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Genetic variability, heritability and genetics advance in tomato

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Abstract
Six genotypes of tomato were evaluated for yield and various yield attributing characters at the Main Experiment Station, Department of Genetics and Plant Breeding, School of Agricultural Sciences, GH Raisoni University, Saikheda Tah. Sausar Dist. Chhidwada (M.P.), India during 2022-2023. The experiment in Randomized Complete Block Design with three replications. Observations were recorded on twelve quantitative characters *viz*., days to 50% flowering, days to first flowering, plant height at 60 and 90 days after transplanting (DAT), fruit length (cm) count of primary branches per plant at 60 and 90 days, stem girth at 60 and 90 days, fruit diameter (cm), average fruit weight (g), days to first maturity, total yield per plant, fruit yield per plot, and Total Soluble Solids (TSS). Significant levels of Genetic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV) were evident across all traits, except for 'days to 50 percent flowering,' which exhibited minimal variability. High heritability, coupled with substantial genetic advancement as a percentage of the mean, was observed in all traits except for 'days to 50 percent flowering.' Notably, 'fruit yield per plant' ranked as the most prominent trait, followed by 'average fruit weight,' 'number of fruits per plant,' and 'plant height.' These top five traits displayed substantial genetic advancement, suggesting ample opportunities for enhanced selection responses.

Keywords: GCV, PCV, Genetics advance, tomato

Introduction
The tomato (*Lycopersicon esculentum* M.) is an annual crop belonging to the Solanaceae family. Plants within the Lycopersicon genus can be either annual or brief perennials. Tomatoes are considered day-neutral plants, primarily undergoing self-pollination, although cross-pollination also occurs. This warm-season crop exhibits adaptability to diverse soil types and climatic conditions, displaying a certain level of resilience to heat and drought. While tomatoes can be cultivated worldwide, they encounter various abiotic stresses, with elevated temperatures posing a significant challenge to production nowadays. These warm-season crops are known for their capacity to thrive in different soil and climatic scenarios, often exhibiting tolerance to heat and drought. Notably recognized as a nutritive vegetable, tomatoes harbor nutrients that contribute to safeguarding the body against several ailments. Furthermore, they hold the distinction of being one of the most widely processed. The probability of identifying a superior genotype rises when genetics constitute the primary driver of population diversity, while minimizing the impact of environmental factors. Fully ripe tomatoes are a versatile resource for creating various processed products, including purees, pastes, powders, ketchup, sauces, soups, and even preserved whole fruits. Moreover, they are commonly enjoyed fresh in salads and when cooked. Unripe, green tomatoes are employed in the preparation of pickles and chutneys. Beyond their visual appeal and taste, tomatoes hold significant value as a rich source of antioxidants like lycopene, ascorbic acid, and beta-carotene. Over time, there has been a gradual increase in both tomato production and cultivated area. Notably, India stands as the second-largest tomato producer globally, following China. The diversity within the population can be categorized into. Vegetables, often found in canned products.
A prevailing approach for enhancing a crop's genetic composition involves the incorporation of existing or newly generated genetic variability.

The likelihood of isolating a superior genotype increases if genetics make up the majority of population variation with the least amount of environmental influence. Ripe fresh tomato fruit can be utilized to make a variety of processed goods, such puree, paste, powder, ketchup, sauce, soup, and canned whole fruits. It is also consumed fresh in salads and cooked. Pickles and chutney are created from unripe, green fruits. Tomatoes are prized for their color and flavor as well as being an important source of the antioxidants lycopene, ascorbic acid, and b-carotene. Over the years, tomato production and production area have gone up gradually. Next to China, India is the location the grows the most tomato. The population's variability can be divided into both heritable and non-heritable sections, involving phenotypic and genotypic coefficients of variation, heritability, and genetic development, on which selection may be effective. Heritability is a measure of the phenotypic variation caused by genotypes and aids breeders in finding the most viable variety for a characteristic. Genetic advance signifies an increase in the mean genotypic values of selected families over the base population, allowing the breeder to choose progenies in the previous generation. However, heritability merely indicates the success. It is possible to select a genotype based on phenotypic performance; however, this does not reflect the projected genetic advancement in a single cycle of selection. Unless information for an enormous amount of genetic progress is available, high heritability alone is required for effective selection in segregating generations is available.

