number of primary branches per plant, days to first flowering, days to 50% flowering, days to first fruit harvest, days to last fruit harvest, number of fruits per plant, fruit length (cm), fruit width (cm), average fruit weight (g), fruit yield per plant (kg), ascorbic acid (mg/100g), total soluble solids (ºBrix), lycopene content (mg/100g) and beta-carotene (mg/100g). Phenotypic and genotypic coefficient of variation was estimated according to Burton and De Vane (1953) [4]. Heritability and genetic advance were calculated as per formula given by Allard (1960) [1] and Johnson *et al.*, (1955) respectively.

Table 1: List of twenty three genotypes and their sources

S. No	Genotypes	Source
1.	EC-615055	NBPGR, Hyderabad
2.	EC-620463	NBPGR, Hyderabad
3.	EC-620428	NBPGR, Hyderabad
4.	AVTO-1219	WVC, Taiwan, China
5.	EC-620378	NBPGR, Hyderabad
6.	EC-620382	NBPGR, Hyderabad
7.	EC-620389	NBPGR, Hyderabad
8.	EC-620395	NBPGR, Hyderabad
9.	EC-620406	NBPGR, Hyderabad
10.	EC-620427	NBPGR, Hyderabad
11.	EC-620394	NBPGR, Hyderabad
12.	EC-620422	NBPGR, Hyderabad
13.	EC-631369	NBPGR, Hyderabad
14.	EC-631379	NBPGR, Hyderabad
15.	EC-620503	NBPGR, Hyderabad
16.	AVTO-9803	WVC, Taiwan, China
17.	AVTO-9804	WVC, Taiwan, China
18.	AVTO-1002	WVC, Taiwan, China
19.	AVTO-0101	WVC, Taiwan, China
20.	Pusa Ruby	IARI, New Delhi
21.	PKM-1	Periyakulam, TNAU
22.	Pant bahar	GBPUAT, Uttarakhand
23.	Arka Vikas	IIHR, Bengaluru

Results and Discussion

Analysis of variance

The result on analysis of variances (ANOVA) using Randomized block design revealed that the genotypes exhibited highly significant differences for fifteen characters (Table 2). Very high variance (mean sum of squares for genotype) was recorded for some characters *viz*., average fruit weight (1236.44), plant height (776.81), number of fruits per plant (360.07) and days to last fruit harvest (208.24) indicated very wide range for these characters. This finding was in agreement with the some earlier reports of Singh *et al*., (2006) [23], Haydar *et al*., (2007) [5] and Meena *et al*., (2015) [12].

Table 2: RBD ANOVA for fifteen fruit yield and yield attributes in tomato

S. No.	Character	Mean sum of squares		
		Replications	Genotypes	Error
1	Plant height (cm)	0.01	776.81 ***	23.16
2	No. of primary branches per plant	0.00	3.97 ***	0.08
3	Days to first flowering	0.11	27.15 ***	2.94
4	Days to 50% flowering	0.05	22.64 ***	4.25
5	Days to first fruit harvest	0.77	25.62 ***	3.41
6	Days to last fruit harvest	0.00	208.24 ***	14.91
7	No. of fruits per plant	0.13	360.07 ***	2.36
8	Fruit length (cm)	0.00	1.35 ***	0.05
9	Fruit width (cm)	0.00	1.05 ***	0.06
10	Average fruit weight (g)	0.02	1236.44 ***	53.62
11	Fruit yield/plant (kg)	0.00	0.72 ***	0.01
12	Ascorbic acid content (mg/100g)	3.06	85.23 ***	1.46
13	TSS (0Brix)	0.00	2.29 ***	0.03
14	Lycopene content (mg/100g)	0.00	0.99 ***	0.02
15	Beta-carotene (mg/100g)	0.00	0.29 ***	0.00

Phenotypic and genotypic coefficient of variation

The phenotypic coefficient of variation was recorded from 4.45% to 38.48% for different characters. High PCV was observed for number of fruits per plant (38.48%) followed by average fruit weight (34.51%), fruit yield per plant (30.62%), moderate PCV was observed in number of primary branches per plant (20.89%), TSS (20.18%), beta-carotene content (20.08%), lycopene content (19.03%), ascorbic acid content (18.99%), plant height (18.12%), fruit length (15.59%) and fruit width (13.46%) (Table 3).

