# ESTIMATE OF HETEROSIS IN TOMATO (*Solanum lycopersicon*L.)


## ABSTRACT

The present study, Estimate of Heterosis in Tomato (*Lycopersicon esculentum*) under the Bundelkhand Region, was conducted in Rabi 2021–22 and 2022–23 at the Experimental, Organic Research farm Kargunwa ji, Department of Horticultural Sciences, Institute of Agricultural Sciences, Bundelkhand University Jhansi (Uttar Pradesh). The study involved raising all 17 parents (5 lines and 12 testers) in separate plots, along with a check grown in RBD *i.e.* to determine the best $F_1$ hybrid, in order to calculate the proportion or amount of heterosis in the crossings, and relationship between different traits. The three most effective line and testers withtheir combinations *viz.,*. H-88-78-5, Kashi Aman, and H-88-78-5. Their $F_1$ hybrids, H-88-78-1×Kashi Chaya, VRT-67 Kashi Chaya, and H-88-78-5VRT-50, outperformed the other treatments by a large margin.



***Key words:***Estimate, Heterosis, Line, Tomato, (*Lycopersicon esculentum L.,*), tester.


## Introduction

Tomato (*Solanum lycopersicum* L.) is the second most popular vegetable in the world after potato. It belongs to the large family Solanaceae with chromosome number of 2n=24 (x=12) and originated from South America. Tomato is a self-pollinated warm season crop equitably resistant to heat, drought and grows well in broad range of soil and climatic conditions (Angadi and Dharmatti, 2012).

Lycorpersicon is a genus that contains nine closely related species, including *L. esculentum, L. pimpinefolium, L.cheesmaniae, L.perviflorum, L.chnielewskii, and L.* species, according to Esquin*et al.*, (1982).The English word "tomato" comes from the word "tomate," which is taken from the Mexican word "tomatal."Globally, the production of tomatoes is surpassed only by that of potatoes Peixoto *et al.*, (2017).India is the world second largest producer of the tomatoes, right after China, Warnock*et al.*,(1991).

Heterosis breeding is utilised because conventional methods are insufficient to increase the amount and quality of tomato (*Solanum lycopersicum* L.) output.Given the increasing demand tomatoes, genotypes with higher yield and quality must be developed, therefore even a small improvement in production per unit area is crucial.

Breeders must look into natural variety as a source of novel alleles in order to boost crop output, quality, and nutritional value, Ayenan*et al.*,(2022). The first to notice heterosis and hybrid vigour in tomatoes as a means of boosting yield and fruit production were Hedrick and Booth (1907). Choudhary (1965) emphasised the widespread use of heterosis to increase tomato yield. Sundaram (1944) emphasised the commercial potential of tomato $F_1$ hybrid production.

Hayes,(1952) attributes the term "heterosis" to Shull. Heterozygous plants possess characteristics that enable their hybrids to be more resilient and alive than their parents Angadi and Dharmatti (2012)and Tamta and Singh, 2018).

Every effective breeding programme must include both the breeding technique and the selection of suitable parents. Heterosis in tomatoes is the occurrence in which $F_1$ hybrids (first-generation offspring) exceed their parental lines in specific attributes.As a result, selecting parents is essential for heterosis exploitation, Warnock *et al.*,(1991). Information from the general mean performance of parents and the specialized combining ability of crosses aid in the identification of suitable parents and related cross-combinations. This study aimed to identify the finest tomato $F_1$ hybrids and assess heterosis in the hybrids relative to their parents.

**Materials and Methods**

The "Estimate of Heterosis in Tomato (*Lycopersicon esculentum*)" experiment was conducted in Rabi 2022–22 and 2022–23 at the Department of Horticultural Sciences, Institute of Agricultural Sciences, Bundelkhand University Jhansi (Uttar Pradesh), at the Experimental, Organic Research farm Kargunwa ji, Jhansi. The performance of 17 parents (5 lines and 12 testers) who were chosen based on how well they performed for different qualities was tested in the current experiment using a Randomised block design (RBD) with three replications.

