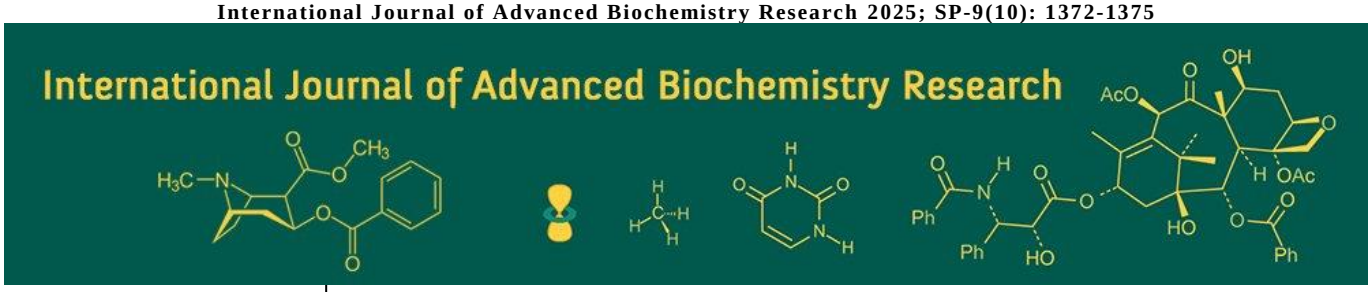

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Studies on genetic variability in tomato (*Solanum lycopersicom* Mill.) Wettsd.

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Abstract
The field experiment was carried out at Horticulture Research Farm No.1, Babasaheb Bhimrao Ambedkar University, Lucknow during *rabi season* 2021-22. In this, twenty genotypes including check cultivars were evaluated to estimate the genetic variability, heritability and genetic advance for different characters. The experiment was laid out in Randomized Block Design (RBD) with three replications. Characters viz., days to 50% flowering, plant height, number of primary branches per plant, polar diameter of fruit, equatorial diameter of fruit, total soluble solids, number of fruits per cluster, average fruit weight, number of fruits per plant, marketable fruit yield per plant and total fruit yield per plant were studied during the experiment. Analysis of variance showed significant differences among genotypes for all the characters under study during the investigation. The Phenotypic coefficient of variance (PCV) was higher than the genotypic coefficient of the variation (GCV) for the characters studied. The highest genotypic coefficient of variation (GCV) was observed for plant height. The moderate GCV was reported for marketable fruit yield per plant followed by average fruit weight, polar diameter of fruit, total fruit yield pre plant, equatorial diameter of fruit, number of primary branch per plant, number of fruit per plant, number of fruits per cluster whereas it was least for TSS followed by days to 50% flowering. Therefore these characters exhibited high heritability coupled with genetic advance thus show some scope for improvement through selection.

Keywords: About tomato, traits, genotypes, heritability, PCV, GCV

Introduction
Tomato (*Solanum lycopersicum* (Mill.) Wettsd.) belongs to the Solanaceae family. Tomatoes are one of the most widely farmed vegetables in the world, both for fresh markets and the processing sector. It is mostly cultivated in open fields, green houses, and net homes. It ranks third in vegetable output behind potatoes and sweet potatoes, but first in processed vegetables. China is the leading tomato producing country, followed by India, the United States, Spain, and Egypt. Tomato output in the world totals 38.82 million metric tonnes. India's total area is 27.77 million hectares, and output is 22.28 million tonnes, with a productivity of 25.74 tonnes per hectare, which is significantly lower than the global average. According to an APEDA Agri Exchange (2021-2022) study, the major states involved in tomato production in India are Madhya Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu, and Orissa, with 14.63%, 10.92%, 10.23%, and 7.34%, respectively.
Tomatoes, being a self-pollinated crop, have a remarkable potential for heterosis breeding and are employed in many breeding programmes. Tomato variability is predicted to be considerable, as the fruits vary significantly in shape and size (Bhardwaj and Sharma, 2005). To increase tomato production, the major focus should be on crop genetic improvement and the generation of improved varieties by selection across and within populations using available genetic variability. Because yield is the primary goal of a breeder, it is critical to understand the link between various traits that contribute to production. Genetic factors such as the genotypic and phenotypic coefficients of variation (GCV and PCV) can be used to detect variability. Heritability and genetic advancement aid in assessing the effect of environment on character expression and the extent to which improvement is feasible following selection (H.F. Robinson *et al.*, 1949) [6]. As a result, the study was conducted in tomato with the goal of estimating the phenotypic coefficient of variation, genotypic coefficient of variation, heritability, and genetic progress.

