



RESEARCH ARTICLE

# Inherited changeability and trait association studies in round tomato genotype (*Solanum lycopersicum* L.) for growth, yield and quality traits

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## Abstract

Screening of 10 genotypes of tomato was carried out to understand inherited changeability and trait association studies for yield and its related horticultural traits during the rabi season from 2020-21 to 2022-23. The objectives were to assess the magnitude of variability among traits at both genotypic and phenotypic levels and to determine the correlation and associative relationships among the characters. Data were analysed using analysis of variance (ANOVA), genetic variability, correlation analysis, heritability and genetic advance (GA) estimates. The data revealed significant variation among the genotypes for the various agronomic traits evaluated, indicating the presence of considerable genetic variability. The genotype RHRT-20-21 exhibited early flowering and recorded the highest fruit yield per plant (1.92 kg), while the genotype RHRT-20-24 was recorded maximum fruit weight (83.82 g). The genotype RHRT-20-23 showed the highest number of fruits per plant (31.13) and the maximum pericarp thickness (6.16 mm). The highest polar diameter was observed in RHRT-20-23 and RHRT-20-26 (5.39 cm) and the highest equatorial diameter was recorded in RHRT-20-26 (6.44 cm). The minimum number of locules per fruit (2.32) was found in RHRT-20-21. The minimum fruit yield per plant was recorded in genotype RHRT-20-18 (1.71 kg) and genotype RHRT-20-24 recorded the highest total soluble solids (4.77 °Brix). The genotype RHRT-20-27, RHRT-20-25 and RHRT-20-23 were identified as the most promising genotypes, exhibiting yields significantly higher than the overall mean. High phenotypic and genotypic coefficients of variation were observed for fruit yield per plot, plant height, number of fruits per plant and number of locules. Traits such as fruit yield per plant, plant height, average fruit weight number of fruits per plant, number of locules and total soluble solids showed high heritability with high GA. Plant height exhibited significant positive correlations with average fruit weight, number of fruits per plant, yield per plant and yield per hectare. ANOVA revealed significant differences among genotypes, indicating strong potential for selection and improvement.

**Keywords:** genetic advance and correlation; genetic variability; heritability

## Introduction

Tomato (*Solanum lycopersicum* L.) is among the most extensively grown and consumed vegetable crop worldwide, valued for its versatility and nutritional content. It is a member of the Solanaceae family and is believed to be originated in the Andean region of South America, particularly the areas encompassing present day Peru, Ecuador and Bolivia. The crop was introduced to Europe around the mid-16<sup>th</sup> century and later brought to India in the 17<sup>th</sup> century, likely by Portuguese traders (1). Tomato is a valuable source of essential nutrients, contributing significantly to a balanced diet, per 100 g of fresh weight, tomato provide approximately 31.0 mg of vitamin C, 1.98 g of protein, 321 IU of vitamin A, 93.1 g of moisture, 0.6 g of minerals, 0.7 g of fibre, 24 mg of sulphur, 38 mg of chlorine and 20 mg of calcium. Due to this rich nutritional profile, tomato plays an important role in human nutrition and are widely incorporated into diets across the globe (2).

Tomato pulp and juice are easily digestible and act as mild aperients with blood-purifying properties. Additionally, they possess antiseptic qualities that helps to combat intestinal infections.

Genetic improvement in crops relies on the presence of significant variation among individuals, which arises from both genetic differences and environmental influences. To achieve progress in tomato breeding, it is crucial to exploit both naturally existing and artificially generated genetic variability. Tomato plants exhibit three distinct types of growth habits determinate, semi-determinate and indeterminate which further contribute to the crop's genetic diversity and breeding potential (3).

Wild tomato species exhibit a high degree of genetic diversity, particularly among self-incompatible species such as *Lycopersicon chilense* and *L. peruvianum* (4, 5). This genetic variation has been extensively explored for traits of agronomic importance and is actively utilised in modern tomato breeding programs. Significant progress in breeding for disease resistance

has been achieved through the incorporation of major resistance genes from wild *Lycopersicon* species (6). Similarly, resistance to major insect pests has been identified in wild species like *L. hirsutum* which is known to resist over 18 pest species (7) and *L. pennellii* (8).

Integrating genetically diverse parental lines into breeding programs is essential for enhancing variability and achieving superior recombinants. As such, evaluating different tomato genotypes is crucial to determine their adaptability and agronomic performance, particularly with respect to growth and yield-related traits. Considering this, the present study was undertaken to assess the performance of selected tomato genotypes, with a primary focus on yield and its contributing components (9).

The extent of variability within a germplasm collection can be effectively assessed using phenotypic and genotypic coefficients of variation (PCV and GCV). While heritability provides insight into the proportion of observed variation attributable to genetic factors, it must be interpreted alongside genetic advance (GA) to evaluate the potential for improvement through selection. High heritability coupled with substantial GA indicates the presence of additive gene action, which is desirable for effective selection, especially in segregating generations (10).

