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STUDIES ON VARIABILITY ANALYSIS FOR YIELD AND YIELD PARAMETERS IN TOMATO (*SOLANUM LYCOPERSICUM* L.)

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ABSTRACT

The present investigation conducted with objective to assess the genetic variability, heritability and genetic advance for yield and yield parameters among twenty two genotypes of tomato for fourteen traits *viz.* days to 50 per cent flowering, days to first fruit set, days to first fruit harvest, plant height (cm), number of primary branches per plant, number of fruits per cluster, fruit length (cm), fruit girth (cm), pericarp thickness (mm), number of locules per fruit, number of fruits per plant, average fruit weight (g), total fruit yield per plant (kg) and total soluble solids (°Brix) were evaluated during November to April, 2024- 2025 at Crop Research Center (CRC)- III, ITM University, Gwalior (M.P.), India. The experiment was described in design of Randomized Block Design (RBD) for this experiment with three replications. The estimates of genotypic as well as phenotypic coefficient of variability were observed higher for number of locules per fruit followed by total fruit yield per plant, number of fruits per plant whereas days to first fruit harvest had the lowest coefficients of variation. Higher GCV and PVC were indicating higher magnitude of variability for those characters average fruit weight recorded the highest number of genotype as well as phenotype variance while, total soluble solid was the lowest number of genotype and phenotype variance. High genotypic variance was indicating more contribution of genetic component for the total variation. The highest heritability was showed on number of locules per fruit whereas, number of fruits per cluster was the lowest value of heritability. All the traits under study showed high broad-sense heritability, suggesting that additive genetic effects play a key role in their expression, making them reliable traits for selection further research in breeding programs.

Key words : Variability, Heritability, Genetic advance, Yield.

Introduction

Tomato (*Solanum lycopersicum* L.) is an herbaceous plant which is belongs to the genus of Solanum and a member of the family of Solanaceae, which also known as “Nightshade family” is one of the most popular & extensively cultivated vegetable throughout the world. It includes more than 3000 families with the chromosome number of 2n=2x=24. It is originated from Peru Ecuador and Bolivia region of Andes of South America (Peralta and Spooner, 2007) from wild ancestor *Solanum lycopersicum* var. *cerasiformae*. Tomato, it is a mainly “Spanish” word which was derived from “Nahuatl” word “Tomatl”, is where the word tomato name first appeared.

India holds the third rank in terms of production after the China and USA and also it is the second consumption vegetable after the potato. In India, total area under tomato cultivation is 864 thousand hectares with production of 204.19 lakh tonnes and its productivity is 23.63 metric tonnes per hectare. In India, the leading tomato growing states are, Andhra Pradesh, Madhya Pradesh, Karnataka, Gujarat, Odisha, West Bengal, Maharashtra, Chhattisgarh, Bihar and Telangana (Anonymous, 2023).

Tomato cultivation in India advanced significantly post-1950 with the introduction of high-yielding exotic varieties like Sioux, Roma, and Marglobe. Since then, improved indigenous cultivars have emerged, mainly from key breeding centers such as IARI, IIVR, PAU, and IIHR, contributing to the development of popular regional varieties (Tiwari *et al.*, 2022).

Tomato, it is a day neutral warm season crop and grows under wide range of soil and climatic conditions. Though tomato is a self-pollinated crop, the unusual high heterosis observed in it, has been attributed to the fact that, originally tomato was a highly out crossing genus which has later evolved into a self-pollinated one (Prajapati *et al.*, 2023) and edible part is botanically known as berry and it is also called as "Love of Apple" (Knapp and Peralta, 2016). The fruits are mainly developed form the plants ovary after pollination and fertilization which makes this to a true fruit. It is globally cultivated for its fleshy fruits that's why it also known as protective food. Under Indian condition, the fruits mainly consumed either as raw or in the preparation of sambar, chatni, pickles etc. (Bhowmik *et al.*, 2012).

Tomato is a vital crop for small farmers and a rich source of nutrition and medicinal benefits. Its pulp and juice aid digestion, improve gastric function, and purify blood. Rich in antioxidants like lycopene and vitamin C, tomatoes help prevent cancer and heart disease. It also known as the "Poor Man's Orange," they are packed with essential nutrients including vitamins A, C, E, potassium, iron, and calcium (Kumar *et al.*, 2020). Tomatoes contain 93–95% water, low calories and beneficial sugars. They have three growth types: determinate, indeterminate and semi-determinate. Flowering occurs early morning, with peak pollen fertility and stigma receptivity around the time of anthesis.

Genetic variability refers to the differences in traits among individuals in a population and plays a vital role in selecting superior parents for hybridization. In crop improvement, collecting, maintaining, and evaluating germplasm is essential to understand the extent of variability, which forms the foundation of an effective breeding programme (Saravanan *et al.*, 2019). Yield is a complex trait influenced by many quantitative, environment-sensitive factors, making it hard to determine if observed differences are genetic. Hence, parameters like variance, phenotypic variance, genetic advance, and heritability are essential to understand the inheritance pattern of yield-related traits (Mishra *et al.*, 2024).

