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Nisha Kataria
Department of Horticulture, University College of Agriculture, Guru Kashi University, Talwandi Sabo, Bathinda, Punjab, India

Simranpreet Kaur
Student M.sc., (Vegetable science) Horticulture Guru Kashi University, Talwandi Sabo Bathinda Punjab, India

Khushveer Singh
Student M.sc., (Vegetable science) Horticulture Guru Kashi University, Talwandi Sabo Bathinda Punjab, India

Navdeep Singh
Assistant Professor, Horticulture Guru Kashi University, Talwandi Sabo Bathinda Punjab, India

Corresponding Author:
Nisha Kataria
Department of Horticulture, University College of Agriculture, Guru Kashi University, Talwandi Sabo, Bathinda, Punjab, India

Genetic variability for growth and yield traits in tomato (*Lycopersicon esculentum*)

Nisha Kataria, Simranpreet Kaur, Khushveer Singh and Navdeep Singh

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Abstract
The present study Genetic Variability for growth and yield traits in Tomato was carried out to investigate yield and quality traits in tomato, in order to generate information regarding the extent of genetic variability, heritability and genetic gain. The experiment conducted on January, 2024 in two row spacing of 45 cm, All rows on which transplanting were done on raised bed to facilitate irrigation and other cultural operation. The treatments were planted in Randomized Block Design with three replications. Observations were recorded on twelve quantitative characters of tomato and these recorded data utilized for estimation of genotypic and phenotypic coefficient of variation, heritability in broad sense, genetic advance, genetic advance in percent of mean, genotypic and phenotypic correlation coefficients and genetic divergence. The analysis of variance of the experiment indicated highly significant differences among twelve genotypes of germplasm collection for all the characters studied. Average fruit weight, number of fruits per plant, locules per fruit, number of primary branches per plant, and total fruit output per plant all showed high heritability combined with high genetic progress, suggesting a strong selection response, these features would be beneficial for increasing tomato productivity since polar and equatorial fruit diameter, average fruit weight, and TSS have a positive, substantial, and favorable correlation with total fruit yield. High magnitude of phenotypic coefficients of variation was observed in case of total fruit yield per plant followed by equatorial diameter of fruit, average fruit weight, plant height, number of primary branches per plant, p Rick. C. M. (1976). Tomato, Evaluation of crop plant, Longman, London. 273-286. olar diameter of fruit and locules per fruit, pericarp thickness and number of fruits per plant while opposite in genotypic coefficient. Substantial positive indirect effect via average fruit weight, equatorial diameter of fruit, polar diameter of fruit, number of primary branches per plant, days to first fruit harvest, plant height were exerted by total fruit yield per plant on average fruit yield per plant. Genetic parameters in association with correlation study indicated that for selection of superior genotypes primary emphasis should be given on fruit yield per plant and average fruit weight.

Keywords: Tomato, variability, range, heritability, genetic gain, yield and phenotypic

Introduction
Vegetables in India are considered to become an important part in the Diet of Indian people, as majority of them are vegetarian. Vegetables are an excellent source of lipids, carbs, protein, vitamins, minerals, and crude fibers. During Vegetables not only offer a diet's nutritional value but also diversity in taste, color, and texture. India holds the distinction of being the world's second-largest producer of vegetables, after China. India's diverse agroclimatic conditions lend themselves to the cultivation of a wide range of vegetable crops, and extensive research has been done in the fields of vegetable breeding, production technology, plant protection, seed production, and post-harvest technology (Passam *et al*. 2007) [1]. Tomato (*Lycopersicon esculentum*) a member of family solanaceae is a herbaceous, annual, prostrate and sexually propagated vegetable having an identical genome formula 2N= 2X= 24. It has tap root with bisexual hypogenous flowers. The growth habit of the plant determinate or indeterminate. Scientific information indicates that cultivated tomato was originated in South Western (Tropical) America (Rick, 1976; 1983) [2], most probably in the Peru - Ecuador region (Kalloo *et al*. 2001) [3]. Tomato has a glorious position among the vegetables and is treated as “protective food" all over the world. It is cultivated extensively through out the world not only for good source of nutrition to the consumer but also for its higher returns to small and marginal farmers. Tomato is used as fresh vegetable and is also