Genetic variability and trait association studies in round tomato (*S. lycopersicum*) are essential for identifying superior genotypes and guiding effective selection strategies aimed at crop improvement. Tomato exhibits substantial variation in growth, yield and quality attributes. Understanding the extent of this variability enables breeders to exploit desirable traits for developing high yielding and high quality cultivars (11). Trait association analysis further helps in determining the interrelationships among key characters, thereby assisting in indirect selection and prioritising traits that significantly contribute to overall productivity and fruit quality. Such studies provide a scientific basis for breeding programs, enhance selection efficiency and support the development of improved tomato varieties suitable for diverse environments and consumer preferences.

## Materials and Methods

The experiment was conducted at Tomato Improvement Scheme, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri which comes under arid and tropical region and have a temperature range of 7.30 °C to 39.30 °C with 65 % relative humidity. The average day length is 8 hr and 30 min. Annual rainfall varies from 307 to 619 mm and average rainfall is 475 mm. Most of this rainfall is received through south-west monsoon. The experimental material for the present study comprised of ten tomato genotypes, along with one check variety: Dhanashree (Table 1). The experiment was conducted during the rabi season of 2020 and continued for three

consecutive years, concluding in the rabi season of 2022–23. The experiment was laid out in a randomized block design (RBD) with three replications, each genotype comprising 40 plants, spaced at 90 × 30 cm. Details of the genotypes and their sources are presented in (Table 1). Recommended agronomic practices were followed throughout the cropping period to ensure optimal plant growth and development.

Observations were recorded on five randomly selected plants per replication for each genotype across 15 traits: (i) plant height (cm), (ii) days to 50 % flowering, (iii) average fruit weight (g), (iv) number of fruits per plant, (v) fruit yield per plant (kg), (vi) fruit yield per plot (kg), (vii) fruit yield per hectare (t), (viii) growth habit, (ix) fruit color, (x) fruit shape, (xi) fruit acidity (%), (xii) fruit diameter (cm), (xiii) number of locules, (xiv) pericarp thickness (mm) and (xv) total soluble solids (°Brix). Quality parameters were estimated using standard procedures described in earlier studies (12).

## Statistical analysis

The data collected for all the measured traits from the ten round tomato genotypes were subjected to statistical analysis (13). The data was analysed using a RBD with three replications per genotype, where genotype was considered as the main factor. ANOVA was performed utilizing XLSTAT software which was employed to determine the significance of differences among genotypes for different traits, with statistical significance set at  $p \leq 0.05$ . The coefficient of variation (CV %) was calculated to evaluate the extent of variability present within the dataset. Descriptive statistics such as mean, range and CV were computed. Genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV) were estimated (14). Broad sense heritability ( $h^2_{bs}$ ) was calculated, while GA and genetic advance as percent of mean (GAPM) were further computed as per standard methods (15, 16), using INDOSTAT software (Indostat Service, Hyderabad, India). Additionally, the correlation matrix for the various traits was computed as well to evaluate the relationships among various morpho-biochemical characteristics using INDOSTAT software (16).

## Results and Discussion

### Analysis of variance

The analysis of variance (ANOVA) revealed significant differences among the genotypes for all the traits studied, indicating the presence of substantial genetic variability within the evaluated germplasm. This variability provides ample scope for the improvement of yield and associated traits through effective selection (Table 2). The mean performance of the genotypes for various morphological and yield-related traits are represented in Table 3. The estimates of genetic parameters, including PCV and GCV, heritability (broad sense) and GAPM, are

**Table 1.** List of tomato genotype accessions and population type included in the study

| Accession I.D Code | Country of origin | Population type  | Color of fruit | Fruit shape | Year of collection |
|--------------------|-------------------|------------------|----------------|-------------|--------------------|
| RHRT-20-18         | India             | Indeterminate    | Red            | Round       | 2019               |
| RHRT-20-19         | India             | Determinate      | Red            | Round       | 2019               |
| RHRT-20-21         | India             | Indeterminate    | Red            | Round       | 2019               |
| RHRT-20-22         | India             | Determinate      | Red            | Round       | 2019               |
| RHRT-20-23         | India             | Semi-determinate | Red            | Round       | 2019               |
| RHRT-20-24         | India             | Determinate      | Red            | Round       | 2019               |
| RHRT-20-25         | India             | Indeterminate    | Red            | Round       | 2019               |
| RHRT-20-26         | India             | Determinate      | Red            | Round       | 2019               |
| RHRT-20-27         | India             | Determinate      | Red            | Round       | 2019               |
| Dhanashree (c)     | India             | Determinate      | Red            | Round       | 2019               |

