

Variability and Heritability Studies in Advanced Tomato (*Solanum lycopersicum* L.) Lines

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Abstract Twenty tomato advanced lines, with a check variety (Megha), were evaluated during *kharif* of 2014 to study the nature and magnitude of genetic variability based on different growth, yield and quality traits. The analysis of variance indicated significantly higher amount of variability among the genotypes for all the 17 characters studied. Genotypic and phenotypic coefficients of variation were high for the characters viz. number of fruits per plant, fruit firmness and shelf life. The characters viz. number of flowers per cluster, number of fruits per cluster, number of fruits per plant, average fruit weight, dry matter content, pericarp thickness and fruit yield per plant exhibited high heritability coupled with high genetic advance as percent mean.

Keywords Variability, Tomato, Advanced lines, Heritability, PCV and GCV.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important, popular and extensively used vegetable as fresh fruit and also in the form of processed products [1] which belongs to the family Solanaceae. It is widely grown all over the world (mainly tropics and subtropics). Tomato is an important commercial and dietary crop. Due to its short duration and high yield, its area is increasing day by day. India being a vast country with varied agro-climatic regions, viz. temperate, sub-tropical, tropical and coastal tropical humid regions, a single variety of tomato is definitely not suitable for all agro-climatic regions. The same variety may perform differently in different agro-ecologies and different varieties may also perform differently in the same agro-ecology. The phenotypic expression of the plant characters is mainly controlled by the genetic makeup of the plant and the environment. Further, the genetic variance of any quantitative traits is composed of additive variance (heritable) and non-additive variance that includes dominance and epistasis (non-allelic interaction). Therefore, it becomes necessary to partition the observed phenotypic variability into its heritable and non-heritable components with suitable parameters such as phenotypic and genotypic coefficient of variation, heritability and genetic advance. Further, genetic advance can be used to predict the efficiency of selection.

Materials and Methods

A field experiment was conducted during *kharif* of 2014 at Regional Horticultural Research and Extension

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Table 1. Analysis of variance for different characters of advanced tomato lines. *Significant at 5% probability level. **Significant at 1% probability level.

| Sl. No. | Characters | Replication | Genotypes | Error | SEm ± | CD @ 1% | CD @ 5% |
|---------|--------------------------------------|-------------|-----------|--------|-------|---------|---------|
| 1 | Plant height (cm) | 5.94 | 190.55* | 68.20 | 5.901 | - | 17.40 |
| 2 | No. of primary branches | 1.52 | 1.62** | 0.46 | 0.50 | 1.93 | 1.41 |
| 3 | Stem thickness (cm) | 0.019 | 0.065** | 0.011 | 0.074 | 0.323 | 0.232 |
| 4 | Days to first flowering | 50.38 | 25.83* | 11.83 | 2.43 | - | 7.19 |
| 5 | Days to 50% flowering | 841.52 | 62.51** | 14.32 | 2.67 | 10.56 | 7.89 |
| 6 | No. of flowers per cluster | 3.72 | 1.92** | 0.32 | 0.404 | 1.62 | 1.187 |
| 7 | No. of fruits per cluster | 0.27 | 0.96** | 0.059 | 0.16 | 0.694 | 0.507 |
| 8 | Percent fruit set | 193.80 | 62.84** | 16.45 | 2.86 | 11.54 | 8.46 |
| 9 | No. of fruits per plant | 197.16 | 276.05** | 10.36 | 2.22 | 8.963 | 6.57 |
| 10 | Average fruit weight (g) | 80.95 | 184.06** | 20.49 | 3.2 | 12.87 | 9.44 |
| 11 | Shape index | 0.004 | 0.023** | 0.0009 | 0.067 | 0.086 | 0.068 |
| 12 | Dry matter content (%) | 9.81 | 29.37** | 1.06 | 0.72 | 2.93 | 2.15 |
| 13 | Pericarp thickness (mm) | 0.002 | 0.014** | 0.0003 | 0.038 | 0.054 | 0.031 |
| 14 | Fruit firmness (kg/cm ²) | 0.184 | 0.237** | 0.017 | 0.094 | 0.376 | 0.273 |
| 15 | TSS (°Brix) | 0.073 | 0.251** | 0.005 | 0.06 | 0.21 | 0.16 |
| 16 | Shelf life | 237.19 | 121.75** | 1.26 | 0.268 | 3.19 | 2.347 |
| 17 | Fruit yield per plant (g) | 3010 | 5617** | 5238 | 161.8 | 651.1 | 477.4 |

