



GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE IN TOMATO (*SOLANUM LYCOPERSICUM* L.)

Neeraj Singh, C. N. Ram, Chandra Deo, G. C. Yadav and Devesh Pratap Singh

Department of Vegetable Sci, College of Horticulture and Forestry, NDU&T, Kumarganj, Faizabad (U.P.), India.

Abstract

Thirty five genotypes of tomato were evaluated for yield and various yield attributing characters at the Main Experiment Station, Department of Vegetable Science, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.), India; during 2012-2013. The experiment was laid out in Randomized Complete Block Design with three replications. Observations were recorded on thirteen quantitative characters *viz.*, days to 50 per cent flowering, plant height (cm), number of primary branches per plant, fruit diameter (cm), fruit length (cm), number of locules per fruit, pericarp thickness (mm), average fruit weight (g), total soluble solids, number of fruits per plant, number of unmarketable fruits per plant, number of marketable fruits per plant and fruit yield per plant (g). High magnitude of phenotypic as well as genotypic coefficients of variation were observed in case of fruit yield per plant followed by average fruit weight, number of locules per fruit, number of fruits per plant, plant height and number of primary branches per plant. High amount of GCV and PCV were observed for all the traits except days to 50 per cent flowering, which showed very low variability. High heritability along with high genetic advance in per cent of mean were estimated for all the traits except days to 50 per cent flowering. Fruit yield per plant followed by average fruit weight, number of locules per fruit, number of fruits per plant and plant height were the top five traits which showed high level of genetic advance indicating opportunity for better selection response.

Key words : Genetic advance, GCV, PCV, climate conditions, tomato (*Solanum lycopersicum* L.).

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important solanaceous vegetable crop having diploid chromosome number $2n = 2x = 24$. It is herbaceous, annual to perennial, prostrate and sexually propagated crop plant with bisexual flowers. There are four to eight flowers in each compound inflorescence. Tomato is a typical day neutral plant and is mainly self-pollinated, but a certain per cent of cross-pollination also occurs. It is a warm season crop, reasonably resistant to heat and drought and grows under wide range of soil and climatic conditions. All the species of tomato are native to Western South America (Rick, 1976). Tomato is used as fresh vegetable and is also very important for processing purposes like soup, ketchups, sauces, concentrates, purees, juices etc. Unripe green fruits are used for preparation of pickles and chutney. Tomatoes are important source of lycopene (an antioxidant), ascorbic acid and beta-carotene and valued for their colour and flavour. One hundred gram of ripe tomato fruit contains 93.1 per cent moisture, 3.6g carbohydrate, 1.9g protein, 1.9g fat, 320 IU vitamin-A, 31 mg vitamin B, 15-30 mg

ascorbic acid and other minerals. It is one of the most popular and widely cultivated vegetable throughout the world and ranking second in importance after potato in many countries including India (Anonymous, 2012-13). The total area of world in tomato under cultivation is 4.58 m ha and total production is 150.51 m tonnes with 32.8 tonnes per hectare productivity. Whereas, in India, total area is 0.88 m ha and production is 18.23 m tones with 20.7 tonnes/ha productivity. Considering the potentiality of this crop, there is a need for improvement and to develop varieties suited to specific agro-ecological conditions and also for specific use.

Materials and Methods

Present investigation was conducted at the Main Experiment Station, Department of Vegetable Science, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.), India during 2012-2013. The experiment was conducted to evaluate 35 genotypes of tomato including three checks in Randomized Block Design with three replications. Seeds were sown in nursery bed on 5th October 2012

Table 1 : Analysis of variance (mean squares) for thirteen quantitative characters in tomato.

| S. no. | Characters | Source of variation | | |
|--------|-----------------------------------|---------------------|------------|-----------|
| | | Replication | Treatment | Error |
| | Degree of freedom | 2 | 34 | 68 |
| 1. | Days to 50 per cent flowering | 7.200 | 22.222 | 1.062 |
| 2. | Plant height (cm.) | 0.385 | 1186.312 | 1.797 |
| 3. | No. of primary branches per plant | 0.057 | 2.770 | 0.150 |
| 4. | Diameter of fruit (cm.) | 0.049 | 1.717 | 0.028 |
| 5. | Pericarp thickness (mm.) | 0.585 | 1.830 | 0.145 |
| 6. | Fruit length (cm.) | 0.003 | 5.127 | 0.040 |
| 7. | Fruit per plant | 1.121 | 80.403 | 0.309 |
| 8. | Average fruit weight (g.) | 2.218 | 332.122 | 1.431 |
| 9. | Total Soluble Solids (TSS%) | 0.056 | 1.277 | 0.086 |
| 10. | No. of locules per fruit | 0.672 | 2.665 | 0.089 |
| 11. | Unmarketable fruit / plant | 0.086 | 9.431 | 0.199 |
| 12. | Marketable fruit / plant | 0.603 | 50.424 | 0.714 |
| 13. | Fruit yield per plant (g.) | 2875.167 | 173310.902 | 1060.128 |