**Table 2.** Analysis of variance (ANOVA) for 13 characters of tomato genotypes

| Trait                        | Replication | Genotype  | Error    |
|------------------------------|-------------|-----------|----------|
| Plant height (cm)            | 216.74      | 1925.41** | 20.27    |
| Days to 50 % flowering       | 36.88       | 58.69**   | 7.24     |
| Avg. Fruit weight (g)        | 69.62       | 174.76**  | 3.69     |
| No. of fruits per plant      | 28.12       | 236.88**  | 3.64     |
| Yield per plant (kg)         | 0.12        | 0.16*     | 0.03     |
| Yield per plot (kg)          | 54.33       | 175.32**  | 29.39    |
| Yield per hectare (t/ha)     | 14.59       | 40.19**   | 3.04     |
| Polar diameter (cm)          | 1.04        | 3.15**    | 0.63     |
| Equatorial diameter (cm)     | 0.97        | 7.04**    | 1.52     |
| No. of locules               | 0.17        | 1.59**    | 0.028    |
| Pericarp thickness (mm)      | 0.55        | 0.68*     | 0.046    |
| Acidity (%)                  | 0.004       | 0.027**   | 0.003    |
| Total soluble solids (°Brix) | 0.13        | 0.18**    | 0.001    |
|                              | d.f = 2     | d.f = 9   | d.f = 29 |

\*\*significant at 1 %, \*significant at 5 %, d.f - degrees of freedom

summarised in Table 4. The genotypic correlation coefficients between yield and its contributing traits, offering insights into the inter-relationships among traits for selection strategies (Table 5).

### Mean performance and range

The results indicated significant variation in plant height among the evaluated tomato genotypes, ranging from 71.71 to 143.00 cm (Table 3). The tallest plants were observed in genotype RHRT-20-18 (143.00 cm) followed closely by RHRT-20-23 (140.43 cm), while the shortest plants were recorded in genotype RHRT-20-26 (71.71 cm) (17, 18). This variation reflects the genetic diversity among the genotypes and suggests the potential for selecting desirable plant architecture in breeding programs. All the evaluated genotypes exhibited either determinate or indeterminate growth habits, with the exception of genotype RHRT-20-23, which displayed a semi-indeterminate growth habit. This variation in growth pattern highlights the morphological diversity among the genotypes and may influence yield potential and agronomic management practices. The number of days to 50 % flowering among the genotypes ranged from 28.33 to 33.00 days (Fig. 1, Table 3). The earliest flowering was observed in genotype RHRT-20-21 (28.33 days), while the latest flowering occurred in genotype RHRT-20-26 (33.00 days). This variation reflects differences in the flowering behaviour of the genotypes, indicating genetic diversity in their reproductive development (19). A highly significant variation in fruit weight was observed among the ten genotypes evaluated (Fig. 1, Table 3). The average fruit weight ranged from 58.52 to 83.82 g. The highest fruit weight was recorded in genotype RHRT-20-24 (83.82 g) followed by RHRT-20-25 (83.23 g) and RHRT-20-26 (81.50 g). In contrast, the lowest fruit weight (58.52 g) was observed in genotype RHRT-20-23 (20). Generally, fruit weight tends to exhibit an inverse relationship with the number of fruits per plant, although both traits are critical components influencing overall yield (21). The mean number of fruits per plant ranged from 21.41 to 31.13 (22). The highest fruit count was observed in genotype RHRT-20-23 (31.13), whereas the lowest was recorded in genotype RHRT-20-24 (21.41) (23, 24). The number of fruits per plant is a key determinant of yield. In this study, several promising genotypes were identified that warrant further refinement through selection to enhance their yield potential.

Analysis of variance revealed a significant difference among genotypes for fruit yield per plant (Fig. 1, Table 3). The yield ranged from 1.71 to 1.92 kg (25). The highest yield was recorded in genotype RHRT-20-21 (1.92 kg), which was statistically at par with RHRT-20-27 (1.91 kg), RHRT-20-25 (1.86 kg), RHRT-20-23 (1.82 kg) and RHRT-20-24 (1.79 kg). In contrast, the lowest yield per plant was

observed in genotype RHRT-20-18 (1.71 kg). Fruit yield per plant is influenced by several contributing traits, including the number of fruits per plant, average fruit weight, number of flowers per truss and number of fruits per truss (23, 25). In the present study, the genotypes exhibited highly significant differences in fruit yield per plot (Fig. 1, Table 3). The yield per plot ranged from 61.74 to 69.05 kg. The highest fruit yield per plot was recorded in genotype RHRT-20-21 (69.05 kg), followed by RHRT-20-27 (68.75 kg), RHRT-20-25 (66.88 kg), RHRT-20-23 (65.58 kg), RHRT-20-24 (64.61 kg), RHRT-20-19 (64.21 kg) and RHRT-20-22 (64.11 kg) (26). Conversely, the lowest yield per plot was observed in genotype RHRT-20-18 (61.74 kg), followed by RHRT-20-26 (62.88 kg) and the check variety Dhanashree (63.91 kg) (18). The investigation revealed considerable variation in fruit yield per hectare among the genotypes, ranging from 51.97 to 58.12 t/ha. The highest yield was recorded in genotype RHRT-20-21 (58.12 t/ha), followed by RHRT-20-27 (57.87 t/ha), RHRT-20-25 (56.29 t/ha), RHRT-20-23 (55.20 t/ha), RHRT-20-24 (54.38 t/ha) and RHRT-20-19 (54.05 t/ha). In contrast, the lowest yield was observed in genotype RHRT-20-18 (51.97 t/ha), followed by RHRT-20-26 (52.93 t/ha), the check variety Dhanashree (53.79 t/ha) and RHRT-20-22 (53.96 t/ha) (27–29).