very important for processing purposes like soup, pickeles, ketchup, sauce concentrates, puree, juice etc. One hundred gram ripe tomato fruit contains 93.1% moisture, 3.6 g carbohydrate, 1.9 g protein, 1.9 g fat, 320 I.U. vitamin- A, 31 mg vitamin-C, vitamin-B (Thiamine-0.07 mg and Riboflavin 0.01 mg), 15-30 mg 100g ascorbic acid and other minerals. Tomatoes are abundant in therapeutic properties. Both the pulp and juice are easily digested, stimulating stomach secretion and acting as a blood purifier. It is claimed to be helpful against oral cancer, sour mouth, etc. It is among the greatest vegetables for maintaining the health of our intestines and stomach. It is one of the most popular and widely cultivated vegetables in the world, and in India, it is the second most important vegetable after potato. Globally, 4.85 million hectares area is under tomato crop cultivation, with a total yield of 179.51 million tonnes and a productivity of 37.05 tonnes per hectare. India's overall tomato area is 0.789 million hectares, with a production of 19.75 million tonnes and productivity of 21.36 tonnes per hectare, which is exceedingly low when compared to global productivity averages (Yadav *et al*. 2022) [4]. This is significantly lower than the global average productivity. Major tomato-producing states in India include Andhra Pradesh, Madhya Pradesh, Karnataka, and Orissa. Every tomato species is indigenous to Western and Southern America.

Objectives

1. To assess the genetic variability, heritability and genetic advance for tomato fruit yield and it's contributing characters in tomato.
2. To estimate co-efficient of correlation for tomato fruit yield and its components.
3. To estimate extent of genetic divergence among the available tomato genotypes.

Materials and Methods

The Guru Kashi University, situated in Talwandi Sabo, Bathinda, was selected as the experimental location for this research. The station, which covers an area of more than 80 acres, is distinguished by an effective irrigation system. Its geographic coordinates are 208 meters above mean sea level and 29°57'38.3"N 75°07'20.3"E. The agricultural farm is located on the main campus of university.

The experiment was conducted to evaluate 20 genotypes of tomato, Seeds were sown in nursery bed on 27th December, 2023 and 25 days old healthy seedlings were transplanted in the experimental field on 23th January, 2024 in two row spacing of 45 cm, respectively. All rows on which transplanting were done on raised bed to facilitate irrigation and other cultural operation. The 20 treatments were planted in Randomized Block Design with three replication. Observations were recorded on five plants from each genotype. Plant height (cm),Number of primary branches, pH level, TSS, Ascorbic acid, Polar diameter (cm), Equatorial Diameter (cm), Pericarp thickness (cm), Number of locules, Days to first fruit harvest, Average fruit weight, Total Fruit yield per plant.

Results and Discussion

To determine the significance of the genotype differences, an analysis of variance was applied to the data collected on fourteen quantitative characters. (Table 1) Analysis of variance showed that the mean squares associated with genotypes were significant for each of the twelve characters, suggesting that there is a good deal of diversity among the genotypes for each character. The assessment of existing variability in the material was done by computing coefficients of variation at genotypic and phenotypic level (Burton and de Vane, 1953) [5]. The heritability in broad sense (Hanson *et al*., 1956) [6] and genetic advance in percent of mean (Johnson *et al*., 1955) [7] were calculated to understand the transmissibility of characters. The nature of associations among different characters was studied by using phenotypic and genotypic correlations (Wright 1921, Dewey and Lu, 1959) [8, 10] and genetic divergence (Rao, 1952) [9]. The salient features of the results have been discussed under the following sub-heads.

Mean performance of genotypes

Mean performance of genotypes in respects of twelve characters has been presented in Table-2 and the same is described head wise in the ensuing paragraphs.

Mean performance of genotypes in respects of twelve characters has been presented in Table-2 and the same is described head wise in the ensuing paragraphs.

Plant height (cm)

The plant height ranged from 65.5 (S13) to 149.1 (S3). The grand mean for this character is 86.44. Five genotypes *viz*., S6 (90.87), S20 (95.53), S9 (92.6), S8 (123.87) and S15 (136.13) were found significant over best check S3 (149.1).

