Study on Genetic Variability, Heritability, Genetic Advance in Tomato (Solanum lycopersicum L.)

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An experiment was conducted to evaluation of genetic variability present in the twenty genotypes and observations were recorded on various yield and yield contributing characters. Analysis of variance showed the significant variability for all the studied characters. High values of GCV and PCV were observed for characters viz., number of fruits per plant (55.74, 56.21), number of locules per fruit (36.44, 37.15), average fruit weight (35.45, 35.97) fruit yield per plant (31.09,32.35) marketable fruit yield per plot (31.10, 32.36) and which indicates the presence of high genetic variation. High heritability coupled with high genetic advance observed for the traits viz., plant height, number of flowers per cluster, number of fruit set per cluster, average fruit weight, number of fruits per plant, fruit yield per plant, fruit yield per plot, fruit shape index, TSS°Brix, Ascorbic acid, Beta carotene, Pericarp thickness, Number of locules per fruit. Which indicates presence of additive gene action and demands for population improvement by selection

Keywords
Genetic variability, Heritability, Genetic advance, Tomato, GCV, PCV

Introduction

Tomato belongs to the family solanaceae and is native of Peru Equador region Rick. Tomato is a typical day neutral plant and is mainly self-pollinated, but a certain percentage 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. The ancestor of cultivated tomato is cherry tomato (Lycopersicon esculentum var. cereasiforme). There are several species of tomato but the fruits are edible only of two species namely (Lycopersicon esculentum and L. pimpinellifolium). Tomato is a major source of vitamins and minerals. The nutrition value of tomato per 100 g fruit weight is, Energy-18 Kcal (1%), Carbohydrates-3.9g (3%), Protein-0.9g (1.6%), Total Fat, 0.2g (0.7%), Folates-15µg (4%), Niacin-0.594mg (4%), Vitamin A-833 IU (28%), VitaminC-13mg (21.5%), Vitamin E-0.54mg (4%), Calcium10 mg (1%), Iron 0.3mg (4%), Magnesium-11mg (3%), β Carotene 449µg, Carotene-α-101µg, Lycopene-2573µg (20-50 mg). (USDA National Nutrient data base, 2012-13)¹⁸. Inheritance of quantitative characters is often influenced by variation in other character which may be due to pleotrophic or genetic
linkage. There, must be a thorough knowledge of the existence genetic variability, mode of inheritance of economic characters, heritability, kind of gene action and the relative magnitude of additive, dominance and total genotypic and phenotypic variance of the population is essential to formulate an effective crop improvement programme. There is a scope of yield and quality improvement and there by develop export potential of tomato. Hence the present investigation carried out for genetic variability for quantitative and qualitative traits in genotypes of tomato. The knowledge of genotypic and phenotypic coefficient of variation is being useful in designing selection criteria from variable population. In general, it was noted that the value of phenotypic coefficient of variation is higher than the genotypic Coefficient of Variation For all the traits.

Materials and Methods

The present investigation the experiment was carried out at the horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Science Technology, Allahabad. The experimental material comprised of twenty genotypes, collected from source (Table 1). The genotypes were grown in a randomized block design with three replicates during winter season 2016-2017. keep distance of line to line distance 60cm. and plant to plant distance 45cm. Observations were recorded on five randomly selected plants per treatment for sixteen quantitative and qualitative characters viz., Plant height (cm), Days to first flowering, Days to 50 % flowering, Flowers/cluster, Fruit set/cluster, Fruit weight (kg), Fruits/ Plant, Fruits/Plant, Fruit yield/Plant (g), Fruit yield/ Plot (kg), Fruit shape index, TSS 0 Brix, Ascorbic acid (Vit C) mg/100g, Lycopene (mg/100g), β Carotene (mg), Pericarp Thickness (mm), Number of Locules/ Fruit. The analysis of variance was done as suggested by Panse and Sukhatme. The phenotypic and phenotypic coefficients of variation were worked out according to the Robinson et al., Heritability in broad sense and expected genetic advance on the basis of percent of mean were worked out according to the method advocated by (Burton and Devane) and Johnson et al., (1955) respectively. The analysis of genetic divergence was worked out by Mahalanobis D² statistics as per Mahalanobis method and genotypes are grouped into different cluster following Tocher’s method as described by Rao.

