Plant Archives Vol. 25, Supplement 2, 2025 pp.1792-1796 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-2.226

GENETIC PARAMETERS INFLUENCING YIELD TRAITS IN TOMATO (*SOLANUM LYCOPERSICUM* L.): A HERITABILITY AND VARIABILITY STUDY

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(Date of Receiving : 10-05-2025; Date of Acceptance : 15-07-2025)

ABSTRACT

Research experiment was conducted to study the genetic variability, heritability, and genetic advance in 25 genotypes including one check. Genotypes cultivated at Main Experiment Station Acharya Narendra Deva University of Agriculture & Technology, Ayodhya, India, during the *Rabi* season of 2023–2024. A randomized block design was employed to assess fifteen growth and yield traits. Analysis of variance revealed significant differences among genotypes for all studied traits, indicating substantial genetic diversity. High genotypic and phenotypic coefficients of variation (GCV and PCV) were recorded for lycopene content and number of fruits per plant, suggesting strong genetic variation. Traits such as average fruit weight and number of locules per fruit exhibited high heritability estimates, indicating minimal environmental influence on their expression. The genetic advance as a percentage of the mean was highest for fruit yield per hectare, high lighting the potential for improvement through selection. The results demonstrate the effectiveness of using genetic parameters in tomato breeding programs. High heritability coupled with substantial genetic advance supports the presence of additive gene action in key yield-related traits. These findings provide valuable insights for developing superior tomato varieties with enhanced productivity, fruit quality, and adaptability. The study emphasizes the importance of genetic selection in improving tomato yield and nutritional composition for commercial cultivation.
***Keywords*:** Genetic variability, heritability, genetic advance, PCV, GCV.

Introduction

Tomato, *Solanum lycopersicum* L. (2n=2x=24) belongs to the solanaceae family and its native to Western South America (Rick, 1976). Tomato word is derived from the Spanish word ‘tomate’ earlier which was derived from Mexican word ‘tomatl’ (Peixoto *etal.*,2017). Globally, India stands at second place in terms of production and area, with 19.05 million tonnes produced by an area of 0.7 million ha (FAO, 2023). Within the genus *Lycopersicon* the rear about twelve species. On the basis of fruit colour, all these species have been divided into two subgenera, namely *Eriopersicon* (Characterised by green fruits with anthocyanin pigmentation) and *Eulycopersicon* (Characterised by red fruits with carotenoid pigmentation and annual growth habit). Tomato is one of the most important warm-season self- pollinated vegetables grown for both fresh market and processing (Das *et al*., 2011; Nwosu *et al*., 2014). Its petals are generally yellow in color; in full bloom. It is chasmogamous, pentamerous, hermaphrodite with pistil enveloped by a solid tube formed by the stamens. The optimum temperature for the growth and development of the tomato is 20 24 °C. Temperatures above 34 °C are considered super-optimal heat stress. The tomato consists of 93-94% water, vitamins such as thiamine, riboflavin, niacin, vitamin C, vitamin A and carotene (Kaur *et al.,* 2013). (Dhaliwal *et al.,* 2003) suggested that tomato is helpful against heart and cancer diseases as it is rich in antioxidants, and a greatest source of minerals (Ca, P and Fe).Tomato fruit contain carbohydrate 3.6 g, protein 19 g, fat 0.1 g, water 93.1 g, mineral 0.6 g, iron 0.8 mg, calcium 20 mg, phosphorous 36 mg, thiamine 2.27 mg, nicotinic acid 0.4 mg, carotene 320 IU and ascorbic acid 3.1mg per 100g of fruit pulp. It also contains biotin, panthonic acid, vitamin K, folic acid and vitamin related inhibitors (Aykroyed 1963). In India, tomato yield is below world averages (Kumar *et al.*, 2013). It is necessary to develop superior varieties/hybrids to increase productivity. Besides, improving fruit quality has also become a major goal in plant breeding. However, the efficiency of selection depends upon the nature and magnitude of genetic variability and heritability of trait of interest. Because yield is a complex character, its direct improvement is difficult. Genotypic and phenotypic coefficients of variation are avantageous in determining the amounts of variability present in genotypes. Heritability and genetic advance aid in establishing the influence of environment in expression of traits and the extent to which improvement is possible after selection (Robinson *et al.*, 1955; Kumar *et al.*, 2013). Heritable variation can be effectively studied in association with genetic advance. According to (Johanson *et al.,* 1955), high heritability alone is ineffective to make efficient selection in segregating generation and needs to be followed by a significant amount of genetic advance.

Materials and Methods

The present investigation conducted during *Rabi* season of 2023–2024, at the Main Experiment Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P.) India. The experimental site is geographically, falls under humid, sub-tropical climate and is located in between 24.470 and 26.560 N latitude and 82.12^0 and 83.98^0 E longitude at an altitude of 113 m above the mean sea stratum in the Gangetic alluvial plains of Eastern Uttar Pradesh. The soil of experimental site was sandy loam with average fertility level with pH in the range of 7.5-8.5. A randomized block design with three replications was used to assess twenty-five distinct genotypes were collected from A.N.D.U.A & T, Kumarganj, Ayodhya (Table 1). Six weeks old healthy seedlings were transplanted into the main field in two-row plots, each measuring three meters. Ten plants per genotype were allowed in each replication, with plant spacing kept at 60 × 50 cm.