Materials and Methods

Twenty-two genotypes of tomato were evaluated for research trial during November to April, 2024- 2025 at Crop Research Center (CRC)- III, ITM University, Sithouli, Gwalior, Madhya Pradesh to germplasm evaluation for genetic variability in tomato (*Solanum lycopersicum* L.) for check their suitability of cultivation in Gwalior region. For this field experiment, I was used 22 genotypes of tomatoes for germplasm evaluation for genetic variability in tomato those are Arka Meghali, Arka Vikas ©, Arka Rakshak, Arka Abhed, Arka Apeksha, Kashi Aman, Kashi Chayan, Tomato-4201, Tomato- 4202, Tomato- 4203, Tomato-4204, Tomato- 4205, Tomato- 4206, Tomato- 4207, Tomato-4208, Tomato- 4209, Tomato- 4210, Tomato-4211, Tomato- 4212, OFT TMTH 244, Desi Red, Navodya, which is collected from IIHR, IIVR, local market and Trimurti Plant Science Pvt. Ltd. The experiment was described in design of Randomized Block Design (RBD) for this experiment with three replications. Respectively genotypes line was grownup in a plot of 1.5 m × 3 m (4.5 square meter) cooperatively 10 plants per plot and 5 plants per row with a spacing of 45 × 60 cm.

The genotypic and phenotypic coefficients of variation were calculated using the formulae of Burton and De Vane (1953). Heritability and genetic advance were calculated according to Allard (1960) and genetic advance as per cent of mean was estimated using the method of Johnson *et al.* (1955). Genetic advance in per cent of mean was calculated by the formula of Comstock *et al.* (1952).

Results and Discussion

The data recorded on fourteen traits from the experiment were subjected to analysis of variance. Mean

Table 1 : Analysis of variance (mean squares) for 14 characters in tomato.

S. no.	Characters	Mean Sum of Squares		
		Replication	Treatment	Error
d.f.		2	21	42
1.	Days to 50% flowering	6.655	25.934**	4.627
2.	Days to first fruit set	29.730	55.320**	9.812
3.	Days to first fruit harvest	63.329	74.564**	9.641
4.	Plant height (cm)	38.575	389.995**	43.302
5.	No. of primary brunches per plant	0.514	1.403**	0.101
6.	No. of fruits per cluster	2.330	1.546**	0.361
7.	Fruit length (cm)	0.103	1.526**	0.073
8.	Fruit girth (cm)	0.106	0.824**	0.098
9.	Pericarp thickness (mm)	0.007	3.259**	0.141
10.	No. of locules per fruit	0.030	1.838**	0.013
11.	TSS (°brix)	0.160	0.346**	0.057
12.	No. of fruits per plant	193.927	182.097**	24.123
13.	Average fruit weight (g)	332.645	643.531**	110.583
14.	Total fruit yield per plant (kg)	0.125	0.973**	0.193

Table 2 : Estimates of phenotypic variance, genotypic variance, phenotypic and genotypic coefficients of variation, heritability (bs) and genetic advance (in percent of mean) for different characters in tomato (*Solanum lycopersicum* L.).

S. no.	Characters	Grand Mean	Range		Genotypic Coefficient of variation (GCV)	Phenotypic Coefficient of variation (PCV)	Genotypic variance ($\sigma^2 g$)	Phenotypic variance ($\sigma^2 p$)	Heritability in Broad Sense (%) (h^2_{bs})	Genetic advance (as percent of mean)
			Min	Max						
1	Days to 50 per cent of flowering	58.30	54.00	64.33	4.57	5.87	7.10	11.72	60.55	7.32
2	Days to first fruit set	78.03	70.87	87.00	4.99	6.40	15.20	25.00	60.78	8.02
3	Days to first fruit harvest	125.66	120.53	142.33	3.70	4.45	21.64	31.28	69.17	6.34
4	Plant height (cm)	86.89	69.47	116.93	12.38	14.47	115.89	158.20	73.26	21.84
5	Number of primary branches per plant	6.06	5.00	8.07	10.87	12.05	0.43	0.53	81.31	20.19
6	Number of fruits per cluster	5.73	4.27	7.60	10.58	14.85	0.36	0.72	50.81	15.55
7	Fruit length (cm)	4.73	3.10	6.20	14.68	15.76	0.48	0.55	86.77	28.18
8	Fruit girth (cm)	4.75	3.28	5.93	10.33	12.26	0.24	0.34	71.00	17.93
9	Pericarp thickness (mm)	5.78	3.19	7.25	17.62	18.78	1.03	1.18	88.03	34.06
10	Number of locules per fruit	3.03	2.08	4.56	25.67	25.96	0.60	0.62	97.77	52.30
11	Total soluble solids (ºbrix)	4.28	3.60	5.04	7.25	9.15	0.09	0.15	62.68	11.82
12	Number of fruits per plant	37.16	18.47	48.93	19.52	23.57	52.65	76.78	68.58	33.30
13	Average fruit weight (g)	77.39	34.92	114.80	17.22	21.93	177.64	288.23	61.63	27.85
14	Total fruit yield per plant (kg)	2.78	1.40	3.55	18.29	24.15	0.26	0.45	57.33	28.53