Number of primary branches

The primary branches per plant ranged from 3.27 (EC 66883) to 6.67 (S15). The grand mean for this character is 4.54. Eight genotypes *viz*. S16, S10, S8, S12, S7, S14 and S13 were found significant over best check S15.

Days to first fruit harvest: Days to first harvest ranged from 72.33 (S3) to 93.33 (S5). The grand mean for this character is 81.44. Five genotypes *viz*. S19 (83.02), S4 (83.02), S1 (92.33), S2 (93.00) and S5 (93.33) were found significant over the best checks S13 (80.47).

Average fruit weight: The average fruit weight ranged from 34.33 (S19) to 118.33 (S15). The grand mean for this character is 60.29. Nine genotypes *viz*. S9 (60.33), S13 (60.33), S8 (64.67), S2 (63.52), S7 (64.67), S6 (68.67), S17 (95.03), S16 (118.33) and S15 (113.33) were found significant Moreover the best check S3 (48.24).

pH level

pH level from 4.02 (S15) to 5.9 (S6). The grand mean for this character is 4.49. Nineteen genotypes *viz*. S6, S10, S2, S19, S3, S9, S12, S14, S20, S13, S11, S4, S1, S18, S8, S17, S16, S5, S7 were found more pH levels than lower one.

TSS: Total soluble solids ranged from 3.12 (S12) to 5.46 (S1). The grand mean for this character is 4.17. Nine genotypes *viz*. S1 (5.46), S5 (5.45), S4 (4.85), S2 (4.83), S8 (4.73), S6 (4.7), S7 (4.61), S18 (4.3), S13 (4.25) were found significant over the best check S14 (4.12).

Polar diameter

The polar diameter of fruit ranged from 3.39 (S20) to 7.66 (S10). The grand mean for this character is 5.22. Nine genotypes *viz*., S10 (7.66), S2 (6.64), S8 (6.57), S16 (6.54),

S9 (6.21), S19 (5.95), S11 (5.69), S13 (5.49) and S15 (5.48) were found significant over best check S17 (5.22).

Equatorial diameter (cm)

The equatorial diameter of fruit ranged from 3.50 (S17) to 7.13 (S2). The grand mean for this character is 5.31. Ten genotypes *viz*. S2 (7.13), S8 (7.05), S11 (6.43), S9 (6.38), S18 (6.26), S16 (6.22), S10 (6.02), S12 (5.62), S5 (5.57), S4 (5.36) were found significant over best check S14 (5.22).

Pericarp thickness (cm)

The pericarp thickness ranged from 2.50 (S11) to 7.1 (S20). The grand mean for this character is 4.61.Eleven genotypes *viz*. S20, S12, S9, S8, S15, S13, S1, S10, S6, S19 and S4 were found significant over the best check S7(4.1).

Number of Locules

The lowest number of locules per fruit was found 2 (S11), while the highest number of locules were found 5.33 (S1). The grand mean for this character is 3.87. None of the genotypes were found significant over the best check S1 (5.33).

Total fruit yield per plant

The number of fruits ranged from 1 (S18) to 3.7 (S2). The grand mean for this character is 2.08. Nine genotypes such as S2, S4, S3, S13, S8, S15, S6, S7 and S16 were found significant over the best check S5 (2.04).

Ascorbic Acid

Ascorbic acid ranged from 17.71 (S5) to 36.41 (S13). The grand mean for this character is 28.38. Ten genotypes *viz*. S13 (36.41), S7 (34.35), S15 (34.01), S17 (33.15), S19 (33.15), S11), S9 (32.5), S14 (32.12), S8 (31.49) and S12 (29.42) were found significant over the best check NDT-4 (21.70). The mean performance of 20 genotypes of tomato for twelve characters is presented in Table 2. A very wide range of variation in mean performance of genotypes was observed for all the characters under study. The comparison of mean performance of 20 genotypes for twelve traits using critical differences revealed existence of very high level of variability in the used genotypes.

