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Variability, Heritability and Genetic Advance in Tomato (Solanum *lycopersicum* L.) Genotypes

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The present experiment was conducted entitled " Variability, heritability and genetic advance in tomato((Solanum *lycopersicum* L.) genotypes" during kharif season of the year 2015-2016 at Horticulture Research Farm, Department of Horticulture, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya- Vihar, Rae Bareli Road, Lucknow-226025 (U.P.) India. The experiment used Randomized Block Design with three replications. The experimental materials consisting fifteen genotypes of tomato i.e. IIVR-Sel.-1, G-3, S. Naveen, DVRT-2, H-24, H-86, H-88, Pusa Sheetal, FLA 7171, Hisar Arun, Sel.-32, Flora Dode, Pusa Sadabhar, Kashi Vishesh and Kashi Amrit). The maximum plant height was found in the cross combination H-86 x Pusa Sadabahar and fruits per plant were found maximum in the cross combination IIVR-Sel.-1 x Kashi Amrit. The maximum fruit weight were found in the cross combination H-88 x Kashi Vishesh. The minimum Days to 50% flowering was found in the cross combination H-24 x Kashi Amrit .The minimum pericarp thickness was found in the cross combination IIVR-Sel. 1 x Kashi Vishesh. The highest TSS and Vitamin C were found in in the cross combination FLA 7171 x Kashi Vishesh and Pusa Sheetal x Kashi Vishesh.

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1. INTRODUCTION

"Tomato (*Solanum lycopersicum* L.) is an important vegetable crop and particularly now a commercial crop widely grown all over tropical, sub-tropical and temperate regions of the world for both fresh and processing purpose" [1].

"Total vegetable production in the country has been estimated to be about 175.01 million tonnes from an area 10.29 million hectare. The area under tomato cultivation in India was 808.54 thousand hectares with a production of 19696.92 thousand metric tonnes" [2].

"It ranks second only after potato" [3]. "The optimum temperature for tomato growth and development is 20–24°C. Temperatures above 34°C are considered super-optimal thermal stress. The optimum range of night temperature for fruit set is 15-20°C. However above 18°C is likely to inhibit pollen production and fruit set" [4]. "With high day and night temperatures, the plant shows symptoms of irregular flower development, reduction in pollen production, pollen viability, fruit drop and ovule abortion, all of which ultimately lead to decreased yield [5,6] thus, lycopene has got great beneficial effects on human health [7]. It may also interfere with oxidative damage to DNA and lipoproteins and inhibits the oxidation of LDL (low density lipoprotein) cholesterol" [8]. "Use of F1 hybrids is the quickest way of combining the traits into one, besides the added advantages of heterotic yield" [9].

"Tomato genotype varies not only in the morphological features but also in the quality" [10]. "Most of the quality traits in tomato show continuous variation and is strongly influenced by environmental conditions" [11]. "The genetic variance of any quantitative trait is composed of additive variance (heritable) and non-additive variance and include dominance and epitasis (non-allelic interaction) therefore, it essential to partition the estimated phenotypic variability into its heritable and non-heritable components with suitable parameters such as genetic variance, phenotypic variance, genotypic coefficient of variation, phenotypic coefficient of variation, genetic advance, and heritability" [1]. Meena et al. [1] "high values of PCV and GCV were present for fruit per plant and plant height indicating the existence of higher magnitude of variability". "Systematic study and evaluation of tomato germplasm is of great importance for current and future agronomic and genetic improvement of the crop, evaluation of germplasm is imperative in order to understand the genetic background and the breeding value of the available germplasm" [12].

"Heritability and genetic advance help in determining the influence of environment in expression of the characters and the extent to which improvement is possible after selection" [13-16]. "Heritable variation can be effectively studied in conjunction with genetic advance. High heritability alone is not enough to make efficient selection in segregation, unless the information is accompanied for substantial amount of genetic advance" [1].

