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RESEARCH PAPER

Genetic variability studies in tomato (*Solanum lycopersicum* L.) for yield and quality traits

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Abstract: A study was carried out to investigate yield and quality traits in tomato, in order to generate information regarding the extent of genetic variability, heritability and genetic gain. The experiment was laid out during kharif 2018 in Randomized Complete Block Design (RCBD) with three replications. Analysis of variance revealed that, the magnitude of phenotypic coefficient of variation was slightly higher than the genotypic coefficient of variation for all the traits under study. Further, high estimates of heritability and genetic gain were recorded for lycopene content, days to 1st harvest, pericarp thickness, number of clusters per plant, number of fruits per plant, titrable acidity, yield per plant, number of locules per fruit, average fruit weight, days to 50% flowering, TSS, number of primary branches, shelf life, equatorial length of fruit, polar length of fruit, number of fruits per cluster, pH and plant height. This suggests that simple selection is sufficient for the improvement of these traits. may bring worthwhile improvement in identifying superior genotypes in tomato.

Key words: Genetic gain, Heritability, Lycopene, Variability

Introduction

Tomato (*Solanum lycopersicum* L.) belongs to family Solanaceae. It is one of most popular and nutritious vegetable, widely grown around the world and ranked second in production after potato. Globally, it is grown in an area of 5.02 million hectares with the production of 170.75 million tonnes and productivity of 33.99 tonnes per hectare (FAO, 2020). China, India and USA are the major tomato producing countries. In India, it is grown in an area of about 0.88 million hectares with production of 18.74 million tonnes and the average productivity is about 21.24 tonnes per hectare. The important tomato growing states are Andhra Pradesh, Karnataka and Madhya Pradesh. In Karnataka, tomato is grown on an area about 0.06 million hectares with production of about 2.13 million tonnes with the productivity of about 31.54 tonnes per hectare (Anon., 2019).

The fruits are eaten raw or cooked, large quantities of tomato are used to produce soup, juice, ketchup, puree, paste and powder. It is a rich source of vitamins, minerals, organic acids, sugars, ascorbic acids and lycopene. Nutritive value varies in different cultivars depending upon the agro-climatic condition. It is also rich in nutrients and calories. It is a good source of Fe and vitamin A, B and C.

Creation and utilization of variability using proper breeding procedure is a prerequisite for the genetic improvement of any crop. Assessment of genetic variation and degree of transmission of desirable characters is helpful for planning a sound breeding programme. In this regard it is necessary to evaluate variability. Therefore, it is essential for a plant breeder to measure the variability with the help of parameters like range, phenotypic coefficient of variation, genotypic coefficient of variation, heritability and genetic advance as per cent mean.

Material and methods

The experimental material consisting of 60 genotypes including germplasms, advance breeding lines and popularly cultivated varieties of tomato collected from various sources *viz.,* AVRDC, Taiwan, IIHR, Bengaluru and from Horticulture and Genetics and plant breedig department, UAS Dharwad, were evaluated at Botany Garden of the Department of Genetics and plant breeding. UAS, Dharwad, during *kharif* 2018. The experiment was laid out in randomized complete block design with three replications at spacing of 60 cm × 45 cm. The observations were recorded for 18 characters *viz*., days to 50% flowering, days to 1st harvest, plant height, number of primary branches, number of clusters per plant, number of fruits per cluster, number of fruits per plant, average fruit weight, polar length of fruit, equatorial length of fruit, pericarp thickness, number of locules per fruit, total soluble solids (TSS), PH, shelf life, lycopene content, titrable acidity and yield per plantin five randomly selected plants from each genotype in each replication.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). Genotypic and phenotypic coefficients of variation were estimated according to Burton and Devane (1952) 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). Genetic advance as percent of mean was given by Johnson *et al.* (1955).

