International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(6): 245-248

Received: 14-09-2018
Accepted: 15-10-2018

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Assessment of genetic variability in tomato (*Solanum lycopersicum* L.) Under polyhouse condition for fruit quality and biochemical traits

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Abstract
The present investigation was carried out at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, with the objective to assess the genetic variability for different fruit quality and biochemical traits in polyhouse grown tomato germplasm. The experimental material for the present study comprised 36 treatments (28 F_1s and 8 parents). The genotypes were studied for ten fruit quality and biochemical traits *viz*., number of locules per fruit, pericarp thickness (cm), diameter of stalk scar (cm), fruit firmness (kg/cm^2), TSS (%), pH of fruit juice, titratable acidity (%), ascorbic acid (mg/100g), lycopene (mg/100g) and total carotenoids (mg/100g). The analysis of variance revealed significant genetic differences among 36 tomato genotypes for all fruit quality and biochemical traits under study. The magnitudes of PCV estimates were higher than the corresponding GCV estimates for all the characters. Moderate to high GCV together with moderate to high heritability and genetic advance as percent of mean was reported for majority of the characters under study.

Keywords: Biochemical traits, GCV, genetic variability, genetic advance, heritability, PCV, quality, tomato

Introduction
Tomato (*Solanum lycopersicum* L.) is one of the most important Solanaceous vegetables. It is grown practically in every country of the world in outdoor fields, greenhouses and net houses. Its production has increased tremendously due to its multifarious uses like raw for salad, cooked as vegetable and processed in many forms as soup, sauces, ketchups, preserves, paste and puree (Tiwari and Choudhury 1986) [21]. Besides being tastier, tomato fruits are good source of vitamins, minerals and organic acids. Although, the vitamins only account for a small proportion of the total dry matter but they are highly significant from the nutritional point of view. There are various types of flavouring compounds found in the fruits, which enrich the taste. The total sugar content is 2.5 percent in ripe fruit and amount of ascorbic acid varies from 16-65mg/100g of fruit weight. Total amino acid is 100-350mg/100g. Tomato is also rich in medicinal values. The pulp and juice are digestible mid aperients, a promoter of gastric secretion and blood purifier. It is also considered to be intestinal antiseptic. It is said to be useful in cancer of the mouth, sore mouth, *etc*. Dried tomato juice retains vitamin C. It stimulates torpid liver and is good in chronic dyspepsia. It is one of the richest vegetables which keep our stomach and intestine in good condition. Tomato, a primary source of lycopene, showed significant association with low prostate cancer risk. Tomato juice has become an exceedingly popular appetizer and beverage.

Although yield and adaptability are the primary concerns of most tomato breeding programmes, there have been several instances of considerable effort to develop cultivars with improved fruit quality. Serious attempts have been made to increase fruit solids content and to alter fruit acid content. Intense effort has been applied for breeding cultivars with improved colour and there have been limited attempts to manipulate genetically the volatile compounds. These efforts have met with varying degree of success; many have had limited success because of the complex interactions between the various components of tomato fruits and between plant and fruit characteristics and fruit composition. The effort needed to screen for fruit composition has been a deterrent to progress on quality.

The efficiency of selection largely depends upon the magnitude of variability present in the breeding population. Hence, knowledge of variability present in the gene pool of a crop species is essential to start a judicious breeding programme. Selection is also effective when there is genetic variability among the individuals in population. Earlier variability used to be assessed by visual observation. Now biometrical methods are available for systematic assessment of genetic variability.

Material and method

The experiment was conducted at Vegetable Research Centre (V.R.C.) of Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand during the year 2017-2018 and biochemical analysis was conducted at Horticultural laboratory, Department of Horticulture, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand. This university is situated in the foot hills of Shivalik range of Himalayas in the narrow belt called '*Tarai*'. The experimental material for this study consists of 8 genotypes which were selected based on their diversity for various traits. From these 8 genotypes, 28 crosses were evolved in a half diallel mating design. The parents which were used in the study was PCT-1 (Cherry tomato), PPT-2 (Pant Polyhouse Tomato-2, as standard check), PBT-2, PBT-4 (Potato leaf type), PBT-5, PBT-9, PBT-10 and PBT-13. The genotypes were studied for ten fruit quality and biochemical traits *viz*., number of locules per fruit, pericarp thickness (cm), diameter of stalk scar (cm), fruit firmness (kg/cm^2), TSS (%), pH of fruit juice, titratable acidity (%), ascorbic acid (mg/100g), lycopene (mg/100g) and total carotenoids (mg/100g). Measurement of these traits were done by different instruments *i.e*., pericarp thickness by vernier calipers, diameter of stalk scar by scale, fruit firmness by hand held penetrometer, TSS by Erga hand refractometer, pH of fruit juice by digital pH meter and lycopene and total carotenoids by spectrophotometer.

