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Assessment of genetic variability for quality traits in F_1 generation tomato (*Solanum lycopersicum* L.) grown under polyhouse conditions

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Abstract
This study aimed to assess genetic variability, heritability, and genetic advance in tomato (*Solanum lycopersicum* L.) genotypes to identify key traits for breeding programs. Ten parent and their twenty-one hybrids which were developed through line x tester design were examined under polyhouse conditions. Significant differences across all traits were observed in the analysis of variance, demonstrating ample genetic variability. High phenotypic and genotypic coefficients of variation for traits like lycopene content (mg/100 g), titrable acidity (%) and beta-carotene (mg/100 g) indicated strong potential for improvement through selection. All the traits exhibited high heritability, among which titrable acidity and lycopene, reflecting a strong genetic influence. All the traits also showed high genetic advance as a percent of the mean, emphasizing their suitability for genetic enhancement. Traits with high heritability and genetic advance were identified as ideal for selection in breeding efforts.

Keywords: Tomato, GCV, PCV, heritability, genetic advance and genetic variability

Introduction
Tomato (*Solanum lycopersicum* L.) is the second most popular vegetable in the world after potato. It belongs to the large Solanaceae family with chromosome number 2n=24 (x=12) and originated from South America. Tomato is a self-pollinated warm-season crop equitably resistant to heat, drought and grows well in a broad range of soil and climatic conditions (Angadi and Dharmatti, 2012) [1]. Tomatoes are high in antioxidants, minerals, and vitamins, eating tomatoes and tomato-based products improves skin health, lowers the risk of cancer and heart disease, and lowers bad cholesterol. Tomatoes became extremely popular due to their potential significance. It is often called "Protective Food" due to its high concentration of various nutritive phytochemical compounds, including minerals like phosphorus, calcium, iron, and flavonoids, phenolic acids, ascorbic acid, and carotenoids like lycopene and β-carotene.
In India tomato is cultivated in an area of 847.29 thousand hectare with an average production of 20372.94 thousand metric tonnes (Ministry of Agriculture and Farmers Welfare, Third Advance Estimates of 2022-23) [2]. In India, major tomato producing states are Telangana, Andhra Pradesh, Madhya Pradesh, Karnataka, Tamil Nadu, Orissa, Gujarat, West Bengal, Chhattisgarh, Maharashtra and Bihar.
Tomatoes are mostly day-neutral and self-pollinating plants, but some cross-pollination does occur. It is a warm-season crop, so in order to get a higher fruit setting at 15°C to 20°C at night, it requires a long growing season with temperatures between 20°C and 28°C. Despite the fact that tomatoes grow well in a range of soil types and climates and can be found in both tropical and temperate regions. It is not possible to produce in open fields year-round due to its susceptibility to different stresses. Excess produce during the main season can lead to gluts, and shortages during lean seasons can artificially raise prices. Thus, cultivating tomatoes in protected areas is one approach to circumvent these circumstances and prevent
Farmers can make more money per unit area with these protected areas because they create a favorable microclimate near the crop that can be used for tomato production both year-round and

off-season. Other benefits include higher yields, better quality, earlier maturity, lower pest and disease infestation, and longer harvesting periods that ensure the availability of off-season produce. Indeterminate tomatoes are usually preferred in polyhouses because they can naturally grow for a longer period of time and make good use of the vertical space inside the structure. To meet the increasing demand from consumers, it is necessary to identify genotypes of indeterminate type tomatoes with traits like higher yield, resistance to pests and diseases, longer harvesting times, desirable shape, size, color and good shelf life, among others. So, there is a much need for genetic improvement and to identify promising indeterminate tomato varieties that suit to particular agro-climatic conditions for protected cultivation.

A successful hybridization program for profitable genetically modified tomato germplasm requires selecting flexible, homozygous parental lines. Understanding gene action, genetic variance and combining ability estimates is critical for influencing the crop's genetic composition and ensuring effective gene fixation in breeding. Tomato breeders may find that using this crucial information will help them identify better parental combinations for future improvement (Pedapati *et al.*, 2013) [3].