Significant differences in fruit diameter were observed among the tomato genotypes (Table 3). The polar diameter ranged from 4.47 to 5.39 cm, with the maximum polar diameter was recorded in genotypes RHRT-20-23 and RHRT-20-26 (5.39 cm), followed by RHRT-20-24 (5.28 cm) and RHRT-20-22 and RHRT-20-25 (5.03 cm). The lowest polar diameter was noted in genotype RHRT-20-18 (4.47 cm) (24). Equatorial diameter varied from 5.00 to 6.44 cm, with the highest value observed in RHRT-20-26 (6.44 cm), followed by RHRT-20-23 (6.28 cm) and RHRT-20-24 (5.99 cm). The smallest equatorial diameter was found in RHRT-20-22 (5.00 cm). These variations underscore the considerable genetic diversity in fruit size and shape among the evaluated genotypes, offering valuable potential for selection in breeding programs targeting these traits (25, 30, 31). All genotypes evaluated in the study exhibited red fruit color (Table 3). With respect to fruit shape, all genotypes were found to produce round fruits, indicating uniformity in this morphological trait among the tested lines (32). Analysis of the number for locules per fruit revealed significant differences among the genotypes (Table 3). The number of locules ranged from 2.32 to 4.05. The minimum locules number was recorded in genotype RHRT-20-21 (2.32), maximum was recorded in RHRT-20-26 (4.05), the check variety Dhanashree (3.99) (22, 25).

The perusal of results on pericarp thickness indicated significant variation among the genotypes for this character. The

**Table 3.** Mean performance of round tomato genotype for growth and yield attributing characters (three years pooled data)

| Genotype      | Plant height (cm) | Growth habit | Days to 50 % flowering | Av. Fruit weight (g) | Number of fruits per plant | Yield per plant (kg) | Yield per plot (kg) | Yield per ha (t/ha.) | Fruit diameter (cm) |      | Number of locules | Pericarp thickness (mm) | Fruit colour | Fruit shape | Acidity (%) | Total soluble solids (°Brix) |
|---------------|-------------------|--------------|------------------------|----------------------|----------------------------|----------------------|---------------------|----------------------|---------------------|------|-------------------|-------------------------|--------------|-------------|-------------|------------------------------|
|               |                   |              |                        |                      |                            |                      |                     |                      | Polar               | Eq.  |                   |                         |              |             |             |                              |
| RHRT-20-18    | 143.00            | Indet.       | 29.67                  | 73.29                | 23.4                       | 1.71                 | 61.74               | 51.97                | 4.47                | 5.07 | 2.84              | 5.48                    | Red          | Round       | 0.54        | 3.93                         |
| RHRT-20-19    | 81.51             | Det.         | 31.67                  | 68.34                | 26.1                       | 1.78                 | 64.21               | 54.05                | 4.65                | 5.46 | 2.87              | 5.46                    | Red          | Round       | 0.51        | 4.30                         |
| RHRT-20-21    | 115.32            | Indet.       | 28.33                  | 76.29                | 25.14                      | 1.92                 | 69.05               | 58.12                | 4.68                | 5.37 | 2.32              | 5.36                    | Red          | Round       | 0.53        | 4.26                         |
| RHRT-20-22    | 97.87             | Det.         | 29.33                  | 78.21                | 22.77                      | 1.78                 | 64.11               | 53.96                | 5.03                | 5.00 | 2.39              | 5.55                    | Red          | Round       | 0.56        | 4.14                         |
| RHRT-20-23    | 140.43            | Semi-Indet.  | 31.00                  | 58.52                | 31.13                      | 1.82                 | 65.58               | 55.20                | 5.39                | 6.28 | 2.67              | 6.16                    | Red          | Round       | 0.53        | 3.97                         |
| RHRT-20-24    | 113.03            | Indet.       | 31.67                  | 83.82                | 21.41                      | 1.79                 | 64.61               | 54.38                | 5.28                | 5.99 | 2.66              | 4.88                    | Red          | Round       | 0.53        | 4.77                         |
| RHRT-20-25    | 119.44            | Indet.       | 30.67                  | 83.23                | 22.32                      | 1.86                 | 66.88               | 56.29                | 5.03                | 5.19 | 4.00              | 4.96                    | Red          | Round       | 0.53        | 4.44                         |
| RHRT-20-26    | 71.71             | Det.         | 33.00                  | 81.50                | 21.43                      | 1.75                 | 62.88               | 52.93                | 5.39                | 6.44 | 4.05              | 6.05                    | Red          | Round       | 0.46        | 4.38                         |
| RHRT-20-27    | 92.32             | Det.         | 31.67                  | 73.14                | 26.11                      | 1.91                 | 68.75               | 57.87                | 4.63                | 5.44 | 3.97              | 5.83                    | Red          | Round       | 0.48        | 4.29                         |
| Dhanshree (c) | 87.68             | Det.         | 32.00                  | 79.18                | 22.42                      | 1.78                 | 63.91               | 53.79                | 4.51                | 5.02 | 3.99              | 6.11                    | Red          | Round       | 0.48        | 4.11                         |
| S.E. ±        | 1.46              | --           | 0.58                   | 1.21                 | 1.07                       | 0.04                 | 1.67                | 1.37                 | 0.12                | 0.15 | 0.36              | 0.17                    | --           | --          | 0.013       | 0.18                         |
| C.D. at 5 %   | 4.34              | --           | 1.72                   | 3.60                 | 3.17                       | 0.13                 | 5.05                | 4.10                 | 0.36                | 0.47 | 1.09              | 0.52                    | --           | --          | 0.039       | 0.55                         |