and 25 days old healthy seedlings were transplanted in the experimental field on 29th October 2012 in two rows of four meter length with inter and intra row spacing of 60 and 50 cm, respectively. All the recommended cultural practices were followed to maintain good crop stand and growth of the plants. Data were recorded for ten characters *viz* days to 50 per cent flowering, plant height (cm), number of primary branches per plant, fruit diameter (cm), fruit length (cm), number of locules per fruit, pericarp thickness (mm), average fruit weight (g), total soluble solids, number of fruits per plant, number of marketable fruits per plant, number of unmarketable fruits per plant and fruit yield per plant (g). The data were analyzed as per methods suggested by Panse and Sukhatme (1967) for analysis of variance, Burton (1952) for variability, Lush (1940) for heritability (Broad Sense) and Johnson *et al.* (1955) for genetic advance in per cent of mean.

Results and Discussion

The mean performance of thirty five genotypes of tomato for thirteen characters had been presented in table 2. A very wide range of variations in mean performance of genotypes were observed for all the characters under study. The comparison of mean performance genotypes for ten traits using critical differences revealed existence of very high level of variability among the genotypes. The Seven genotypes *viz*. NDT-7 (1443.00g), NDGCT-1 (1171.00g), Arka Abha (1121.38g), NDTG-18

(1109.60g), NDTG-10 (988.47g), NDTG-15 (984.14g) and Navodaya (932.67g) were found significantly higher for fruit yield per plant than the best check H-86 (913.71g) in determinate group, while none of the genotypes were found higher fruit yield per plant than the best check NDT-4 (1224.75) in case of indeterminate group.

The genetic variability is the raw material in the plant breeding industry on which selection act to evolve superior genotypes. Thus, higher the amount of variation presents for a character in the breeding materials, greater the scope for its improvement through selection. The genotypic and phenotypic coefficients of variation were computed to assess the exiting variability in the germplasm (table 3). High magnitude of phenotypic as well as genotypic coefficients of variation were observed in case of average fruit weight followed by unmarketable fruits per plant, fruit yield per plant, plant height, number of locules per fruit, number of primary branches per plant, pericarp thickness, marketable fruits per plant and number of fruits per plant. This indicates possibility of obtaining higher selection response in respect of above traits. The high estimates of PCV and GCV for these characters were also reported by Dar and Sharma (2011) and Rani and Anitha (2011). Moderate variations were noted in case of fruit length, diameter of fruit, total soluble solids (TSS). While, low GCV and PCV were observed for days to 50 per cent flowering. Moderate and low variability for these traits in tomato were also reported by Sahanur *et al.* (2012) and Madhurina and Paul (2012).

Table 2 : Mean performance of 35 genotypes for thirteen characters in tomato.