Materials and Methods

The experiment was conducted at Vegetable block, College of Horticulture, SKLTGHU, Rajendranagar, Telangana under naturally ventilated polyhouse with plot area of 600 m^2 during *Summer*, 2024 which is situated at Latitude 18.1124° N, Longitude 79.0193° E and an altitude of about 536 meters above the mean sea level (MSL). The experimental material included ten parents (seven lines and three testers) and twenty-one hybrids developed through line x tester design (Kempthorne 1957) [4] and three Commercial checks (Sahoo, Arka vardan and kashi Chayan). The experiment was laid out in Randomized Complete Block design with two replications. Each entry consist of 10 plants and grown on raised beds with a row to row spacing of 90 cm and plant to plant spacing of 50 cm each. The observation was recorded on six different quality traits from five randomly selected plants per replication for each germplasm on twenty-two quantitative characters. Analysis of variance was done by the method suggested by Panse and Sukhatme (1985) [5]. Genotypic and phenotypic coefficients of variance were estimated by Burton and Devane (1953) [6] based on estimates of genotypic and phenotypic variance. Heritability (h^2) in broad sense was categorized by Hanson *et al*. (1956) [7]. The range of heritability and genetic advance as percent of Mean (GAM) were classified as suggested by Johnson *et al*. (1955) [8]. The composition of different quality parameters were calculated by the following procedures and formulae

Ascorbic acid content (mg/100 g fresh weight)

Ten grams of fruit pulp was grinded and adding three percent metaphosphoric acid (HPO_3), the volume was increased to hundred millilitres. Solution should be well shaked and filtered through Whatman No. 1 filter paper. 2, 6-Dichlorophenol-Indophenol dye was titrated into a ten millilitre filter until the light pink colour persisted for at least fifteen seconds.

The ascorbic acid content was estimated using the given formula and expressed as mg 100 g^{-1} (Ranganna, 1986) [9].

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{(Titre value x Dye factor x Volume made up)}}{\text{(Aliquot of extra taken for estimation x Volume of sample for estimation)}} \times 100$$

Where, Titre value = Volume of dye used to titrate the aliquot of extract of a given sample.

Beta-carotene (mg/100 g)

Five grams of the sample were crushed with a pestle and mortar into ten to fifteen milliliters of acetone, and then some crystals of anhydrous sodium sulphate were added. Supernatant was poured into a beaker. Repeat it. Then, pour the combined supernatant into a separatory funnel, add 10 to 15 milliliters of petroleum ether, and stir well. Two layers were visible when standing. In a 100 milliliter volumetric flask, the upper layer was collected and the lower layer was disposed. Using petroleum ether as a blank, the volume was adjusted to 100 milliliters, and the optical density was measured at 452 nm.

Milligrams of β-carotene per 100 gram sample was calculated using the formula given by R.P. Srivastava and Sanjeev kumar (2002) [10]:

$$\text{β-carotene content (mg/100 g)} = \frac{\text{O.D. of sample x } 13.9 \times 10^4 \text{ x 100}}{\text{Weight of sample x 560 x 1000}}$$

Lycopene content (mg/100 g of fruit)

A sample weighing five to ten grams was taken and repeatedly crushed in an acetone-filled pestle and mortar until the residue had no color. Place the extracted acetone in a separatory funnel with 10 to 15 milliliters of petroleum ether in it. To incorporate the pigments into the petroleum ether phase, gently mix. The lower (acetone) phase was transferred to a 100 milliliter volumetric flask, and it was continuously extracted with petroleum ether until it became colorless. Mix the petroleum ether extracts together and sprinkle a small amount of anhydrous sodium sulfate on top. Petroleum ether was used to make up to 100 milliliters, and 503 nm was chosen as the reference wavelength for measuring the O.D. of the mixture.

Milligrams of lycopene per 100 gram sample, using the formula given by R.P. Srivastava and Sanjeev kumar (2002) [10]:

$$\text{Lycopene (mg/100 g)} = \frac{\text{3.1206 x O.D. of sample x volume made up x dilution}}{\text{Weight of sample}} 100$$

Shelf-life days (at room temperature)

Fruits harvested at red ripe stage were kept in room temperature and observed for days till the consumption stage was over and shelf-life in days was recorded.