sion Center (RHREC), University of Horticultural Sciences, Bagalkot, situated in the Northern dry zone (Zone 3) of Karnataka. It is located at 75° 42' East longitude and 16° 10' North latitude at an altitude of 542 m above mean sea level (MSL). The total rainfall of 249.5 mm was received in 17 rainy days during crop growth period from August to December 2014. Mean maximum and minimum relative humidity were 78.79 and 60.87% respectively. The mean maximum temperature was 31.25°C and the mean minimum temperature was 19.75°C. Treatments of the experiment involved advanced lines (the pre-released genotypes have been developed by the plant breeder for use in modern scientific plant breeding and are under pipeline to release to farmers). Such 20 advanced lines of tomato viz. DTR-1, DTR 1-1, DTR-3, DTR-4, DTR-5, DTR-6, DTR-7, DTR-8, DTO-1, DTO-2, DTO-3, DTO-4, DTO-5, DTO-6, DTO-7, DTO-8, DTO-9, DTO-10, DTO-11, DTO-12 from Horticultural Research Station, Haveri (Devihossur) with Megha, a variety released by UAS, Dharwad as check constituted 21 treatments for the present investigation. Randomized complete block design was adopted with two replications with 20 plants in each replication. The experimental data collected were statistically analyzed using Fisher's method of Analysis of variance (Table 2) as outlined by Sundararaj et al. [2]. GCV and PCV were calculated

by using the formula given by Burton [3]. PCV and GCV were classified as suggested by Shivasubramanian and Menon [4]. Heritability in broad sense, it is the heritable variation and was computed using the formula given by Weber and Moorthy [5]. Heritability percentage was categorized as demonstrated by Robinson et al. [6]. The extent of genetic advance to be expected from selecting five percent of superior progeny was calculated using the formula given by Johnson et al. [7]. The genetic advance as percentage over mean was categorized into low, moderate and high as given by Johnson et al. [7].

Results and Discussion

Genetic variability, heritability and genetic advance

The estimates of mean, range, genotypic and phenotypic coefficients of variation, heritability, genetic advance and genetic advance as percent mean for all the characters were studied and the results are presented in Table 2.

The grand mean plant height (Table 2) recorded at final picking was 98.65 cm. It ranged from 77.3 cm to 120.00 cm. The genotypic (8.64%) and phenotypic (12.56%) coefficients of variability were low. It exhib-

Table 2. Different genetic parameters for different advanced tomato lines. σ_p^2 : Phenotypic variance σ_g^2 : Genotypic variance. PCV : Phenotypic coefficient of variability. GCV : Genotypic coefficient of variability.