| Characters | Days to 50% flowering | Plant height (cm) | Primary branches/plant | Diameter of fruits (cm) | Pericarp thickness (mm) | Fruit length (cm) | No. of fruits/plant | Average fruit weight (g) | TSS % | No. of locules/fruit | No. of unmarketable fruits/plant | No. of marketable fruits/plant | Fruit yields/plant (g) |
|---------------|-----------------------|-------------------|------------------------|-------------------------|-------------------------|-------------------|---------------------|--------------------------|-------|----------------------|----------------------------------|--------------------------------|------------------------|
| NDT1 | 56.33 | 85.70 | 3.37 | 5.75 | 4.67 | 7.68 | 19.03 | 27.00 | 4.99 | 4.73 | 4.80 | 14.23 | 513.06 |
| NDT3 | 55.33 | 54.78 | 3.43 | 6.03 | 3.47 | 7.57 | 19.55 | 30.67 | 4.17 | 3.29 | 6.99 | 12.73 | 608.72 |
| NDT5 | 56.00 | 91.75 | 5.08 | 5.49 | 4.27 | 6.53 | 18.00 | 62.33 | 4.50 | 4.20 | 4.59 | 13.41 | 1128.73 |
| Angoorlata | 55.00 | 86.48 | 4.15 | 4.92 | 4.07 | 6.02 | 21.75 | 37.33 | 5.19 | 4.20 | 7.23 | 14.42 | 808.33 |
| HS-7 | 54.00 | 106.00 | 4.20 | 3.92 | 1.87 | 5.00 | 29.96 | 16.20 | 4.70 | 2.00 | 9.37 | 20.59 | 482.61 |
| NDTG-9 | 57.33 | 110.85 | 5.33 | 4.30 | 1.80 | 7.33 | 34.72 | 15.68 | 4.33 | 2.13 | 9.30 | 25.42 | 546.87 |
| NDTG-16 | 61.67 | 74.45 | 3.85 | 4.12 | 2.70 | 6.03 | 21.10 | 33.05 | 4.71 | 4.17 | 5.35 | 15.75 | 728.55 |
| NDTG-19 | 64.67 | 66.13 | 5.23 | 4.62 | 4.60 | 6.17 | 26.58 | 22.28 | 4.36 | 3.30 | 7.53 | 19.04 | 597.06 |
| NDT4(C) | 54.33 | 110.85 | 4.27 | 6.24 | 3.73 | 7.43 | 22.65 | 53.38 | 5.18 | 6.47 | 5.91 | 16.74 | 1224.75 |
| Pusa Rubi (C) | 55.67 | 72.25 | 3.63 | 4.64 | 3.60 | 5.98 | 25.64 | 42.67 | 4.92 | 3.67 | 5.27 | 20.37 | 1095.95 |
| NDT2 | 57.00 | 63.47 | 4.73 | 6.55 | 4.03 | 7.50 | 16.05 | 43.00 | 4.75 | 5.13 | 5.10 | 10.95 | 686.97 |
| NDT7 | 57.67 | 56.00 | 4.53 | 5.79 | 3.13 | 7.13 | 24.63 | 58.20 | 4.68 | 4.67 | 4.76 | 19.55 | 1443.00 |
| Navodaya | 56.00 | 85.17 | 3.47 | 4.36 | 3.60 | 5.43 | 23.21 | 40.00 | 6.03 | 4.20 | 3.20 | 20.03 | 932.67 |
| NDTG-1 | 56.33 | 59.05 | 3.27 | 5.90 | 4.80 | 6.90 | 23.85 | 38.00 | 4.81 | 4.47 | 6.00 | 17.85 | 908.33 |
| NDTG-2 | 56.33 | 83.58 | 3.33 | 4.16 | 3.17 | 5.30 | 26.11 | 22.05 | 6.12 | 3.43 | 4.17 | 21.94 | 574.82 |
| NDTG-3 | 54.67 | 59.28 | 4.18 | 6.15 | 4.13 | 7.61 | 20.64 | 31.58 | 5.47 | 3.17 | 5.47 | 14.17 | 652.33 |
| NDTG-4 | 54.33 | 48.17 | 3.98 | 4.65 | 3.87 | 5.53 | 18.08 | 23.68 | 5.43 | 3.33 | 3.32 | 14.76 | 430.08 |
| NDTG-5 | 58.33 | 55.08 | 3.27 | 6.32 | 3.00 | 7.00 | 16.87 | 38.13 | 5.91 | 3.53 | 3.97 | 12.89 | 659.50 |
| NDTG-6 | 54.00 | 62.05 | 3.37 | 5.13 | 3.20 | 7.15 | 24.12 | 29.00 | 6.10 | 3.40 | 8.16 | 15.96 | 700.50 |
| Navodaya-2 | 54.33 | 66.27 | 3.00 | 5.45 | 4.60 | 6.87 | 27.27 | 31.33 | 5.73 | 4.37 | 5.65 | 21.62 | 852.63 |
| NDTG-7 | 56.33 | 52.00 | 4.25 | 5.95 | 3.40 | 7.02 | 21.72 | 40.35 | 5.65 | 3.07 | 7.44 | 14.28 | 880.00 |
| NDGCT-1 | 54.67 | 54.67 | 6.72 | 6.56 | 3.57 | 7.73 | 25.63 | 45.38 | 5.29 | 3.60 | 5.86 | 19.04 | 1171.00 |
| Arka Abha | 57.00 | 73.17 | 3.53 | 5.73 | 2.93 | 7.73 | 25.05 | 43.98 | 5.03 | 2.20 | 6.44 | 18.61 | 1121.38 |
| NDTG-8 | 53.67 | 47.40 | 3.28 | 4.81 | 5.23 | 7.12 | 18.00 | 42.33 | 4.70 | 3.12 | 3.62 | 14.04 | 772.49 |
| NDTG-10 | 58.00 | 53.00 | 5.40 | 5.89 | 3.87 | 7.18 | 31.27 | 33.00 | 6.20 | 4.80 | 6.29 | 24.98 | 988.47 |
| NDTG-11 | 55.33 | 56.37 | 3.67 | 6.12 | 4.33 | 8.10 | 19.97 | 31.67 | 4.63 | 2.73 | 5.39 | 14.28 | 638.14 |

