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# Variability Studies for Growth, Yield and Quality Characters of Tomato (*Lycopersicon esculentum* Mill.)

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**ABSTRACT**

*Tomato [Lycopersicon esculentum Mill.] being an under exploited vegetable has a wide range of variability. Exploitation of hybrid vigour provides ample scope for improving the genetic architecture of tomato. The study material comprised of genetically diverse thirteen tomato genotypes which were evaluated in randomized block design. The genotypes were evaluated on the basis of plant height, number branches, days to 50% flowering, number of trusses per plant, number of flowers per cluster, number of fruits per truss, number of fruits per plant, leaf area index, marketable yield, average fruit weight, equatorial and polar diameter of fruit, number of locules per fruit, pericarp thickness of fruit, total soluble solids, acidity, ascorbic acid content ,chlorophyll a:b ratio, test weight of seed and days to first harvest, which differentiate the tomato genotypes. Analysis of variance studies indicated a significant difference among all the genotypes for all the characters under study. Genetic variability studies showed high PCV and GCV values for number of branches per plant, pericarp thickness and acidity indicating that a greater amount of genetic variability was present for these characters. High heritability coupled with high genetic advance as per cent of mean was observed for marketable yield, days to 50% flowering, plant height at 90 days after transplanting, number of fruits per plant, number of branches per plant, total soluble solids number of locules per fruit, which indicated that these traits were under the strong influence of additive gene action.*

***Keywords:*** *Tomato, Variability, Heritability, GCV and PCV*

## INTRODUCTION

Tomato (*Lycopersiconesculentum* Mill.), a member of Solanaceae family, is one of the most popular vegetable crops grown widely all over the world as it is a very versatile vegetable, ranking second in importance to potato in many countries. In fact, tomato tops the list of processed vegetables and occupies a distinct place in the realm of vegetables because of its large-scale utilization and high nutritive value, as it supplies lycopene, ascorbic acid and β-carotene (potent antioxidants), and add colour and flavour, therefore, in many countries, it is considered as *poor man's orange*.

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The production of tomato is highly influenced by environmental factors such as temperature, light, relative humidity and carbon dioxide level in the atmosphere. The prime objective of the breeder is to improve the plant characters both qualitatively and quantitatively. Hence, adequate knowledge of genetics for various traits is essential to obtaining desirable results. For a successful crop improvement programme, the magnitude of genetic variability and the degree of transmission is of immense importance. Phenotypic plant characters are controlled by the genetic makeup of a plant and its prevailing environment conditions. By considering the parameters such as phenotypic genetic variability, genotypic genetic variability, heritability and genetic advance, phenotypic variability present in the population can be divided into heritable and non-heritable components

Heritability denotes the proportion of phenotypic variation due to genotype. An effective breeding programme involves the improvement of both yield and quality parameters. Likewise, heritability and genetic advance both are important considerations for a selection than heritability alone because, though high heritability helps the breeder to select the desirable genotype for a character based on phenotype but does not mean genetic gain for a particular character. Genetic advance denotes the improvement in the genotypic values of the selected population over the base. The selection of new parents is of prime importance for achieving better heterosis since; commercial $F_1$ hybrids are common in tomato. Generally, plants that are genetically diverse are expected to give high hybrid vigor. Hence, the study of genetic divergence among the existing varieties necessitates the identification of parents for the hybridization programme. The potentiality of this crop made its need for improvement and to develop varieties suitable for cultivation under specific agro-climatic conditions. Plant productivity requires the consideration of both yield and quality parameters for the breeding programme. Existence of genetic variability among the parents for specific characters is prerequisite for crop improvement. Evolution of germplasm is an imperative hence breeder will have to create the genetic variability through hybridization, mutation and polyploidy breeding.

## MATERIALS AND METHODS

The experiment was carried out at Research Farm and Laboratory of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during a spring-summer season of the year 2018. The experimental material comprised of 13 genetically diverse genotypes of tomato *viz.*, 16/TODVAR-1 to 16/TODVAR-12 (IIVR, Varanasi) and Sel-7 (Hisar, Haryana). These genotypes were grown in Randomized Block Design with 3 replications and 60 x 45 cm spacings. Observations were recorded for plant height, number branches, days to 50% flowering, number of trusses per plant, number of flowers per cluster, number of fruits per truss, number of fruits per plant, leaf area index, marketable yield, average fruit weight, equatorial and polar diameter of fruit, number of locules per fruit, pericarp thickness of fruit, total soluble solids, acidity, ascorbic acid content, chlorophyll a:b ratio, test weight of seed and days to first harvest.