Materials and Methods

This experiment was examined out at the Horticultural Research Farm No.1 of the Department of Horticulture of Babasaheb Bhimrao Ambedkar University, Lucknow, on a well-leveled field with appropriate drainage facilities during the Rabi Season 2021-22. The experimental material included 20 genotypes with two check cultivars NDT-4© and NDT-7©. Geographically, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya-Vihar, Rae Bareli Road, Lucknow, is located at 80.52' east longitude; 26.56' north latitude and 111 metres above mean sea level (MSL), lies is in upper Gangetic Alluvial Plain and it has a humid subtropical climate.

Experimental Details

In this experiment there are 20 genotypes of tomato including two checks which were maintain by ANDUAT, Kumarganj, Ayodhya were collected for the examination. The list of genotypes used in this experiment are mentioned in Table 1. The experiment used randomized block design (RBD), with three replications for each treatment. On November 2021, the plants were transplanted. The spacing between rows and between plants was set at 60 cm and 45cm, respectively. Each plot is 2.0 m X 2.0 m in size and accommodated 16 seedlings.

Parameter Recorded

In this study, 10 characters were studied from 16 sample plants in each net plot and the results were expressed as mean values. List of characters for experimental analysis during the trial are Days to 50% flowering, Plant height (cm), Number of primary branches per plant, Polar diameter of fruit (cm), Equatorial diameter, TSS (^{0} B), Number of fruit per cluster, Average fruit weight (gm), Number of fruits per plant, Marketable fruit yield per plant (kg),Total fruit yield per plant (kg) All the data represent per plant observation except for marketable fruit yield which are computed from net plot observation and days to flowering and maturity were computed on the basis of harvestable rows in each net plot.

Results and Discussion

Analysis of variance for 10 characters revealed that mean squares due to treatments were highly significant for all the traits showing the existence of sufficient variability in the genotypes. Mean performance for the character days to 50% flowering ranged from 29.65-38.33. The genotype NDT-47 (29.65 days) took minimum days to reach 50% flowering whereas NCT-1 and NCT-2 (38.33 days) recorded the maximum days for50% flowering. Comparison to genotypes for plant height, the mean ranged from 74.60-178.8 Maximum plant height was recorded inNDT-52 (178.8 cm) and the minimum was recorded in NDT-5-1-1 (74.60 cm). Data recorded for the no. of primary branches per plant ranged from 3.37-7.77. NDT-P (3.37) andNDT-38 (7.77) had minimum and maximum no. of primary branches per plant respectively. The mean range for polar diameter of fruit was recorded from 3.47-8.37. NDT-P (8.37 cm) had the maximum polar diameter of the fruit which was superior over other genotypes and NDT-27 (3.47 cm) showed the minimum polar diameter of the fruit. Data recorded for equatorial diameter of the fruit ranged from 3.87-8.17. Among all the genotype studied, NDT-8 (3.87 cm) recorded for minimum equatorial fruit diameter and NDT-P (8.17cm) showed maximum equatorial diameter of the fruit. The TSS among all genotypes varied from 4.87-6.73. In which the highest TSS was recorded for NDT-2 (6.73^{0}B) and the minimum content was found in NDT-38 (4.87^{0}B). Data recorded for the number of fruits per cluster ranged from 3.63-5.10. Among all genotypes, the maximum fruit per cluster was recorded inNDT-5 (5.10) and the minimum was recorded in NCT-1 (3.63). Average fruit weight ranged from 35.90-83.27 among all the studied genotypes. In which NDT-8 (35.90g) possesed minimum average fruit weight and NDT-5-1-1 (83.27 g) possesed maximum average fruit weight. The mean values for number of fruits per plant and the maximum no. of fruits per plant was recorded in NDT-7 © (66.12). Marketable fruit yield per plant among all genotypes varied from 1.51-4.28. Highest marketable fruit yield per plant was recorded in NDT-45 (4.28) and the least marketable fruit yield per plant was observed in NDT-27 (1.51). Maximum and minimum total fruit yield per plant was seen in NDT-45(4.55) and minimum no. of total fruit yield per plant was observed in NDT-27 (1.71) respectively.

