

Original Research Article

Assessment of Genetic Variability in F₁ Generation of Indeterminate Tomato (*Solanum lycopersicum*. L) for growth and yield attributes under polyhouse conditions.

Abstract

This study aimed to assess the 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 mating 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 co-efficients of variation for traits like fruit yield, plant height, and leaf area indicated strong potential for improvement through selection. Most traits exhibited high heritability, especially for leaf area and fruit yield, reflecting a strong genetic influence. Several 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

1. 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]. Tomato is rich in antioxidants, minerals and vitamins; therefore, consumption of tomatoes and tomato-based products enhances skin health, reduces the risk of heart disease and cancer and trims down bad cholesterol. Because of its potential importance, tomatoes gained huge demand due to presence of higher ~~Because of its high~~ concentration of various nutritive phytochemical compounds and including minerals like calcium, iron, and phosphorus, flavonoids, phenolic acids, ascorbic acid and carotenoids like lycopene and β -carotene; therefore it is commonly referred to as "Protective Food".

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.

Although tomatoes are primarily self-pollinating and day neutral crops, some cross-pollination does happen. Since it is a warm-season crop, it needs a long growing season with temperatures between 20°C and 28°C to ensure a higher fruit setting at 15°C to 20°C at night. Despite the fact that tomatoes grow in both tropical and temperate regions and are well suited

to a variety of soil types and climates. Because it is vulnerable to various stresses, year-round production in open fields is not feasible. The arrival of massive quantities of produce during the main season can result in glut situations and shortages during lean periods can drive up prices unnecessarily. Therefore, growing tomatoes in protected environments is one possible way to get around these conditions and avoid the majority of issues that arise from outdoor cultivation.

Since these protected areas create a favorable microclimate near the crop that can be used for tomato production both year-round and off-season, farmers are able to earn more money per unit area with additional benefits like higher yields, better quality, earlier maturity, lower pest, disease infestation and longer harvesting periods that guarantee off-season produce availability. Because they can naturally grow for a longer period of time and make good use of the vertical space inside the polyhouse, indeterminate tomatoes are typically preferred in polyhouses. 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)[15].

2. Materials and Methods

The experiment was conducted at Vegetable block, College of Horticulture, SKLTSHU, Rajendranagar, Telangana under naturally ventilated polyhouse with plot area of 600 m² 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) [9] 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 **consists** 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 different growth, yield and yield contributing **characters** 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) [14] using a software OPSTAT. Genotypic and phenotypic co-efficients of variance were estimated by Burton and Devane (1953) [4] based on estimates of genotypic and phenotypic variance using the R Software. Heritability (h^2) in broad sense was categorized by Hanson *et al.* (1956) [6]. The range of heritability and genetic advance as percent of Mean (GAM) were classified as suggested by Johnson *et al.* (1955) [8].

3. Results and Discussions

3.1 Variability

The analysis of variance (Table 1) demonstrated highly significant differences among the genotypes for all traits, suggesting that the material selected for the study contains sufficient variability. This highlights the potential for choosing suitable initial breeding material for crop improvement. However, the absolute variability in the different traits does not indicate which traits exhibit the highest degree of variability. Therefore, PCV and GCV values were calculated. Both genotypic and phenotypic coefficients of variation are valuable for assessing the degree of variability in different traits, as they provide a measure of the range of variation.

A high genotypic variance suggests that the genetic component contributes significantly to the overall variation. Therefore, these traits could be considered and utilized for selection purposes, while high phenotypic variance indicates a strong influence of environmental factors on their expression. High GCV and PCV values suggest greater variability, offering more potential for improvement through selection, especially with higher GCV. Low GCV and PCV values for traits like days to flowering and fruit size indicate limited genetic variation. Heritability and genetic advance estimates are needed to supplement these observations.