Results and Discussion

The mean sum of squares in ANOVA revealed high variability among 20 genotypes. The variation due to genotypes was significant for all the characters under study both at 5 and 1 per cent probability levels (Table 2). The high variability observed might be attributed to their genetic makeup of germplasm lines and the different geographical regions from which they have originated. This result of present investigation is in accordance with Singh and Cheema, Mahesha et al., (2006) and Basavaraj et al., (2010) also recorded highly significant difference among the tomato genotypes with respect to all the characters under studied. Mean performance for various genotypes has also showed good range of variability for various characters, studied in present investigation (Table 2). The range recorded for plant height (78.00-171.00) number of days taken to first flowering (31.33-40.6), number of days taken to 50% flowering (30.66-43.33) average fruit weight (6.88-87.46g), Number of fruits per plant (164.93-27.86), Fruit yield per plant (kg) (1.13-3.98kg), Marketable fruit yield per plot (10.24-35.89), Soluble Solid TSS 0 Brix (3.12-
7.78), Ascorbic acid (mg/100g) (11.61-18.65mg), lycopene content (5.20-6.46mg) per 100 g of pulp. Beta carotene content (0.21-0.37mg) per 100 g of pulp, fruit shape index (0.38-1.53), Pericarp Thickness (1.77-5.27mm), Number of locules per fruit (2.27-6.27), The characters under investigation were analyzed for genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (broad sense) and genetic advance as percent of mean (Table 2). In the present study, magnitude of phenotypic variances has high values than genotypic variances for the all characters, which is an indicator of additive effect of the environment on expression of traits. Low range of GCV and PCV reveals that these traits have low sensitivity to environmental effect and it is reducible. High values of GCV and PCV were observed for characters viz., number of fruits per plant, number of locules per fruit, average fruit weight, fruit yield per plant, marketable fruit yield per plot, fruit shape index, plant height, number of fruit set per cluster, TSS\textsuperscript{Brix}. Moderate GCV and PCV were observed for traits viz., number of fruits per plant, number of locules per fruit, average fruit weight, fruit yield per plant, marketable fruit yield per plot, fruit shape index, plant height, number of fruit set per cluster, Beta carotene, Ascorbic acid. Low GCV and PCV were observed for traits viz., days to first flowering, Lycopene content, days to 50% flowering.

Table 1 List of different genotypes was used in present investigation (Source of collection from IIVR Varanasi)

| S.No. | Genotype Symbol | Name of Genotypes | Determinate/Indeterminate / Semi Determinate | Source of Released |
|-------|------------------|-------------------|----------------------------------------------|--------------------|
| 1     | G\textsubscript{1} | ArkaVikas         | Determinate                                  | IIHR, Bangalore    |
| 2     | G\textsubscript{2} | Punjab Chhuhara   | Determinate                                  | PAU, Ludhiana      |
| 3     | G\textsubscript{3} | Azad T-5          | Determinate                                  | CSAUA&T, Kanpur    |
| 4     | G\textsubscript{4} | Azad T-6          | Determinate                                  | CSAUA&T, Kanpur    |
| 5     | G\textsubscript{5} | EC-501574         | Determinate                                  | IARI New Delhi     |
| 6     | G\textsubscript{6} | Kashi Vishesh     | Determinate                                  | IIVR, Varanasi     |
| 7     | G\textsubscript{7} | S 22              | Determinate                                  | IARI New Delhi     |
| 8     | G\textsubscript{8} | Pant T-5          | Semi Determine                               | GBPUA&T, Pantnagar,|
| 9     | G\textsubscript{9} | Pant T-7          | Semi Determine                               | GBPUA&T, Pantnagar,|
| 10    | G\textsubscript{10} | Hissar Lalit      | Semi Determine                               | HAU, Hissar        |
| 11    | G\textsubscript{11} | Kashi Aman        | Semi Determine                               | IIVR, Varanasi     |
| 12    | G\textsubscript{12} | Kashi Hemant      | Semi Determine                               | IIVR, Varanasi     |
| 13    | G\textsubscript{13} | Kashi Sharad      | Indeterminate                                | IIVR, Varanasi     |
| 14    | G\textsubscript{14} | H-88-78-1         | Indeterminate                                | IIVR, Varanasi     |
| 15    | G\textsubscript{15} | H-88-78-5         | Indeterminate                                | IIVR, Varanasi     |
| 16    | G\textsubscript{16} | Ageta-32          | Indeterminate                                | IARI New Delhi     |
| 17    | G\textsubscript{17} | Pusa Cherry       | Indeterminate                                | IARI New Delhi     |
| 18    | G\textsubscript{18} | Angoorlata        | Indeterminate                                | IIVR, Varanasi     |
| 19    | G\textsubscript{19} | Pusa Ruby         | Indeterminate                                | IARI, New Delhi    |
| 20    | G\textsubscript{20} | Arka Abha         | Indeterminate                                | IIHR, Bangalore    |
Table 2: Analysis of variance for yield and its components in Tomato