Analysis of variance (ANOVA) of the observations recorded on different characteristics was carried out as per the standard procedure is given by Panse and Sukhatme (1978). Heritability in broad sense was calculated as the ratio of genotypic variance to the phenotypic variance and it was expressed in percentage (Falconer, 1981).Genetic advance as per cent mean of each character was worked out by adopting the following formula given by Johnson et al. (1955).

## RESULTS AND DISCUSSION

The observational data were recorded as per the materials and methods discussed in the previous chapter. The experimental data for different characters were arranged and analyzed by following the Randomized Block

Design. The results obtained are presented under the following headings:

4.1 Analysis of variance

4.2 Mean performance and range

4.3 Components of variation and estimates of genetic parameters.

### 4.1 Analysis of variance

The analysis of variance indicated a significantly higher amount of variability among the genotypes for all the characters studied *viz*., plant height at 60, 90 and 120 days after transplanting, number of branches per plant, leaf area index, days to 50% flowering, number of flowers per cluster, number of trusses per plant, number of fruits per truss, number of fruits per plant, average fruit weight, equatorial diameter of fruit, polar diameter of fruit, number of locules per fruit, total soluble solids, ascorbic acid content, acidity, chlorophyll a:b ratio, days to first harvest, test weight of seed, days to first harvest and marketable yield

**Table 4.1: Analysis of variance (mean sum of square) for growth, yield and quality parameters in different tomato genotypes**

| Sr. No. | Characters | Mean sum of square | | |
|---|---|---|---|---|
| | | Replications (df=2) | Genotypes (df=12) | Error (df=24) |
| 1 | Plant height at 60 DAT (cm) | 10.230 | 229.55* | 36.30 |
| 2 | Plant height at 90 DAT (cm) | 14.021 | 133.38* | 3.000 |
| 3 | Plant height at 120 DAT (cm) | 19.560 | 335.88* | 10.670 |
| 4 | Number of branches per plant | 1.022 | 19.03** | 0.600 |
| 5 | Days to 50% flowering | 22.480 | 90.16* | 1.980 |
| 6 | Leaf area index ($m^2/m^2$) | 0.013 | 0.07** | 0.013 |
| 7 | Number of flowers per cluster | 0.058 | 0.44** | 0.028 |
| 8 | Number of trusses per cluster | 1.789 | 3.58** | 0.485 |
| 9 | Number of fruits per truss | 0.023 | 0.02** | 0.020 |
| 10 | Number of fruits per plant | 3.266 | 136.37** | 3.700 |
| 11 | Days to first harvest | 1.333 | 13.11** | 2.300 |
| 12 | Average fruit weight (g) | 0.487 | 15.26* | 1.570 |
| 13 | Marketable yield (q/ha) | 57.970 | 2122.19** | 40.840 |
| 14 | Polar diameter (cm) | 0.021 | 0.01** | 0.086 |
| 15 | Equatorial diameter (cm) | 0.085 | 0.46** | 0.030 |
| 16 | Number of locules per fruit | 0.011 | 0.438** | 0.027 |
| 17 | Pericarp thickness (mm) | 0.001 | 0.038** | 0.004 |
| 18 | Total soluble solids (°Bx) | 0.102 | 0.49** | 0.016 |
| 19 | Acidity (%) | 0.013 | 0.03* | 0.004 |
| 20 | Ascorbic acid(mg/100g) | 0.907 | 9.39** | 0.715 |
| 21 | Chlorophyll a:b ratio | 1.823 | 4.57** | 1.150 |
| 22 | Test weight of seed (g) | 0.007 | 0.07** | 0.011 |

**Significant at 1%, * Significant at 5%

DAT-Days after transplanting

### 4.3 Components of variation and estimates of genetic parameters

The estimates of components of variances, coefficients of variation, minimum, maximum values and the genetic parameters like. genotypic variance, phenotypic variance, genotypic coefficient of variation, phenotypic coefficient of variation, heritability (broad sense), and genetic advance as percent of mean along with mean and the range of various characters investigated in the present study had been mentioned in Table 4.3

The mean values for different parameters under study were already explained previously under subheading mean performance of respective characters. However, the remaining estimates have been explained below:

In general, the magnitude of phenotypic variances, as well as coefficients of variation, was higher than their respective genotypic estimates, indicating the environment influence on the expression of these characters.