Table 1: Mean performance for twelve characters in Tomato

Genotypes	Plant height (cm)	Number of primary branches	pH level	TSS	Ascorbic Acid (mg)	Polar diameter	Equatorial diameter (cm)	Pericarp thickness (cm)	Number of Locules	Day s to first fruit harvest	Ave rage fruit weight	Total fruit yield per plant (kg)
S1	80.54	3.71	4.38	5.46	18.01	4.02	4.03	5.02	5.33	92.33	35.02	1.93
S2	73.99	3.40	4.57	4.83	23.73	6.64	7.13	2.85	3.98	93.00	63.52	3.70
S3	149.10	4.41	4.55	3.51	22.65	5.03	5.07	3.63	3.71	72.33	48.24	2.73
S4	76.03	3.61	4.39	4.85	17.71	4.37	5.36	4.71	3.50	83.02	53.37	3.19
S5	72.36	3.93	4.28	5.45	19.36	5.07	5.57	2.55	4.94	93.33	55.84	2.04
S6	90.87	3.27	5.90	4.70	26.96	4.29	4.47	5.00	3.00	80.47	68.67	2.53
S7	83.27	5.33	4.25	4.61	34.35	4.49	4.59	4.10	4.00	79.53	64.67	2.33
S8	123.87	5.27	4.38	4.73	31.49	6.57	7.05	6.20	3.00	78.80	61.67	2.60
S9	92.60	4.33	4.55	4.10	32.50	6.21	6.38	6.30	2.00	79.07	60.33	1.87
S10	81.00	5.27	4.57	3.90	27.45	7.66	6.02	5.00	4.15	79.87	55.67	1.33
S11	72.60	4.80	4.40	3.13	32.55	5.69	6.43	2.50	2.00	78.23	47.00	1.33
S12	78.40	5.33	4.52	3.12	29.42	4.17	5.62	6.59	3.00	79.63	37.33	1.38
S13	65.53	5.87	4.50	4.25	36.41	5.49	4.70	5.12	4.98	80.47	60.33	2.67
S14	67.67	5.73	4.50	4.12	32.12	3.68	5.22	4.00	3.97	78.03	37.00	1.67
S15	136.13	6.67	4.02	4.12	34.01	5.48	4.70	5.23	4.85	80.23	118.33	2.60
S16	68.93	5.00	4.37	3.91	27.34	6.54	6.22	4.02	4.00	79.52	113.33	2.27
S17	72.33	4.13	4.38	4.10	33.15	5.22	3.50	4.00	5.00	78.23	95.03	1.89
S18	70.33	3.27	4.38	4.30	27.63	4.62	6.26	3.41	3.56	79.52	41.52	1.00
S19	83.93	3.40	4.55	3.20	33.15	5.95	4.08	5.00	4.52	83.02	34.33	1.10
S20	95.53	4.13	4.50	3.20	27.63	3.39	3.96	7.10	4.00	80.23	54.67	1.47
SE	4.17	0.26	0.67	0.16	0.35	0.44	0.24	0.26	0.33	3.35	2.08	0.16
CV	4.19	5.37	4.51	3.51	2.03	10.09	5.53	7.26	0.84	4.83	4.56	3.51

Table 2: Estimates of Range, Grand mean, Phenotypic and Genotypic coefficients of variation, Heritability in broad sense(h2bs) and Genetic advance in percent of mean (GA) for 12 characters in tomato