Materials and Methods

The research work ‘‘Genetic Variability, Heritability and genetic advance in tomato (*Solanum lycopersicon* M.)” was conducted during Rabi 2022 at Experiment will be conducted at department of genetics and plant breeding School of agricultural Science, Saikheda Tah. Sausar, Dist. Chhindwara (M.P.) 480106, India during 2022-2023.

The experimental material is comprised of six cultivars of tomato *viz.* Abhilasha, Brahma, Aarya, Indam 14301, Ananta and Vishawanath super. The study of a Randomized Block Design (RBD) with four replicates. The seeds were sown in the nursery bed on November 14, 2022, and subsequently transplanted into the main field on December 13, 2022. Each plot measures 3×2.5 meters and accommodates 25 plants, with a row-to-row spacing of 60 centimeters and a plant-to-plant spacing of 50 centimeters.

Data were recorded for twelve characters *viz* days to 50% flowering, days to first flowering, plant height at 60 and 90 days after transplanting (DAT), count of primary branches per plant at 60 and 90 DAT, stem girth at 60 and 90 DAT, fruit length (cm), fruit diameter (cm), average fruit weight (g), days to first maturity, total yield per plant, fruit yield per plot, and total soluble solids (TSS). The data were analyzed as per methods suggested by Panse and Sukhatme (1967) [21] for analysis of variance, Burton (1952) [22] for variability, Lush (1940) [23] for heritability (Broad Sense) and Johnson *et al.* (1955) [24] for genetic advance in percent of mean.

Results and Discussion

The table displays the performance measures and various genetic parameters, including phenotypic and genotypic coefficient of variability (PCV, GCV), heritabilit (h2), genetic advance (GA), and genetic advance as a percentage of the mean (GAM) for the twelve quantitative traits

Table 3: Estimation of variability, heritability and genetic advance as % of mean for twelve characters in six genotypes of tomato

Sr. No.	Characters	Range		Mean	Variance		PCV (%)	GCV (%)	Genetics advance	GA as % of mean
		Maximum	Minimum		Phenotypic	Genotypic				
1	Plant height	68.60	197.56	109.56	994.66	961.95	28.78	28.30	62.83	57.34
2	No. of branches per plant	2.43	9.83	5.89	4.83	4.71	37.30	36.86	4.42	75.05
4	Days of 1st flowering	21.26	43.86	31.62	22.45	14.26	14.98	11.94	6.20	19.61
5	Days to 50% flowering	29.00	52.00	37.13	26.94	21.85	13.98	12.59	8.67	23.35
6	Fruit length (cm)	3.12	5.34	4.47	3.83	3.71	15.59	14.71	3.24	28.60
7	Fruit width (cm)	3.47	5.94	4.67	4.03	3.93	13.46	12.32	3.44	23.23
8	No. of fruit per plant	10.58	323.00	54.45	6038.11	6026.12	142.69	142.54	159.75	293.35
9	Average fruit weight (g)	0.96	194.44	53.87	1645.41	1625.22	75.29	74.82	82.53	153.19
10	Fruit yield per plant (kg)	0.26	2.28	1.17	0.28	0.27	45.30	44.82	1.07	91.38
11	Days to 1st fruit harvest	69.06	82.90	73.86	68.45	70.75	4.45	3.68	63.75	6.27
12	TSS (%)	2.96	8.16	4.31	1.35	1.31	26.92	26.57	2.33	54.03

PCV and GCV: Phenotypic and genotypic coefficient of variation, h2 BS: Heritability in broad sense, GA: Genetic Advance

Table 2a: Mean performance of various genotypes for different characters

Sr. No.	Genotypes	Plant Height 60 DAT	Plant Height 90 DAT	No. of primary branches per plant 60 DAT	No. of primary branches per plant 90 DAT	No. of leaves per plant 60 DAT	No. of leaves per plant 90 DAT	Days to 50% flowering
1	Abhilasha	23.3	80.54	4.8	8.53	31.06	54.66	85.33
2	Ananta	21.86	81.33	4.53	8.53	30.23	60.66	76
3	Vishwanath super	20.63	78.40	4.46	8.06	30.3	55.26	74.66
4	Arya	18	83.48	4.6	8.46	25.53	52.66	83
5	Indam-14301	20.93	86.43	4.86	8.3	32.30	50.4	79
6	Brahma	21.2	83.83	4.60	7.53	26	51.13	71
	S.E (m)	1.06	1.73	0.46	0.28	2.09	2.79	3.90
	C.D (5%)	2.37	3.84	1.03	0.63	4.67	6.23	8.70