**Table 4.** Mean, range, variance, PCV, GCV, heritability and genetic advance of 13 morphological traits of different tomato genotypes

| Characters                   | Mean   | Range  |       | Variance                 |                           | PCV (%) | GCV (%) | Heritability (h²%) | Genetic Advance (% of mean) |
|------------------------------|--------|--------|-------|--------------------------|---------------------------|---------|---------|--------------------|-----------------------------|
|                              |        | Max.   | Min.  | Genotypic Variance (σ²g) | Phenotypic Variance (σ²p) |         |         |                    |                             |
| Plant height (cm)            | 105.25 | 143.24 | 71.83 | 635.05                   | 655.32                    | 24.32   | 23.94   | 96.91              | 48.55                       |
| Days to 50 % flowering       | 31.05  | 33.33  | 28.61 | 2.04                     | 2.44                      | 5.03    | 4.60    | 83.52              | 8.66                        |
| Avg. Fruit weight (g)        | 76.31  | 85.22  | 59.50 | 57.02                    | 60.71                     | 10.21   | 9.89    | 93.92              | 19.75                       |
| Number of fruits per plant   | 23.92  | 31.18  | 21.45 | 7.56                     | 11.20                     | 13.99   | 11.50   | 67.52              | 19.46                       |
| Yield per plant (kg)         | 1.82   | 1.94   | 1.73  | 0.07                     | 0.10                      | 4.06    | 3.74    | 73.30              | 6.13                        |
| Yield per plot (kg)          | 65.95  | 70.20  | 62.77 | 594.94                   | 596.55                    | 37.04   | 36.98   | 99.73              | 76.09                       |
| Yield per ha (t/ha.)         | 54.77  | 58.22  | 52.06 | 3.85                     | 6.89                      | 4.81    | 3.59    | 55.87              | 5.53                        |
| Polar diameter (cm)          | 4.92   | 5.44   | 4.51  | 0.10                     | 0.14                      | 7.61    | 6.58    | 74.85              | 11.73                       |
| Equatorial diameter (cm)     | 5.57   | 6.55   | 5.08  | 0.23                     | 0.32                      | 10.11   | 8.66    | 73.35              | 15.28                       |
| Number of locules            | 3.11   | 4.06   | 2.33  | 0.52                     | 0.55                      | 23.84   | 23.23   | 94.89              | 46.61                       |
| Pericarp thickness (mm)      | 5.60   | 6.22   | 4.93  | 0.17                     | 0.22                      | 8.28    | 7.33    | 78.35              | 13.37                       |
| Acidity (%)                  | 0.52   | 0.57   | 0.47  | 0.08                     | 0.09                      | 6.23    | 6.02    | 93.46              | 11.99                       |
| Total soluble solids (°Brix) | 4.26   | 4.78   | 3.94  | 0.06                     | 0.07                      | 5.83    | 5.75    | 97.55              | 11.71                       |

Table 5. Estimates of genotypic correlation coefficient between different characters in tomato genotype