Table 1: List of genotypes and their source of origin

S.No.	Name of genotypes	Source of origin
1.	NDT-1	A.N.D.U.A.&T. Ayodhya
2.	NDT-2	A.N.D.U.A.&T. Ayodhya
3.	NDT-3	A.N.D.U.A.&T. Ayodhya
4.	NDT-5	A.N.D.U.A.&T. Ayodhya
5.	NDT-6	A.N.D.U.A.&T. Ayodhya
6.	NDT-7	A.N.D.U.A.&T. Ayodhya
7.	NDT-8	A.N.D.U.A.&T. Ayodhya
8.	NDT-9	A.N.D.U.A.&T. Ayodhya
9.	NDT-10	A.N.D.U.A.&T. Ayodhya
10.	NDT-11	A.N.D.U.A.&T. Ayodhya
11.	NDT-12	A.N.D.U.A.&T. Ayodhya
12.	NDT-13	A.N.D.U.A.&T. Ayodhya
13.	NDT-14	A.N.D.U.A.&T. Ayodhya
14.	NDT-15	A.N.D.U.A.&T. Ayodhya
15.	NDT-16	A.N.D.U.A.&T. Ayodhya
16.	NDT-17	A.N.D.U.A.&T. Ayodhya
17.	NDT-18	A.N.D.U.A.&T. Ayodhya
18.	NDT-19	A.N.D.U.A.&T. Ayodhya
19.	NDT-20	A.N.D.U.A.&T. Ayodhya
20.	NDT-21	A.N.D.U.A.&T. Ayodhya
21.	NDT-22	A.N.D.U.A.&T. Ayodhya
22.	NDT-23	A.N.D.U.A.&T. Ayodhya
23.	NDT-24	A.N.D.U.A.&T. Ayodhya
24.	NDT-25	A.N.D.U.A.&T. Ayodhya
25.	NDT-4(Check)	A.N.D.U.A.&T. Ayodhya

In order to ensure good crop growth, the cultivation followed the guidelines and tactics that were recommended. Five randomly chosen plants from each plot were taken into consideration for recording observations for fifteen different features. Phenotypic and genotypic coefficient of variation (Burton, 1952), heritability (Lush, 1940), and genetic advance as per cent of mean (Robinson *et al.,* 1949) were calculated. The ratio of genotypic variation to total phenotypic variance was used to calculate the broad- sense heritability (h^2) for each characteristic. Each trait's genetic progress estimates were derived using the formula proposed by (Johnson *et al.,* 1955).

Results and Discussion

The mean sum of squares for fifteen characters in genotypes of Tomato is presented in table 2. Analysis of variance revealed highly significant differences among genotypes for all seventeen characters. The results pertaining to mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense (h^2) and expected genetic advance as per cent of mean (GAM) for all the fifteen characters.

Table 2 : Analysis of variance (mean squares) for fifteen quantitative characters in tomato germplasm

S. No.	Characters	Source of variation		
		Replication	Treatment	Error
	Degree of freedom	2	24	48
1.	Days to 50% flowering	0.65	54.47**	2.83
2.	Days to first harvest	6.09	51.56**	6.82
3.	Plant height(cm)	7.54	110.98**	33.72
4.	Number of primary branches per plant	0.023	2.754**	0.208
5.	Polar diameter of fruit(cm)	0.290	1.307**	0.190
6.	Equatorial diameter of fruit(cm)	0.318	1.268**	0.123
7.	Pericarp thickness(mm)	0.308	1.338**	0.163
8.	Average fruit weight(g)	42.50	366.95**	15.36
9.	Number of fruits per plant	1.04	32.60**	1.12
10.	Number of locules per fruit	0.137	1.783**	0.069
11.	TSS(^{0}Brix)	0.175	0.686**	0.070
12	Ascorbic acid (mg/100gm)	0.25	11.70**	0.78
13.	Lycopene content(mg/100gm)	0.12	4.98**	0.02
14.	Fruit yield per plant(kg)	0.001	0.027**	0.004
15	Fruit yield(q/ha)	14.52	2985.93**	401.57

The phenotypic variance ranged from 4.99 to 22.47, and the lowest variance was recorded for Days of first fruit harvest and the maximum was recorded for Lycopene content (mg/100gm), followed by Number of fruits per plant and Number of primary branches per plant. The genotypic coefficient of variance (GCV) ranged from 3.76 to 22.25. High GCV was observed for Lycopene content (mg/100gm) followed by Number of fruits per plant and number of primary branches per plant, whereas the lowest GCV was recorded in Days to first fruit harvest. The investigation revealed that the genotypic variation was high as compared to the phenotypic variation for all the traits studied, indicating the influence of environment. This result is in accordance with the reports of (Kumar *et al.*, 2013), (Kumari *et al.,* 2020).