2. MATERIALS AND METHODS

The present investigation entitled "Heterosis and Combining Ability Studies in Tomato (*Solanum lycopersicum* L.)" was carried out at Horticulture Research Farm, Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Rae Bareli Road, Lucknow- 226025 (U.P.), India, during the summer season of 2015-16. The details of materials used and methodology to execute the investigation have been described in the chapter are given below:

2.1 Location and Site of Experiment

The Horticulture Research Farm, Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Vidya-Vihar, Rae Bareli Road, Lucknow is situated at an elevation of 111 meter above mean sea level in the subtropical tracts of central U.P. at 26^0 56' North latitude. The Horticulture Research Farm is located approximately 10 km away from the Lucknow Railway station towards the South-East of Lucknow, Rae Bareli Road, near South city.

2.2 Topography, Climate and Weather Conditions

The climate of this region is subtropical with maximum temperature ranging from 29.3^0C to 45^0C in summer and minimum temperature ranging from 3.5 to 15^0C in winter and relative humidity (RH) of 60-80% during different seasons of the year. Lucknow is characterized by subtropical climate with hot summer and cold winter. The annual rainfall is about 750 mm, most of which is received from June to September with

some irregular showers in winter from the North-East monsoon.

The experimental materials consisted of 12 lines, 3 testers and 36 F_1 hybrids obtained from Line x Tester mating design. The parents were randomly selected inbred representing wide range of variation in yield and different yield attributing traits.

2.3 Genetic Variability

The coefficient of variation value is presented in Table 3. The phenotypic coefficient of variation (PCV) was higher than their respective genotypic coefficient of variation (GCV) for all the traits under study.

Phenotypic coefficient of variation was higher for fruit yield per plant (34.40%) followed by ridges on fruit (29.58%), fruits per plant (21.82%), fruits per cluster (20.39%), average fruit weight (18.48%) and flowers per cluster (17.76%) The results were in agreement with the findings of Bhandari et al. (2017) , whereas, it was moderate for locules per fruit (14.59%) followed by number of branches per plant (13.80%) and pericarp thickness (13.27%), low was recorded for clusters per plant (13.18%) followed by fruit length (11.49%), fruit width (11.42%), vitamin C (9.76%), TSS (9.31%) and it was lowest recorded for plant height (4.36%) followed by days to 50% flowering(2.72%).

Highest genotypic coefficient of variation was observed for fruit yield per plant (28.53%) followed by ridges on fruit (27.55%), fruits per plant (20.67%) and fruits per cluster (18.66%), whereas moderate for flowers per cluster (15.96%), average fruit weight (14.97%) and locules per fruit (12.16%) and low was recorded for pericarp thickness (10.81%), number of branches per plant (10.02%), clusters per plant (9.82%) and lowest for days to 50% flowering (2.12%).

2.4 Heritability

Heritability value in broad sense is presented in Table 3. The highest heritability was recorded for fruits per plant (0.90%) and ridges on fruit (0.87%) followed by fruits per cluster (0.84%), flowers per cluster (0.81%), locules per fruit (0.70%), fruit yield per plant (0.69%), pericarp thickness (0.66%), days to 50% flowering (0.61%), plant height (0.60%) and clusters per plant (0.56%). whereas, minimum was recorded for fruit length (0.37%). Therefore, these characters can be improved by simple selection. Similar results were also reported by Amarjeet et al. [3] and Arya et al. [9].

2.5 Genetic Gain

The maximum genetic gain (%) was recorded for ridges on fruit (52.87%) followed by fruit yield per plant (48.73%), fruits per plant (40.32%), fruits per cluster (35.18%), flowers per cluster (29.54%), average fruit weight (25.00%), locules per fruit (20.89%), pericarp thickness (18.14%), clusters per plant (15.08%), number of branches per plant (14.98%), fruit width (12.90%), TSS (11.49%), fruit length (8.69%), vitamin C (8.54%), plant height (5.38%), whereas, minimum was recorded for days to 50% flowering (3.40%).