|                              | Plant height (cm) | Days to 50 % flowering | Av. Fruit weight (g) | No. of fruits per plant | Yield per plant (kg) | Yield per plot (kg) | Yield per hectare (g) | Polar diameter (cm) | Equatorial diameter (cm) | No. of locules | Pericarp thickness (mm) | Acidity (%) | Total soluble solids (°Brix) |
|------------------------------|-------------------|------------------------|----------------------|-------------------------|----------------------|---------------------|-----------------------|---------------------|--------------------------|----------------|-------------------------|-------------|------------------------------|
| Plant height (cm)            | 1                 | -0.561                 | 0.349**              | 0.368**                 | 0.528**              | 0.052               | 0.552**               | 0.031               | -0.075                   | -0.499         | -0.255                  | 0.676*      | -0.338                       |
| Days to 50 % flowering       |                   | 1                      | 0.088                | -0.132                  | -0.282               | -0.296              | -0.295                | 0.304               | 0.527                    | 0.621          | 0.358                   | -0.780**    | 0.339                        |
| Av. Fruit weight (g)         |                   |                        | 1                    | -0.950**                | -0.046               | -0.063              | -0.064                | 0.036               | -0.212                   | 0.376          | -0.491                  | -0.125      | 0.633*                       |
| No. of fruits per plant      |                   |                        |                      | 1                       | 0.334*               | 0.350**             | 0.351**               | 0.04                | 0.253*                   | -0.270         | 0.413**                 | 0.119       | -0.494                       |
| Yield per plant (kg)         |                   |                        |                      |                         | 1                    | 0.999**             | 0.999**               | -0.084              | -0.064                   | 0.251          | -0.145                  | -0.031      | 0.211                        |
| Yield per plot (kg)          |                   |                        |                      |                         |                      | 1                   | 0.999*                | -0.085              | -0.062                   | 0.217          | -0.168                  | -0.003      | 0.217                        |
| Yield per hectare (kg)       |                   |                        |                      |                         |                      |                     | 1                     | -0.085              | -0.062                   | 0.217          | -0.167                  | -0.004      | 0.216                        |
| Polar diameter (cm)          |                   |                        |                      |                         |                      |                     |                       | 1                   | 0.784**                  | 0.421**        | 0.007                   | 0.041       | 0.377                        |
| Equatorial diameter (cm)     |                   |                        |                      |                         |                      |                     |                       |                     | 1                        | 0.1            | 0.262                   | -0.354      | 0.302                        |
| No. of locules               |                   |                        |                      |                         |                      |                     |                       |                     |                          | 1              | 0.285                   | -0.792**    | 0.237                        |
| Pericarp thickness (mm)      |                   |                        |                      |                         |                      |                     |                       |                     |                          |                | 1                       | -0.547      | -0.622**                     |
| Acidity (%)                  |                   |                        |                      |                         |                      |                     |                       |                     |                          |                |                         | 1           | -0.147**                     |
| Total soluble solids (°Brix) |                   |                        |                      |                         |                      |                     |                       |                     |                          |                |                         |             | 1                            |

\*Significance at 5 % level, \*\*Significance at 1 % level. The colour scale represents the value of the correlation between two variables, green highlights strongly positive correlation while red highlights strongly negative correlation