The highest estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) was recorded for number of branches per plant (23.54 and 23.93%), pericarp thickness (15.42 and 16.46%), acidity (14.79 and 15.8%), plant height 60 DAT (13.37 and 14.57%), number of fruits per plant (12.28 and 12.45%), plant height 120 DAT(12.11 and 12.31%), marketable yield (9.175 and 9.266%) plant height 90 DAT(9.09 and 9.19%), and whereas, the lowest estimates of GCV and PCV was observed for traits like days to first harvest (2.27 and 2.5%), polar diameter (2.82 and 4.8%), test weight of seed ( 3.57 and 3.88%), average fruit weight (3.96 and 4.18%), chlorophyll a:b ratio(4.31 and 4.98%), leaf area index (4.49 and 4.97%)

Moderate PCV and GCV was estimated for, number of flowers per cluster (5.41 and 5.59%), total soluble solids (6.09 and 6.19%),number of trusses per plant (6.297 and 6.77%), ascorbic acid (6.85 and 7.13%), equatorial diameter of fruit (7.83 and 8.09%), number of locules per fruit (7.84 and 8.1%) and days to 50% flowering (8.56 and 8.656%.), number of fruits per truss (8.41 and 8.74) The high estimates of heritability (broad sense) were noticed in almost all characters *viz*, marketable yield (98.08%), days to 50% flowering (97.80%), plant height at 90 DAT (97.75%), number of fruits per plant (97.29%), plant height at 120 DAT (96.82%), number of branches per plant (96.81%), total soluble solids (96.74%),number of locules per fruit (93.68%) equatorial diameter of fruit (93.55%), number of flowers per cluster (93.49%) number of fruits per truss (92.42%), ascorbic acid(92.38%), average fruit weight (89.71%), number of trusses per plant (89.47%), pericarp thickness (87.78%), acidity (87.50%), test weight of seed (84.83%), plant height at 60 DAT (84.16%), days to first harvest (82.43%), leaf area index (81.48%),chlorophyll a:b ratio (74.79%).

Estimates of genetic advance as percent of mean were recorded very high for number of branches per plant (47.72%) followed by pericarp thickness (29.77%), acidity (28.53%), plant height at 60 DAT (25.27), number of fruits per plant (24.96%) plant height at 120 DAT(24.55). while ,the estimates of genetic advance as per cent of mean for marketable yield (18.72%), plant height at 90 DAT (18.52%), days to 50% flowering (17.43%) and number of fruits per truss (16.65%) were in average range and found very low for polar diameter of fruit (3.42%), days to first harvest (4.25), test weight of seed (6.74), chlorophyll a:b ratio (7.68%), average fruit weight (7.74%), leaf area index (8.35%), number of flowers per cluster (10.77%), number of trusses per plant (12.06%), total soluble solids (12.35%), ascorbic acid (13.56%), equatorial diameter of fruit (15.63%), number of locules per fruit (15.64%).

The reports of analysis of variance investigated during the study indicated a significantly higher amount of variability among the genotypes for all the characters studied (Table 4.1) They clearly indicate that the presence of high variability existed for yield and yield components among all the genotypes studied. Hence, there is a scope for selection or hybridization followed by selection for the majority of the traits in the genotypes for their further improvement. The earlier workers (Mehta & Asati, 2008; Dar et al., 2012; Kumar et al., 2013; Ramzan et al.,2014; Singh et al., 2014; Prajapati et al., 2015) also reported a large and exploitable variation in different tomato germplasm. The genotypes showed a wide range of variation, which helps in the selection of desired genotypes for further improvement and exploitation through selection, hybridization, heterosis and combination breeding (Table 4.1)