S. No.	Genotypes Characters	Range		Grand Mean	PCV (%)	GCV (%)	ECV (%)	Heritability in Broad sense (%)	Genetic Advance	Genetic advance in percent mean
		Lowest	Highest							
1.	Plant height (cm)	65.5	149.1	86.75	24.295	24.282	0.782	99.9	2.06	2.37
2.	Number of primary branches	3.27	6.67	4.54	44.145	43.031	9.851	97.5	2.01	44.23
3.	pH level	4.02	5.9	4.49	28.084	27.638	4.980	98.4	2.03	45.15
4.	TSS	3.12	5.46	4.17	16.087	15.907	2.398	98.9	2.04	48.85
5.	Ascorbic Acid	17.71	36.41	28.38	37.209	37.144	2.200	99.8	2.06	7.25
6.	Polar diameter	3.39	7.66	5.22	93.091	92.319	11.964	99.2	2.04	39.14
7.	Equatorial diameter (cm)	3.5	7.13	5.31	142.771	142.621	6.524	99.9	2.06	38.75
8.	Pericarp thickness (cm)	2.5	4	4.61	106.894	104.692	21.583	97.9	2.02	43.77
9.	Number of Locules	2	5.33	3.87	73.299	73.025	6.329	99.6	2.05	53.03
10.	Days to first fruit harvest	72.33	93.33	81.44	3.910	3.801	0.919	97.2	2.00	2.46
11.	Average fruit weight	34.33	118.33	60.29	14.408	14.374	0.995	99.8	2.06	3.41
12.	Total fruit yield per plant	1	3.7	2.08	266.035	264.860	24.982	99.6	2.05	98.60

Conclusion

The experiment was conducted to evaluate twenrty genotypes of tomato; Seedlings were transplanted in the experimental field on 23th January, 2024 in two row spacing of 45 cm, respectively. All rows on which transplanting were done on raised bed to facilitate irrigation and other cultural operation. The treatments were planted in Randomized Block Design with three replications. All recommended cultural practices were followed to maintain good crop stand and growth of the plants.

1. To assess the genetic variability, heritability and genetic advance for tomato fruit yield and it's contributing characters in tomato.
2. To estimate co-efficient of correlation for tomato fruit yield and its components.
3. To estimate extent of genetic divergence among the available tomato genotypes.

Observations were recorded on twelve quantitative characters *viz*. Plant height, Number of primary branches, Days to first fruit harvest, Average fruit weight, pH level, TSS, Polar diameter, Equatorial diameter (cm), Pericarp thickness (cm), Number of Locules, Total fruit yield per plant (kg) and Ascorbic Acid. The data on twelve quantitative characters were utilized for estimation of genotypic and phenotypic coefficient of variation, heritability in broad sense, genetic advance, genetic advance in percent of mean, genotypic and phenotypic correlation coefficients and genetic divergence. The salient findings of the study and conclusion drawn are summarized below:

1. The analysis of variance of the experiment indicated highly significant differences among twelve genotypes of germplasm collection for all the characters studied.
2. Based on performance, the genotypes S2, S4, S3, S13, S15, S8, S6, S7, S16 and S5 significantly out yielded in respect of all genotypes
3. High magnitude of phenotypic coefficients of variation was observed in case of total fruit yield per plant followed by equatorial diameter of fruit, average fruit weight, plant height, number of primary branches per plant, polar diameter of fruit and locules per fruit, pericarp thickness and number of fruits per plant while high magnitude of genotypic coefficient of variation was observed in case of total fruit yield per plant followed by equatorial diameter of fruit, average fruit weight, plant height, number of primary branch per plant, polar diameter of fruit, locules per fruit, number of fruits per plant and pericarp thickness are indicating possibility of obtaining higher selection response in respect of these traits. Moderate variation was found between ascorbic acid and TSS. The occurrence of moderate value for these parameters revealed reasonable scope of improvement through selection. Days to first fruit harvest, exhibited low value of GCV and PCV and likely to show less response under selection
4. All of the traits showed high heritability. Average fruit weight, number of fruits per plant, locules per fruit, number of primary branches per plant, and total fruit output per plant all showed high heritability combined with high genetic progress, suggesting a strong selection response.
5. Strong intrinsic relationships between various pairs of attributes were suggested by genotypic correlation coefficients that were generally greater than the matching phenotypic correlation coefficients. Selection of these features would be beneficial for increasing tomato productivity since polar and equatorial fruit diameter, average fruit weight, and TSS have a positive, substantial, and favorable correlation with total fruit yield.
6. Total fruit yield per plant and average fruit weight were identified as most important traits which had positive direct effect on TSS and ascorbic acid. Substantial positive indirect effect via average fruit weight, equatorial diameter of fruit, polar diameter of fruit, number of primary branches per plant, days to first fruit harvest, plant height were exerted by total fruit yield per plant on average fruit yield per plant.

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