Parameters of variability

The parameters of variability i.e., mean range, coefficients of variation (genotypic and phenotypic), heritability (broad sense), genetic advance and genetic gain were worked out for various characters (Table 4).

1. Genetic variability

For all characters, the mean sums of squares linked to treatments were extremely significant. In other words, the genotypes' performance on these traits was statistically significant indicating that there is plenty of room for selection in several qualities for tomato improvement. But to know the absolute extent of the variability the phenotypic coefficient of variance and genotypic coefficient of variance was calculated.

The genotypic coefficient of variation (G.C.V.) was lower than the phenotypic coefficient of variation (P.C.V.), suggesting that the environment had a role in the expression of the features under observation. As a result, the variances in P.C.V. and G.C.V values for all characters are minor. The difference in P.C.V and G.C.V value observed for different morphological traits suggest that characters will demonstrate notable genetic advancement. As result of the additive gene effect, it is obvious that selection based on phenotypic values for these qualities may be useful in improving these characters. The highest phenotypic coefficient of variation (PCV) was recorded in plant height i.e., 28.21% which was followed by marketable fruit yield per plant 27.31%.The least PCV was observed in TSS (7.74) which was followed by day to 50% flowering (8.01%).The genotypic coefficient of variation (GCV) result showed that the plant height had the highest GCV (27.45%) and was followed by marketable fruit yield per plant (26.18%) whereas the least genotypic coefficient of variation was observed in TSS 5,51 followed by day to 50% flowering 5.26% .The moderate to low variation observed for their attributes suggested that there is substantial room for improvement. Madhurina (2012) [11] found similar results in their research.

Table 1: List of tomato genotypes used in the present study

S. N.	Name of genotypes	Source of origin
1.	NDT-2	A.N.D.U.A.&T, Ayodhya
2.	NDT-p	A.N.D.U.A.&T, Ayodhya
3.	NDT-5	A.N.D.U.A.&T, Ayodhya
4.	NDT-6	A.N.D.U.A.&T, Ayodhya
5.	NDT-8	A.N.D.U.A.&T, Ayodhya
6.	NDT-5-1-1	A.N.D.U.A.&T, Ayodhya
7.	NDT-67	A.N.D.U.A.&T, Ayodhya
8.	NDT-45	A.N.D.U.A.&T, Ayodhya
9.	NDT-27	A.N.D.U.A.&T, Ayodhya
10.	NCT-2	A.N.D.U.A.&T, Ayodhya
11.	NCT-1	A.N.D.U.A.&T, Ayodhya
12.	NDT-56	A.N.D.U.A.&T, Ayodhya
13.	NDT-17	A.N.D.U.A.&T, Ayodhya
14.	NDT-15	A.N.D.U.A.&T, Ayodhya
15.	NDT-52	A.N.D.U.A.&T, Ayodhya
16.	NDT-25	A.N.D.U.A.&T, Ayodhya
17.	NDT-47	A.N.D.U.A.&T, Ayodhya
18.	NDT-38	A.N.D.U.A.&T, Ayodhya
19	NDT-4 ©	A.N.D.U.A.&T, Ayodhya
20	NDT-7 ©	A.N.D.U.A.&T, Ayodhya

Table 2: Mean performances of different tomato genotypes with respect to the various traits

Source of variation	D.F	Days to 50% flowering	Plant height (cm)	Number of primary branches per plan	Polar diameter of fruit (cm)	Equatorial diameter of fruit (cm)	TSS (0B)	Number of fruits/cluster	Average fruits weight (gm)	Number of fruits/plant	Marketable fruits yield/plant (kg)	Total yield [fruit per plant (kg)]
Replication	2	8.00	54.79	0.32	0.70	0.24	0.09	0.14	0.87	3.01	0.36	0.72
Treatment	19	14.75**	3864.97**	3.96**	5.50**	4.57**	0.45**	0.56**	565.36**	210.43**	1.30**	1.30**
Error	38	4.50	71.06	0.18	0.22	0.16	0.11	0.12	8.23	9.30	0.04	0.04
Total	59	8.26	1305.83	1.40	1.93	1.58	0.22	0.27	187.39	73.86	0.45	0.47