The analysis of variance for design of experiment was done for partitioning the variance into treatments and replications according to procedure given by Panse and Sukhatme (1967) [14]. Genotypic and phenotypic coefficients of variance were estimated according to Burton and Devane (1953) [2] based on estimate of genotypic and phenotypic variance. The broad sense heritability (h^2bs) was estimated by following the procedure suggested by Weber and Moorthy (1952) [23]. Genetic advance as percent of mean was categorized as low, moderate and high as given by Johnson *et al.* (1955) [5].

Results and discussions

Mean data of ten fruit quality and biochemical traits were subjected to Analysis of variance (ANOVA) for Randomized Block Design (RBD) is presented in Table 1. The mean sum of square due to treatments was found highly significant for all fruit quality and biochemical traits under study at 1% and 5% level of significance, which indicated that considerable amount of variability were present in the genotypes. Hence, there is ample scope for selection of promising genotypes in breeding programme for fruit quality and biochemical traits. Similar results with respect to analysis of variance was also reported by Narolia *et al*. (2012) [13], Agarwal *et al*. (2014) [1], Singh *et al*. (2014) [20], Meena *et al*. (2015) [11], Prajapati *et al*. (2015) [16], Shokat *et al*. (2015) [18], Ullah *et al*. (2015) [22], Hasan *et al*. (2016) [4] and Kumar *et al.* (2017) [9].

Table 1: Analysis of variance for different fruit quality and biochemical traits in tomato

S. N.	Characters		Mean sum of squares		
			Replication	Genotype	Error
		df	2	35	70
1	Number of locules per fruit		0.028	1.505**	0.085
2	Pericarp thickness (cm)		0.031	0.110**	0.009
3	Diameter of stalk scar (cm)		0.045	0.403**	0.012
4	Fruit firmness (kg/cm^2)		0.200	1.112**	0.042
5	Total soluble solids (%)		0.146	2.053**	0.109
6	pH of fruit juice		0.016	0.103**	0.018
7	Titratable acidity (%)		0.0005	0.022**	0.001
8	Ascorbic acid (mg/100g)		4.455	24.184**	3.904
9	Lycopene (mg/100g)		0.922	10.655**	0.638
10	Total carotenoids (mg/100g)		0.305	31.571**	1.161

* Significant at 5% level of probability
** Significant at 1% level of probability

The read through data presented in Table 2 revealed that high GCV and PCV estimates were observed for many traits *viz.*, diameter of stalk scar (32.59 and 34.06%), number of locules per fruit (26.92 and 29.24%), titratable acidity (23.20 and 24.80%) and pericarp thickness (22.14 and 24.92%). Moderate GCV and PCV were observed in total carotenoids (18.65 and 19.69%), lycopene (17.43 and 19.02%), fruit firmness (13.16 and 13.91%) and TSS (12.99 and 14.04%). Moderate to high GCV and PCV for these traits clearly indicate ample scope for yield improvement in tomato through selection due to the presence of sufficient variability genotypes studied. The GCV and PCV were low for pH of fruit juice (3.68 and 4.70%) and ascorbic acid (8.88 and 11.16%). The results of the present investigation agreed with the finding of Dar *et al.* (2012) [3], Patil *et al*. (2013) [15], Kumar *et al*. (2015) [8], Singh *et al*. (2015) [19], Ullah *et al*. (2015) [22], Kumar *et al*. (2016) [7], Nalla *et al*. (2016) [12] and Kaushal *et al*. (2017) [6].