The GCV and PCV estimates were analysed and computed in Table 2 and recorded high (>20 %) for plant height (cm) (23.23 % and 23.41 %), number of primary branches per plant (49.74 % and 49.96 %), leaf area (cm²) (21.75 % and 21.80 %), number of fruit clusters per plant (33.71 % and 33.95 %), number of fruits per plant (27.72 % and 28.73 %), fruit yield per plant (g) (45.93 % and 46.58 %) number of locules per fruit (21.08 % and 22.04 %), pericarp thickness (mm) (28.43 % and 29.49 %), pulp to seed ratio (24.01 % and 24.48 %), average fruit weight (g) (21.67 % and 22.64 %). Number of fruits per cluster exhibited high PCV (20.04 %) and medium GCV (19.14 %). The results are in line with the results reported earlier by Singh *et al.* (2015) [22], Sunil kumar *et al.* (2016) [24], Ligade *et al.* (2017) [11], Singh and Singh (2018) [21], Panchbhaiya *et al.* (2018) [13], Anuradha *et al.* (2020) [3], Sathiyavarsha *et al.* (2023) [20], Rasheed *et al.* (2023) [17], Varun *et al.* (2023) [25], Srinivasulu *et al.* (2024) [23] and Sairam *et al.* (2024) [18].

Moderate PCV values (10-20 %) were noticed observed for characters such as stem girth (cm) (10.47%), number of water suckers per plant (16.73%), number of flowers per cluster (19.00%), days taken from flowering to fruit set (17.15%) fruit set percentage (%) (10.52%), days taken to first fruit harvest (11.79%) and days taken from first harvest to last harvest (17.19%). Almost similar findings were also obtained by Golani *et al.* (2007) [5], Javed *et al.* (2022) [7] and Rasheed *et al.* (2023) [17] in their experiments.

Lowest PCV (<10 %) was reported were-observed in traits days taken to first flowering (8.89%), days taken to 50 percent flowering (7.01%), fruit length (cm) (9.92%) and fruit diameter (cm) (7.93%). Singh *et al.* (2015) [22] and Mahurtale *et al.* (2023) [12] evidenced at par near results for the same traits.

Moderate GCV were observed (10-20 %) for the characters such as stem girth (cm) (10.31%), number of water suckers per plant (15.97%), number of flowers per cluster (18.84%), days taken from flowering to fruit set (16.12%), days taken for first fruit harvest (11.59%), number of fruits per cluster (19.14%) and days taken from first harvest to last harvest (17.01%). The results were indicated the similar trend to the results of Golani *et al.* (2007) [5], Javed *et al.* (2022) [7] and Rasheed *et al.* (2023) [17].

Lowest GCV (<10 %) were observed in traits days taken to first flowering (8.34%), days taken to 50 per cent flowering (6.45%), fruit set percentage (9.57%), fruit length (cm) (9.12%) and fruit diameter (cm) (6.66%). Singh *et al.* (2015) [22] and Mahurtale *et al.* (2023) [12] results found in line with present findings.

High GCV and PCV values indicate greater variability, offering more potential for improvement through selection, especially when GCV is higher. Moderate to low GCV and PCV values were less frequent among the traits studied. Large differences between GCV and PCV suggest environmental influence on certain traits, while low values for traits like days to first flowering and fruit dimensions indicate limited genetic variation. The similarity between PCV and GCV values across traits suggests minimal environmental impact. However, determining heritable and non-heritable variation requires estimates of heritability and genetic advance, as coefficients of variation alone are insufficient.

3.2 Estimation of Heritability, genetic advance

GCV alone cannot determine genetic variation but combining it with heritability and genetic advance provides a clearer picture. Heritability and genetic advance enhance the reliability of genotype identification through phenotype.

