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Studies on genetic parameters for yield and yield attributing traits in tomato (*Solanum lycopersicum* L.)

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Abstract

59 genotypes of tomato including three checks were subjected to study the extent of variability present in the experimental material for yield and yield attributing traits at V.R.C., G.B.P.U.A. & T., Pantnagar, Uttarakhand, India for two consecutive years i.e. 2014 and 2015. Analysis of variance revealed the presence of high variability for all the 14 characters studied. Evaluation of 59 genotypes of tomato elucidated high magnitude of PCV as well as GCV for number of fruits/plant followed by average fruit weight (g), fruit yield (q/ha) and ascorbic acid (mg/100 g). The heritability coupled with genetic advance as per cent of mean were high for ascorbic acid (mg/100 g), number of fruits/plant, average fruit weight (g), fruit yield (q/ha), number of locules/fruit, pericarp thickness (mm) and number of fruits/cluster which suggests that these characters could be improved by selection.

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

Introduction

Tomato scientifically known as *Solanum lycopersicum* L. belongs to the nightshade family i.e. Solanaceae and is one of the most economically important and widely grown vegetable throughout the world due to its popularity as a fresh as well as processed crop. It is an important source of vitamin A, ascorbic acid and lycopene and its consumption prevents cancer and heart diseases due to the antioxidant properties of lycopene. A major portion of tomato is used to prepare processed products such as ketchup, paste, puree, juice and soup. The evaluation of new untested genetic material is necessary so that improvement can be made in the yield and quality of the existing varieties and for the development of high yielding varieties with good processing attributes. Efficient selection of genotypes is dependent not only on the nature and extent of genetic variability present in the available germplasm but also on the degree of transmissibility of desirable characters [1]. PCV and GCV helps to estimate the amount of variability present in the genotypes. The estimates of heritability and genetic advance helps to determine the effect of environment in the expression of characters [2]. Study at different regions and years may be beneficial for the precise estimation of genetic parameters and predict the progress of selection as the quantitative characters are mostly influenced by environment. Presence of high variability in the population offers enormous scope for improvement through selection. Therefore, in order to frame an effective breeding programme for the improvement of tomato, the present investigation was undertaken to study the genetic variability, heritability and genetic gain among the different genotypes of tomato.

Materials and Methods

The study was conducted at the Vegetable Research Centre of Govind Ballabh Pant University of Agriculture & Technology, Pantnagar during the year 2014 and 2015 (February to June). The experimental material comprised 59 genotypes of tomato including three checks, namely; PT 3, Arka Vikas and Roma which were evaluated in an Augmented Block Design-II. Seedlings were raised in the nursery and after thirty days these were transferred to the experimental plot at a spacing of 50 cm × 50 cm. Each block had eleven rows of different genotypes including three checks of 5 m length. There were ten plants per genotype. Recommended practices were followed to raise the crop. 5 plants were randomly selected and tagged in each genotype to record the observations on growth, yield and yield attributing characters and quality characters i.e. plant height (cm), number of primary branches/plant, days to 50% flowering, days to 1st fruit ripening, number of fruits/cluster, average fruit weight (g), number of fruits/plant, number of locules/fruit, equatorial fruit diameter (cm), polar fruit diameter (cm), pericarp thickness (mm), fruit yield (q/ha), T.S.S. (˚B) and ascorbic acid (mg/100 g). The means were calculated to compute the variance components and coefficient of variation by following the procedure suggested by Burton and De Vane [3]. Broad sense heritability and genetic gain were estimated according to the formulae given by Johnson *et al.* [4].

Results and Discussion

Mean Performance

Analysis of variance (ANOVA) for fourteen characters in Augmented Block Design-II (ABD-II) are presented in Table 1. These differences indicated variability in the germplasm and offer opportunity for improvement in yield and quality traits of tomato through selection. Most of the characters studied showed highly significant differences among check varieties except number of fruits/cluster, number of locules/fruit and equatorial fruit diameter during 2014 and days to first fruit ripening, polar fruit diameter and TSS during 2015 which showed non-significant differences.