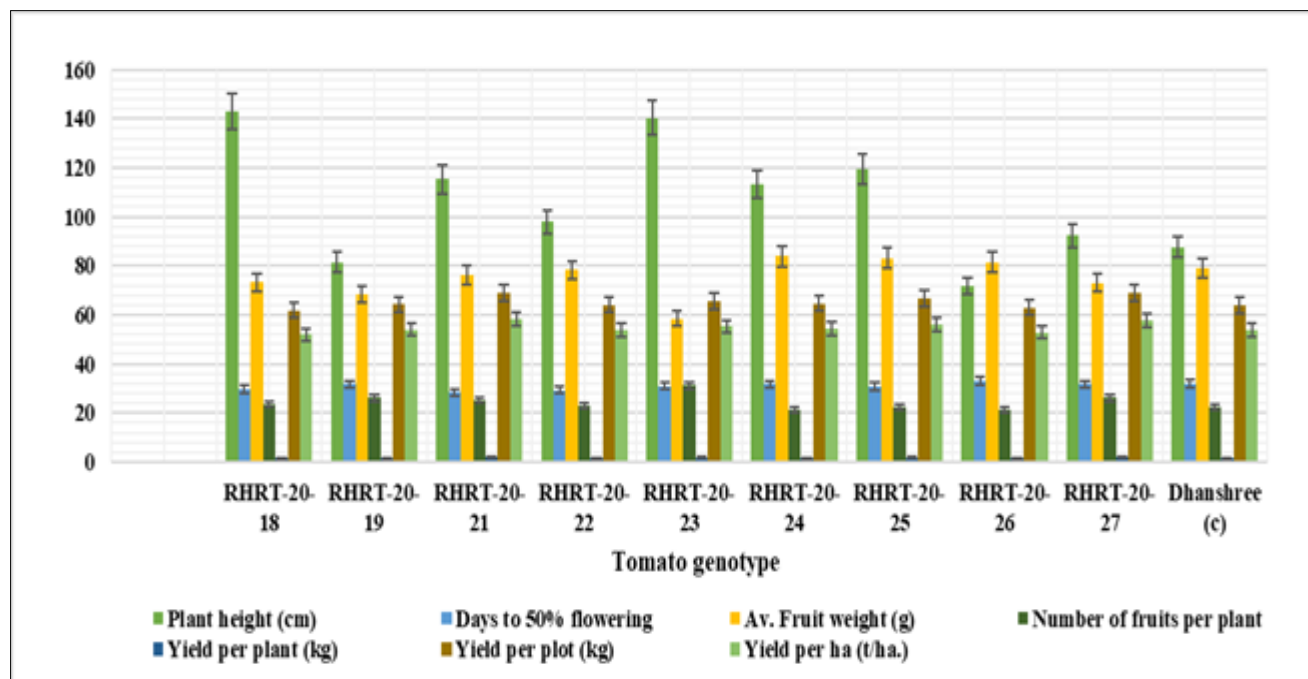


**Fig. 1.** Growth and yield performance of round tomato genotype.

mean value of the fruit pericarp thickness ranged from 4.88 mm to 6.16 mm. The maximum fruit pericarp thickness was observed in genotype RHRT-20-23 (6.16 mm), which was statistically at par with check variety Dhanashree (6.11 mm), genotype RHRT-20-26 (6.05 mm) and RHRT-20-27 (5.83 mm). Whereas minimum fruit pericarp thickness was recorded in genotype RHRT-20-24 (4.88 mm) (Table 3). A thick pericarp is advantageous for the postharvest handling of fruits during transportation. Comparable findings regarding variability in fruit pericarp thickness among the tomato genotype have been reported by (21, 22, 25, 33). The analysis revealed significant differences among genotypes for total soluble solids ( $^{\circ}$ Brix) content (Table 3). The highest TSS was recorded in genotype RHRT-20-24 (4.77  $^{\circ}$ Brix), followed by RHRT-20-25 (4.44  $^{\circ}$ Brix), RHRT-20-26 (4.38  $^{\circ}$ Brix), RHRT-20-19 (4.30  $^{\circ}$ Brix), RHRT-20-27 (4.29  $^{\circ}$ Brix) and RHRT-20-21 (4.26  $^{\circ}$ Brix). The lowest TSS value was observed in genotype RHRT-20-23 (3.97  $^{\circ}$ Brix) (32, 34–36). The lowest titratable

acidity was recorded in genotype RHRT-20-26 (0.46 %), whereas the highest was observed in genotype RHRT-20-22 (0.56 %) (37, 38).

#### Phenotypic and genotypic coefficient of variation

The phenotypic coefficient of variation (PCV) was higher than the corresponding genotypic coefficient of variation (GCV) for all the morphological traits (Fig. 2, Table 4), indicating the influence of environmental factors on trait expression. The highest PCV and GCV values were recorded for total fruit yield per plot (37.04 % and 36.98 %), followed by plant height (24.32 % and 23.94 %) and number of locules per fruit (23.84 % and 23.23 %). Moderate variability was observed for total number of fruits per plant (13.99 % and 11.50 %), average fruit weight (10.21 % and 9.89 %), equatorial diameter (10.11 % and 8.66 %), pericarp thickness (8.28 % and 7.33 %), polar diameter (7.61 % and 6.58 %), fruit acidity (6.23 % and 6.02 %), total soluble solids (5.83 % and 5.75 %), days to 50 % flowering (5.03 % and 4.60 %), fruit yield per hectare (4.81 % and