DF: Degree of freedom, TSS: Total Soluble Solids
, * significant at 5% and 1% level, respectively

Table 3: Mean performance of different tomato genotypes with respect to the various traits

S. N	Genotypes	Days to 50% flowering	Plant height (cm)	Number of primary branches per plan	Polar diameter of fruit (cm)	Equatorial diameter of fruit (cm)	TSS (0B)	Number of fruits/cluster	Average fruits weight (gm)	Number of fruits/plant	Marketable fruits yield/plant (kg)	Total yield [fruit per plant (kg)]
1	NDT-2	37.33	93.83	4.20	4.73	5.10	6.73	4.50	38.60	61.95	1.73	2.12
2	NDT-P	36.67	162.63	3.77	8.37	8.17	6.20	3.83	66.97	61.13	3.39	3.65
3	NDT-5	35.20	143.90	5.53	4.97	5.90	6.17	5.10	58.85	58.07	2.74	3.08
4	NDT-6	35.67	125.17	4.33	4.47	5.10	6.53	4.13	45.47	63.72	2.50	2.73
5	NDT-8	33.67	169.50	3.53	3.73	3.87	6.10	4.40	35.90	60.12	1.91	2.21
6	NDT-5-1-1	31.00	74.60	5.33	7.63	8.00	6.00	4.63	83.27	38.33	2.38	2.70
7	NDT-67	34.33	84.47	3.37	4.77	4.90	6.00	4.70	38.33	60.63	2.16	2.48
8	NDT-45	35.67	86.83	6.60	8.20	7.87	6.13	5.03	78.13	60.15	4.28	4.55
9	NDT-27	37.00	166.63	7.10	3.47	4.87	6.23	4.83	36.73	55.27	1.51	1.71
10	NCT-2	38.33	83.90	5.37	5.40	3.87	5.73	4.03	58.80	56.32	2.99	3.43
11	NCT-1	38.33	95.27	4.30	6.50	4.80	6.10	3.63	71.73	45.72	2.47	2.81
12	NDT-56	35.33	159.47	5.80	5.50	5.90	6.17	4.23	57.07	38.13	1.92	2.25
13	NDT-17	33.00	162.53	5.30	4.90	5.83	6.00	3.93	58.35	47.94	2.34	2.72
14	NDT-15	35.00	160.83	4.77	5.27	6.37	6.23	4.03	47.75	57.12	2.31	2.66
15	NDT-52	34.33	178.80	5.90	5.27	5.97	5.87	4.03	60.24	61.36	3.06	3.35
16	NDT-25	37.00	158.30	4.60	4.97	6.70	6.23	3.93	48.12	56.13	2.70	3.08
17	NDT-47	29.67	107.97	5.07	6.23	6.90	6.67	4.53	68.95	45.52	2.24	2.51
18	NDT-38	35.67	131.67	7.77	4.97	5.87	4.87	3.70	56.77	61.73	3.02	3.22
19	NDT4©	33.67	154.00	4.35	3.90	5.60	5.77	4.63	46.18	46.52	1.61	1.86
20	NDT-7 ©	36.00	90.90	4.93	5.47	4.97	6.17	4.00	48.61	66.12	2.30	2.64
	Mean	35.14	129.56	5.10	5.44	5.83	6.10	4.29	55.24	55.10	2.48	2.79
	Min	29.67	74.60	3.37	3.47	3.87	4.87	3.63	35.90	38.13	1.51	1.71
	Max	38.33	178.80	7.77	8.37	8.17	6.73	5.10	83.27	66.12	4.28	4.55
	SE(d)	1.73	6.88	0.35	0.38	0.33	0.27	0.29	2.34	2.49	0.16	0.16
	C.D.	3.52	13.99	0.71	0.77	0.66	0.55	0.58	4.76	5.06	0.32	0.33a
	C.V.	6.04	6.51	8.41	8.55	6.84	5.43	8.15	5.19	5.53	7.78	7.15