Table 1: Analysis of variance (ANOVA) for different characters of tomato genotypes

S. N.	Characters	Mean sum of square								
		2014				2015				
		Total (20)	Block (6)	Check (2)	Error (12)	Total (20)	Block (6)	Check (2)	Error (12)	Total (20)
1	Plant height (cm)	212.55	145.40	1041.70**	107.94	229.46	72.11	1837.18**	40.18	170.12
2	No. of primary branches/plant	2.76	0.46	20.82**	0.90	1.67	0.35	12.04**	0.60	1.51
3	Days to 50% flowering	67.83	0.73	635.59**	6.75	4.16	3.32	15.75*	2.64	3.38
4	Days to 1st fruit ripening	97.95	1.61	953.89**	3.47	7.32	6.82	9.61	7.19	4.15
5	No. of fruits/cluster	10.12	1.27	37.62	9.97	0.51	0.08	3.99**	0.15	0.12
6	No. of locules/fruit	0.11	0.09	0.28	0.10	0.13	0.15	0.49**	0.07	0.07
7	Equatorial fruit diameter (cm)	0.10	0.05	0.21	0.11	0.10	0.01	0.59**	0.06	0.08
8	Polar fruit diameter (cm)	18.27	12.51	95.63**	8.26	0.04	0.04	0.06	0.05	0.05
9	Pericarp thickness (mm)	0.17	0.16	0.84**	0.06	0.43	0.18	3.30**	0.08	0.47
10	TSS (˚B)	0.13	0.12	0.69**	0.05	0.20	0.19	0.06	0.23	0.08
11	Ascorbic acid (mg/100 g)	17060.26	351.70	168596.80**	158.44	55.14	90.21**	277.26**	0.58	47.58
12	Average fruit weight (g)	0.76	1.27**	3.50**	0.05	11.85	4.21	79.53**	4.40	30.56
13	No. of fruits/plant	0.14	0.02	0.54*	0.13	44.82	14.11*	379.19**	4.45	6.17
14	Fruit yield (q/ha)	36.87	27.22**	285.86**	0.19	444.25	45.65	3556.17**	124.89	3173.44

*, **Significant at 5% and 1% level of probability, respectively; Degree of freedom are shown in parenthesis

The general mean, range of variation and per cent range of variation in different characters of tomato genotypes is presented in Table 2. A wide variation was observed in the expression of tomato genotypes for growth, yield and quality traits under different environmental conditions as reported by Manna and Paul [5] and Mohamed *et al.* [6] which indicates enormous opportunities for its improvement.

Table 2: General mean, range of variation and % range of variation for different characters of tomato genotypes

S. N.	Characters	First year (2014)				Second year (2015)			
		General mean	Range		% Range variation	General mean	Range		% Range variation
			Min	Max			Min	Max	
1	Plant height (cm)	109.71	57.31 (EC 519758)	162.11 (S 816)	100-282.87	85.17	46.20 (EC 519724)	124.14 (EC 519823)	100-268.70
2	No. of primary branches/plant	15.05	6.04 (CLN 2413)	24.06 (S816)	100-398.34	9.07	5.02 (EC 519724)	13.11 (NDT 1)	100-261.16
3	Days to 50% flowering	32.53	27.01 (AC 05-06)	38.04 (PT 11)	100-140.84	24.56	22.01 (PT 2009-08, S 108, Sel 06-01)	27.11 (EC 519724)	100-123.17
4	Days to 1st fruit ripening	72.60	65.10 (CLN 2237 A)	80.10 (Sel 03-05)	100-123.04	63.54	57.05 (PT 8)	70.02 (EC 519712)	100-122.73
5	No. of fruits/cluster	5.56	3.01 (EC 519769)	8.10 (CLN 2237 A)	100-269.10	6.12	2.73 (NDT 4)	9.50 (EC 519811)	100-347.99
6	No. of locules/fruit	4.51	2.01 (AC 05-06, Pant Selection-1)	7.01 (Marglobe)	100-348.76	4.02	2.01 (EC 519712)	6.02 (NDT 1)	100-299.50
7	Equatorial fruit diameter (cm)	4.15	2.60 (EC 519823)	5.70 (NDT 1)	100-219.23	3.90	1.90 (Pant Selection-1)	5.90 (NDT 1)	100-310.53
8	Polar fruit diameter (cm)	3.60	2.40 (EC 519778, EC 519821)	4.80 (EC 519800)	100-200.00	2.86	1.70 (Pant Selection-1)	4.01 (NDT 1)	100-235.88
9	Pericarp thickness (mm)	3.81	1.97 (EC 519770)	5.64 (NDT 3)	100-286.29	3.75	1.74 (EC 519770)	5.75 (EC 519758)	100-330.46
10	TSS (˚B)	5.10	3.10 (EC 519758)	7.10 (CLN 2870 A, PT 2009-02)	100-229.03	6.00	3.40 (NDT 1)	8.60 (EC 519772)	100-252.94