Table 3 : General mean, range and PCV, GCV, heritability and genetic advance for various growth and yield characters in tomato

S.No.	Characters	Range		Grand mean	P.CV. (%)	G.C.V. (%)	Heritability Broad Sense (%)	Genetic advance
		Lowest	Highest					
1.	Days to 50% flowering	32.67	47.67	43.45	8.35	7.40	78.47	5.86
2.	Days to first fruit harvest	69.00	84.33	79.49	4.99	3.76	56.77	4.64
3.	Plant height (cm)	57.54	80.70	71.83	9.76	5.47	31.43	4.54
4.	No primary branches per plant	3.49	6.91	5.07	16.71	14.08	70.99	1.24
5.	Polar diameter of fruit(cm)	3.92	6.40	5.06	12.70	9.33	54.04	0.72
6.	Equatorial diameter of fruit(cm)	3.30	6.01	4.80	12.38	9.98	64.97	0.79
7.	Pericarp thickness(mm)	2.80	5.32	4.25	14.85	11.42	59.13	0.77
8.	Average fruit weight(g)	48.17	85.33	63.48	14.58	13.21	82.07	15.65
9.	Number of fruits per plant	8.33	21.00	13.55	20.09	18.51	84.90	4.76
10.	Number of locules per fruit	2.80	5.51	4.40	14.59	13.31	83.22	1.10
11.	TSS(0B)	4.37	6.30	5.72	7.68	6.13	63.69	0.58
12.	Ascorbic acid(mg/100gm)	17.54	23.64	20.68	8.32	7.15	73.71	2.61
13.	Lycopene content(mg/100gm)	2.70	6.47	4.48	22.47	22.25	98.05	2.03
14.	Fruit yield per plant(kg)	0.69	1.10	0.82	11.19	8.34	55.63	0.10
15.	Fruit yield (q/ha)	225.47	364.02	271.06	11.18	8.39	56.28	35.13

Highly estimates for both PCV and GCV were obtained for lycopene content (mg/100gm) and number of fruits per plant in the present study. Moderate estimates of PCV and GCV were recorded for no primary branches per plant, polar diameter of fruit (cm), equatorial diameter of fruit (cm), pericarp thickness (mm), average fruit weight (g), number of locules per fruit, fruit yield per plant (kg) and fruit yield (q/ha). The lowest estimates of PCV and GCV were recorded for days to 50% flowering, days to first fruit harvest, plant height (cm), TSS(^{0}B) and ascorbic acid (mg/100gm). Such findings are in conformity with the reports of (Sinha *et al.,* 2020), (Mishra *et al.,* 2022), (Madhavi *et al.,* 2022) and (Eppakayala *et al.,* 2021).

In the present study, low heritability ranges from 0-30%, moderate heritability ranges from 30-60% and high heritability ranges from >60% almost all the characters exhibited high heritability, which ranged from 31.43 to 98.05 percent. The highest degree of heritability was observed for the characters Days to 50% flowering, No primary branches per plant, Equatorial diameter of fruit (cm), Average fruit weight (g), Number of fruits per plant, Number of locules per fruit, TSS (^{0}B), Ascorbic acid (mg/100gm) and Lycopene content (mg/100gm) while moderate heritability was observed for Days to first fruit harvest, Plant height (cm), Polar diameter of fruit (cm), Pericarp thickness (mm), Fruit yield per plant (kg) and Fruit yield (q/ha). Similar results were also reported by (Dutta *et al.,* 2018), (Singh *et al.,* 2018), (Reddy *et al.,* 2019), (Madhavi *et al.,* 2022) and (Yadav *et al.,* 2022). Heritability along with genetic advance as percent of mean would be helpful in assessing the nature of gene action low genetic advance is ranges from 0-10%, medium is ranges from 10-20% & high genetic advance is ranges from >20%. In the present study, the characters namely Fruit yield (q/ha) showed high estimates of genetic advance as per cent of mean, while the Average fruit weight (g) showed medium and rest parameters are showed low estimates of genetic advance as per cent of mean, which indicated that the expression of these characters was governed by non-additive genes. Above research is in accordance with the findings of (Tasisa *et al*., 2011), (Madhurin and Paul 2012) and (Sahanur *et al*., 2012).

Conclusion

This study highlights significant genetic variability among tomato genotypes, particularly for lycopene content and number of fruits per plant. High heritability estimates suggest that most traits are primarily controlled by genetic factors, making them suitable for selection in breeding programs. The genetic advance analysis further confirms the presence of additive gene action, indicating the potential for substantial improvement in yield and quality traits through selective breeding. These findings provide valuable insights for developing superior tomato varieties with enhanced productivity, nutritional value, and adaptability to different environmental conditions. Future research should focus on refining breeding strategies to maximize genetic gains and improve tomato crop performance.

Acknowledgment

The authors are highly thankful for the facilities provided by the Department of Vegetable Science, A.N.D.U.A. & T, Kumarganj, Ayodhya (UP) India-224229.

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