**Hybridization program**

Each of the 5 lines was crossed with 12 testers to produce 60 hybrids, and F1S was allowed to self to produce $F_2$S. The healthy flower buds from the new flush, which were due to open the next day, were selected for emasculation and pollination. The selected buds were emasculated by hand using forceps in the evening hours between 4:00pm and 5:30pm. The emasculated flowers were covered with cotton to avoid contamination by foreign pollen.

Statistical methods: Analysis of variance (ANOVA) was calculated for each character by following the standard statistical procedure. Heterosis was estimated in terms of Standard heterosis (expressed over the standard check). Heterosis was measured as the proportion of deviation of the value from the standard check (Shull, 1952). The estimation was expressed in percentage.

**Results and Discussion**

**Mean performance of parents and their crosses.**

The mean performance of 60 genotypes of tomato for 2 morphologicalcharacters are presented in (Table 1&1a). Mean values of various characters based on line × tester and their hybrids observations of both the individual environments (2021-22 and 2022-23) and combined over environments. It is cleared from the data that, all germplasm were showed a wide range of variations for most of the traits, which are described as under. The results reflected in the table are given below.

**Plant height (cm)**

Significant variation exists between genotypes when it comes to plant height at 15, 30, 45, 60, 75, and 90 days following transplantation. At 15 days following transplantation, the plant height for 12 lines was recorded as maximum under (14.40 cm) under H-88-78-5 and minimum under (10.53 cm) under VRT-19; for tester, it was maximum exhibited under (12.92 cm) under VRT-50 and minimum under (11.07 cm) under Kashi Chaya. At 30 days following transplantation, the plant height for 12 lines was recorded as maximum under (36.66 cm) under H-88-78-5 and minimum under (32.72 cm) under VRT-19. For tester, it was maximum exhibited under (33.94 cm) under Kashi Chaya and minimum under (30.50 cm) under VRT-30 as referred by Amin *et al.*,[1] and Atugwu *et al.*,[3]. At 45 days after transplantation the plant height for 12 lines was recorded maximum under (47.80 cm) under H-88-78-5 and minimum under (41.84 cm) under VRT-51. However, for tester was maximum exhibited under (46.62 cm) under Kashi Chaya and minimum (44.74 cm) under VRT-30 as quoted by Avdikos*et al.*,[4]. At 60 days after transplantation the plant height for 12 lines was recorded maximum under (64.81 cm) under H-88-78-5 and minimum under (57.81 cm) under VRT-50. However, for tester was maximum exhibited under (58.88 cm) under Kashi Aman and minimum (57.46 cm) under VRT-30 as noted by Ayenan*et al.*,[5].At 75 days after transplantation the plant height for 12 lines was recorded maximum under (79.48 cm) under H-88-78-5 and minimum under (74.66 cm) under H-88-78-4. However, for tester was maximum exhibited under (77.85 cm) under VRT-50 and minimum (76.34cm) under Kashi Chaya, Bhalala *et al.*,[7].

At 90 days after transplantation the plant height for 12 lines was recorded maximum under (97.34cm) under H-88-78-5 and minimum under (90.29cm) under VRT-51. However, for tester was maximum exhibited under (90.26 cm) under Kashi Aman and minimum under (88.71 cm) VRT-30. It may be noted that plant height was superior due to interaction components which was highly significant in terms of plant height as per the findings of Baraskar*et al.*,[6] and Choudhury *et al.*,[8].

Similarly, the mean performance for their $F_1$ hybrids after the crosses were transplanted the data revealed significant variability among different genotypes in terms of the plant height at 15, 30, 45, 60, 75, and 90 days. At 15 days the plant height was recorded (16.42) VRT-67 × Kashi Chaya followed by (15.70) and (15.19) under the genotypes VRT-01 ×Kashi Aman and H-88-78-1 × Kashi Chaya and minimum plant height recorded (11.03) under the genotype Tolev-16 × VRT-50. At 30 days the plant height was recorded (35.70) VRT-67 × Kashi

Chayafollowed by (34.33) and (33.17) under the genotypes H-88-78-1 × Kashi Chaya and Tolev-16 ×Kashi Chaya and minimum plant height recorded (24.32) under the genotype VRT-51 ×VRT-50. At 45 days the plant height was recorded (50.0) VRT-67 × Kashi Chaya followed by (49.68) and (48.32) under the genotypes H-88-78-1 × Kashi Chaya and Tolev-16 ×Kashi Chaya and minimum plant height recorded (38.62) under the genotype VRT-51 ×VRT-50.