11	Ascorbic acid (mg/100 g)	43.57	13.15 (EC 519811)	73.98 (EC 519824)	100-562.59	43.48	13.04 (EC 519811)	73.91 (EC 519824)	100-566.79
12	Average fruit weight (g)	44.17	10.00 (EC 519712)	78.33 (NDT 4)	100-783.30	33.68	8.30 (EC 519712)	59.05 (NDT 4)	100-711.45
13	No. of fruits /plant	51.37	4.93 (Marglobe)	97.80 (CLN 2237 A)	100-1983.77	35.71	6.38 (Marglobe)	65.03 (EC 519713)	100-1019.28
14	Fruit yield (q/ha)	318.42	96.58 (Sel 03-05)	540.26 (PT 2009-10)	100-559.40	164.01	27.01 (EC 519712)	301.01 (CLN 2127 B)	100-1114.44

Parameters of Variability

Coefficient of variability

Variation at the phenotypic level is a combination of genetic as well as environmental variability, which alone does not help in effective selection. Higher genotypic coefficients of variability indicates more chances of improvement in that character. Hence, the decisive factors primarily rest on genetic variability and specifically the additive genetic variance is more important as it indicates the genetic gain through selection. Analysis of data revealed that coefficients of variability obtained in this study varied in magnitude from character to character (low, moderate, or high), which indicated a large amount of diversity (Table 3).

Table 3: Estimates of variability *i.e.*, coefficient of variability, heritability and genetic advance as % of mean for different characters (2014 & 2015)

S. N.	Characters	Year	PCV	GCV	ECV	h^2 (Broad sense) (%)	Genetic advance	Genetic advance as % of mean
1	Plant height (cm)	2014	19.72	17.07	9.88	74.9	32.03	30.45
		2015	16.09	14.26	7.47	78.5	22.08	26.01
2	No. of primary branches/plant	2014	24.17	22.96	7.55	90.2	5.65	44.93
		2015	19.17	17.08	8.70	79.4	2.78	31.36
3	Days to 50% flowering	2014	6.22	2.67	5.61	18.4	0.80	2.36
		2015	8.23	5.00	6.55	36.8	1.55	6.24
4	Days to 1st fruit ripening	2014	4.28	1.63	3.96	14.5	0.93	1.27
		2015	3.85	1.45	3.57	14.1	0.70	1.12
5	No. of fruits/cluster	2014	22.31	20.76	8.17	86.6	1.65	39.80
		2015	23.03	21.91	7.10	90.5	2.34	42.94
6	No. of locules/fruit	2014	31.17	30.24	7.55	94.1	1.91	60.45
		2015	25.98	24.73	7.97	90.6	1.58	48.49
7	Equatorial fruit diameter (cm)	2014	15.99	13.50	8.59	71.2	0.86	23.45
		2015	20.53	19.22	7.22	87.6	1.25	37.05
8	Polar fruit diameter (cm)	2014	16.51	15.04	6.80	83.0	0.90	28.24
		2015	14.97	12.73	7.87	72.3	0.60	22.30
9	Pericarp thickness (mm)	2014	23.22	22.37	6.24	92.8	1.54	44.38
		2015	26.37	25.03	8.29	90.1	1.65	48.95
10	TSS (˚B)	2014	17.79	15.69	8.40	77.7	1.24	28.48
		2015	16.08	14.11	7.59	77.5	1.60	25.59
11	Ascorbic acid (mg/100 g)	2014	31.04	30.95	2.40	99.4	24.60	63.57
		2015	31.12	31.06	1.97	99.6	24.66	63.86
12	Average fruit weight (g)	2014	46.87	46.06	8.68	96.6	27.90	93.24
		2015	45.61	44.79	8.57	96.5	22.17	90.63
13	No. of fruits/plant	2014	57.09	56.55	7.82	98.1	27.49	115.40
		2015	46.32	45.77	7.12	97.6	27.60	93.16
14	Fruit yield (q/ha)	2014	42.69	42.20	6.42	97.7	168.58	85.95
		2015	30.87	30.06	7.03	94.8	95.81	60.29