Total soluble solids (°Brix)

By dropping a small amount of the filtered juice onto the digital refractometer prism, the percentage of the total soluble solids was calculated using a hand refractometer. Distilled water was used to check the refractometer for errors before getting the reading (Ranganna, 1986) [9].

Titrable acidity (%)

Diluting tomato juice to a known amount (25 ml) from a known volume (2 ml), the titrable acidity of the juice was obtained. Using phenolphthalein (1%) as an indicator, a 5 millilitre aliquot was collected and titrated against a reference solution of 0.1 N NaOH. The end point was defined as the appearance of light pink color. The value was given as a percentage of the juice's titrable acidity in terms of citric acid (Anon., 1984) [11].

$$\text{Titrable acidity (\%)} = \frac{\text{Titre value x volume made up x equivalent weight of acid}}{\text{Aliquot taken x weight or volume of sample x 100}} \text{ X } 100$$

Results and Discussions

Variability: The extremely significant differences between the genotypes for all variables were shown by the analysis of variance (Table 1), indicating that there is enough diversity in the material chosen for the study. This demonstrates the possibility of selecting appropriate starting breeding stock for crop improvement. Which attributes show the greatest degree of variability is not indicated by the absolute variability of the many traits. Consequently, values for PCV and GCV were computed. Since they give an indication of the range of variation, both genotypic and phenotypic coefficients of variation are useful for determining the degree of variability in various traits.

A high genotypic variance indicates a significant contribution of the genetic component to the total variation. High phenotypic variance suggests a strong influence of environmental factors on the expression of these traits, so they could be taken into consideration and used for selection. Greater variability is suggested by high GCV and PCV values, particularly with higher GCV, which presents more opportunity for improvement through selection. Limited genetic variation is indicated by low GCV and PCV values for traits like fruit size and days to flowering. To complement these observations, estimates of heritability and genetic advance are required.

The GCV and PCV estimates were analysed and computed in Table 2 and recorded high (>20 %) for ascorbic acid content (mg/100 g) (21.47 % and 21.62 %), beta-carotene (mg/100 g) (21.77 % and 22.21 %), lycopene (mg/100g) (33.80 % and 33.88 %) and titrable acidity (%) (43.38 % and 43.76 %). The results are in line with the results reported earlier by Meena *et al.* (2015) [12], Singh *et al*. (2015) [13], Sunil kumar *et al*. (2016) [14], Panchbhaiya *et al*. (2018) [15], Anuradha *et al*. (2020) [16], Sathiyavarsha *et al*. (2023) [17] and Sairam *et al.* (2024) [18].

Moderate GCV and PCV estimates were observed for the characters shelf life (days) (18.19 % and 18.41% respectively) and total soluble solids (^{0} brix) (13.58 % and 13.78 %). The results were indicated the similar trend to the results of Golani *et al*. (2007) [19]; Javed *et al*. (2022) [20] and Rasheed *et al.* (2023) [21].

Greater variability is indicated by high GCV and PCV values, particularly when GCV is higher, which presents more opportunity for improvement through selection. Among the features examined, moderate to low GCV and PCV levels were less common. There is limited genetic variation indicated by low values for variables like days to first flowering and fruit dimensions, whereas large variations between GCV and PCV reflect environmental influence on specific features. The PCV and GCV levels are consistent among traits, indicating little effect from the environment. However, coefficients of variation alone are not adequate to distinguish between heritable and non-heritable variation; estimates of heritability and genetic progress are needed.

Estimation of Heritability, genetic advance

Genetic variation cannot be determined only by GCV; however, when combined with genetic progress and heritability, a more distinct picture is presented. The reliability of genotype identification by phenotype is improved by heritability and genetic advancement. The broad sense of heritability was found high for all the six characters under study. The maximum estimates of heritability (Table 2) was recorded in lycopene (mg/100g) (99.52 %), which is followed by titrable acidity (%), (98.92 %), ascorbic acid (mg/100g) (98.64 %), shelf life (days) (97.57 %), total soluble solids (^{0}brix) (97.10 %) and beta-carotene (mg/100g) (96.10 %), these characters are least influenced by the environment. The results of Golani *et al*. (2007) [19], Sunilkumar *et al*. (2016) [14], Anuradha *et al*. (2020) [16] and Rasheed *et al*. (2023) [21] mimic the present findings.