Table 1. Name and sources of the lines and testers

S. No.	Name of Parents	Symbol	Sources of origin
Lines	IIVR-Sel.-1	L_1	IIVR, Varanasi
	G-3	L_2	IIVR, Varanasi
	S. Naveen	L_3	IIVR, Varanasi
	DVRT-2	L_4	IIVR, Varanasi
	H-24	L_5	IIVR, Varanasi
	H-86	L_6	IIVR, Varanasi
	H-88	L_7	IIVR, Varanasi
	Pusa Sheetal	L_8	IIVR, Varanasi
	FLA 7171	L_9	IIVR, Varanasi
	Hisar Arun	L_{10}	IIVR, Varanasi
	Sel.-32	L_{11}	IIVR, Varanasi
	Flora Dode	L_{12}	IIVR, Varanasi
Testers	Pusa Sadabahar	T_1	IARI, New Delhi
	Kashi Vishesh	T_2	IIVR, Varanasi
	Kashi Amrit	T_3	IIVR, Varanasi
Standard variety	Pusa Rohini		IARI, New Delhi

Table 2. Analysis of variance for the 36 F_1 hybrids of tomato

S. No	Source of variation	D.F.	Characters															
			Plant height (cm)	Branches per plant	Days to 50% flowering	Clusters per plant	Flowers per cluster	Fruits per cluster	Fruits per plant	Average fruit weight (g)	Locules per fruit	Pericarp thickness (mm)	Fruit length (cm)	Fruit width (cm)	Ridges on fruit	Fruit yield per plant (kg)	TSS (°Brix)	Vit. C (Mg/100g)
1.	Replication	2	1.11	0.04	0.72	0.03	0.08	0.05	4.70	2.66	0.07	0.07	0.06	0.01	0.00	0.00	0.07	2.28
2.	Treatments	35	11.57**	0.61**	2.94**	0.39**	0.42**	0.59**	29.71**	56.55**	0.25**	0.38**	0.28**	0.25**	0.14**	0.12**	0.26**	4.22**
3.	Errors	70	1.72	0.18	0.90	0.16	0.19	0.09	3.69	9.67	0.11	0.04	0.06	0.09	0.02	0.01	0.07	1.75

**, ** Significant at 5% and 1% level, respectively.*

Table 3. Estimation of range, mean, genotypic coefficient of variance (GCV), phenotypic coefficient variance (PCV), heritability, genetic advance and genetic gain for 36 F_1 hybrids for 16 characters of tomato

S. No.	Characters	Range		Grand mean	GCV	PCV	Heritability	Genetic advance	Genetic gain
		Min.	Max.						
1	Plant height (cm)	59.52	62.73	61.13	3.38	4.36	0.60	3.21	5.38
2	Branches per plant	4.58	5.26	4.92	10.02	13.80	0.53	0.69	14.98
3	Days to 50% flowering	59.71	61.74	60.73	2.12	2.72	0.61	2.03	3.40
4	Clusters per plant	4.52	5.21	4.87	9.82	13.18	0.56	0.68	15.08
5	Flowers per cluster	5.15	6.67	5.91	15.96	17.76	0.81	1.52	29.54
6	Fruits per cluster	4.05	5.47	4.76	18.66	20.39	0.84	1.42	35.18
7	Fruits per plant	22.07	30.97	26.52	20.67	21.82	0.90	8.90	40.32
8	Average fruit weight (g)	37.71	47.14	42.43	14.97	18.48	0.66	9.43	25.00
9	Locules per fruit	3.50	4.23	3.87	12.16	14.59	0.70	0.73	20.89
10	Pericarp thickness (mm)	3.76	4.45	4.11	10.81	13.27	0.66	0.68	18.14
11	Fruit length (cm)	3.81	4.14	3.98	6.96	11.49	0.37	0.33	8.69
12	Fruit width (cm)	3.94	4.44	4.19	8.46	11.42	0.55	0.51	12.90
13	Ridges on fruit	1.16	1.77	1.47	27.55	29.58	0.87	0.61	52.87
14	Fruit yield per plant (kg)	0.85	1.27	1.06	28.53	34.40	0.69	0.42	48.73
15	TSS (°Brix)	4.05	4.51	4.28	7.20	9.31	0.60	0.47	11.49
16	Vit C mg/100g	24.80	26.92	25.86	6.36	9.76	0.42	2.12	8.54