Phenotypic coefficient of variation was highest for number of fruits/plant (57.09%, 46.32%) followed by average fruit weight (46.87%, 45.61%), fruit yield (42.69%, 30.87%) and ascorbic acid (31.04%, 31.12%) whereas lowest estimate of PCV were recorded for days to first fruit ripening (4.28%, 3.85%) and days to 50% flowering (6.22%, 8.23%) during the years 2014 and 2015, respectively. Characters such as number of primary branches/plant (24.17%, 19.17%), pericarp thickness (23.22%, 26.37%), number of fruits/cluster (22.31%, 23.03%), plant height (19.72%, 16.09%) and TSS (17.79%, 16.08%) showed moderate values of PCV during 2014 and 2015, respectively.

High GCV in both the cropping seasons i.e. 2014 and 2015 was observed for number of fruits/plant (56.55%, 45.77%), average fruit weight (46.06%, 44.79%), fruit yield (42.20%, 30.06%) and ascorbic acid (30.95%, 31.06%). High GCV values for number of fruits/plant were also reported by Kumari and Sharma [7], Ullah *et al.* [8] and Zhou *et al.* [9]; for fruit yield by Ullah *et al.* [8] and Shashikanth *et al.* [10] and for average fruit weight by Kumari and Sharma [7], Zhou *et al.* [9] and Tiwari *et al.* [11] in different genotypes of tomato. Moderate GCV values in both the seasons were observed for number of locules/fruit (30.24%, 24.73%) and pericarp thickness (22.37%, 25.03%).

Low GCV values in both the cropping seasons were observed for polar fruit diameter (15.04%, 12.73%), TSS (15.69%, 14.11%) and days to 50% flowering (2.67%, 5.00%). Lowest estimate of GCV for days to 50% flowering was also obtained by Narolia *et al.* [12] and Patel *et al.* [13] in tomato genotypes. PCV was higher in magnitude than GCV for all the characters which indicated the influence of environmental factors on their expression to some degree. The characters which exhibited lesser differences in estimates of PCV and GCV, were less affected by environment and were therefore, stable.

Heritability and Genetic Advance

Heritability is the transmission of characters from parents to off springs, while genetic advance is the improvement over the base population. The estimation of heritability becomes necessary as genotypic coefficient of variation alone does not determine the heritable variations. Burton and De Vane[3] suggested that genetic coefficient of variability, along with the heritability estimates can provide a reliable indication of the expected degree of improvement through selection. The heritability estimates along with genetic advance as % of mean as presented in Table 3 were high during the year 2014 for ascorbic acid content (99.4%, 63.57%), number of fruits per plant (98.1%, 115.40%), fruit yield (97.7%, 85.95%), average fruit weight (96.6%, 93.24%), number of locules/fruit (94.1%, 60.45%) and pericarp thickness (92.8%, 44.38%) and during 2015 for ascorbic acid (99.6%, 63.86%), number of fruits/plant (97.6%, 93.16%), average fruit weight (96.5%, 90.63%), fruit yield (94.8%, 60.29%), number of locules/fruit (90.6%, 48.49%) and pericarp thickness (90.1%, 48.95%) which indicate that these characters are governed by additive gene effects and thus, are more reliable for effective selection [14]. These were the potential characters in terms of genetic advance which could respond to selection easily.

High heritability along with high genetic advance expressed as % of mean for number of fruits/plant was also reported by Kumari and Sharma [7], Ullah *et al.* [8], Buckseth *et al.* [15], Taiana *et al.* [16]; for fruit yield by Kaushik *et al.* [17]; for average fruit weight by Kumari and Sharma[7], Ullah *et al.* [8] Shashikanth *et al.* [10], Buckseth *et al.* [15] and for pericarp thickness by Buckseth *et al.* [15] in various genotypes of tomato studied under varied environmental conditions. Johnson *et al.* [4] suggested that high heritability with high genetic advance as % of mean provided better information and was more useful than heritability estimates alone during the selection of best individual genotype.

Conclusion

Significant genotypic differences were obtained in all the characters studied which suggested greater PCV and GCV among the tomato genotypes and sensitiveness of the characters for further improvement by selection. Thus, it may be concluded that the traits which exhibited high values of GCV, high heritability (broad sense) along with high genetic advance as % of mean portrayed that these traits are governed by additive gene action and their improvement could be achieved by simple selection. Therefore, more emphasis should be given for the selection of these traits.

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