Table 2: Estimation of coefficient of variance and other genetic parameters for different fruit quality and biochemical traits in tomato

S.N.	Characters	Range	GM	GCV (%)	PCV (%)	ECV (%)	Heritability (%)	GA as % of mean
1	Number of locules per fruit	1.67-5.00	2.56	26.92	29.24	11.41	84.78	51.06
2	Pericarp thickness (cm)	0.35-1.21	0.83	22.14	24.92	11.45	78.91	40.51
3	Diameter of stalk scar (cm)	0.31-2.17	1.11	32.59	34.06	9.89	91.57	64.24
4	Fruit firmness (kg/cm^2)	3.62-5.81	4.54	13.16	13.91	4.51	89.46	25.63
5	Total soluble solids (%)	4.37-8.07	6.20	12.99	14.04	5.33	85.60	24.76
6	pH of fruit juice	4.25-4.91	4.58	3.68	4.70	2.93	61.15	5.93
7	Titratable acidity (%)	0.22-0.63	0.36	23.20	24.80	8.77	87.50	44.70
8	Ascorbic acid (mg/100g)	25.33-40.11	29.27	8.88	11.16	6.75	63.39	14.57
9	Lycopene (mg/100g)	6.93-15.04	10.49	17.43	19.02	7.62	83.96	32.89
10	Total carotenoids (mg/100g)	10.87-24.76	17.07	18.65	19.69	6.31	89.72	36.39

Broad sense heritability estimates ranged from 61.15 percent (pH of fruit juice) to 91.57 percent (diameter of stalk scar) (Table 2). Diameter of stalk scar recorded maximum heritability (91.57%) followed by total carotenoids (89.72%), fruit firmness (89.46%), titratable acidity (87.50%), TSS (85.60%), number of locules per fruit (84.78%), lycopene (83.96%) and pericarp thickness (78.91%). Ascorbic acid (63.39%) and pH of fruit juice (61.15%) exhibited moderate level of heritability. The heritability estimates for these traits indicate that these characters are least influenced by the environment. However, low heritability (<50%) was not observed for any character.

High estimates of genetic advance as percentage of mean (>20%) was observed for most of the characters under study *viz.*, diameter if stalk scar (64.24%), number of locules per fruit (51.06%), titratable acidity (44.70%), pericarp thickness (40.51%), total carotenoids (36.39%), lycopene (32.89%), fruit firmness (25.63%) and TSS (24.76%). High estimates of genetic advance as percentage of mean indicated that the preponderance of additive genetic effects in expression of these characters. Therefore, selection for these characters in segregating generations based on phenotypic performance would likely be more effective. Moderate level of genetic advance as percentage of mean (10-20%) were observed only for ascorbic acid (14.57%) and low level was also observed for single character pH of fruit juice (5.93%).

High heritability does not always mean high genetic advance. For yield improvement, selection of superior parents possessing better heritability and genetic advance for yield contributing traits is an essential prerequisite. Heritability in conjunction with genetic advance determines the best picture of the amount of progress to be expected from selection and also the selection method to improve a character (Johnson *et al.* 1955) [5].

The traits under study were categorized into three different groups as per the analysis: First group included majority of the characters under study showed high estimates of broad sense heritability and high estimates of genetic advance as percentage of mean *viz.*, number of locules per fruit, pericarp thickness, diameter of stalk scar, TSS, titratable acidity, fruit firmness, lycopene and total carotenoids. The second group of traits included single character ascorbic acid, which had medium heritability estimates coupled with moderate genetic advance as percent of mean. The third group included pH of fruit juice which had moderate heritability coupled with low genetic advance. For different quality traits, similar results were also observed by various researchers like Dar *et al*. (2012) [3], Patil *et al*. (2013) [15], Singh *et al*. (2014) [20], Kumar *et al*. (2015) [8], Singh *et al*. (2015) [19], Nalla *et al.* (2016) [12], Rai *et al.* (2016) [17], Kaushal *et al.* (2017) [6] and Lekshmi and Celine (2017) [10].

Conclusion

Thus, based on the findings of present investigation, it can be concluded that sufficient quantum of genetic variability for different fruit quality and biochemical traits was generated involving diverse genotypes of tomato, which indicates the existence of considerable scope for the improvement of these genotypes for these traits through selection and hybridization. Furthermore, moderate to high GCV together with moderate to high heritability and genetic advance as percent of mean was reported for all characters under study which indicated predominant additive gene action thus these fruit quality and biochemical traits has ample scope for the improvement of concerned traits through selection.

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