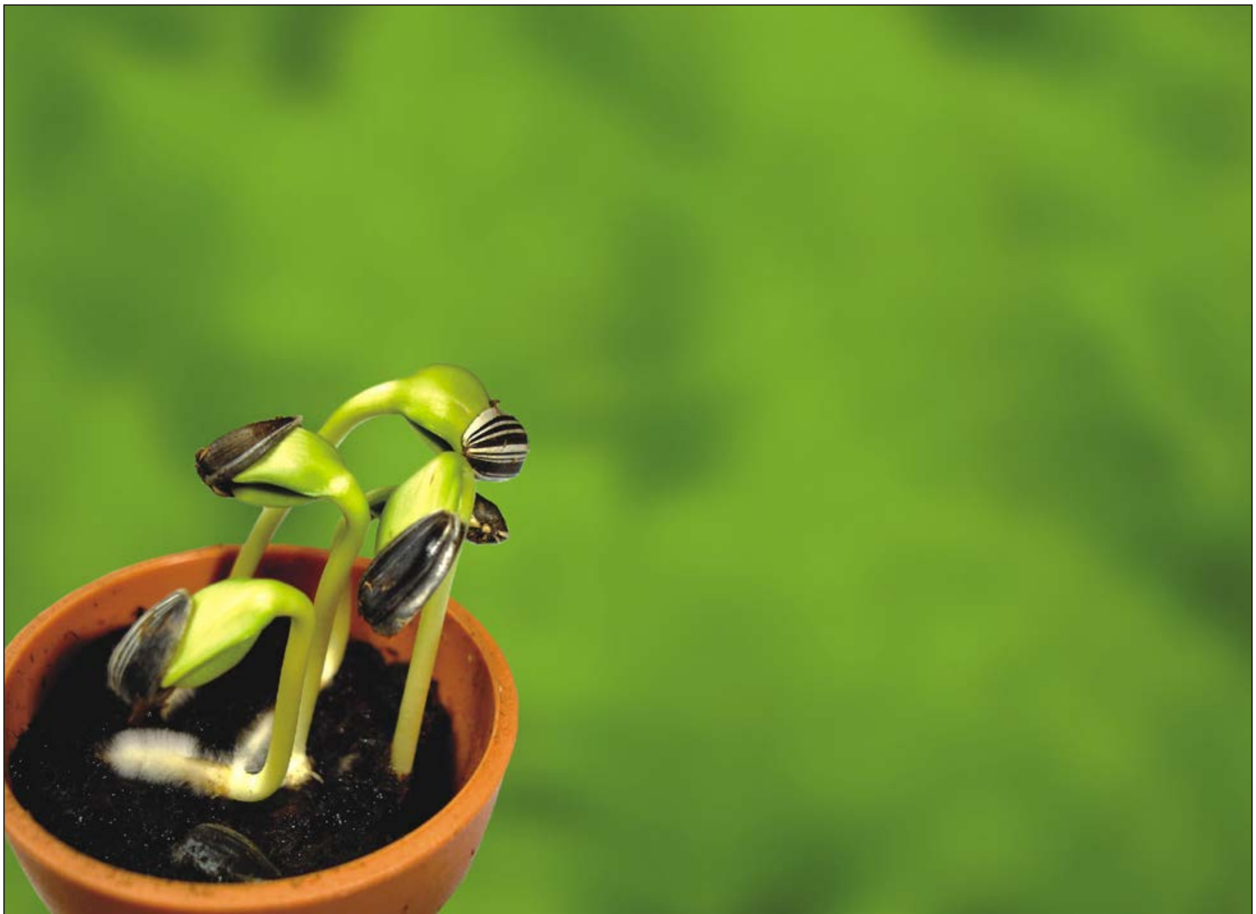

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Genetic Variability Studies of Yield and Quality Traits in Tomato (*Solanum lycopersicum* L.)