The genotypic coefficient of variation ranged from 3.68% to 38.11%. High GCV was observed for number of fruits per plant (38.11%) followed by average fruit weight (32.39%), moderate GCV was observed in fruit yield per plant (29.65%), number of primary branches per plant (20.28%), TSS (19.76%), beta-carotene content (19.50%), ascorbic acid content (18.51%), lycopene content (18.37%), plant height (17.34%), fruit length (14.71%) and fruit width (12.32%). These were in accordance with the findings of Mahesha *et al*., (2006) [11], Asati *et al*., (2008) [3], Hedau *et al*., (2008) [6], Singh (2009) [22], Shashikanth *et al*., (2010) [20], Kumar *et al*., (2013) [10], Prajapati *et al*., (2015) [14], Ullah *et al*., (2015) [24], Priyanka *et al*., (2017) [15] and Omkar *et al*., (2018) [13].

Table 3: Estimates of mean range, phenotypic and genotypic coefficients of variability, heritability, genetic advance as percent of mean

S. No	Characters	Range		Mean	PCV (%)	GCV (%)	h_2 (%)	GA as per cent of mean
		Max	Min					
1	Plant height (cm)	63.58	133.63	91.37	18.12	17.34	91.60	34.19
2	No. of primary branches per plant	4.03	8.13	5.61	20.89	20.28	94.20	40.55
3	Days to first flowering	29.30	42.33	34.05	9.74	8.34	73.30	14.71
4	Days to 50% flowering	32.66	44.50	38.20	8.43	6.47	59.00	10.25
5	Days to first fruit harvest	69.06	82.90	73.86	4.45	3.68	68.50	6.27
6	Days to last fruit harvest	109.06	136.56	122.32	7.28	6.56	81.20	12.18
7	No. of fruits per plant	14.46	58.43	28.65	38.48	38.11	98.10	77.74
8	Fruit length (cm)	3.12	5.34	4.47	15.59	14.71	89.10	28.60
9	Fruit width (cm)	3.47	5.94	4.67	13.46	12.32	83.70	23.23
10	Average fruit weight (g)	33.91	110.06	61.32	34.51	32.39	88.10	62.61
11	Fruit yield/plant (kg)	0.86	2.39	1.64	30.62	29.65	93.70	59.13
12	Ascorbic acid content (mg/100g)	19.37	36.24	28.54	18.99	18.51	95.00	37.17
13	TSS (0Brix)	3.20	7.46	4.39	20.18	19.76	95.80	39.84
14	Lycopene content (mg/100g)	2.26	3.98	3.10	19.03	18.37	93.20	36.54
15	Beta-carotene (mg/100g)	0.83	2.16	1.59	20.08	19.50	94.40	39.04

Heritability (h^2) and Genetic advance

The investigation revealed that the heritability estimates ranged from 59.00 to 98.10% for the different characters. High heritability was recorded for number of fruits per plant (98.10%) followed by TSS (95.80%), ascorbic acid content (95.00%), beta-carotene content (94.40%), number of primary branches per plant (94.20%), fruit yield per plant (93.70%), lycopene content (93.20%), plant height (91.60%), fruit length (89.10%) and average fruit weight (88.10%) (Table 3).

The genetic advance in percent of mean varies from 6.27% to 77.74% for different characters (Table 3). Highest genetic advance was observed for the number of fruits per plant (77.74%) followed by average fruit weight (62.61%), fruit yield per plant (59.13%), number of primary branches per plant (40.55%), TSS (39.84%), beta-carotene content (39.04%), ascorbic acid content (37.17%), lycopene content (36.54%), plant height (34.19%), fruit length (28.60%) and fruit width (23.23%). These were in accordance with the findings of Singh *et al.*, (2006) [23], Asati *et al.*, (2008) [3], Ara *et al.*, (2009) [2], Rahaman *et al.*, (2012) [16], Kumar *et al.*, (2013) [10], Reddy *et al.*, (2013) [17], Khapte and Jansirani (2014) [9], Prajapati *et al.*, (2015) [14], Kaushal *et al.*, (2017) [8] and Shyam *et al.*, (2018) [21].

Conclusion

Thus, it may be concluded that among twenty three genotypes a wide range of variation was observed. The characters like number of fruits per plant, average fruit weight, fruit yield per plant, number of primary branches per plant, TSS, beta-carotene content, ascorbic acid content, lycopene content and plant height are important traits for which selection based on the phenotypic performance could be very effective in improvement of tomato.

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