squares due to genotypes were highly significant for all the fourteen traits (Table 1) indicating therefore, significant differences among the genotypes with respect to the traits under study. Various genetic parameters such as genotypic and phenotypic coefficients of variation (GCV and PCV), heritability and genetic advance as a percentage of the mean were estimated during the study described in Table 2. The estimates of coefficient of variation revealed that the magnitude of phenotypic coefficient of variation for all the traits were higher than the genotypic coefficient of variation indicating affective role of environment expression of traits studied. The estimates of genotypic as well as phenotypic coefficient of variability were observed higher for number of locules per fruit (25.96%) followed by total fruit yield per plant (24.15%), number of fruits per plant (23.57%), average fruit weight (21.93%), pericarp thickness (18.78%), fruit length (15.76), whereas number of fruits per cluster (14.85%), plant height (14.47%), fruit girth (12.26%), number of primary branches per plant (12.05%), total soluble solids (ºBrix) (9.15%) showed moderate coefficient of variability while days to first fruit harvest (4.45%) had the lowest coefficients of variation. The results are closely relatable with the earlier findings of Singh (2005), Samadia *et al.* (2006).

The estimates of genotypic and phenotypic variance for fourteen traits showed phenotypic variance were higher genotypic variance in tomato germplasm and were recorded ranged between 288.23 (average fruit weight) to 0.34 (fruit girth). The estimates of genotypic as well as phenotypic variance were observed highest for the trait of 288.23 (average fruit weight) followed by 158.20 (plant height), 76.78 (number of fruits per plant), 31.28 (days to first fruit harvest), 25.00 (days to first fruit set) while, 0.15 (total soluble solid) was the lowest value of variance. The results are closely relatable with the earlier findings of Shankar *et al*. (2016), Bhandari *et al*. (2017).

Estimates of heritability in broad sense (h^2_{bs}) for fourteen characters in tomato germplasm are ranged from 50.81% (number of fruits per cluster) to 97.77% (number of locules per fruit). Heritability ranged between low heritability (<30%), moderate heritability (30–60%) and high heritability (>60%) while characters *viz.*, days to 50 per cent of flowering (60.55), days to first fruit set (60.78), average fruit weight (61.63), Total soluble solids

(62.68), number of fruits per plant (68.58), days to first fruit harvest (69.17), fruit girth (71.00), plant height (73.26), number of primary branches per plant (81.31), fruit length (86.77), pericarp thickness (88.03), number of locules per fruit (97.77) were observed highest estimates of heritability. Whereas, characters *viz*., number of fruits per cluster (50.81), total fruit yield per plant (57.33) showed moderate estimates of heritability. The results are closely relatable with the earlier findings of Somraj *et al*. (2013), Umesh *et al*. (2015), Shokat *et al*. (2013).

The estimates of genetic advance in per cent of mean was recorded from days to first fruit harvest (6.34%) to number of locules per fruit (52.30%). Genetic advance as percent of mean ranged between low genetic advance (<10%), moderate genetic advance (10-20%) and high genetic advance (>20%) while characters *viz*., number of primary branches per plant (20.19%), plant height (21.84%), average fruit weight (27.85%), fruit length (28.18%), total fruit yield per plant (28.53%), number of fruits per plant (33.30 %), pericarp thickness (34.06%), number of locules per fruit (52.30%) were observed highest estimates of genetic advance as percent of mean. Characters *viz*., total soluble solids (11.82%), number of fruits per cluster (15.55%), fruit girth (17.93%) showed moderate estimates of genetic advance as percent of mean. Whereas, lower estimates of genetic advance as percent of mean characters *viz.*, days to first fruit harvest (6.34%), days to 50 per cent of flowering (7.32%), days to first fruit set (8.02%) was observed the lowest estimates of genetic advance as percent of mean. The results are closely relatable with the earlier findings of Anitha *et al*. (2013), Meitei *at al*. (2014), Patel *et al*. (2015).

Conclusion

The results of the present study discovered a significant level of genetic variability among the diverse tomato genotypes for various characters. This variability highlights a promising opportunity to enhance these characters through both selection and hybridization. The observed uniformity between high heritability values and corresponding genetic gain suggests that additive gene effects play a significant role in the inheritance of these characters, making them dependable for effective selection. Moreover, several traits exhibited moderate to high genotypic coefficients of variation (GCV), along with moderate to high heritability and genetic advance as a percentage of the mean. This pattern further supports the impact of additive gene action, indicating that these traits can be effectively improved through a well-planned selection strategy.

Authors contribution

The authors involved in this study have made remarkable contributions toward enhancing the scientific understanding of tomato. Their cooperative efforts comprehended all stages of the research process, including the formulation of the research proposal, execution of experiments, systematic data collection, statistical analysis, and the drafting, reviewing and final editing of the manuscript. Each phase of the study reflects their dedicated involvement and shared commitment to the quality and completeness of the research work.

Declaration

The authors contributed significantly to the research. The authors are thankful to the Dean of the School of Agriculture, ITM University, Gwalior - 474 001 (M.P.), for providing all the necessary facilities required for conducting the research work.

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