| Sl No. | Characters | Range | | Variance | | PCV (%) | GCV (%) | H^2 (bs) | Genetic advance | Genetic advance over mean (%) | |
|--------|--------------------------------------|-------|-------|----------|--------------|---------|---------|------------|-----------------|-------------------------------|--------------|
| | | Min | Max | Mean | σ_p^2 | | | | | | σ_g^2 |
| 1 | Plant height (cm) | 77.3 | 120 | 98.65 | 129.37 | 61.17 | 12.56 | 8.64 | 47.28 | 11.07 | 11.22 |
| 2 | No. of primary branches | 8.5 | 11.8 | 10.15 | 1.04 | 0.58 | 9.94 | 7.43 | 55.76 | 1.17 | 11.52 |
| 3 | Stem thickness (cm) | 1.4 | 2.14 | 1.77 | 0.038 | 0.026 | 11.8 | 9.86 | 68.42 | 0.27 | 15.25 |
| 4 | Days to first flowering | 32 | 50 | 41 | 18.83 | 7.00 | 10.91 | 6.65 | 37.17 | 3.32 | 8.09 |
| 5 | Days to 50% flowering | 41.5 | 56 | 48.75 | 38.41 | 24.09 | 13.16 | 10.42 | 62.71 | 8.00 | 16.41 |
| 6 | No. of flowers per cluster | 5.05 | 8.0 | 6.525 | 1.12 | 0.80 | 15.93 | 13.43 | 71.42 | 1.55 | 23.75 |
| 7 | No. of fruits per cluster | 2.2 | 5.0 | 3.6 | 35.79 | 31.66 | 20.77 | 19.53 | 88.48 | 10.90 | 30.27 |
| 8 | Percent fruit set | 41.8 | 63.75 | 52.77 | 39.64 | 23.19 | 12.05 | 9.21 | 58.50 | 7.58 | 14.36 |
| 9 | No. of fruits per plant | 28.75 | 82.13 | 55.44 | 143.20 | 132.84 | 23.95 | 23.06 | 92.76 | 22.86 | 41.23 |
| 10 | Average fruit weight (g) | 50.22 | 81.4 | 65.81 | 102.27 | 81.78 | 15.75 | 14.08 | 79.96 | 16.65 | 25.30 |
| 11 | Shape index | 0.94 | 1.33 | 1.135 | 0.012 | 0.011 | 9.86 | 9.49 | 91.66 | 0.20 | 17.62 |
| 12 | Dry matter content (%) | 17.36 | 31.25 | 24.305 | 307.07 | 254.6 | 18.14 | 17.5 | 82.94 | 9.46 | 38.95 |
| 13 | Pericarp thickness (mm) | 0.43 | 0.75 | 0.59 | 15.22 | 14.15 | 12.97 | 12.65 | 92.96 | 0.15 | 26.6 |
| 14 | Fruit firmness (kg/cm ²) | 0.92 | 2.26 | 1.59 | 0.007 | 0.006 | 21.7 | 20.13 | 85.71 | 0.14 | 8.80 |
| 15 | TSS (^o Brix) | 3.9 | 5.2 | 4.55 | 0.12 | 0.11 | 7.95 | 7.76 | 91.66 | 0.65 | 14.28 |
| 16 | Shelf life | 10.55 | 35.25 | 22.9 | 0.121 | 0.12 | 32.48 | 32.15 | 99.17 | 0.71 | 3.10 |
| 17 | Fruit yield per plant (g) | 2341 | 4125 | 3233 | 61.50 | 60.24 | 17.67 | 16.1 | 97.95 | 15.82 | 48.00 |

ited moderate heritability (47.28%) and genetic advance (11.22) as percent mean. The earlier findings of Prashanth [8] are in line with the present findings.

The number of primary branches (Table 2) recorded at final picking was ranged from 8.5 to 11.8 with a mean value of 10.15. Genotypic (7.43%) and phenotypic (9.94%) coefficients of variability were low. Moderate genetic advance (11.52) as percent mean was similar to the results obtained by Upadhyay [9]. This character also showed moderate heritability (55.76%) estimates. The results of Upadhyay [9] are in agreement with the obtained results.

The stem thickness (Table 2) recorded at final picking was ranged from 1.4 to 2.14 cm with a mean value of 1.77 cm. The PCV and GCV observed were 11.8 and 9.86%, respectively. Heritability (bs) of 68.42% coupled with moderate genetic advance over percent of mean 15.25% were noticed.

The mean number of days to first flowering (Table 2) was 41.00. It had a range of 32.00 to 50.0 days for different lines with low GCV (6.65%) and PCV (10.91%). This character showed moderate heritability (37.17%) and also genetic advances as per-

cent of mean (8.09) was low.

Significant differences were recorded among the entries with respect to days to 50% flowering (Table 2). The value ranged from 41.5 to 56 days. Moderate genotypic (10.42%) and phenotypic (13.16%) coefficients of variability were observed Prashanth [8] and Dhankhar and Dhankar [10] were also of same opinion. In the present study, high heritability (62.71%) coupled with low genetic advance (16.41%) was observed Dhankhar and Dhankar [10] found similar kind of results.