Estimation of genetic advance as a percent rate of mean

High estimates of genetic advance as a percent rate of mean (>20 %) (Table 2) was observed for all the characters studied *viz*., titrable acidity (%) (88.88 %), lycopene content (mg/100g) (69.47 %), beta-carotene (mg/100g) (43.95 %), ascorbic acid content (mg/100g) (43.93 %), shelf life (days) (37.01 %) and total soluble solids (^{0}brix) (27.57 %), this indicates that additional genetic influences predominate in the expression of these characters**.** The values arrived in this experiment are matching with the records of Golani *et al*. (2007) [19], Sunilkumar *et al*. (2016) [14], Anuradha *et al*. (2020) [16], Rahimi *et al*. (2022) [22] and Srinivasulu *et al*. (2024) [23].

All the characters under study showed high heritability along with high genetic advance which indicates the characters are directly suitable for further selection process.

Table 1: Analysis of variance for quality traits of parents, crosses and checks in tomato under polyhouse conditions

Trait	Mean sum of squares		
	Replicatio df = 1	Treatments df=33	Error df = 33
Ascorbic acid content (mg/100 g)	0.05	70.00**	0.48
Beta-carotene (mg/100 g)	0.00	0.29**	0.01
Lycopene content (mg/100 g)	0.01	5.04**	0.01
Shelf days (days) at room temperature	0.04	4.49**	0.06
Total soluble solids (º brix)	0.02	0.67**	0.01
Titrable acidity (%)	0.00	0.04**	0.00

** Significance at 1% level, df = degrees of freedom

Table 2: Estimation of general mean, range, genotypic variance, phenotypic variance, Coefficient of variation, heritability, genetic advance and genetic advance as per cent of mean for different quality traits in tomato under polyhouse conditions

Characters	General mean	Range	Coefficient of variation			h^2 (%)	GA	GAM (%)
			GCV%	PCV %	ECV%			
Ascorbic acid (mg/100 g)	27.46	16.59-42.01	21.47	21.62	2.52	98.64	12.06	43.93
Beta-carotene (mg/100 g)	1.72	1.21-2.75	21.77	22.21	4.37	96.10	0.75	43.95
Lycopene content (mg/100 g)	4.68	2.61-9.52	33.80	33.88	2.36	99.52	3.25	69.47
Shelf days (days)	8.18	5.90-11.90	18.19	18.41	2.86	97.57	3.03	37.01
Total soluble solids (º brix)	4.24	2.85-5.25	13.58	13.78	2.35	97.10	1.17	27.57
Titrable acidity (%)	0.31	0.09-0.61	43.53	43.76	4.44	98.92	0.28	88.88

GCV- Genotypic Coefficient of Variation, PCV-Phenotypic Coefficient of Variation, ECV- Environmental Coefficient of Variation, h^2- heritability in broad sense, GA- Genetic advance, GAM(%)-Genetic Advance over per cent of Mean

4. Conclusion

All of the quality traits under investigation showed strong variability and high heritability in the study, underscoring their potential for genetic advancement. Significant genetic progress in characteristics such as titrable acidity (88.88%) and lycopene (69.47%) lends credence to the possibility of efficient selection leading to improved performance. Characters with high genetic progress as a percentage of mean and high heritability were immediately taken into consideration for a more thorough selection process. To optimise breeding techniques, however, features with reduced variability and heritability need further research.