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ABSTRACT

The present study was aimed to investigate the yield and quality traits in tomato in order to generate information regarding the extent of genetic variability, heritability and genetic advance in *Solanum lycopersicum* L. The experiment was laid under Randomized Block Design with three replications to investigate the genetic variability among 60 genotypes. Analysis of coefficient of variation revealed that magnitude of phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the characters under study. The higher values of Phenotypic Coefficient of Variation (PCV) were recorded for yield quintals per hectare, average fruit weight, number of fruits per plant whereas high Genotypic Coefficients of Variation (GCV) was recorded with β-carotene. High heritability was recorded for the characters β-carotene, ascorbic acid and lycopene content inferring easy selection and improvement of these characters in breeding lines.

Key words: Genetic variability, heritability, genetic advance, yield and quality, tomato

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is the world's major traded vegetable. It is considered protective food as it possesses several special nutritive value traits particularly antioxidant compounds which are being used in several commercial therapeutical formulations. Tomato is protective supplementary food and used in preserved products like ketch-up, sauce, chutney, soup, paste, puree etc. The nutritional importance of the crop indicates there is need to formulate breeding programme and to develop cultivar rich in lycopene, β-carotene, processing traits with high quality of fruit as well as yield. Recent studies indicate that lycopene, the carotenoids that give the ripe tomato its bright red colour, is a very effective natural antioxidant and quencher of free radicals (Simon, 1992). Lycopene is especially efficient in neutralizing Reactive Oxygen Species (ROS). These properties of lycopene are due to its unique chemical structure: a very long chain of conjugated double bonds. Di Mascio *et al.* (1989) compared the free radical neutralizing properties of carotenoids at the University of Dusseldorf and found that lycopene is by far the most efficient biological singlet oxygen quencher. β-Carotene is an organic compound and classified as a terpenoid. It is a strongly-coloured red-orange pigment abundant in plants and fruits. As a carotene with beta-rings at both ends, it is the most common form of carotene. It is a precursor (inactive form) of Vitamin A (Van Arnum, 1998). The plant growth characteristics range from indeterminate to highly determinate type. The branches of indeterminate plants keep on growing and producing fruits until frost kills the plant. Tomato is well fitted in different cropping systems of cereals, grains, pulses and oilseeds. Numerous processed items are being prepared on large scale for consumption as well as for export purpose. Previously tomatoes were grown only in season-wise but the production scenario has been changed since few years. Nowadays tomatoes are grown round the year. Tomato is the most popular vegetable grown throughout the world with the production of 126.24 million tonnes. According to FAO (2007), the top producers of tomatoes in 2007 were China with a production of 33.64 million tonnes, followed by USA 11.5 million tonnes Turkey 9.91 million tonnes, India 8.85 million tonnes and Egypt 7.55 million tonnes. Genetic variability is essentially the first step of plant breeding for crop improvement which is immediately available from germplasm. Germplasm is considered as the reservoir of variability for different characters (Vavilov, 1951).