**Table 4.3: Estimation of variability, heritability and expected genetic advance for 22 characters**

| Sr. No. | Characters | Range Min-Max | General Mean | Phenotypic variance | Genotypic variance |
|---|---|---|---|---|---|
| 1 | Plant height at 60 DAT (cm) | 50.33 -76.33 | 60.00 | 76.51 | 64.39 |
| 2 | Plant height at 90 DAT (cm) | 63.33 - 84.33 | 72.49 | 44.46 | 43.46 |
| 3 | Plant height at 120 DAT (cm) | 81.00 – 105.0 | 85.94 | 111.96 | 108.41 |
| 4 | Number of branches per plant | 7.43 - 13.30, | 10.52 | 6.34 | 6.14 |
| 5 | Days to 50% flowering | 56.00 -72.67 | 63.33 | 30.05 | 29.39 |
| 6 | Leaf area index | 2.96 - 3.47 | 3.16 | 0.024 | 0.02 |
| 7 | Number of flowers per cluster | 6.50 -7.30 | 6.85 | 0.14 | 0.13 |
| 8 | Number of trusses per plant | 13.47 -17.20 | 16.14 | 1.19 | 1.03 |
| 9 | Number of fruits per truss | 2.80 - 3.93 | 3.41 | 0.09 | 0.08 |
| 10 | Number of fruits per plant | 45.67 – 63 | 54.12 | 45.45 | 44.22 |
| 11 | Days to first harvest | 80.67 - 87.33 | 83.41 | 4.37 | 3.604 |
| 12 | Average fruit weight (g) | 51.67 - 60.00 | 53.94 | 5.08 | 4.56 |
| 13 | Marketable yield (q/ha) | 235.0 - 318.33 | 287.06 | 707.39 | 693.78 |
| 14 | Polar diameter (cm) | 4.10 -4.73 | 4.37 | 0.045 | 0.015 |
| 15 | Equatorial diameter (cm) | 4.4 -5.60 | 4.87 | 0.15 | 0.14 |
| 16 | Number of locules per fruit | 4.10 - 5.13 | 4.71 | 0.14 | 0.13 |
| 17 | Pericarp thickness (mm) | 0.43 - 0.78 | 0.68 | 0.01 | 0.02 |
| 18 | Total soluble solids (%) | 6.13 - 7.31 | 6.56 | 0.16 | 0.16 |
| 19 | Acidity (%) | 0.53 - 0.83 | 0.66 | 0.01 | 0.009 |
| 20 | Ascorbic acid(mg/100g) | 21.50 - 26.63 | 24.81 | 3.13 | 2.89 |
| 21 | Chlorophyll a:b ratio | 2.2:1 - 1:1 | 24.74 | 1.52 | 1.14 |
| 22 | Test weight (g) | 3.67 - 4.27 | 4.16 | 0.02 | 0.022 |

The analysis of variance investigated during the study indicated a significantly higher amount of variability among the genotypes for all the characters studied *viz*., plant height at 60, 90 and 120 DAT, number of branches per plant, days to 50% flowering, leaf area index, number of flowers per cluster, number of trusses per plant, number of fruits per truss, number of fruits per plant, equatorial diameter of fruit, polar diameter of fruit, number of locules per fruit, average fruit weight, pericarp thickness, total soluble solids ascorbic acid content, acidity, chlorophyll a:b ratio, test weight of seed, marketable yield and days to first harvest. These results indicate that there is plenty of scope for the improvement of germplasm through selection and utilization in heterosis breeding. Based on variability assessed in present study and that assessed by earlier workers like (Shasikant et al., 2010; Khan and Samadia, 2012; Ahirwar and Prashad, 2013; Kumar et al., 2013; Meena and Bahadur, 2014; Kumar et al., 2015)

In tomato, it could be stated that there ample scope of variation in traits that could be utilized for improvement through selection for the traits investigated in the present material. Further, based on fruit yield per plant in the present investigation, the tomato genotypes 16/TODVAR-5 followed by 16/TODVAR-8, 16/TODVAR-11 and 16/TODVAR-4 appeared to be most promising for their exploitation and utilization for the incorporation of fruit yield potential in other promising materials. Thus, the materials assessed possessed ample scope of their improvement through selection and

utilization of heterosis breeding for higher yield and quality. The high estimates of heritability for twenty-two traits were noticed (Table 4.3).

