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# Genetic variability, heritability and genetic advance for yield and quality attributes in tomato (*Solanum lycopersicum* L.)

**Rakesh Kumar Meena, Sanjay Kumar, ML Meena and Shashank Verma**

## Abstract
The present experiment was carried out entitled " Genetic variability, heritability and genetic advance for yield and quality attributes in tomato (*Solanum lycopersicum* L.)" during kharif season of the year 2014-2015 at Horticulture Research Farm, Department of Horticulture, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya- Vihar, Rae Bareli Road, Lucknow-226025 (U.P.) India. The experiment was laid out in Randomized Block Design with three replications. The experimental materials consisting fifteen genotypes of tomato i.e. IIVR-Sel.-1, G-3, S. Naveen, DVRT-2, H-24, H-86, H-88, Pusa Sheetal, FLA 7171, Hisar Arun, Sel.-32, Flora Dode, Pusa Sadabhar, Kashi Vishesh and Kashi Amrit). The maximum phenotypic and genotypic variance, genetic advance was observed for average fruit weight (g). The highest of PCV and GCV, Heritability (broad sense), GA percent of mean was estimated for fruit yield per plant (kg).

**Keywords:** Genetic variability, heritability, genetic advance, yield

## Introduction
Tomato (*Solanum lycopersicum* L.) is an important vegetable crop and particularly now a commercial crop widely grown all over tropical, sub-tropical and temperate regions of the world for both fresh and processing purpose. It ranks second only after potato (Bose *et al.*, 2002) [3]. The optimum temperature for tomato growth and development is 20–24 °C. Temperatures above 34°C are considered super-optimal thermal stress. The optimum range of night temperature for fruit set is 15-20 °C. However above 18 °C is likely to inhibit pollen production and fruit set (Peet and Bartholemew, 1996) [14]. With high day and night temperatures, the plant shows symptoms of irregular flower development, reduction in pollen production, pollen viability, fruit drop and ovule abortion, all of which ultimately lead to decreased yield (Dane *et al*., 1991; Hazara and Ansary, 2008) [6, 8] thus, lycopene has got great beneficial effects on human health (Khachik *et al.*, 1995) [10]. It may also interfere with oxidative damage to DNA and lipoproteins and inhibits the oxidation of LDL (low density lipoprotein) cholesterol (Gester, 1997) [7]. Use of F1 hybrids is the quickest way of combining the traits into one, besides the added advantages of heterotic yield (Choudhury *et al.*, 1965) [5]. Tomato genotype varies not only in the morphological features but also in the quality (Abhusita *et al.,* 1997) [1]. Most of the quality traits in tomato show continuous variation and is strongly influenced by environmental conditions (Lecomte *et al.,* 2004) [11]. The genetic variance of any quantitative trait is composed of additive variance (heritable) and non-additive variance and include dominance and epitasis (non-allelic interaction) therefore, it essential to partition the estimated phenotypic variability into its heritable and non-heritable components with suitable parameters such as genetic variance, phenotypic variance, genotypic coefficient of variation, phenotypic coefficient of variation, genetic advance, and heritability. Taisa *et al*., (2011) [16] high values of PCV and GCV were present for fruit per plant and plant height indicating the existence of higher magnitude of variability. Systematic study and evaluation of tomato germplasm is of great importance for current and future agronomic and genetic improvement of the crop, evaluation of germplasm is imperative in order to understand the genetic background and the breeding value of the available germplasm (Agong *et al.,* 2000) [2]. Heritability and genetic advance help in determining the influence of environment in expression of the characters and the extent to which improvement is possible after selection (Robinson *et al*., 1949) [15]. Heritable variation can be effectively studied in conjunction with genetic advance. High heritability alone is not enough to make efficient selection in segregation, unless the information is accompanied for substantial amount of genetic advance.