MATERIALS AND METHODS

The experimental material comprised of 60 diverse genotypes of tomato collected from various places including IIVR, Varanasi and some local cultivars were also used in an experiment. The observations were recorded on different yield and quality traits to generate information regarding the extent of genetic variability, heritability, genetic advance. The analysis of variance was calculated as per methodology suggested by Gomez and Gomez (1984). The estimation of lycopene was carried as described by Ranganna (1978), β-Carotene and ascorbic acid were estimated as per procedures given by Sadasivam and Theymoli (1987). The marketable fruits harvested from each plant taken randomly were counted at each harvest and averaged to obtain number of fruit per plant. Weight of five randomly selected fruits from each selected plant from each plot was taken on a pan balance. The average weight was calculated and statistical analysis was made. Total yield per plot was calculated and then it was converted to hectare. Genotypic parameters such as phenotypic coefficient of variation, genotypic coefficient of variation, heritability (broad sense), genetic advance was calculated following the procedure as described by Burton and devane (1953). Heritability (H) in broad sense was calculated for different characters according to the formula suggested by Hanson *et al.* (1956). Genetic advance was computed by the formula as suggested by Lush (1949).The experimental area is located in the sub-tropical zone of Jammu and Kashmir at 32°40'N latitude and 74°58'E longitude at an elevation of 332 m above mean sea level. The climate of Vegetable Research Farm at Chatha is sub-tropical with hot dry summer, hot humid rainy and cold winter months. The maximum temperature raises upto 45°C during summers (May to June) and minimum temperature falls to 1°C during winters. The mean annual rainfall is about 1000-1200 mm. The information on climatic conditions prevailed during the crop season was recorded at the meteorological observatory located at the University Research Farm, Chatha. Weekly data on the mean maximum and minimum atmospheric temperatures, relative humidity and rainfall are depicted in Fig. 1 and 2. For soil chemical analysis, composite soil samples were collected from the experimental site from 0-15 cm depth before sowing as per the procedure of random sampling (Peterson and Calvin, 1965). The collected samples were mixed thoroughly and representative samples were air dried, grounded and sieved on 2 mm sieve and stored in cloth bags for subsequent analysis.