Table 2 continued...

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| | | | | | | | | | | | | | |
|----------------|--------------|--------------|-------------|-------------|-------------|-------------|--------------|--------------|-------------|-------------|-------------|--------------|---------------|
| Panjab Chuhara | 58.00 | 51.58 | 3.30 | 5.31 | 2.70 | 8.12 | 28.28 | 29.00 | 4.22 | 2.61 | 7.42 | 20.84 | 823.40 |
| NDTG-12 | 54.67 | 41.50 | 3.40 | 4.31 | 2.70 | 6.40 | 23.68 | 29.25 | 6.30 | 4.23 | 4.67 | 19.01 | 746.34 |
| NDTG-13 | 57.33 | 48.08 | 4.62 | 5.01 | 3.75 | 12.17 | 26.00 | 34.48 | 5.58 | 3.37 | 5.87 | 20.13 | 870.83 |
| NDTG-14 | 58.00 | 56.33 | 4.63 | 4.73 | 3.08 | 6.22 | 16.94 | 31.33 | 5.40 | 4.55 | 3.70 | 13.24 | 540.33 |
| NDTG-15 | 58.33 | 62.58 | 3.33 | 5.18 | 4.37 | 5.20 | 28.80 | 34.03 | 3.75 | 4.67 | 8.32 | 20.52 | 984.13 |
| AZAD T-1 | 63.67 | 60.35 | 2.25 | 5.56 | 2.93 | 8.95 | 29.38 | 21.07 | 4.77 | 4.67 | 6.03 | 23.36 | 617.68 |
| NDTG-17 | 60.67 | 56.10 | 3.48 | 5.83 | 3.25 | 7.52 | 31.52 | 28.17 | 4.32 | 3.20 | 8.08 | 23.43 | 907.53 |
| NDTG-18 | 61.67 | 51.25 | 6.48 | 4.48 | 3.23 | 5.43 | 35.75 | 31.03 | 5.32 | 3.92 | 10.07 | 25.68 | 1109.60 |
| H-86 (C) | 55.33 | 79.92 | 3.64 | 5.18 | 3.57 | 7.05 | 31.14 | 29.70 | 5.42 | 4.70 | 7.39 | 23.33 | 913.71 |
| Mean | 56.91 | 68.05 | 4.05 | 5.29 | 3.58 | 6.97 | 24.37 | 34.30 | 5.10 | 3.81 | 6.08 | 18.21 | 818.87 |
| C.V. | 1.81 | 1.97 | 9.57 | 3.20 | 10.68 | 2.89 | 2.28 | 3.49 | 5.75 | 7.86 | 7.35 | 4.64 | 3.98 |
| S.E.M \pm | 0.60 | 0.77 | 0.22 | 0.10 | 0.22 | 0.12 | 0.32 | 0.69 | 0.17 | 0.17 | 0.26 | 0.49 | 18.80 |
| C.D. 5% | 1.68 | 2.18 | 0.63 | 0.28 | 0.62 | 0.33 | 0.91 | 1.95 | 0.48 | 0.49 | 0.73 | 1.38 | 53.05 |
| Range Lowest | 53.67 | 41.50 | 2.25 | 3.92 | 1.80 | 5.00 | 16.05 | 15.68 | 3.75 | 2.00 | 3.20 | 10.95 | 430.08 |
| Range Highest | 64.67 | 113.17 | 6.72 | 6.56 | 5.23 | 12.17 | 35.75 | 62.33 | 6.30 | 6.47 | 10.07 | 25.68 | 1443.00 |