The broad sense of heritability was found high for almost all the character studied. The maximum estimates of heritability (Table 2) was recorded in leaf area (cm²) (99.47%), number of primary branches per plant (99.07%), number of fruit clusters per plant (98.61%), plant height (cm) (98.51%), number of flowers per cluster (98.32%), days taken from first harvest to last harvest (97.70%), fruit yield per plant (g) (97.22%), stem girth (cm) (97.00%), days taken for first fruit harvest (96.51%), pulp to seed ratio (96.18%), number of fruits per plant (93.07%), pericarp thickness (mm) (92.85%), average fruit weight (g) (91.58%), number of locules per fruit (91.45%), number of fruits per cluster (91.16%), number of water suckers per plant (91.10%), days taken from flowering to fruit set (88.30%), days taken to first flowering (87.88%), fruit length (cm) (84.47%), days taken to 50 per cent flowering (84.47%) and fruit set percentage (%) (82.82%) these characters are least influenced by the environment. The results of Golani *et al.* (2007) [5], Sunilkumar *et al.* (2016) [24], Kerketta *et al.* (2019) [10], Anuradha *et al.* (2020) [3], Javed *et al.* (2022) [7], Rahimi *et al.* (2022) [16] and Rasheed *et al.* (2023) [17] mimic the present findings.

Moderate estimates observed for the trait character fruit diameter (cm) (70.46 %). These traits are highly influenced by the environment and genetic improvement through selection for these trait is difficult because environmental effects can mask the effects of genotype.

3.3 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 most of the traits studied viz., number of primary branches per plant (101.98%), fruit yield per plant (g) (93.30%), number of fruit clusters per plant (68.96%), pericarp

thickness (mm) (56.43%), number of fruits per plant (55.08%), pulp to seed ratio (48.51%), plant height (cm) (47.51%), leaf area (cm²) (44.69%), average fruit weight (g) (42.72%), number of locules per fruit (41.53%), number of flowers per cluster (38.48%), number of fruits per cluster (37.64%), days taken from first harvest to last harvest (34.67%), number of water suckers per plant (31.41%), days taken from flowering to fruit set (31.21%), days taken for first fruit harvest (23.46%) and stem girth (cm) (20.92%) 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) [5]; Sunilkumar *et al.* (2016) [24], Panchbhaiya *et al.* (2018) [13], Kreketa *et al.* (2019) [10], Saravanan *et al.* (2019) [19], Anuradha *et al.* (2020) [3], Javed *et al.* (2022) [7], Rahimi *et al.* (2022) [16] and Srinivasulu *et al.* (2024) [23].

Moderate genetic advance as a percent of mean (<20 %) was observed in fruit set percentage (%) (17.95%), fruit length (cm) (17.26%), days taken for first flowering (16.10%), days taken for 50 % flowering (12.20%) and fruit diameter (cm) (11.51%).

Maximum character ~~revealed~~ ~~showed~~ high heritability along with high genetic advance except days to first flowering, days to 50 per cent flowering, fruit set percentage (%), fruit length (cm) and fruit diameter (cm) which exhibit moderate to low heritability and genetic advance as a percent mean.

Table 1: Analysis of variance for growth, yield and yield contributing characters in tomato parents, crosses and checks under polyhouse conditions

Character	Mean Sum of Squares		
	Replications df=1	Treatments df=33	Error df =33
Plant height (cm)	8.17	5222.77**	39.07
Number of primary branches per plant	10.11	126.04**	0.59
Leaf area (cm ²)	1141.85	31253.32**	83.07
Stem girth (cm)	0.15	0.06**	0.00
Number of water suckers per plant	3.41	89.86**	4.18
Days taken to first flowering	0.24	10.69**	0.69
Days taken to 50 per cent flowering	0.72	8.52**	0.72
Number of flowers per cluster	0.27	3.46**	0.03
Days taken from flowering to fruit set	0.05	3.85**	0.24

Fruit set percentage (%)	9.12	120.15**	11.29
Days taken for first fruit harvest	13.68	88.16**	1.56
Number of fruits per cluster	0.27	1.45**	0.07
Number of fruit clusters per plant	1.89	16.16**	0.11
Days taken from first harvest to last harvest	4.43	139.74**	1.48
Number of fruits per plant	24.24	118.64**	4.26
Fruit yield per plant (g)	2047.91	1639226.75**	5236.59
Fruit length (cm)	1.02	0.35**	0.03
Fruit diameter (cm)	0.03	0.27**	0.05
Number of locules per fruit	0.04	1.05**	0.05
Pericarp thickness (mm)	0.01	1.73**	0.06
Pulp to seed ratio	9.73	613.53**	11.93
Average fruit weight (g)	0.66	510.72**	22.43