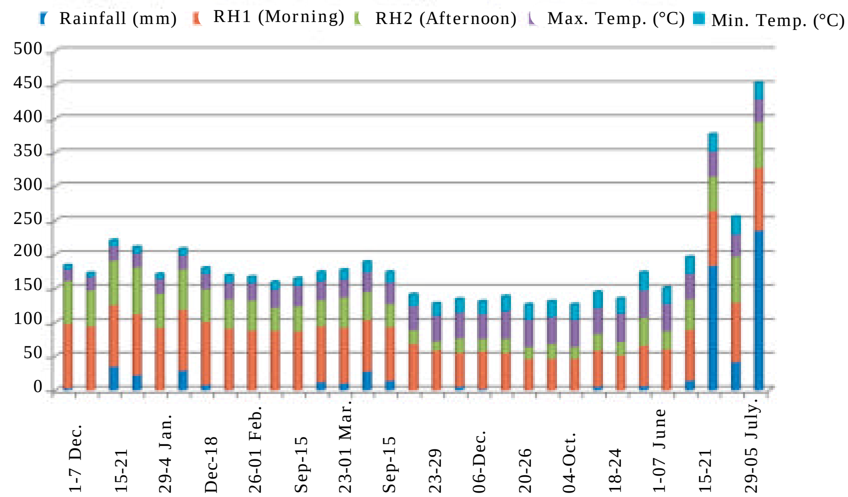

Fig. 1: Standard meteorological weekly data for the year 2007-08

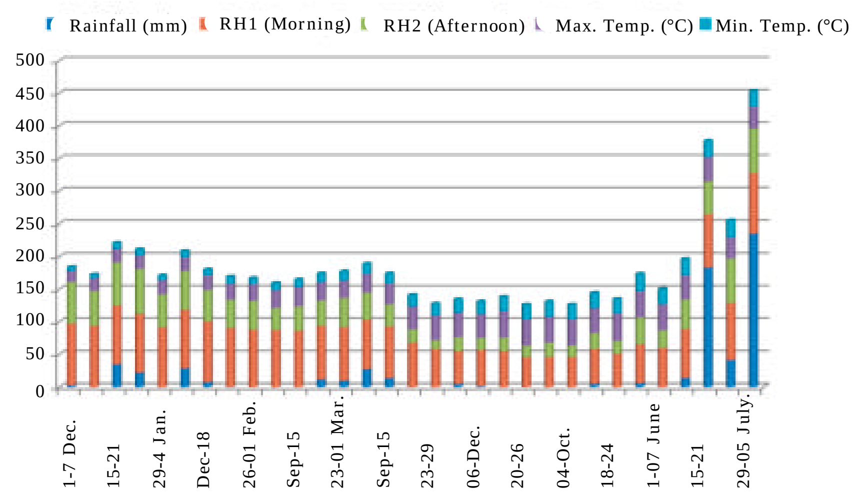

Fig. 2: Standard meteorological weekly data for the year 2008-09

RESULTS AND DISCUSSION

The analysis of variance indicated that there was highly significant difference among the genotypes for all the characters. The significant difference indicated existence of good deal of variability with respect to various traits. The mean values pooled over two years are presented in Table 1. The data pertaining to lycopene content revealed that EC-251581 (4.62 mg/100 g) was significantly higher over all other genotypes, while the genotype CGNT-5 (4.52 mg/100 g) was found at par. However, the minimum value of lycopene content was recorded with genotype CGNT-11 (1.95 mg/100 g) and the grand mean value of population was (3.08 mg/100 g). Findings

Table 1: Mean performance of different genotypes of tomato (*Lycopersicon esculentum* L.) for yield and quality traits

Genotypes	Lycopene (mg/100 g)	ß-carotene (mg/100 g)	Ascorbic acid (mg/100 g)	No. of fruits/plant	Average fruit weight (g)	Yield (q ha^{-1})
EC-164660	4.32	2.18	24.06	15.80	21.58	122.17
EC-363942	4.32	2.16	28.84	17.59	62.65	394.42
EC-538151	3.20	1.59	27.54	16.39	82.42	487.11
Pant T-7	3.13	1.51	31.19	19.17	55.60	381.59
EC-521056	2.61	1.19	25.49	14.25	70.89	361.48
EC-520059	3.55	1.90	21.53	19.55	57.09	403.26
JTP-02-05	3.90	1.90	33.41	13.34	57.52	277.84
EC-521086	3.27	1.66	23.53	18.87	78.25	525.82
EC-521067	4.23	2.08	25.76	24.35	31.89	278.00
EC-251581	4.62	2.52	29.78	12.87	77.10	357.42
EC-521059	3.60	2.24	29.55	17.78	48.82	313.09
EC-521044	2.89	1.38	25.78	12.42	72.87	325.49
EC-27995	3.23	1.60	28.92	14.40	47.34	243.78
EC-521041	2.98	1.51	32.05	20.72	39.59	295.97
EC-538151/3	3.46	1.22	27.04	21.75	59.14	465.06
EC-3526	2.60	1.30	22.04	15.90	57.47	328.46
EC-9046	2.52	1.57	19.77	14.25	77.57	398.77
DT-2	3.55	2.53	27.54	12.15	66.00	315.11
Punjab chhuhara	3.63	1.85	28.13	12.90	77.95	358.68
Pant T-8	3.11	1.48	21.04	11.50	65.57	274.26
CO-3	2.47	1.24	24.91	11.32	58.64	238.13
EC-521045	3.52	2.33	24.64	17.34	54.90	286.66
CTS-02	2.06	1.17	26.01	12.05	48.62	224.48
CTS-06-19	2.31	1.09	20.85	12.03	74.73	327.48
EC-521079	3.39	1.19	23.71	13.78	72.55	361.55
EC-35293	1.98	1.32	26.91	10.94	87.85	342.80
EC-5888	2.44	1.20	32.73	12.77	75.55	348.66
PAU-2371	2.49	1.26	29.11	12.18	75.84	330.97
PAU-2372	2.58	1.43	23.74	10.67	72.55	277.66
EC-3668	3.38	2.27	22.28	13.72	51.32	253.80
EC-529081	3.32	1.68	25.41	16.48	52.07	307.50
EC-2798	2.92	1.18	26.25	11.30	55.55	224.98
PAU-1374	2.08	1.95	27.87	13.90	56.64	284.08
EC-528374	2.86	1.53	22.57	15.70	51.82	291.64
NDT-9	3.18	1.59	26.74	18.72	48.22	325.97
EC-29914	3.33	1.68	29.37	14.27	56.65	292.48
Local-2707	3.01	1.52	25.68	14.39	65.70	342.40
VTG-85	3.15	1.44	25.13	12.64	63.05	284.33
VTG-86	3.15	1.66	30.43	12.83	56.53	260.97
VR-415	2.74	1.30	24.16	13.69	86.07	436.68
Pant T-10	2.92	1.53	20.67	17.42	50.70	318.83
EC-521054	2.51	2.33	24.63	11.52	51.30	212.27
EC-381213	2.61	1.38	29.16	12.22	50.50	221.75
KS-227	3.10	1.48	26.61	11.90	35.94	154.19
KS-229	2.55	1.32	22.73	14.60	50.47	265.66
CO-2	3.43	1.68	20.04	12.97	65.79	311.67
EC-52077	2.64	1.21	24.03	16.47	55.69	327.75
EC-135580	2.36	1.22	29.99	11.90	43.84	187.31