## Materials and Methods

The present investigation was done at Horticulture Research Farm, Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Vidya- Vihar, Rea Bareli Road, Lucknow during the year 2014-15. Lucknow is characterized by sub-tropical climate with hot, dry summer and cold winter. The soil of experimental farm was saline with soil pH 8.2, Electrical conductivity 4.0 and sodium exchangeable percentage 15.0. During the period of experiment, meteorological observations were recorded from Indian Institute of Sugarcane Research, Lucknow. The experiment was laid out in Randomized Block Design Twelve genetically diverse germplasm lines as females of tomato were crossed with the three testers as male to constitute thirty six crosses. These crosses along with fifteen parents constituted the total experimental materials for this present investigation. The lines were collected from Indian Institute of Vegetable Research, Varanasi considering the genetic constitution, the three tester namely Pusa Sadabhar, Kashi Vishesh and Kashi Amrit were chosen which were the popular commercial varieties grown Uttar Pradesh. Out of fifteen genotypes, twelve (IIVR-Sel.-1, G-3, S. Naveen, DVRT-2, H-24, H-86, H-88, Pusa Sheetal, FLA 7171, Hisar Arun, Sel.-32 and Flora Dode ) were used as a lines and three (Pusa Sadabhar, Kashi Vishesh and Kashi Amrit ) used as a testers. Each of the twelve lines (female parents) was crossed to all three testers (male parents) giving rise to 36 $F_1$'s in line x testers during season 2014-15. The crosses were made by hand emasculation followed by pollination. Lines and testers were also maintained during season 2014-15. Observations were recorded on four randomly selected plants from each entry and the average of these four plants was worked out for the purpose of statistical computation. The observation was recorded on five randomly selected plants per replication for each germplasm on sixteen important characters including yield/plant. Observations were recorded like plant height (cm), number of branches/plant, days to 50 percent flowering, number of clusters/plant, number of flowers/cluster, number of fruits/cluster, number of fruits/plant, average fruit weight, number of locules/fruit, pericarp thickness, fruit length, fruit width, number of ridges on fruit, fruit yield/plant, TSS ($^0$brix) and vitamin c (mg/100g) were recorded. The data were analyzed as per methods suggested by Panse and Sukhatme (1967) [13] for analysis of variance, Burton (1952) [4] for variability, Lush (1949) [12] for heritability (Broad Sense) and Johnson *et al*., (1955) [9] for genetic advance in per cent of mean.

## Results and Discussion

The extent of variability present in germplasm of tomato was measured in terms of range, SEM, phenotypic variance ($\sigma^2$p), phenotypic coefficient of variation (PCV), genotypic ($\sigma^2$G) variance, genotypic coefficient variation (GCV), heritability (broad sense) and genetic advance (GA) (Table-1& 2). All the varieties differed significantly with respect of different characters studied.

Mean performance of tomato germplasm for different characters are showed in Table-1 and the coefficient of variation, heritability and genetic gain value are presented in Table-2. The phenotypic coefficient of variation (PCV) was higher than their respective genotypic coefficient of variation (GCV) for all the traits under study.

The widest range was recorded for average fruit weight (26.98- 48.36 ) followed by plant height (53.49-63.65), fruits per plant (16.63 -25.05), flowers per cluster (4.39-8.01), days to 50% flowering(59.24- 62.36), vit C (22.70- 25.49 ), clusters per plant(3.58- 6.10 ), fruits per cluster (3.87- 6.09 ), branches per plant (3.27- 5.37), locules per fruit(2.57- 4.25), while lowest range were recorded in fruit yield per plant (0.53-1.39).

Phenotypic coefficient of variation was higher for fruit yield per plant (33.17%) followed by ridges on fruit (28.38%), average fruit weight (24.16%) and branches per plant (16.23%), whereas, it was moderate for fruits per cluster (15.53%) followed by flowers per cluster (15.39%), locules per fruit (15.03%) and clusters per plant (14.31%) and low was recorded for fruits per plant (13.42%) followed by pericarp thickness (13.08%) and fruit length (11.34%) and it was lowest recorded for days to 50% flowering (2.06%).

Highest genotypic coefficient of variation was observed for fruit yield per plant (31.30%), ridges on fruit (26.56%), flowers per cluster (12.95%) and branches per plant (12.82%) and it was moderate for fruits per cluster (12.58%) followed by locules per fruit (11.68%), clusters per plant (11.36%) and fruits per plant ( 11.02%), while, it was showed low rate for pericarp thickness (10.76%) followed by tss (8.99%), fruit length (6.37%) and lowest was recorded for fruit width (5.98%).

Heritability value in broad sense is presented in table-2. The highest heritability was recorded for fruit yield per plant (0.89%) followed by ridges on fruit (0.88%), plant height (0.81%), tss (0.72%), flowers per cluster (0.71%), pericarp thickness ( 0.68%), fruits per plant ( 0.67%), fruits per cluster (0.66%), clusters per plant ( 0.63%) and branches per plant (0.62%), whereas, minimum was recorded for vit. C (0.29%).