References

1. Angadi A, Dharmatti PR. Heterosis for processing quality traits in tomato (*Solanum lycopersicum* L.). Res J Agric Sci. 2012;3(5):1028-1030.
2. Anonymous. Ministry of Agriculture and Farmers Welfare. Third Advance Estimates. 2023.
3. Pedapati A, Reddy RV, Babu JD, Kumar SSN. Combining ability analysis for yield and physiological drought related traits in tomato (*Solanum lycopersicum* L.) under moisture stress. Database. 2013;2012:13.
4. Kempthorne O. An introduction to genetic statistics. 1957;17:545.
5. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. ICAR, New Delhi, India; 1985.
6. Burton GW, Devane EM. Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. Agron J. 1953;45:478-81.
7. Hanson CH, Robinson HF, Comstock RE. Biometrical studies of yield in segregating populations of Korean lespedeza. Agron J. 1956;48(6):268-72.
8. Johnson HW, Robinson HF, Comstock RE. Estimates of genetic and environmental variability in soybean. Agron J. 1955;47:314-8.
9. Ranganna S. Manual Analysis of Fruits and Vegetable Products. Tata McGraw-Hill Publishing Company Ltd, New Delhi; 1986.
10. Srivastav RP, Sanjeev Kumar. Fruit and Vegetable Preservation, Principles and Practice. International Book Distribution Company, New Delhi; c2002.
11. Anonymous. Official methods of analysis. Ed. Sioney Williams. Association Official Analytical Virginia; 1984. 14th Edition: 423-62.
12. Meena OP, Bahadur V, Jagtap AB, Saini P, Meena YK. Genetic variability studies of fruit yield and its traits among indeterminate tomato genotypes under open field condition. Afr J Agric Res. 2015;10(32):3170-7.
13. Singh N, Ram CN, Deo C, Yadav GC, Singh DP. Genetic variability, heritability and genetic advance in tomato (*Solanum lycopersicum* L.). Plant Arch. 2015;15(2):869-73.
14. Sunilkumar MK, Rathod V, Bommesh JC, Vijeth SC, Muthaiah K. Genetic variability in tomato (*Solanum lycopersicum* L.). J Environ Biosci. 2016;30(1):47-55.
15. Panchbhaiya A, Singh KD, Verma P, Mallesh S. Assessment of genetic variability in tomato (*Solanum lycopersicum* L.) under polyhouse condition for fruit quality and biochemical traits. Int J Chem Stud. 2018;6(6):245-8.
16. Anuradha B, Saidaiah P, Reddy KR, Sudini H, Geetha A. Genetic Variability, Heritability and Genetic Advance for Yield and Yield Attributes in Tomato (*Solanum lycopersicum* L.). Int J Curr Microbiol Appl Sci. 2020;9(11):2385-91.
17. Sathiyavarsha K, Wilson D, Yadhuraj VK, Chimmalagi U, Dinesh P, Kumar GB, Kingsly NJ. Genetic variability studies in tomato (*Solanum lycopersicum* L.) under protected cultivation. The Pharma Innovation Journal. 2023;12(6):2067-72.
18. Sairam V, Raut N, Bhavidoddi AK, Chittapur R, Hiremath VM, Jawadagi RS. Genetic variability studies in tomato (*Solanum lycopersicum* L.) under protected cultivation. Int J Adv Biochem Res. 2024;8(1):242-6.
19. Golani IJ, Mehta DR, Purohit VL, Pandya HM, Kanzariya MV. Genetic variability, correlation and path coefficient studies in tomato. Indian J Agric Res. 2007;41(2):146-9.
20. Javed A, Nawab NN, Gohar S, Akram A, Javed K, Sarwar M, Tabassum MI, Ahmad N, Mallhi AR. Genetic analysis and heterotic studies in tomato (*Solanum lycopersicum* L.) hybrids for fruit yield and its related traits. SABRAO J Breed Genet. 2022;54(3):492-501.
21. Rasheed A, Ilyas M, Khan TN, Mahmood A, Riaz U, Chattha MB, Qari SH. Study of genetic variability, heritability, and genetic advance for yield-related traits in tomato (*Solanum lycopersicon* Mill.). Front Genet. 2023;13:1030309.
22. Rahimi S, Singh B, Kumar V, Alam GK, Gupta S, Ahmad M. Studies on genetic variability, heritability and genetic advance among the characters of tomato (Lycopersicon esculentum Mill.). Ann Hortic. 2022;15(1):108-14.
23. Srinivasulu B, Jasmitha M, Vamsi B, Rajendra Sagar K. Estimation of genetic variation, heritability and genetic advance in tomato (*Solanum lycopersicum* L.) for vital horticultural traits under Kashmir's temperate climate. Plant Arch. 2024;24(1):184-8.