



E-ISSN: 2278-4136

P-ISSN: 2349-8234

JPP 2020; 9(1): 1683-1686

Received: 01-11-2019

Accepted: 03-12-2019

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## Studies on genetic variability, heritability and genetic advance for yield and quality traits in Tomato (*Solanum lycopersicum* L.)

**Sooraj Maurya, AK Singh, SK Rai, Udit Kumar and Om Prakash Kumawat**

**Abstract**

The genetic parameters were studied to elucidate the genetic variability, heritability and genetic advance in tomato (*Solanum lycopersicum* L.). Evaluation of thirty genotypes of tomato was done in randomized block design at vegetable research farm, RPCAU, Pusa, Samastipur, Bihar. The genotypes exhibited a wide range of variability for all the characters studied. Phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the characters studied. High heritability combined with high genetic advance was observed for the characters plant height, number of clusters per plant, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, fruit length, fruit weight, fruit yield per plant, ascorbic acid and TSS. High heritability combined with high genetic advance indicates that additive gene action plays a major role in governing these traits and these traits can be improved by simple selection.

**Keywords:** Genetic parameters, PCV, GCV, heritability and genetic advance

**Introduction**

Tomato is one of the most economically important vegetables in the world with a production of 168.96 million tonnes with a value of \$78.17 billion (FAOSTAT Database, 2017) [1]. In terms of human health, tomato fruit provide significant quantities of betacarotene, a provitamin-A carotenoid and ascorbic acid. Lycopene is the major carotenoid in tomato fruit, is a powerful anti-oxidant and is associated with reduced risk of certain cancers, heart diseases and age-related diseases (Heber and Lu, 2002) [4]. Depletion of genetic reserves is manifest in a reduction to extremely low levels of enzyme variability and consequent difficulties experienced by breeders in finding the genes essential for desired improvements. It is therefore no surprise that special measures were needed to increase the range of genetic variation (Rick, 1987) [13].

**Materials and Methods**

The experiment has been carried out at vegetable research farm, RPCAU, Pusa, Samastipur, Bihar with thirty genotypes including one check viz., Arka Meghali. The genotypes were grown in a randomized block design with three replicates during rabiseason of 2018-2019 keep distance of line to line distance 75cm and plant to plant distance 45cm. Observations were recorded on five randomly selected plants per treatment for yield and qualitative characters viz., plant height at maturity stage, primary branches per plant, number of days to 50% flowers initiation, days to 50% fruits initiation, number of flowers per cluster, number of fruits per cluster, number of locules per fruits, number of days to physiological maturity of fruits, polar diameter of fruits (cm), equilateral diameter of fruits (cm), plant height at maturity stage (cm), fruit weight (g), number of fruits per plant, total soluble solids (°Brix), ascorbic acid content (mg/100g) and fruit yield per plant (kg). The analysis of variance was done as suggested by Panse and Sukhatme (1985) [10]. The phenotypic and phenotypic coefficients of variation were worked out according to the Robinson *et al.*, (1949) [12]. Heritability in broad sense and expected genetic advance on the basis of percent of mean were worked out according to the method advocated by (Burton and Devane, 1953) [3] and Johnson *et al.*, (1955) [5] respectively.

**Results and Discussion**

The mean sum of squares in ANOVA revealed high variability among all the thirty genotypes. The variation due to genotypes was significant for all the characters under studied (Table 1).

The high variability observed might be attributed to their genetic makeup of germplasm lines and the different geographical regions from which they have originated. This result of present investigation is in accordance with Mahesha *et al.*, (2006)<sup>[9]</sup> recorded highly significant difference among the tomato genotypes with respect to all the characters under studied.