Results and discussion

Analysis of variance revealed significant differences among the genotypes for all the traits indicating the presence of sufficient genetic variability in the genotypes and considerable scope for their improvement (Table 1). The extent of variability with respect to 18 characters in different genotypes measured in terms of range, genotypic co-efficient of variation (GCV), phenotypic co-efficient of variation (PCV), along with the amount of heritability (h^2), expected genetic advance as per cent of mean (GAM) are given in Table 2. The phenotypic

Table 1. Analysis of variance for different quantitative and qualitative characters in tomato genotypes

Source of Variation	Df	Days to fifty percent flowering	Days to 1st harvest	Plant Height (cm)	Number of primary branches	Number of clusters per plant	Number of fruits per cluster	Number of fruits per plant
Treatments	59	118.91**	354.63**	945.76**	5.17**	80.49**	1.08**	1048.54**
Replication	2	3.02	0.09	68.64	0.21	0.12	0.12	10.04
Error	118	1.73	2.00	57.79	0.11	0.81	0.05	10.74
Mean		35.69	86.58	91.3	4.8	9.53	3.25	30.62
CD @ 5 %		2.12	2.28	12.29	0.55	1.45	0.38	5.30
CV (%)		3.68	1.63	8.32	7.11	9.44	7.25	10.70

Source of Variation	Df	Average fruit weight	Polar length of fruit	Equatorial length of fruit	Pericarp thickness	Number of locules per fruit
Treatments	59	2473.38**	172.07**	177.34**	6.22**	6.24**
Replication	2	70.84	17.88	15.5	0.05	0.10
Error	118	35.48	6.02	5.81	0.04	0.08
Mean	74.22	43.68	47.48	4.2	4.23	
CD @ 5 %	9.63	3.96	3.89	0.34	0.45	
CV (%)	8.02	5.61	5.07	5.03	6.68	

Source of Variation	Df	TSS	pH	Shelf Life	Lycopene content	Titrable acidity	Yield per plant
Treatments	59	2.20**	0.070**	16.71**	407.78**	0.02317**	4.67**
Replication	2	0.01	0.005	0.91	3.13	0.00003	0.16
Error	118	0.03	0.004	0.51	1.02	0.00024	0.06
Mean	5.03	4.27	14.7	42.15	0.45	2.38	
CD @ 5 %	0.3	0.10	1.15	1.63	0.02	0.39	
CV (%)	3.69	1.48	4.87	2.4	3.43	10.32	

** - Significant at 1% level of probability

Table 2. Genetic parameters in respect of growth, yield and quality related traits in tomato genotypes

Characters	Mean	Range		PCV (%)	GCV (%)	h^2 (%)	GAM (%)
		Minimum	Maximum				
Days to 50 per cent flowering	35.69	24.53	51.4	17.89	17.5	95.8	35.29
Days to 1st harvest	86.58	63.4	112.46	12.62	12.52	98.3	25.57
Plant height (cm)	91.3	65.6	144.46	20.6	18.84	83.7	35.5
Number of primary branches	4.8	1.66	7.4	27.94	27.01	93.5	53.82
Number of clusters per plant	9.53	3.7	32.73	54.87	54.05	97	109.68
Number of fruits per cluster	3.25	2.13	5.26	19.42	18.01	86	34.41
Number of fruits per plant	30.62	10.86	155.74	61.66	60.73	97	123.2
Average fruit weight (g)	74.22	8.33	211.93	39.23	38.4	95.8	77.44
Polar length of fruit(mm)	43.68	27.76	65.72	17.93	17.03	90.2	33.32
Equatorial length of fruit (mm)	47.48	24.5	65.92	16.71	15.92	90.8	31.25
Pericarp thickness (mm)	4.2	1.92	7.49	34.54	34.17	97.9	69.24
Number of locules per fruit	4.23	1.94	7.75	34.48	33.82	96.2	69.36
TSS (^{0} brix)	5.03	3.03	6.84	17.28	16.88	95.4	33.98
pH of fruit juice	4.27	3.95	4.58	3.7	3.4	84.7	6.6
Shelf life (days)	14.7	9.53	23.13	16.53	15.8	91.3	31.1
Lycopene content (mg/kg of fresh weight)	42.15	8.14	75.26	27.72	27.62	99.2	56.69
Titrable acidity (%)	0.45	0.33	0.91	19.6	19.3	96.9	39.14
Yield per plant (kg)	2.38	0.74	6.551	52.97	51.95	96.2	104.97