The maximum genetic advance (%) was recorded for fruit yield per plant (60.84%) followed by ridges on fruit (51.21%), average fruit weight (23.81%), flowers per cluster (22.45%), fruits per cluster (21.01%), branches per plant (20.85%), locules per fruit (18.69%), fruits per plant (18.63% ), clusters per plant(18.59%), pericarp thickness (18.24%), TSS (15.74%), whereas, minimum was recorded for days to 50% flowering (1.55%).

**Table 1:** Mean performance of tomato germplasms for different characters.

| Germplasms | Plant height (cm) | No. of Branches / plant | Days to 50% flowering | Clusters/ plant | Flowers/ cluster | Fruits/ cluster | Fruits/ plant | Average fruit weight (g) | Locules/ fruit | Pericarp thickness (mm) | Fruit length (cm) | Fruit width (cm) | Ridges on fruit | Fruit Yield/ plant (kg) | TSS (°Brix) | Vit C mg/100g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IIVR-Sel.-1 | 59.80 | 5.01 | 59.52 | 4.53 | 5.41 | 4.42 | 21.52 | 31.34 | 4.25 | 3.78 | 3.69 | 3.92 | 1.21 | 0.74 | 4.28 | 23.26 |
| G-3 | 63.65 | 4.55 | 60.13 | 6.11 | 8.02 | 6.10 | 25.06 | 29.77 | 3.25 | 3.92 | 3.52 | 4.18 | 1.56 | 0.62 | 4.10 | 23.93 |
| S. Naveen | 60.74 | 3.90 | 59.24 | 4.80 | 6.35 | 5.63 | 18.00 | 48.36 | 3.52 | 4.48 | 3.76 | 4.55 | 1.15 | 1.40 | 3.71 | 25.04 |
| DVRT-2 | 56.13 | 4.05 | 61.44 | 3.99 | 6.48 | 4.83 | 20.48 | 26.98 | 3.70 | 3.97 | 3.62 | 4.42 | 1.12 | 0.87 | 4.46 | 24.51 |
| H-24 | 60.12 | 4.21 | 61.80 | 4.28 | 6.46 | 5.32 | 22.30 | 47.26 | 3.07 | 3.85 | 4.02 | 3.93 | 1.81 | 1.15 | 4.75 | 23.89 |
| H-86 | 54.62 | 3.27 | 60.22 | 5.11 | 6.21 | 4.75 | 20.03 | 28.02 | 3.15 | 3.86 | 3.79 | 3.61 | 2.29 | 0.63 | 3.84 | 24.16 |
| H-88 | 57.92 | 4.23 | 60.66 | 4.67 | 5.73 | 4.37 | 21.52 | 39.40 | 2.57 | 4.76 | 4.55 | 4.61 | 1.28 | 0.88 | 4.63 | 22.70 |
| Pusa Sheetal | 53.49 | 3.76 | 59.44 | 4.91 | 5.39 | 4.30 | 21.59 | 28.95 | 3.65 | 4.33 | 4.33 | 4.32 | 1.45 | 1.26 | 4.56 | 23.23 |
| FLA 7171 | 55.18 | 5.38 | 60.50 | 4.63 | 5.16 | 3.87 | 18.89 | 27.87 | 3.93 | 3.77 | 3.91 | 4.07 | 1.66 | 0.74 | 4.78 | 24.74 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hisar Arun | 59.21 | 3.78 | 62.36 | 3.58 | 6.30 | 5.38 | 20.73 | 36.85 | 3.39 | 4.40 | 4.21 | 4.05 | 1.58 | 0.93 | 3.71 | 23.83 |
| Sel.-32 | 61.21 | 3.46 | 61.14 | 4.33 | 6.02 | 4.93 | 17.55 | 32.59 | 3.69 | 3.19 | 3.33 | 3.70 | 0.79 | 0.59 | 4.41 | 25.01 |
| Flora Dode | 59.26 | 4.41 | 60.41 | 5.20 | 6.47 | 5.33 | 17.20 | 34.96 | 4.04 | 4.01 | 3.93 | 4.41 | 1.37 | 0.56 | 4.17 | 24.19 |
| Pusa Sadabhar | 61.66 | 4.50 | 61.54 | 4.95 | 6.58 | 4.89 | 16.97 | 33.41 | 3.30 | 4.18 | 3.95 | 4.25 | 1.45 | 0.53 | 3.73 | 25.49 |
| Kashi Vishesh | 55.89 | 5.13 | 60.06 | 4.91 | 4.39 | 4.00 | 20.02 | 32.43 | 3.80 | 3.49 | 3.64 | 4.17 | 1.73 | 0.64 | 4.15 | 24.53 |
| Kashi Amrit | 60.02 | 4.27 | 59.56 | 4.37 | 5.45 | 4.00 | 16.64 | 30.20 | 4.23 | 3.11 | 4.17 | 4.43 | 0.84 | 0.85 | 3.62 | 22.94 |
| SEM | 0.7839 | 0.2449 | 0.5724 | 0.2355 | 0.2894 | 0.2525 | 0.8809 | 3.4150 | 0.1950 | 0.1690 | 0.2109 | 0.1606 | 0.0819 | 0.0524 | 0.1348 | 0.5457 |
| CD at 5% | 2.2709 | 0.7095 | 1.6581 | 0.6822 | 0.8383 | 0.7315 | 2.5519 | 9.8930 | 0.5650 | 0.4897 | 0.6109 | 0.4651 | 0.2372 | 0.1517 | 0.3906 | 1.5810 |