At 60 days the plant height was recorded (65.63) VRT-01 ×Vaibhavfollowed by (65.4) and (63.6) under the genotypes VRT-67 × Kashi Chaya and H-88-78-1× Kashi Chayaand minimum plant height recorded (49.55) under the genotype Tolev-16 × VRT-50.

At 75 days the plant height was recorded (88.73) VRT-16-1 ×VRT-30 followed by (88.53) and (87.77) under the genotypes H-88-78-1× Kashi Chaya andVRT-67 × Kashi Chaya and minimum plant height recorded (75.14) under the genotype VRT-19 × VRT-50.

At 90 days the plant height was recorded (98.11,) VRT-67 × Kashi Chaya followed by (97.88) and (94.54) under the genotypes VRT-67 × Kashi Chaya and Tolev-28 ×VRT-30 and minimum plant height recorded (89.22) under the genotype VRT-51 ×VRT-50.

**Number of fruit per cluster**

The analysis of the Table-1 demonstrates significant variability among different genotypes in terms of the number of fruit per cluster at 30,45,60,75 and 90 days. At 30 days after transplantation the number of fruit per cluster for 12 lines was recorded maximum under (1.00) under H-88-78-5 and minimum under (0.33) under VRT-51. However, for tester maximum exhibited under (1.00) under Kashi Chaya and minimum number of fruit per cluster recorded (0.33) under the genotype Vaibhav.At 45 days after transplantation the number of fruit per cluster for 12 lines was recorded maximum under (3.10) under H-88-78-5 and minimum under (1.93) under VRT-50. However, for tester maximum exhibited under (2.37) under Kashi Chaya and minimum number of fruit per cluster recorded (2.03) under Vaibhav as mentioned by Peixoto *et al.*,[15] and Sundaram*et al.*,[16].

Similarly, the mean performance for their $F_1$ hybrids after the crosses were transplanted the data revealed significant variability among different genotypes in terms of the number of fruit per cluster at 30,45,60,75 and 90 days. At 30 days the number of fruit per cluster recorded (1.07) under the genotype H-88-78-5 × VRT-30 which was *at par* under (1.07) the genotype VRT-16-1 ×VRT-30 and minimum number of fruit per cluster recorded (0.33) under the genotype VRT-51 ×Kashi Chaya.At 45 days the number of fruit per cluster recorded (3.63) under the genotype H-

88-78-4 × Kashi Aman followed by (3.60) which was *at par* under the genotype H-88-78-4 × Kashi Chaya and TOLeV-28 × Kashi Chaya and minimum number of fruit per cluster recorded (2.13) under the genotype VRT-19 × VRT-50.At 60 days after transplantation the number of fruit per cluster for 12 lines was recorded maximum under (6.07) H-88-78-5 ×Kashi Chayafollowed by (5.87 and 5.83) H-88-78-4 × Kashi Amanand H-88-78-5 × Vaibhav. However, minimumwas observed under (3.2) under H-88-78-1 ×VRT-50. as stated by Farwah *et al.*,[10] and Gascuel*et al.*,[12].

At 75 days after transplantation the number of fruit per cluster in $F_1$ hybrids Line was recorded (9.67) under Tolev-16 × Kashi Amanwhich was *at par* with (9.63)under VRT-51 ×VRT-30 and VRT-01 ×Kashi Aman. It may be well noted that number of fruit per cluster was superior due to interaction components which was highly significant in terms of number of fruit per cluster asper the findings of Atugwu*et al.*,[3] andAvdikos*et al.*,[4]. Finally at 90 days after transplantation the number of fruit per cluster in $F_1$ hybrids Line was recorded (13.25) under Tolev-16 × Kashi Amanwhich was *at par* with (13.15) and (13.02) under Tolev-16 ×Kashi Chaya and VRT-16-1×Kashi Chaya. It may be well noted that number of fruit per cluster was superior due to interaction components which was highly significant in terms of number of fruit per cluster as per the findings of Atugwu*et al.*,[3] andAvdikos*et al.*,[4]

**CONCLUSION**

Between all the various lines used in the current study. It was discovered that an excellent general combiner for maximal characters was the (H-88-78-5), tester (Kashi Aman) with (H-88-78-1x Kashi Chaya).The results gained can be used to determine the best parents and crossings for a certain feature that can be improved upon and used even more in tomato breeding programmes.