Table 4: Mean, Range, Genotypic and Phenotypic coefficient of Variance, Heritability, and Genetic Advance in percentage of mean of different traits of Tomato

Genotypes	Mean	Min	Max	Var (g)	Var (p)	Heritability (%)	GA	GA% mean	GCV (%)	PCV (%)	ECV (%)	% Cont
Days to 50% flowering	35.14	29.67	38.33	3.42	7.91	43.17	2.50	7.12	5.26	8.01	6.03	13.56
Plant height (cm)	129.56	74.60	178.80	1264.64	1335.69	94.68	71.28	55.02	27.45	28.21	6.51	7.51
Number of primary branches/plan	5.10	3.37	7.77	1.26	1.44	87.27	2.16	42.37	22.02	23.57	8.41	9.47
Polar diameter of fruit (cm)	5.44	3.47	8.37	1.76	1.98	89.09	2.58	47.49	24.43	25.88	8.55	10.07
Equatorial diameter of fruit (cm)	5.83	3.87	8.17	1.47	1.63	90.25	2.37	40.74	20.82	21.91	6.84	8.51
TSS (0B)	6.10	4.87	6.73	0.11	0.22	50.74	0.49	8.09	5.51	7.74	5.43	12.60
Number of fruit/cluster	4.29	3.63	5.10	0.15	0.27	54.65	0.58	13.62	8.94	12.10	8.15	10.07
Average fruits weight (gm)	55.24	35.90	83.27	185.71	193.94	95.76	27.47	49.73	24.67	25.21	5.19	6.82
Number of fruits/plant	55.10	38.13	66.12	67.04	76.34	87.82	15.81	28.69	14.86	15.86	5.53	3.85
Marketable fruits yield/plant (kg)	2.48	1.51	4.28	0.42	0.46	91.90	1.28	51.70	26.18	27.31	7.77	8.40
Total yield [fruit per plant (kg)]	2.79	1.71	4.55	0.42	0.46	91.37	1.28	45.79	23.25	24.33	7.15	9.14

3.2 Heritability

The present investigation revealed that low to high heritability estimates represent in almost all the characters. The heritability estimates for characters ranged from 43.17 to 95.76 percent. High heritability recorded for average fruit weight (95.76) followed by plant height (94.68), marketable fruit yield per plant (91.90), total fruit yield per plant (91.37), equatorial diameter of fruit (90.25), polar diameter of fruit (89.09), number of fruit per plant (87.82),number of primary branches/plant (87.27), number of fruit per cluster (54.65), TSS (50.74), The days to 50% flowering showed to have least heritability (43.17). This result was found in accordance with Sushma *et al.*, 2020 [9]. It was obvious that improvement of the character exhibiting high heritability would be more efficient by adopting normal selection procedures were used, but improving those with low heritability would necessitate the use of other suitable breeding approaches, such as a population improvement programme.

3.3 Genetic advance and genetic gain

The genetic gain (genetic advance expressed in the percentage of the population mean) was ranged from 7.17 to 55.02%. High heritability combined with high genetic was found for Plant height (55.02), marketable fruit yield per plant(51.70), average fruit weight (49.73), polar diameter of fruit (47.49), total fruit yield per plant (45.79), number of primary branches per plant (42.37) equatorial diameter of fruit (40.74). Moderate heritability with high genetic advance was recorded for number of fruit per plant (28.69), and number of fruits per plant (13.62), total soluble solids (8.09). While least heritability was observed in days to 50% flowering (7.17). Plant height had the most genetic diversity, followed by marketable fruit yield per plant. Prema *et al.* (2011) [10] found similar results in their research.

4. Conclusion

The primary purpose of the study was to find significant variation, heritability, and genetic advances in the numerous genotype traits studied. The outcomes of the study can be utilized to guide future tomato breeding initiatives. We identified significant genetic variety in the variables studied. Except for Days to 50% flowering (43.17%), all characteristics had high heritability along with high genetic progress. As an outcome of the high heritability and genetic advancement of these features, selection may successfully improve the attributes to increase tomato yield. The data presented above confirmed that additive gene activity and the suggested parameters would be beneficial for future enhancement.

5. Competing Interests

Authors have declared that no competing interests exist.

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