**Table 2:** Estimates of variability, heritability and genetic advance as per cent of mean for sixteen characters in tomato

| S. No. | Character | Range | | Mean | Variance | | PCV (%) | GCV (%) | $h^2$ (%) | Genetic Advance | GA% of mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Max. | | Phenotypic | Genotypic | | | | | |
| 1. | Plant height (cm) | 53.49 | 63.65 | 58.59 | 9.83 | 7.98 | 5.35 | 4.82 | 0.81 | 5.25 | 8.95 |
| 2. | Branches/ plant | 3.27 | 5.37 | 4.26 | 0.48 | 0.30 | 16.23 | 12.82 | 0.62 | 0.89 | 20.85 |
| 3. | Days to 50% flowering | 59.24 | 62.36 | 60.53 | 1.55 | 0.57 | 2.06 | 1.24 | 0.37 | 0.94 | 1.55 |
| 4. | Clusters/ plant | 3.58 | 6.10 | 4.69 | 0.45 | 0.28 | 14.31 | 11.36 | 0.63 | 0.87 | 18.59 |
| 5. | Flowers/ cluster | 4.39 | 8.01 | 6.02 | 0.86 | 0.61 | 15.39 | 12.95 | 0.71 | 1.35 | 22.45 |
| 6. | Fruits/ cluster | 3.87 | 6.09 | 4.80 | 0.56 | 0.37 | 15.53 | 12.58 | 0.66 | 1.01 | 21.01 |
| 7. | Fruits/ plant | 16.63 | 25.05 | 19.90 | 7.14 | 4.81 | 13.42 | 11.02 | 0.67 | 3.71 | 18.63 |
| 8. | Average fruit weight (g) | 26.98 | 48.36 | 33.89 | 67.08 | 32.09 | 24.16 | 16.71 | 0.48 | 8.07 | 23.81 |
| 9. | Locules/ fruit | 2.57 | 4.25 | 3.56 | 0.29 | 0.17 | 15.03 | 11.68 | 0.60 | 0.67 | 18.69 |
| 10. | Pericarp thickness (mm) | 3.11 | 4.75 | 3.93 | 0.27 | 0.18 | 13.08 | 10.76 | 0.68 | 0.72 | 18.24 |
| 11. | Fruit length (cm) | 3.33 | 4.55 | 3.89 | 0.19 | 0.06 | 11.34 | 6.37 | 0.32 | 0.29 | 7.38 |
| 12. | Fruit width (cm) | 3.60 | 4.60 | 4.17 | 0.14 | 0.06 | 8.95 | 5.98 | 0.45 | 0.34 | 8.23 |
| 13. | Ridges on fruit | 0.78 | 2.29 | 1.42 | 0.16 | 0.14 | 28.38 | 26.56 | 0.88 | 0.73 | 51.21 |
| 14. | Fruit yield/ plant (kg) | 0.53 | 1.39 | 0.82 | 0.08 | 0.07 | 33.17 | 31.30 | 0.89 | 0.50 | 60.84 |
| 15. | TSS (°Brix) | 3.62 | 4.77 | 4.19 | 0.20 | 0.14 | 10.57 | 8.99 | 0.72 | 0.66 | 15.74 |
| 16. | Vit C mg/100g | 22.70 | 25.49 | 24.09 | 1.26 | 0.37 | 4.66 | 2.52 | 0.29 | 0.68 | 2.80 |

PCV and GCV: Phenotypic and genotypic coefficient of variation, h2: Heritability in broad sense, GA: Genetic Advance

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