Mean performance for various genotypes has also showed good range of variability for various characters, studied in present investigation (Table 2). The range recorded for plant height (63.53-167.38), number of primary branches per plant (5.98-18.19), number of days to fifty percent flower initiation (35.73-75.45), number of flower per cluster (4.70-9.50), number of days to 50 percent fruit initiation (52.29-88.20), number of fruit per cluster (1.13-7.97), number of fruit per plant (12.97-144.72), average fruit weight (2.48-101.11g), number of days to fruit maturity at physiological stage (74.92-121.67), polar diameter of fruit (0.15-5.28 cm), equilateral diameter of fruit (0.15-4.89), number of locules per fruit (2.28-9.00), fruit yield per plant (0.35-1.75), TSS<sup>0</sup>Brix (3.47-6.93) and Ascorbic acid (18.93-37.79 mg/100g). The characters under investigation were analyzed for genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (broad sense) and genetic advance as percent of mean (Table 4). In the present study, magnitude of phenotypic variances has high values than genotypic variances for the all characters, which is an

indicator of additive effect of the environment on expression of traits. Low range of GCV and PCV reveals that these traits have low sensitivity to environmental effect and it is reducible. High values of GCV and PCV were observed for characters *viz.*, number of fruits per plant, number of locules per fruit, average fruit weight, fruit yield per plant, fruit yield per plot, plant height, number of fruit set per cluster, TSS<sup>0</sup>Brix. Moderate GCV and PCV were observed for traits *viz.*, number of flowers per cluster, Ascorbic acid. Low GCV and PCV were observed for traits *viz.*, days to first flowering, days to 50% flowering. The results are in accordance with the Ara *et al.* (2009)<sup>[2]</sup> for plant height, Joshi and Singh (2003) for number of primary branches per plant, Singh (2009)<sup>[14]</sup> for days to 50% flowering, kumar and Veeraragavathatham (2005)<sup>[7]</sup> for number of clusters per plant, Singh *et al.* (2017) for days to first fruit set, Ara *et al.* (2009)<sup>[2]</sup> for days to first fruit harvest, Kumari *et al.* (2007)<sup>[8]</sup> for number of fruits per cluster, Ara *et al.* (2009)<sup>[2]</sup> and Singh (2009)<sup>[14]</sup> for number of fruits per plant, acidity and TSS, Ara *et al.* (2009)<sup>[2]</sup>, Singh (2009)<sup>[14]</sup> and Prema *et al.* (2011)<sup>[11]</sup> for fruit yield. The heritability in broad sense ranged from 36.60 for days to last fruit harvest to 99.70 for number of fruits per cluster. Higher values of heritability (>60) has been observed for plant height, days to 50% flowering, number of clusters per plant, number of flowers per cluster, days to first fruit set, number of fruits per cluster, number of fruits per plant, fruit length, fruit weight, fruit yield and ascorbic acid.

**Table 1:** Analysis of Variance for fifteen characters of thirty genotypes in Tomato

Sl. No.	Characters	Mean Sum of Square		
		Replication	Treatment	Error
1.	Plant height at maturity(cm)	131.3951	2550.9931**	99.8115
2.	No. of primary branch per plant	0.9487	25.1339**	0.9770
3.	No. of days to 50% flower initiation	0.6060	140.0050**	3.2219
4.	No. of flowers per cluster	0.1496	3.6561**	0.7005
5.	No. of days to 50% fruit initiation	0.6152	180.7416**	3.3501
6.	No. of fruits per cluster	0.1095	5.8414**	0.1374
7.	No. of fruits per plant	11.8837	1577.7707**	13.0576
8.	Average fruit weight (g)	0.3800	1598.4879**	6.1792
9.	No. of days to fruit maturity at physiological stage	0.5575	303.2004**	7.6917
10.	Polar diameter of fruit (cm)	0.0853	3.3833**	0.0840
11.	Equilateral diameter of fruit (cm)	0.0503	3.1046**	0.0556
12.	No. of locules per fruit	0.0139	4.4287**	0.0264
13.	Total soluble solids ( <sup>0</sup> Brix)	0.0110	2.0274**	0.0257
14.	Ascorbic acid (mg/100g)	0.6678	89.5455**	0.2936
15.	Fruit yield per plant (Kg)	0.0045	0.3959**	0.0181