Table 1: Continue

EC-2517	2.53	1.30	28.28	14.22	57.27	293.04
Improved shalimar	3.32	1.73	28.78	24.79	59.10	556.76
CGNT-1	3.88	1.94	25.58	13.88	66.74	336.45
CGNT-2	3.70	2.37	31.86	15.74	38.95	219.86
CGNT-3	2.38	1.47	29.02	28.60	29.77	299.41
CGNT-5	4.52	2.55	34.53	24.92	35.39	315.06
CGNT-6	3.58	2.28	33.99	14.77	43.88	220.42
CGNT-10	2.51	1.22	36.53	16.38	47.67	280.71
CGNT-11	1.95	1.08	30.66	19.62	39.42	277.82
CGNT-12	3.30	1.64	26.44	18.17	32.48	213.67
CGNT-13	2.75	1.33	30.20	16.19	45.14	261.91
CGNT-14	3.22	1.71	37.80	14.45	50.25	260.79
C.D 5%	0.20	0.07	1.330	3.550	9.89	92.26
CV	4.07	2.53	3.050	14.23	10.73	18.52

of Adalid *et al.* (2008) and Cantore *et al.* (2008), who also found high variability for lycopene and β-carotene supports the results. The highest lycopene and β-carotene content were recorded in genotype UPVI7790 (7.37 mg/100 g) followed by UPV22487 (3.85 mg/100 g) and LA3538 (1.34 mg/100 g), UPV20525 (1.06mg/100 g). The pooled data analysis revealed that the genotypes CGNT-5 registered the maximum β- carotene (2.55 mg/100 g) followed by DT-2 (2.53 mg/100 g) and EC-251581 (2.52 mg/100 g). However, the genotype CGNT-11 registered the minimum β-carotene content (1.08 mg/100 g). The mean value of population was (1.64 mg/100 g), respectively. The finding of present investigation reveal that good nutritional quality genotypes are available for tomato breeding programmes as reported by Frusciante *et al.* (2007), who evaluated 18 genotypes of tomato and found six genotypes were high level of β-carotene. Maximum ascorbic acid content was observed in genotype CGNT-14 (37.80 mg/100 g) which was at par with CGNT-10 (36.53 mg/100 g). However, the genotype EC-9046 reported the minimum ascorbic acid content (19.77 mg/100 g). The grand mean value of the population for ascorbic acid content was recorded (27.04 mg/100 g). This variation in ascorbic acid may be due to varietal characteristics of the fruit. Similar variation for this trait were observed by Trivedi *et al.* (2003) and Adebooye *et al.* (2006) who evaluated 22 varieties of tomato to assess the qualitative character and found that cv. Casado had higher ascorbic acid content (16.72 mg/10 g) and lowest in cv. Mystro (7.18). The highest number of fruits per plant was observed in genotype CGNT-3 (28.60) which was followed by CGNT-5 (24.79), whereas the minimum number of fruits was recorded in PAU-2372 (10.67). However, the grand mean value of population was (15.45). Similar results were observed by Ashrufzzaman *et al.* (2010); Arshad and Audil (1999). The pooled data pertaining to average fruit weight showed that the maximum average fruit weight were observed in genotype EC-35293 (87.85 g) which was at par with VR-415 (86.07 g), EC-538151 (82.42 g) and EC-521086 (78.25 g), minimum average fruit weight was recorded in EC-164660 (21.58 g). However, the grand mean of population was 57.04 g respectively. Similar trend was reported by Zorzoli *et al.* (2000), Hussain *et al.* (2001) and Rehman *et al.* (2000) indicating greatest values for fruit weight and shelf-life with a fruit weight mean of 20.15 g and shelf period of 21.55 days. Considerable variability was observed for yield in quintals per hectare between the genotypes. The pooled data of mean values of genotypes revealed that Improved Shalimar registered the maximum yield (556.76 q ha^{-1}) which was at par with EC-521086 (525.82q ha^{-1}), EC-538151 (487.11 q ha^{-1}) and EC-538151/3 (465.06 q ha^{-1}) whereas the minimum fruit yield was recorded in EC-164660 (122.17 q ha^{-1}). The grand mean value of population was (308.10 q ha^{-1}), respectively. This suggested that these genotypes should be utilized for the improvement of yield and yield