Table 2b: Mean performance of various genotypes for different characters

Sr. No.	Genotypes	Days to 1st Flowering	Fruit Length (cm)	Fruit Width (cm)	No. of fruit per plant	Average fruit weight	Fruit yield per plant	Days to 1st Harvest	TSS
1	Abhilasha	57.66	19.17	3.57	138.33	188.78	1.59	34.66	3.86
2	Ananta	56.66	18.26	3.82	135.06	178.49	1.72	36.06	6.48
3	Vishwanath super	64.66	20.7	4.72	135.53	175.1	2.09	35.46	5.48
4	Arya	65.33	20.45	4.6	137.76	178.81	2.42	35.36	6.5
5	Indam-14301	51.33	20.34	3.95	138.43	194.3	2.73	37	6.2
6	Brahma	70	21.55	4.1	141	191.18	1.79	40.83	6.65
	S.E (m)	2.07	0.74	0.29	1.38	5.45	0.26	1.63	0.80
	C.D (5%)	4.61	1.64	0.66	3.07	12.14	0.59	3.64	1.78

The average performance of different genotypes for the twelve studied characteristics revealed a significant and diverse range of variability. Analysis of variance demonstrated significant differences among all the genotypes for each characteristic. These findings signify the substantial variability within the genetic material under investigation, which is suitable for conducting additional analyses.

The character plant height ranged from 68.60 to 197.56 cm with a grand mean value of 109.56 cm. Number of branches per plant ranged from 2.43 to 9.83 cm with a grand mean value of 5.89 cm. Number of leaves per plant ranged from 37.60 to 63.13 cm with a grand mean value of 45.40 cm. The grand mean value of number of days required to 1st flowering is 31.62 days ranging from 21.26 to 43.86 days. The grand mean value of number of days required to 50% flowering is 37.13 days ranging from 29 to 52 days. Fruit length ranged from 3.12 to 5.34 cm with a grand mean value of 4.67 cm. Fruit width ranged from 3.47 to 5.94 cm with a grand mean value of 4.47 cm. Number of fruit per plant ranged from 10.58 to 323 cm with a grand mean value of 54.45 cm. The mean average fruit weight is found as 53.87 g with minimum and maximum values of 0.96 g to 194.44 g. Fruit yield per plant ranged from 0.26 kg to 2.28 kg with a mean value of 1.17 kg. The grand mean value of number of days required to 1st fruit harvest is 73.86 days ranging from 69.06 to 82.90 days. The grand mean value of TSS is 4.31ranging from 2.96 to 8.16. In a general sense, when the phenotypic coefficient of variability (PCV) surpasses the genotypic coefficient of variability (GCV), it signifies the substantial impact of the environment on specific traits. However, for all the examined characteristics in this study, we have observed minimal disparities between PCV and GCV values. This suggests that these traits are less susceptible to environmental influence, reinforcing the reliability of selection based on these particular traits. Traits like plant height (28.78%, 28.30%), number of branches per plant (37.30%, 36.86%), number of leaves per plant (14.64%, 11.94%), Days to 50% flowering (13.98%, 12.59%), Days to 1st flowering (14.26%, 11.94%), fruit length (15.59%, 14.71%), fruit width (13.46%, 12.32%), Number of fruit per plant (142.69%, 142.54%), average fruit weight (75.29%, 74.82%) fruit yield per plant (45.30%, 44.82%), days to 1st harvest (4.45%,3.68%), TSS (26.92%, 26.57%) The characters under consideration display a moderate degree of genetic variability, as suggested by their PCV and GCV values.

Heritability estimates play a crucial role in assisting breeders with the selection of genotypes for further utilization. A higher heritability magnitude indicates the significant influence of genotypic factors on the expression of specific traits. Notably, the trait of plant height exhibited the highest heritability estimates. Across all traits, except for days to 50 percent flowering, both high heritability and substantial genetic advancement in percentage of means were observed. These findings are consistent with previous studies conducted by researchers such as Joshi and Singh (2003) [25], Singh *et al*. (2006) [26], Maurya *et al*. (2011) [28] and Tasisa *et al.* (2011) [27].

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