**FUTURE SCOPE**

Consequently, this study's use of a range of tomato genotypes allows for the identification of the most suitable inbred lines to be used in future breeding programmes. The results of crossing demonstrated that some parents were a good general match for many character, indicating that depending on specific qualities taken into account, some parents will need to be chosen for genetic enhancement. Since tomatoes are a highly consumed produce, experts are concentrating on developing superior hybrids with desired parent combinations through crop improvement programmes. Furthermore, hybrids that produce larger yields help farmers meet the market's ongoing demands.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Authors declare Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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**Table 1:** Mean performance for parents

| S.No | Parents | Plant height (cm) | | | | | | Number of fruit per cluster | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 DAT | 30 DAT | 45 DAT | 60 DAT | 75 DAT | 90 DAT | 30 DAT | 45 DAT | 60 DAT | 75 DAT | 90 DAT |
| | **Line** | | | | | | | | | | | |
| 1 | H-88-78-5 | 14.40 | 36.66 | 47.80 | 64.81 | 79.48 | 97.34 | 1.00 | 3.10 | 5.90 | 9.60 | 12.48 |
| 2 | H-88-78-4 | 12.37 | 33.32 | 46.18 | 62.38 | 74.66 | 94.65 | 0.67 | 2.10 | 4.23 | 8.57 | 12.20 |
| 3 | VRT-67 | 13.34 | 35.85 | 47.15 | 62.86 | 78.12 | 95.11 | 1.00 | 3.03 | 3.57 | 8.23 | 12.30 |
| 4 | TOLeV -15 | 13.22 | 34.42 | 45.35 | 62.17 | 74.99 | 93.79 | 0.33 | 2.90 | 4.23 | 7.57 | 13.18 |
| 5 | VRT-16-1 | 12.21 | 33.49 | 44.98 | 61.41 | 75.33 | 92.88 | 0.33 | 2.90 | 4.20 | 7.40 | 12.87 |
| 6 | VRT-06 | 12.33 | 32.97 | 43.87 | 60.28 | 76.55 | 93.40 | 0.67 | 1.97 | 4.30 | 8.27 | 12.29 |
| 7 | VRT-19 | 10.53 | 32.72 | 42.86 | 59.89 | 76.68 | 92.80 | 0.67 | 1.93 | 4.40 | 8.20 | 12.14 |
| 8 | H-88-78-1 | 13.17 | 34.98 | 46.42 | 62.28 | 78.32 | 95.09 | 1.00 | 2.27 | 5.73 | 8.20 | 11.82 |
| 9 | VRT-51 | 11.12 | 34.44 | 41.84 | 59.29 | 76.21 | 90.29 | 0.33 | 2.00 | 4.77 | 8.73 | 11.53 |
| 10 | TOLeV-28 | 13.21 | 33.12 | 42.18 | 58.69 | 77.13 | 91.23 | 0.67 | 2.10 | 5.23 | 8.27 | 11.34 |
| 11 | VRT-50 | 13.21 | 33.54 | 42.87 | 57.81 | 77.92 | 91.98 | 0.33 | 1.97 | 5.33 | 8.17 | 11.65 |
| 12 | TOLeV -32 | 13.09 | 33.01 | 42.97 | 58.52 | 78.15 | 90.36 | 0.33 | 2.10 | 5.37 | 7.50 | 11.62 |
| | **Tester** | | | | | | | | | | | |
| 1 | Kashi Chaya | 11.07 | 33.94 | 46.62 | 58.70 | 76.34 | 89.48 | 1.00 | 2.37 | 5.63 | 8.27 | 11.28 |
| 2 | Vaibhav | 12.13 | 33.32 | 46.25 | 57.79 | 76.73 | 90.24 | 0.33 | 2.03 | 4.80 | 8.63 | 11.47 |
| 3 | Kashi Aman | 12.30 | 33.93 | 46.15 | 58.88 | 77.20 | 90.26 | 0.67 | 2.10 | 5.27 | 8.40 | 11.31 |
| 4 | VRT-50 | 12.92 | 33.43 | 45.48 | 58.87 | 77.85 | 89.30 | 0.33 | 2.03 | 5.37 | 8.23 | 11.54 |
| 5 | VRT-30 | 12.06 | 30.50 | 44.74 | 57.46 | 77.82 | 88.71 | 0.67 | 2.07 | 5.43 | 7.67 | 11.42 |
| | Mean | **12.51** | **33.74** | **44.92** | **60.12** | **77.03** | **92.17** | **0.61** | **2.29** | **4.93** | **8.23** | **11.91** |
| | Min | 10.53 | 30.50 | 41.84 | 57.46 | 74.66 | 88.71 | 0.33 | 1.93 | 3.57 | 7.40 | 11.28 |
| | Max | 14.40 | 36.66 | 47.80 | 64.81 | 79.48 | 97.34 | 1.00 | 3.10 | 5.90 | 9.60 | 13.18 |