Table 3 : Estimates of range, grand mean, phenotypic (PCV), genotypic (GCV), environmental (ECV) coefficient of variation, heritability in broad sense, genetic advance (GA) and GA (in per cent of mean) for thirteen characters in tomato germplasm.

| S.no. | Characters | Genetic parameters | | Range | | Grand mean | PCV (%) | GCV (%) | ECV (%) | Heritability in broad sense (%) (h^2_{bs}) | Genetic advance | Genetic advance in per cent of mean |
|-------|--------------------------------|--------------------|---------|--------|---------|------------|---------|---------|---------|--|-----------------|-------------------------------------|
| | | Lowest | Highest | Lowest | Highest | | | | | | | |
| 1. | Days to 50 per cent flowering | 53.66 | 64.66 | 56.91 | 5.01 | 4.67 | 1.81 | 86.91 | 5.10 | 8.96 | | |
| 2. | Plant height (cm) | 41.50 | 113.16 | 68.04 | 29.27 | 29.20 | 1.97 | 99.55 | 40.84 | 60.01 | | |
| 3. | No. of primary branches/ plant | 2.25 | 6.71 | 4.04 | 25.00 | 23.09 | 9.57 | 85.34 | 1.77 | 43.94 | | |
| 4. | Diameter of fruit (cm) | 3.91 | 6.55 | 5.29 | 14.54 | 14.18 | 3.20 | 95.15 | 1.50 | 28.50 | | |
| 5. | Pericarp thickness (mm) | 1.80 | 5.23 | 3.57 | 23.51 | 20.94 | 10.68 | 79.38 | 1.37 | 38.44 | | |
| 6. | Fruit length (cm) | 5.00 | 12.16 | 6.97 | 18.89 | 18.67 | 2.89 | 97.66 | 2.65 | 38.01 | | |
| 7. | Fruits per plant | 16.05 | 35.75 | 24.36 | 21.33 | 21.20 | 2.28 | 98.85 | 10.58 | 43.42 | | |
| 8. | Average fruit weight (g) | 15.68 | 62.33 | 34.29 | 30.81 | 30.61 | 3.49 | 98.72 | 21.48 | 62.65 | | |
| 9. | Total Soluble Solids (TSS) | 3.75 | 6.29 | 5.10 | 13.62 | 12.34 | 5.75 | 82.20 | 1.17 | 23.05 | | |
| 10. | No. of locules per fruit | 2.00 | 6.46 | 3.80 | 25.57 | 24.33 | 7.86 | 90.55 | 1.81 | 47.70 | | |
| 11. | Unmarketable fruit / plant | 3.20 | 10.07 | 6.07 | 29.78 | 28.86 | 7.35 | 93.92 | 3.50 | 57.61 | | |
| 12. | Marketable fruit / plant | 10.95 | 25.68 | 18.20 | 22.84 | 22.36 | 4.64 | 95.86 | 8.21 | 45.09 | | |
| 13. | Fruit yield per plant (g) | 430.08 | 1443.00 | 818.87 | 29.53 | 29.26 | 3.98 | 98.19 | 489.11 | 59.73 | | |

Heritability estimates the information which helps the breeders for selecting the genotypes for further use. Higher magnitude of heritability suggests the measure of genotypic factors in the expression of the characters. The highest estimates of heritability were observed in case of plant height. High heritability and high genetic advance in per cent of means were observed for all the characters except days to 50 percent flowering in genetic advance. Similar findings are also reported by various workers such as Joshi and Singh (2003), Singh *et al.* (2006), Maurya *et al.* (2011) and Tasisa *et al.* (2011).

The degree of success in selection depends upon the magnitude of the heritability. Furthermore, the progress in the selection is also directly proportional to the amount of genetic advance. Therefore, the effect of selection is realized more quickly in those characters, which have high heritability as well as high genetic advance. Perusal of data (table 3) on heritability and genetic advance revealed that high heritability coupled with high genetic advance (>15%) were recorded for all the traits except days to 50 per cent flowering. Thus, these traits which exhibited high heritability in broad sense and high expected genetic advance as per cent of mean may be considered to be largely governed by additive gene action and therefore, could be effectively improved through selection. High heritability along with high genetic advance have also been reported for most of the yield and yield attributing traits by Mahesha *et al.* (2006), Kumari *et al.* (2007), Saeed *et al.* (2007), Prema *et al.* (2011), Tasisa *et al.* (2011), Madhurina and Paul (2012) and Sahanur *et al.* (2012).

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