**Table 2:** Mean, range and coefficient of variation for fifteen characters in Tomato

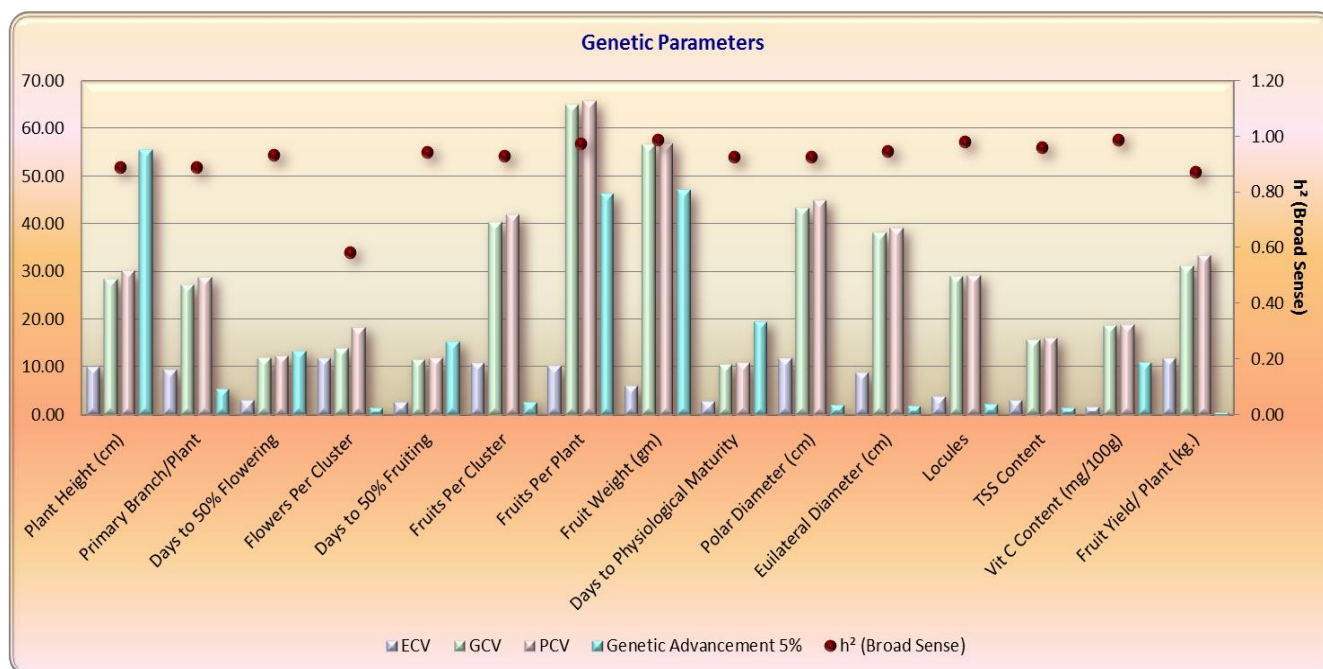
Sl. No.	Characters	Mean	Range		CV
			Minimum	Maximum	
1.	Plant height at maturity (cm)	99.77	63.53	167.38	10.01
2.	No. of primary branch per plant	10.39	5.98	18.19	9.51
3.	No. of days to 50% flower initiation	55.84	35.73	75.45	3.21
4.	No. of flowers per cluster	7.02	4.70	9.50	11.90
5.	No. of days to 50% fruit initiation	65.42	52.29	88.20	2.79
6.	No. of fruits per cluster	3.40	1.13	7.97	10.89
7.	No. of fruits per plant	35.15	12.97	144.72	10.28
8.	Average fruit weight (g)	40.64	2.48	101.11	6.11
9.	No. of days to fruit maturity at physiological stage	93.00	74.92	121.67	2.98
10.	Polar diameter of fruit (cm)	2.41	0.15	5.28	11.98
11.	Equilateral diameter of fruit (cm)	2.63	0.15	4.89	8.94
12.	No. of locules per fruit	4.16	2.28	9.00	3.90
13.	Total soluble solids ( <sup>0</sup> Brix)	5.14	3.47	6.93	3.12
14.	Ascorbic acid (mg/100g)	28.81	18.93	37.79	1.88
15.	Fruit yield per plant (Kg)	1.13	0.35	1.75	11.91