**Table 1a.** Mean performance of $F_1$-hybrids

| S.No | Crosses (Line × tester) | Plant height (cm) | | | | | | Number of fruit per cluster | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 DAT | 30 DAT | 45 DAT | 60 DAT | 75 DAT | 90 DAT | 30 DAT | 45 DAT | 60 DAT | 75 DAT | 90 DAT |
| 1 | H-88-78-5 ×Kashi Chaya | 13.81 | 31.00 | 42.63 | 59.07 | 82.50 | 93.34 | 1.03 | 3.13 | 6.07 | 9.43 | 12.41 |
| 2 | H-88-78-5 × Vaibhav | 13.64 | 32.65 | 47.46 | 62.28 | 78.62 | 90.48 | 1.00 | 3.20 | 5.83 | 7.53 | 11.39 |
| 3 | H-88-78-5 ×Kashi Aman | 13.91 | 32.28 | 46.35 | 62.88 | 84.47 | 92.66 | 1.00 | 2.97 | 4.63 | 9.53 | 12.09 |
| 4 | H-88-78-5 ×VRT-50 | 14.12 | 30.11 | 45.86 | 59.29 | 82.39 | 92.65 | 1.00 | 2.53 | 5.83 | 9.37 | 12.09 |
| 5 | H-88-78-5 × VRT-30 | 13.99 | 32.48 | 46.14 | 59.07 | 82.63 | 92.59 | 1.07 | 3.00 | 5.77 | 9.20 | 12.49 |
| 6 | H-88-78-4 × Kashi Chaya | 13.90 | 32.74 | 43.00 | 58.52 | 82.21 | 92.52 | 1.03 | 2.33 | 4.33 | 8.53 | 12.22 |
| 7 | H-88-78-4 × Vaibhav | 13.42 | 30.22 | 42.95 | 60.21 | 77.44 | 90.04 | 1.00 | 3.27 | 4.83 | 7.60 | 12.08 |
| 8 | H-88-78-4 × Kashi Aman | 13.96 | 30.06 | 42.95 | 62.58 | 85.05 | 92.37 | 0.67 | 3.63 | 5.87 | 9.57 | 12.15 |
| 9 | H-88-78-4 × VRT-50 | 13.79 | 31.84 | 42.17 | 59.34 | 82.61 | 92.77 | 0.67 | 2.90 | 4.83 | 9.27 | 12.71 |
| 10 | H-88-78-4 ×VRT-30 | 13.85 | 31.15 | 42.57 | 56.44 | 82.32 | 93.11 | 1.03 | 2.67 | 4.83 | 9.27 | 13.25 |
| 11 | VRT-67 × Kashi Chaya | 16.42 | 35.70 | 50.00 | 65.40 | 87.77 | 97.88 | 1.03 | 2.17 | 3.97 | 8.23 | 12.21 |
| 12 | VRT-67 × Vaibhav | 13.68 | 31.85 | 43.15 | 58.77 | 77.96 | 89.66 | 1.00 | 3.13 | 5.23 | 7.60 | 12.12 |
| 13 | VRT-67 × Kashi Aman | 13.93 | 31.33 | 43.12 | 61.70 | 84.64 | 92.92 | 1.00 | 2.80 | 5.23 | 9.60 | 12.18 |
| 14 | VRT-67 × VRT-50 | 13.99 | 29.92 | 42.71 | 58.40 | 82.57 | 93.50 | 1.00 | 3.00 | 5.23 | 9.37 | 12.39 |
| 15 | VRT-67 ×VRT-30 | 14.01 | 32.57 | 42.64 | 58.06 | 86.07 | 93.37 | 1.03 | 2.90 | 5.17 | 9.33 | 12.21 |