Table 2: Estimate of range, mean, genotypic and phenotypic co-efficient of variation (GCV and PCV), heritability and genetic advance for different traits of tomato genotypes

				Coefficient of variation		Hertaibility %	Genetic advance %	
Characters	Range	Grand mean	SEM±	GCV	PCV	(H)	GA	GA % of mean
Lycopene	1.95-4.62	3.08	0.07	20.19	20.99	92	1.23	39.93
β-carotene	1.08-2.55	1.64	0.02	25.02	25.22	98	0.83	50.91
Ascorbic acid	19.77-37.80	27.04	0.48	15.21	15.72	94	8.19	30.28
No. of fruits per plant	10.67-28.60	15.45	1.27	24.52	29.15	70	6.59	42.65
Average fruit weight	21.58-87.85	57.04	3.53	24.96	28.01	80	26.20	45.93
Yield (q ha^{-1})	122.17-556.76	308.10	32.94	24.21	32.29	59	119.41	38.75

contributing traits in tomato. The yield results of present investigation of in accordance to those of Sharma *et al.* (2009) and Satesh *et al.* (2007), who have also reported variation in yield ranged from 125.40 to 414.33 q ha^{-1} and other workers have also found yield of tomato is associated with various yield attributing characters, such as number of fruit bunch per plant, average fruit weight, fruit per plant etc. The product of these components determine the fruit yield per plant, as well as yield per hectare.

The genotypic and phenotypic coefficient of variation of the characters are presented in Table 2. The data depicted in the table indicated that in general phenotypic coefficient of variability were higher in magnitude than the genotypic ones for most of the characters studied indicating the involvement of environmental factors in manifestation of yield traits under study. Similar observation were made in tomato by Singh (2005). The higher phenotypic coefficient of variation was recorded for yield in quintals per hectare (32.29%) which was significantly higher than all other characters. This was closely followed by number of fruits per plant (29.15%), average fruit weight (28.01%) and **β-** carotene (25.22%). Moderate phenotypic variability was recorded for lycopene (20.99) and ascorbic acid (15.72%). The higher amount of coefficient of genotypic variability was recorded for **β**-carotene (25.02%) whereas moderate genotype coefficient of variation was observed in average fruit weight (24.96%), number of fruits per plant (24.52), yield in quintals per hectare (24.21%) and lycopene (20.19%) and ascorbic acid (15.21). These results corroborate the views of Singh *et al.* (2002) and Ara *et al.* (2009). Very high heritability estimates were recorded for beta-carotene, ascorbic acid and lycopene indicating easy selection and improvement of these characters in breeding lines.

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