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Table 2: Estimation of general mean, range, Coefficient of variation, heritability, genetic advance and genetic advance as per cent of mean for different morphological traits in tomato

Characters	General mean	Range	Coefficient of variation			h ² (%)	GA	GAM (%)
			GCV %	PCV %	ECV %			
Plant height (cm)	219.09	131.93 – 318.75	23.23	23.41	2.85	98.51	104.09	47.51
Number of primary branches per plant	15.92	5.80 – 35.80	49.74	49.96	4.81	99.07	16.24	101.98
Leaf area (cm ²)	573.93	159.66 – 762.37	21.75	21.80	1.59	99.47	256.49	44.69
Stem girth (cm)	1.71	1.36 – 2.11	10.31	10.47	1.82	97.00	0.35	20.92
Number of water suckers per plant	40.97	28.70 – 55.20	15.97	16.73	4.99	91.10	12.87	31.41
Days taken to first flowering	26.82	19.50 – 32.00	8.34	8.89	3.09	87.88	4.32	16.10
Days taken to 50 percent flowering	30.63	22.00 – 34.50	6.45	7.01	2.77	84.41	3.74	12.20
Number of flowers per cluster	6.94	4.60 – 9.56	18.84	19.00	2.46	98.32	2.67	38.48
Days taken from flowering to fruit set	8.33	4.75 – 11.35	16.12	17.15	5.86	88.30	2.60	31.21
Fruit set percentage (%)	77.04	62.05 – 93.25	9.57	10.52	4.36	82.82	13.83	17.95
Days taken for first fruit harvest	56.76	42.75 – 69.50	11.59	11.79	2.20	96.51	13.32	23.46
Number of fruits per cluster	4.34	3.05 – 6.20	19.14	20.04	5.96	91.16	1.63	37.64
Number of fruit clusters per plant	8.40	4.30 – 14.40	33.71	33.95	4.01	98.61	5.79	68.96
Days taken from first harvest to last harvest	48.87	34.25 – 66.75	17.01	17.19	2.48	97.90	16.94	34.67
Number of fruits per plant	27.28	14.10 – 49.50	27.72	28.73	7.56	93.07	15.03	55.08
Fruit yield per plant (g)	1956.85	770.00 – 5588.68	45.93	46.58	7.77	97.22	1825.83	93.30
Fruit length (cm)	4.40	3.38 – 5.39	9.12	9.92	3.91	84.47	0.76	17.26
Fruit diameter (cm)	5.05	3.91 – 6.07	6.66	7.93	4.32	70.46	0.58	11.51
Number of locules per fruit	3.35	2.05 – 4.75	21.08	22.04	6.44	91.45	1.39	41.53
Pericarp thickness (mm)	3.2	1.20 – 5.35	28.43	29.49	7.88	92.85	1.81	56.43
Pulp to seed ratio	72.23	43.44 – 109.24	24.01	24.48	4.78	96.18	35.04	48.51
Average fruit weight (g)	72.11	44.74 – 117.80	21.67	22.64	6.56	91.58	30.80	42.72

GCV- Genotypic Coefficient of Variation, PCV-Phenotypic Coefficient of Variation, ECV- Environmental Coefficient of Variation, h²- heritability in broad sense, GA- Genetic advance, GAM (%) – Genetic Advance over per cent of Mean

CONCLUSION

The study demonstrated significant variability and high heritability for key tomato traits, highlighting their potential for genetic improvement. High genetic advance in traits like fruit yield and plant height supports the prospect of effective selection for enhanced performance. Characters with high heritability along with high genetic advance as percent of mean were directly considered for further selection process. Conversely, traits with lower variability and heritability require additional investigation to optimize breeding strategies.

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