**Table 3:** Mean performance of thirty genotypes of tomato for fifteen characters

Characters Genotypes	PHM	PB/P	50%FL	FL/C	50%Fr	Fr/C	Fr/P	Av.Fr. W	Fr.M. Ph	PD	ED	Lo/Fr	TSS	AA	Y/P
Palam Pink	77.46	7.54	61.06	6.49	71.61	4.01	30.04	58.66	100.80	2.17	2.33	3.96	4.04	22.68	1.75
KashiSharad	106.63	11.03	49.46	7.13	58.23	2.99	32.90	51.70	86.49	2.78	2.70	3.96	6.35	35.94	1.69
KashiAmrit	66.29	8.37	53.67	5.45	68.00	2.70	22.45	74.58	101.08	3.42	3.68	2.93	5.95	29.61	1.67
ArkaMeghali	75.34	8.47	54.60	6.82	62.26	3.23	27.23	60.40	86.35	3.40	4.21	2.28	5.10	36.00	1.64
EC-257463	75.75	8.30	56.53	6.63	63.79	2.65	22.10	69.69	89.11	3.10	3.23	2.33	5.10	22.68	1.55
EC-257751	125.77	12.75	48.76	6.23	56.76	1.83	23.26	64.04	74.92	3.09	3.90	4.68	5.37	22.82	1.48
ArkaVikas	95.33	10.52	54.95	6.36	61.48	1.53	15.98	92.48	88.56	3.26	4.87	4.15	4.00	22.67	1.47
HisarLalit	127.73	13.49	55.05	6.80	65.18	4.24	56.82	25.50	92.48	2.18	2.64	4.34	6.24	30.87	1.44
KashiAman	73.99	10.02	59.38	5.87	67.82	2.73	27.27	48.97	97.62	2.95	3.36	5.12	4.12	23.94	1.33
Jawahar- 99	102.10	11.52	53.37	7.45	59.27	1.13	12.97	101.11	82.91	3.67	4.89	3.72	4.43	25.49	1.30
Hawai	92.75	8.81	55.59	6.48	62.50	3.83	33.54	38.55	90.20	2.74	2.76	2.46	4.36	26.79	1.29
Punjab Chhuhara	63.53	8.46	52.84	7.55	64.08	2.81	23.55	51.96	86.03	4.33	2.46	3.61	5.65	25.67	1.22
HisarAnmol	74.11	8.49	52.83	7.58	58.40	2.99	25.39	45.71	87.07	1.66	1.60	4.01	5.32	33.63	1.16
RT-1	114.07	11.63	56.85	4.70	65.02	2.97	34.54	33.45	88.93	2.79	3.06	4.16	4.44	26.72	1.15
EC-235484	94.25	8.37	55.35	6.53	62.49	3.16	26.69	41.93	87.55	0.98	3.29	9.00	5.89	24.02	1.13
ArkaSaurabh	81.11	7.87	52.82	6.48	63.41	3.62	28.48	38.31	92.31	2.12	2.19	4.33	3.47	29.45	1.09
EC-320574	152.35	15.90	52.62	7.57	60.94	2.63	41.78	25.66	82.28	1.70	2.28	3.83	4.48	26.74	1.07
SawarnaKanchan	79.39	8.55	62.11	7.62	75.37	3.61	31.03	32.55	106.09	5.28	2.56	4.76	4.40	35.89	1.01
EC-177516	150.34	14.62	58.57	5.44	72.43	2.18	31.92	30.22	109.42	3.16	2.16	4.05	5.80	37.59	0.96
EC-165952	82.40	8.17	52.15	7.72	60.42	4.58	37.48	25.70	85.96	1.73	2.43	3.86	5.19	26.97	0.96
EC-177343	124.26	12.58	58.42	7.41	70.51	4.50	56.43	16.67	102.09	1.46	1.96	4.06	5.17	18.93	0.94
EC-230571	78.43	7.56	56.07	7.90	63.17	6.21	46.35	19.65	88.02	2.18	1.50	4.54	4.55	26.86	0.91
EC-177393	121.09	11.88	63.41	5.48	71.16	2.13	25.29	35.35	94.42	2.06	2.47	3.93	5.54	36.25	0.89
PKM-1	64.66	5.98	55.70	8.46	63.62	5.35	31.81	27.67	93.78	1.33	1.82	3.14	4.97	37.51	0.88
EC-167860	111.50	11.01	48.79	7.25	59.09	3.21	34.98	24.73	81.54	1.70	2.28	4.97	5.34	22.53	0.86
EC-179038	138.12	13.44	75.45	6.68	88.20	2.83	37.97	21.44	121.67	2.50	2.58	4.37	6.93	25.70	0.80
EC-175957	125.74	12.63	53.44	7.43	62.63	2.22	27.99	24.50	93.95	1.85	1.81	3.62	4.41	30.63	0.67
EC-251578	87.04	8.97	69.31	9.38	86.17	4.28	38.54	17.05	113.56	1.51	2.60	5.77	5.82	31.10	0.65
PunjabUpma	64.10	6.48	60.28	8.39	66.54	3.86	24.91	18.63	93.36	1.18	1.21	3.76	6.13	30.85	0.46
EC-257580	167.38	18.19	35.73	9.50	52.29	7.97	144.72	2.48	91.45	0.15	0.15	5.02	5.63	37.79	0.35
C.D. 5%	16.32	1.61	2.93	1.36	2.99	0.60	5.90	4.06	4.53	0.47	0.38	0.26	0.26	0.88	0.22