co-efficient of variation (PCV) was higher than the genotypic co-efficient of variation for all the characters under study *viz.*, number of primary branches per plant (27.01 and 27.94), number of clusters per plant (54.05 and 54.87), number of fruits per plant (60.73 and 61.66), average fruit weight (38.40 and 39.23), pericarp thickness (34.17 and 34.54), number of locules per fruit (33.82 and 34.58), lycopene content (27.62 and 27.72) and yield per plant (51.95 and 52.97). Moderate GCV and PCV were observed in days to 50% flowering (17.5 and 17.89), days to 1st harvest (12.52 and 12.62), number of fruits per cluster (18.01 and 19.42), polar length of fruit (17.03 and 17.93), equatorial length of fruit (15.92 and 16.71), TSS (16.88 and 17.28), shelf life(15.8 and 16.53) and titrable acidity (19.3 and 19.6).

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 in the genotypes studied. The GCV and PCV were low for pH of fruit juice (3.4 and 3.7). Environmental influence was very meagre on expression of these characters as it was evident by narrow gap between genotypic and phenotypic coefficient of variation. Selection among the genotypes showing higher values of PCV and GCV will be beneficial for improvement of the traits on account of variation present for the traits between the genotypes. The results of the present investigation were in agreement with the finding of Meena *et al.* (2015), Prajapati *et al.* (2015), Singh *et al.* (2015), Rai *et al.* (2016), Patel *et al.* (2017) and panchbhaiya *et al.* (2018) they also observed the high PCV and GCV for the above said traits.

Broad sense heritability estimates for different traits ranged from 83.7 per cent (plant height) to 99.2 per cent (Lycopene content). Lycopene content recorded maximum heritability (99.2%) followed by days to 1st harvest (98.3), pericarp thickness (97.9), number of clusters per plant (97.0%), number of fruits per plant (97.0 %), titrable acidity (96.9%), yield per plant (96.2%), number of locules per fruit (96.2), average fruit weight (95.8%), days to 50% flowering (95.8%), TSS (95.4%), number of primary branches (93.5%), shelf life (91.3%), equatorial length of fruit (90.8%), polar length of fruit (90.2%), number of fruits per cluster (86.0%) and Ph of fruit juice (84.7%). The heritability estimates for these traits indicate that these characters are least influenced by the environment.

High estimates of genetic advance as percentage of mean (GAM) (>20%) was observed for most of the characters under study *viz.*, number of fruits per plant (123.2%), number of clusters per plant (109.68%), yield per plant (104.97%), average fruit weight (77.44%), number of locules per fruits (69.36%), pericarp thickness (69.24%), lycopene content (56.69%), number of primary branches (53.82%), titrable acidity (39.14%), plant height (35.5%), days to 50% flowering (35.29%), number of fruits per cluster (34.41%),TSS (33.98%), polar length of fruit (33.32%), equatorial length of fruit (31.25%), shelf life (31.1%) and days to 1st harvest (25.57%), low level of GAM was observed for single character pH of fruit juice (6.6 %), High heritability coupled with high GAM was noticed for all traits except pH of fruit juice (Table 2). High estimates of genetic advance as percentage coupled with high heritability indicates 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.

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). Meena *et al.* (2015), Prajapati *et al.* (2015), Singh *et al.* (2015), Rai *et al.* (2016), Patel *et al.* (2017) and Panchbhaiya *et al.* (2018) also observed the high heritability and high GAM for most of the traits mentioned in Table 2.

Conclusion

From the evaluation of 60 genotypes including germplasms, advance breeding lines and popularly cultivated varieties of tomato, it can be concluded that sufficient quantum of genetic variability for different fruit quality and yield attributing 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. Further, 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 yield attributing traits has ample scope for improvement through simple phenotypic selection.

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