The value ranged from 5.05 to 8.00 with a mean of 6.52. The coefficients of variability observed at genotypic (13.43) and phenotype (15.93) levels were moderate for number of flowers per cluster. Aradhana and Singh [11] were also of the same opinion.

In the present study, the genotypic (19.53%) and phenotypic (20.77%) coefficients of variability were moderate for number of fruits per cluster, which were in agreement with Aradhana and Singh [11]. It was ranged from 2.2 to 5.0 with a mean of 3.6. However, heritability (88.48%) and genetic advance (30.27%) over mean were found higher Mayavel et al. [12] and

Samadia et al. [13] also obtained high heritability and high genetic advance in tomato.

Wide variation of 41.8 to 63.75% fruit set with a mean of 52.77% fruit set was observed. The differences between the values of PCV and GCV were 12.05 and 9.21% respectively. Heritability estimates of 58.50% with expected genetic advance as per cent mean (14.36) were recorded for this traits (Table 2).

A wide variation was found among the 21 advanced lines for the number of fruits per plant. It varied 28.75 to 82.13 significantly among the genotypes with an overall mean of 55.44. Coefficient of variations observed at genotypic (23.06%) and phenotypic (23.95%) levels were high for number of fruits per plant. This characters showed high heritability (92.76%) coupled with high genetic gain (41.23%). The present findings were in agreement with the earlier findings [11, 14, 15].

The average fruit weight ranged from 50.22 to 81.4 g with a mean of 65.81 g. Moderate genotypic (14.08%) and phenotypic (15.75%) coefficients of variation for average fruit weight were noticed. High heritability (79.96%) with high genetic advance (25.30%) was found for this character.

Fruit shape index showed low value for genotypic (9.49%) and phenotypic (9.86%) coefficient of variation. The values ranged from 0.94 to 1.33 with a mean of 1.13. This character exhibited high heritability (91.66%) estimates with moderate genetic advance (17.62%) and the results were in accordance with earlier reports of Singh et al. [16].

The dry matter content ranged from 17.36g to 31.25g with mean of 24.30g. The coefficient of variability at phenotypic and genotypic level was 18.14 and 17.5% respectively. The high heritability of 82.94% with the high genetic advance over mean of 38.95% was found.

The mean pericarp thickness noticed was 0.59 cm with a range of 0.43 cm to 0.75 cm. The moderate genotypic (12.65%) and phenotypic (12.97%) coefficients of variation were exhibited by pericarp thickness. The high heritability estimate of 92.96% was

recorded with high genetic advance over mean 26.6% was noted (Table 2).

The mean fruit firmness noticed was 1.59 kg/cm² with a range of 0.92 to 2.26 kg/cm². The values of 21.7 and 20.13 are noticed for PCV and GCV respectively. The heritability estimate was 85.71% with low genetic advance over mean of 8.80% was noted (Table 2).

Significant difference among genotypes for TSS content of fruit was noticed. It ranged from 3.9 to 5.2 with a mean of 4.55. The genotypic (7.76%) and phenotypic (7.95%) coefficients of variability were low for total soluble solids. Highest heritability (91.66%) coupled with moderate genetic advance (14.28%) was noticed.

The mean shelf life of fruits noticed was 22.9 days with a range of 10.55 to 35.25 days. High phenotypic coefficient of variability (32.48%) and genotypic coefficient of variability (32.15%) along with high heritability (99.17%) and low genetic advance as percentage over mean (3.10) were recorded (Table 2).

The mean fruit yield per plant noticed was 3,233 g with a range of 2,341 g to 4,125 g. The moderate genotypic (16.1%) and phenotypic (17.67%) coefficient of variability with high heritability (97.95%) and high genetic advance (48.00%) were exhibited by fruit yield per plant. These findings are similar with earlier reports of Singh et al. [17].

In the present investigation, high heritability coupled with high genetic advance as per cent of mean was observed for number of flowers per cluster, number of fruits per cluster, dry matter content, pericarp thickness and fruit yield per plant indicating that these traits are controlled by additive gene action, which is useful in selection.