**Table 4:** Genetic parameters of fifteen characters in Tomato

Sl. No.	Character	$\sigma^2_g$	$\sigma^2_p$	GCV (%)	PCV (%)	$h^2(b.s.)$ (%)	G.A as % Mean
1.	Plant height at maturity (cm)	817.06	916.87	28.65	30.43	89.11	55.71
2.	No. of primary branch per plant	8.05	9.02	27.31	28.92	89.18	53.12
3.	No. of days to 50% flower initiation	45.59	48.81	12.09	12.51	93.40	24.07
4.	No. of flowers per cluster	0.98	1.68	14.12	18.47	58.44	22.23
5.	No. of days to 50% fruit initiation	59.13	62.48	11.75	12.08	94.64	23.55
6.	No. of fruits per cluster	1.901	2.038	40.52	41.96	93.26	80.62
7.	No. of fruits per plant	521.57	534.62	64.97	65.77	97.56	132.19
8.	Average fruit weight (g)	530.76	536.94	56.67	57.00	98.85	116.08
9.	No. of days to fruit maturity at physiological stage	98.50	106.19	10.67	11.08	92.76	21.17
10.	Polar diameter of fruit (cm)	1.09	1.18	43.37	44.99	92.90	86.11
11.	Equilateral diameter of fruit (cm)	1.01	1.07	38.24	39.27	94.81	76.70
12.	No. of locules per fruit	1.46	1.49	29.11	29.37	98.23	59.44
13.	Total soluble solids ( $^{\circ}$ Brix)	0.66	0.69	15.88	16.18	96.28	32.10
14.	Ascorbic acid (mg/100g)	29.75	30.04	18.93	19.02	99.02	38.80
15.	Fruit yield per plant (Kg)	0.12	0.14	31.37	33.56	87.40	60.42



**Fig 1:** Histogram depicting estimates of GCV, PCV heritability (broad sense) and genetic advance as percent of mean for Fifteen traits in tomato

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