| S. No. | Character                        | Mean sum of squares |
|--------|----------------------------------|---------------------|
|        |                                  | Replications | Genotypes | Error |
| 1      | Plant Height (cm)                | 22.73        | 2994.3   | **23.14** |
| 2      | Days to First Flowering          | 0.88         | 17.76**  | 0.92   |
| 3      | Days to 50% Flowering            | 0.61         | 11.01**  | 1.529  |
| 4      | Number of Flowers/cluster        | 0.13         | 9.47**   | 0.42   |
| 5      | Number Fruit set/cluster         | 0.10         | 6.15**   | 0.19   |
| 6      | Average Fruit Weight (g)         | 11.77        | 1188.08**| **12.28** |
| 7      | Number of Fruits/Plant           | 25.75        | 2511.23**| 14.09  |
| 8      | Fruit Yield/Plant (kg)           | 0.065        | 1.88**   | 0.05   |
| 9      | Marketable Fruit Yield/Plot (kg) | 5.38         | 152.87** | 4.09   |
| 10     | Fruit shape Index                | 0.029        | 0.259**  | 0.023  |
| 11     | TSS (°Brix)                      | 0.050        | 2.861**  | 0.04   |
| 12     | Ascorbic Acid (Vit C) mg/100g    | 0.33         | 12.00**  | 0.70   |
| 13     | Lycopene Content (mg/100g)       | 0.005        | 0.30**   | 0.01   |
| 14     | ß Carotene (mg)                  | 0.00         | 0.005**  | 0.001  |
| 15     | Pericarp Thickness (mm)          | 0.02         | 1.66**   | 0.009  |
| 16     | Number of Locules/ Fruit         | 0.04         | 5.52**   | 0.07   |

*Significant at 5% level of probability, ** Significant at 1% level of probability
Table 3 Range, mean, variance, coefficient of variations, heritability, genetic advance and genetic advance as % of mean for 16 characters of tomato

| S. No. | Characters                        | Mean   | Range            | Coefficient of variance | h^2 (b.s.) (%) | Genetic Advance (5%) | Genetic Advance as % of mean (5%) |
|--------|----------------------------------|--------|------------------|-------------------------|---------------|----------------------|----------------------------------|
|        |                                  |        | Min.  | Max.  | GCV (%) | PCV (%) |                      |                                  |
| 1      | Plant Height (cm)                | 116.46 | 78.00 | 171.00 | 27.02   | 27.34   | 97.71              | 64.08                            | 55.03                         |
| 2      | Days to First Flowering          | 34.66  | 31.33 | 40.07  | 6.83     | 7.38     | 85.83              | 4.52                             | 13.04                        |
| 3      | Days to 50 % Flowering           | 40.08  | 35.65 | 43.33  | 4.44     | 5.40     | 67.40              | 3.01                             | 7.50                         |
| 4      | Number of Flowers/cluster        | 9.06   | 6.13  | 11.93  | 19.16    | 20.46    | 87.68              | 3.35                             | 36.97                        |
| 5      | Number of Fruit set/cluster      | 6.34   | 4.33  | 8.87   | 22.23    | 23.31    | 90.93              | 2.77                             | 43.67                        |
| 6      | Average Fruit Weight (g)         | 55.90  | 6.89  | 87.47  | 35.45    | 35.97    | 96.95              | 40.16                            | 71.84                        |
| 7      | Number of Fruits/ Plant          | 51.76  | 27.87 | 164.93 | 55.74    | 56.21    | 98.33              | 58.94                            | 113.86                       |
| 8      | Fruit Yield/ Plant (g)           | 2.52   | 1.14  | 3.99   | 31.09    | 32.35    | 92.33              | 1.55                             | 61.54                        |
| 9      | Marketable Fruit Yield/ Plot (kg)| 22.64  | 10.24 | 35.89  | 31.10    | 32.36    | 92.23              | 13.94                            | 61.57                        |
| 10     | Fruit shape Index                | 0.92   | 0.38  | 1.53   | 30.46    | 34.71    | 77.02              | 0.51                             | 55.08                        |
| 11     | TSS (°Brix)                      | 4.37   | 3.12  | 7.78   | 22.17    | 22.70    | 95.36              | 1.95                             | 44.60                        |
| 12     | Ascorbic Acid(Vit C)mg/100g      | 14.17  | 11.61 | 18.65  | 13.20    | 14.38    | 84.28              | 3.67                             | 24.96                        |
| 13     | Lycopene Content (mg/100g)       | 5.61   | 5.20  | 6.46   | 5.54     | 5.83     | 90.03              | 0.61                             | 10.82                        |
| 14     | β Carotene (mg)                  | 0.26   | 0.21  | 0.37   | 16.68    | 16.94    | 97.03              | 0.09                             | 33.85                        |
| 15     | Pericarp Thickness (mm)          | 5.35   | 1.77  | 5.27   | 19.36    | 19.32    | 98.30              | 1.52                             | 39.54                        |
| 16     | Number of Locules/ Fruit         | 6.42   | 2.27  | 6.27   | 36.44    | 37.15    | 96.21              | 2.72                             | 73.64                        |
### Table 4: Summary of genotypic and phenotypic coefficient of variation with heritability and genetic as percent of mean for yield and its component in tomato