Genotypic and phenotypic coefficients of variation were high for the characters viz. number of fruits per plant, fruit firmness and shelf life. They were moderate for days to 50% flowering, number of flowers per cluster, number of fruits per cluster, average fruit weight, dry matter, pericarp thickness and fruit yield per plant. Rest of the traits showed low GCV and PCV. The characters viz. number of flowers per cluster, num-

ber of fruits per cluster, number of fruits per plant, average fruit weight, dry matter content, pericarp thickness and fruit yield per plant exhibited high heritability coupled with high genetic advance as percent mean. These characters therefore, are governed by additive gene effects. It may be concluded that selection on the basis of these characters will be more useful for higher yield. Days to 50% flowering, shape index and total soluble solids had high heritability with moderate genetic advance. Fruit firmness and shelf life had high heritability with low genetic advance indicating that these characters are controlled by both additive and non-additive gene effects. Plant height, primary branches and percent fruit set showed moderate heritability and moderate genetic advance. Days to first flowering and stem thickness had moderate heritability with low values of genetic advance.

References

1. Toor RK, Savage GP (2005) Antioxidant activity and total phenolics in selected fruits, vegetables and grain products. *J Agric Food Chem* 46 : 4113—4117.
2. Sundararaj N, Nagaraju S, Venkataramu MN, Jaganath MK (1972) Design and analysis of field experiments.
3. Burton GW (1952) Quantitative interaction in grasses. In : *Proc 6th Inter Grassl Cong* 1 : 277—283.
4. Shivasubramanian S, Menon N (1973) Heterosis and inbreeding depression in rice. *Madrass Agric J* 60 : 1139—1144.
5. Weber CR, Moorthy HR (1952) Heritable and non-heritable relationship and variability of oil content and agronomic characters in the F₂ generation of soybean crosses. *Agron J* 44 : 202—209.
6. Robinson HF, Comstock RE, Harvey VH (1949) Estimates of heritability and degree of dominance in corn. *Agron J* 41 : 353—359.
7. Johnson HW, Robinson HF, Comstock RE (1955) Estimation of genetic and environmental variability in soybean. *Agron J* 47 : 477—483.
8. Prashanth SJ (2003) Genetic variability and divergence study in tomato (*Lycopersicon esculentum* Mill.). MSc (Ag) thesis. Univ Agric Sci Dharwad (India).
9. Upadhyay Megha, Singh JP, Singh Anita, Joshi Aradhana (2005) Studies on genetic variability in tomato (*Lycopersicon esculentum* Mill.). *Prog Hort* 3 : 463—465.
10. Dhankhar SK, Dhankar SS (2006) Variability, heritability, correlation and path coefficient studies in tomato. *Haryana J Hort Sci* 35 : 179—181.
11. Aradhana JC, Singh JP (2003) Studied on genetic variability in tomato. *Prog Hort* 35 : 179—182.
12. Mayavel A, Balakrishnamurthy G, Natarajan S (2005) Correlation and path analysis in tomato (*Lycopersicon esculentum* Mill.). *South Ind Hort* 53 : 253—257.
13. Samadia DK, Aswani RC, Dhandar G (2006) Genetic analysis for yield components in tomato land races. *Haryana J Hort Sci* 35 : 116—119.
14. Singh B, Singh SP, Kumar D, Verma HPS (2001) Studies on variability, heritability and genetic advance in tomato. *Prog Agric* 1 : 76—78.
15. Mariane F, Ravishankar H, Dessalegne L (2003) Study on variability in tomato germplasm under conditions of Central Ethiopia. *Veg Crop Res Bull* 58 : 41—50.
16. Singh JK, Singh JP, Jain SK, Joshi Aradhana, Joshi A (2002) Studies on genetic variability and its importance in tomato (*Lycopersicon esculentum* Mill.). *Prog Hort* 34 : 77—79.
17. Singh Parvinder, Singh Surjan, Cheema DS, Dhaliwal MS, Singh S (2002) Genetic variability and correlation study of some heat tolerant tomato genotypes. *Veg Sci* 29 : 68—70.