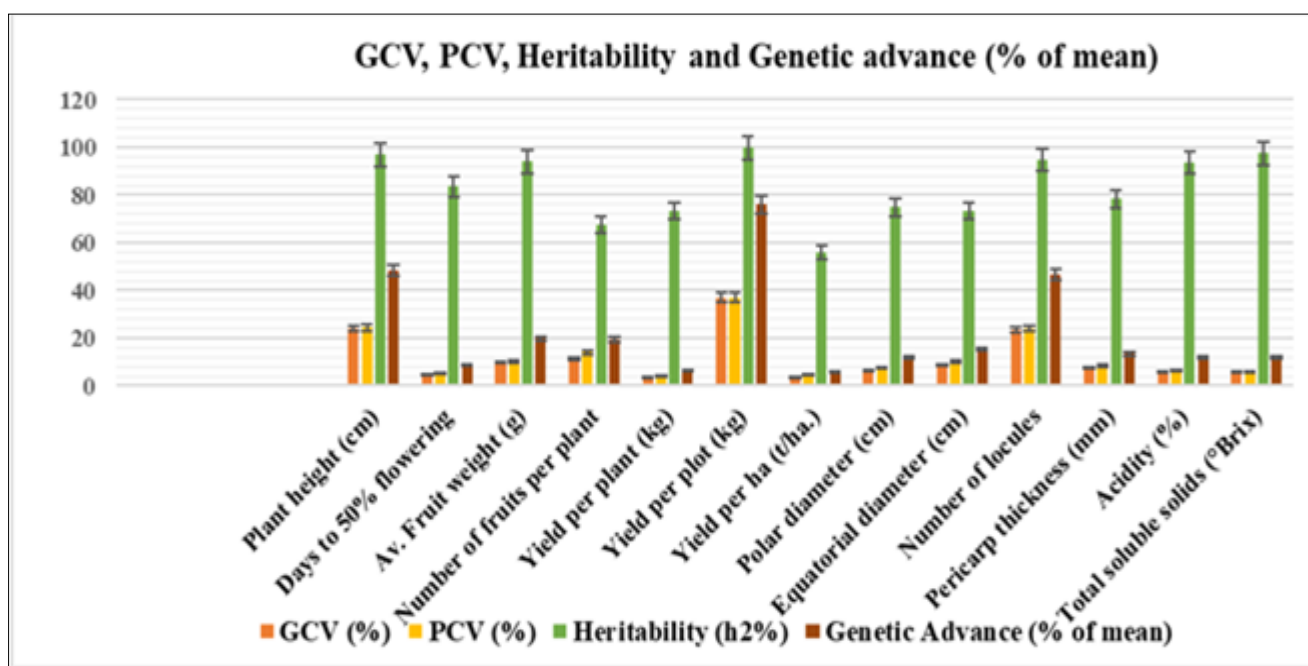


**Fig. 2.** GCV, PCV, heritability and genetic advance (% of mean) for different characters of round tomato genotype.

3.59 %). In contrast, fruit yield per plant exhibited very low PCV and GCV values (4.06 % and 3.74 %), indicating a narrow genetic base for this trait. This suggests the need to broaden the genetic variability for fruit yield per plant through the introduction of diverse germplasm or hybridization among genetically divergent genotypes to obtain transgressive segregants.

High heritability estimates (>20 %) were recorded for all traits, including plant height, fruit yield per plot and number of locules, suggesting that these traits are largely governed by genetic factors with minimal environmental influence for number of locules (27, 39, 40), fruit yield per plant (41–48), fruit weight and pericarp thickness (27).

### Heritability and genetic advance

High heritability estimates coupled with high GA as a percentage of the mean (Fig. 2, Table 4) were recorded for total fruit yield per plot (99.73 % and 76.09 %), plant height (96.91 % and 48.55 %), number of locules (94.89 % and 46.61 %), total soluble solids (97.55 % and 11.71 %) and average fruit weight (93.92 % and 19.75 %). These results suggest that these traits are primarily governed by additive gene effects and are less influenced by environmental factors, making them highly amenable to improvement through direct selection.

A combined assessment of heritability, genotypic coefficient of variation (GCV) and GA further supports the potential for effective selection, particularly for traits such as fruit yield per plot, plant height and average fruit weight. Based on the findings from the evaluation of ten tomato genotypes, it can be concluded that fruit yield per plot, plant height, average fruit weight, number of locules per fruit, total soluble solids (°Brix) and fruit acidity are key traits for selection in tomato breeding programs.

High heritability indicates that genetic factors play a predominant role in trait expression, making these traits reliable for selection. However, heritability estimates, when interpreted alongside GA, provide a more accurate prediction of selection efficiency. The observation that all studied traits exhibited high heritability (>60 %) along with high GA as a percentage of the mean (>20 %) confirms the presence of additive gene action, suggesting that these traits can be effectively improved through selection. These findings are in agreement with previous reports on number of primary branches (49), plant height (50), pericarp thickness (51), number of locules per fruit (30) and fruit weight and fruit yield per plant (28).

### Correlation coefficient

Understanding the inter-relationships among quantitative traits is essential for effective selection in breeding programs. In the present study, genotypic correlation coefficients among 13 traits were analysed in all possible combinations (Table 5). Plant height exhibited significant positive correlations with average fruit weight, number of fruits per plant, yield per plant and yield per hectare. These associations suggest that selection based on these traits could be effective in enhancing overall yield potential (52).

Additionally, significant positive correlations were observed between number of fruits per plant and traits such as fruit yield per plant, fruit yield per plot and fruit yield per hectare. Polar diameter also showed a significant positive association with the equatorial diameter and number of locules. Number of fruits per plant exhibited significant positive correlations with yield per plant, yield per plot, yield per hectare and pericarp thickness (53, 54). A yield per

plant demonstrated significant positive correlations with fruit yield per plot and fruit yield per hectare. Furthermore, average fruit weight, polar diameter and equatorial diameter exhibited both positive and negative significant relationships with acidity, indicating a complex association between fruit size and acidity (55). Acidity, in turn, showed a significant negative correlation with total soluble solids (56).

## Conclusion

The significant genetic variability observed among the evaluated tomato genotypes highlights substantial potential for the selection and improvement of key agronomic traits. Genotypes such as RHRT-20-21, RHRT-20-27, RHRT-20-25, RHRT-20-23 and RHRT-20-24 demonstrated superior performance in terms of both yield and quality attributes, making them promising candidates for future breeding programs.

The high magnitude of both genotypic and phenotypic coefficients of variation for traits such as plant height, fruit yield per plant, fruit yield per plot, number of locules and average fruit weight suggests that these traits can be effectively improved through selection. Moreover, the consistently high heritability estimates coupled with high GAPM across all traits studied indicate the predominance of additive gene action, reinforcing the efficacy of selection-based breeding strategies. Correlation analysis further supported these findings, identifying plant height, average fruit weight, number of fruits per plant and fruit yield per plant as critical traits for selection in tomato crop improvement. These traits, due to their strong association with yield potential, should be prioritised in breeding programs aimed at developing high-yielding and quality tomato varieties.

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## Authors' contributions

CAV, MSM, GSD conceptualised and designed the experiment. CAV executed the experiment and performed data analysis. MSM, GSD and BDR wrote the manuscript under the supervision of CAV. All authors read and approved the final manuscript.

## Compliance with ethical standards

**Conflict of interest:** Authors do not have any conflict of interest to declare.

**Ethical issues:** None

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