| Sr. No. | Components                        | Status in present study | Characters                                                                                                                                                                                                 | Supported by                                                                                   |
|---------|-----------------------------------|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| 1       | GCV and PCV                        | High                    | Number of fruits per plant, number of locules per fruit average Fruit Weight, fruit yield per plot, fruit yield per plant, fruit shape index, plant height, number of fruit set per cluster, TSS<sub>0</sub>Brix. | Supe et al., (2006), Sharma et al., (2006), Lal et al., (1991), Bharti et al., (2002), Brar et al., (2000), Mohanty (2002), Kaushik et al., (2011), Islam et al., (2012), Rahaman et al., (2012), Vinod Kumar et al., (2013), Dar and Sharma (2011), Rani and Anitha (2011), Golani et al., (2007). |
|         |                                   | Moderate                | Pericarp thickness, Number of flowers per cluster, Beta carotene, Ascorbic acid.                                                                                                                            | Manna and Paul (2012)                                                                                                                          |
|         |                                   | Low                     | Days to first flowering, Lycopene content, days to 50% flowering                                                                                                                                           | Islam et al., (2012)                                                                                                                           |
| 2       | Genetic Advance as a percent mean  | High                    | Plant Height, Number of fruits per plant average fruit weight, Number of Flowers/cluster, number of fruit set/cluster, average fruit weight, number of fruits per plant, fruit yield/plant, marketable fruit yield, fruit shape index, TSS, Ascorbic acid, beta carotene, pericarp thickness, number of locules/fruit | Haydar et al., (2007), Tasisa et al., (2011), Ahmed et al., (2006), Bharti et al., (2002), Manna and Paul (2012)                                      |
|         |                                   | Moderate                | Days to first flowering, lycopene content                                                                                                                                                               | -                                                                                                                                            |
|         |                                   | Low                     | Days to 50% flowering                                                                                                                                                                                     | -                                                                                                                                            |
| 3       | Heritability                       | High                    | Plant Height, Days to First Flowering, Days to 50% Flowering, Flowers/cluster, Fruit set/cluster, Fruit Weight, Fruits/Plant, Fruits/Plant, Fruit Yield/Plant (g), Fruit Yield/Plot, Fruit shape index, TSS<sub>0</sub>Brix, Ascorbic Acid (Vit C) mg/100g, Lycopene (mg/100g), β Carotene (mg), Pericarp Thickness (mm), Number of Locules/Fruit. | Phookan et al., Ahmed et al., (2006), Mahesha et al., Joshi and Singh, Singh et al., Bharti et al., (2002), Dar and Sharma (2011), Kumar et al., (2004). |
|         |                                   | Moderate                | -                                                                                                                                                                                                       | -                                                                                                                                            |
|         |                                   | Low                     | -                                                                                                                                                                                                       | -                                                                                                                                            |
GCV measures the amount of variation present in a particular character but it doesn’t provide an idea about the proportion of heritable variation present in the total variation therefore, heritability estimates were calculated in the present study. In the present study heritability estimates were high for all the studied character as categorized (Low <30%; Moderate 30-60%; high >60%) by Johnson et al., (1955) (Table 3).

High heritability coupled with high genetic advance observed for the traits viz., plant height, number of flowers per cluster, number of fruit set per cluster, average fruit weight, number of fruits per plant, fruit yield per plant, fruit yield per plot, fruit shape index, TSSBrix, Ascorbic acid, Beta carotene, Pericarp thickness, Number of locules per fruit. High heritability coupled with moderate genetic advance was observed for characters viz., days to first flowering, lycopene content. indicates the presence of both additive and non-additive gene action for these traits. High heritability coupled with low genetic advance found for only one character days to 50% flowering, which clearly states the presence of non-additive gene action and selection is not rewarding for this trait. Recombination breeding and recurrent selection may be used for such type of traits for population improvement.

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1782
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