3. RESULTS AND DISCUSSION

The present findings recorded higher value of phenotypic coefficient of variation than their respective genotypic coefficient of variation for all the characters under study, which indicates that the characters studied were influenced by the environmental. The phenotypic coefficient of variation and genotypic coefficient of variation was higher for phenotypic coefficient of variation and genotypic coefficient of variation was higher for fruit yield per plant and number of branches per plant, but was lowest for days to 50% flowering, show that the characters would respond to selection.

The highest value of broad sense heritability was showed for fruit yield per plant followed by ridges on fruit , plant height , TSS , flowers per cluster , pericarp thickness , fruits per plant , fruits per cluster , clusters per plant and number of branches per plant , while, lowest was recorded for vitamin C. It is also measures the genetic relationship between parents and their progenies, hence, it is widely used in determining the degree to which characters may be transmitted from parent to offspring.

There is a good genetic variability in tomato which can be utilized for varietals improvement. This variability is of much helpful to the breeders in the evolution of new genotypes for selection. The estimates of genetic variability, heritability and genetic gain decide the breeding for improvement in tomato. For the present investigation, widest range was recorded for average fruit weight followed by plant height.

The genetic advanced is another important selection parameter because it measures the difference between the mean genotypic value of the original population from which these were selection. Thus, it adds an advantage over heritability as a guiding factor to breeding in the selection programme. The maximum genetic advance was recorded for fruit yield per plant followed by ridges on fruit , average fruit weight , flowers per cluster, fruits per cluster, number of branches per plant, locules per fruit, fruits per plant, clusters per plant, pericarp thickness , TSS, whereas, minimum was recorded for days to 50% flowering .

4. SUMMARY AND CONCLUSION

A. Variance due to lines (female) was highly significant for all the characters except plant height (cm) and vitamin C (mg/100 g).Variance due to testers (males) was also highly significant for all the characters except plant height, clusters per plant, fruits per plant, average fruit weight and fruit width .Whereas, variances due to parents vs. hybrids were highly significant for days to 50% flowering, clusters per plant, flowers per cluster, fruits per cluster, fruits per plant, average fruit weight (g), locules per fruit, pericarp thickness (mm), fruit length (cm), fruit width (cm), ridges on fruit except for plant height (cm), branches per plant, fruit yield per plant (kg) and vitamin C (mg/100g) were non-significant under study.

B. The parental, line S. Naveen, Flora Dode , FLA 7171 , Sel.-32 and H-86 were found to be best general combiners for most of the characters, while, *per se* performance for parental Pusa Sheetal was found good general combiners for yield and its related component traits out of thirty-six crosses, H-86 x Pusa Sadabahar for plant height, FLA 7171 x Pusa Sadabahar for number of branches per plant, H-24 x Kashi Amrit for days to 50% flowering, S. Naveenx Kashi Vishesh for clusters per plant, FLA 7171 x Pusa Sadabahar for flowers per cluster, FLA 7171 x Pusa Sadabahar for fruits per cluster, H-86 x Kashi Amrit for fruits per plant, H-88 x Kashi Vishesh for average fruit weight, H-24 x Pusa Sadabahar for locules per fruit, IIVR-Sel.-1 x Kashi Amrit for pericarp thickness, S. Naveen x Kashi Amrit for fruit length, H-86 x Pusa Sadabahar for fruit width,G-3 x Kashi Amrit for ridges on fruit, S. Naveen x Kashi Vishesh for fruit yield per plant, G-3 x Kashi Vishesh for TSS and H-88 x Kashi Amrit for vitamin C were showed significant and desirable specific combiner.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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