**Estimation of variability, heritability and expected genetic advance for 22 characters**

| Sr. No. | Characters | Phenotypic coefficient of variation | Genotypic coefficient of variation | Heritability in broad sense ($h^2b$) in % | Genetic advance as % of mean |
|---|---|---|---|---|---|
| 1 | Plant height at 60 DAT (cm) | 14.57 | 13.37 | 84.16 | 25.27 |
| 2 | Plant height at 90 DAT (cm) | 9.19 | 9.09 | 97.75 | 18.52 |
| 3 | Plant height at 120 DAT (cm) | 12.31 | 12.11 | 96.82 | 24.55 |
| 4 | Number of branches per plant | 23.93 | 23.54 | 96.81 | 47.72 |
| 5 | Days to 50% flowering | 8.65 | 8.56 | 97.80 | 17.43 |
| 6 | Leaf area index | 4.97 | 4.49 | 81.48 | 8.35 |
| 7 | Number of flowers per cluster | 5.59 | 5.41 | 93.49 | 10.77 |
| 8 | Number of trusses per plant | 6.77 | 6.29 | 89.47 | 12.06 |
| 9 | Number of fruits per truss | 8.74 | 8.41 | 92.42 | 16.65 |
| 10 | Number of fruits per plant | 12.45 | 12.28 | 97.29 | 24.96 |
| 11 | Days to first harvest | 2.5 | 2.27 | 82.43 | 4.25 |
| 12 | Average fruit weight (g) | 4.18 | 3.96 | 89.71 | 7.74 |
| 13 | Marketable yield (q/ha) | 9.26 | 9.17 | 98.08 | 18.72 |
| 14 | Polar diameter (cm) | 4.8 | 2.82 | 34.66 | 3.42 |
| 15 | Equatorial diameter (cm) | 8.09 | 7.83 | 93.55 | 15.63 |
| 16 | Number of locules per fruit | 8.1 | 7.84 | 93.68 | 15.64 |
| 17 | Pericarp thickness (mm) | 16.46 | 15.42 | 87.78 | 29.77 |
| 18 | Total soluble solids (%) | 6.19 | 6.09 | 96.74 | 12.35 |
| 19 | Acidity (%) | 15.8 | 14.79 | 87.50 | 28.53 |
| 20 | Ascorbic acid(mg/100g) | 7.13 | 6.85 | 92.38 | 13.56 |
| 21 | Chlorophyll a:b ratio | 4.98 | 4.31 | 74.79 | 7.68 |
| 22 | Test weight (g) | 3.88 | 3.57 | 84.83 | 6.74 |

Further, genetic advance as per cent of mean observed for most of the characters under study showed that the number of branches per plant. pericarp thickness, number of fruits per plant, marketable yield, plant height, ascorbic acid, total soluble solids, average fruit weight, number of trusses per plant, number of locules per fruit had moderate to high magnitude, indicating that the improvement of these through selection as well as their exploitation through combination breeding. However, the estimates of high heritability coupled with high genetic advance observed for most of the characters except days to first harvest, polar diameter of fruit, chlorophyll a:b ratio and leaf area index, suggesting that simple selection could be done for the improvement of most of the traits in the existing material. Results of the present investigation are also in agreement with previous studies carried out on tomato crop by several workers (Ghosh et al., 2010; Dar et al., 2012; Meena and Bahadur, 2014; Sharma and Paul, 2014; Khapte and Jansirani, 2014).

## CONCLUSION

Based on the results of one year study it can be concluded that out of thirteen tomato genotypes studied, the tomato genotype 16/TODVAR-5 recorded th**e** maximum number of fruits per plant (63.00)and marketable yield per plant and per hectare (318.33 q/ha)**.**Whereas, for quality purpose the tomato genotype which are found most

suitable for total soluble solids(16/TODVAR-12), acidity (16/TODVAR-3), for chlorophyll (16/TODVAR-4) and ascorbic acid (16/TODVAR-4 and 16/TODVAR-5) were found most promising. Which can be further utilized in future breeding programme.

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