| 16 | Tolev-16 ×Kashi Chaya | 13.82 | 33.17 | 43.22 | 58.08 | 80.37 | 93.81 | 1.03 | 3.10 | 4.37 | 7.40 | 13.15 |
| 17 | Tolev-16 ×Vaibhav | 14.43 | 30.06 | 43.14 | 58.41 | 76.78 | 92.00 | 1.00 | 2.80 | 5.33 | 7.60 | 12.38 |
| 18 | Tolev-16 ×Kashi Aman | 14.51 | 29.88 | 42.69 | 60.65 | 84.49 | 91.63 | 1.00 | 2.87 | 5.33 | 9.67 | 12.38 |
| 19 | Tolev-16 × VRT-50 | 11.03 | 28.55 | 39.92 | 49.55 | 78.85 | 89.78 | 0.43 | 2.33 | 3.23 | 6.73 | 10.22 |
| 20 | Tolev-16 × VRT-30 | 14.63 | 30.66 | 42.90 | 59.14 | 86.25 | 93.95 | 1.03 | 2.80 | 5.27 | 8.73 | 12.10 |
| 21 | VRT-16-1 ×Kashi Chaya | 13.74 | 31.00 | 40.89 | 57.59 | 79.77 | 92.60 | 0.67 | 3.17 | 4.07 | 7.37 | 13.02 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | VRT-16-1 × Vaibhav | 13.43 | 32.61 | 43.18 | 59.02 | 78.49 | 89.74 | 1.00 | 2.50 | 5.37 | 7.43 | 11.49 |
| 23 | VRT-16-1 × Kashi Aman | 13.89 | 30.07 | 43.06 | 61.23 | 83.81 | 91.80 | 1.00 | 2.93 | 5.33 | 9.47 | 12.09 |
| 24 | VRT-16-1 ×VRT-50 | 11.73 | 27.44 | 39.29 | 50.37 | 77.11 | 90.00 | 0.93 | 2.30 | 3.43 | 6.57 | 10.38 |
| 25 | VRT-16-1 ×VRT-30 | 14.30 | 32.15 | 43.06 | 58.60 | 88.73 | 92.63 | 1.07 | 2.30 | 5.27 | 8.87 | 12.34 |
| 26 | VRT-06 × Kashi Chaya | 13.47 | 31.22 | 48.29 | 58.51 | 79.36 | 94.18 | 0.67 | 3.20 | 5.83 | 7.43 | 12.27 |
| 27 | VRT-06 ×Vaibhav | 14.56 | 30.21 | 48.32 | 59.70 | 77.12 | 90.66 | 1.00 | 2.80 | 5.83 | 7.47 | 11.39 |
| 28 | VRT-06 ×Kashi Aman | 14.68 | 32.13 | 47.59 | 62.32 | 83.61 | 92.74 | 1.00 | 3.00 | 5.83 | 9.47 | 12.06 |
| 29 | VRT-06 ×VRT-50 | 12.07 | 26.85 | 39.24 | 51.26 | 75.44 | 89.59 | 0.90 | 2.17 | 3.47 | 7.07 | 10.50 |
| 30 | VRT-06 ×VRT-30 | 14.29 | 30.26 | 46.48 | 58.54 | 83.93 | 93.80 | 1.03 | 2.57 | 5.77 | 9.57 | 12.29 |
| 31 | VRT-19 ×Kashi Chaya | 11.48 | 30.17 | 46.14 | 62.94 | 80.28 | 93.98 | 1.03 | 3.30 | 4.27 | 7.30 | 12.09 |
| 32 | VRT-19 ×Vaibhav | 11.59 | 31.81 | 46.22 | 59.18 | 78.51 | 92.19 | 1.00 | 2.53 | 4.27 | 7.60 | 11.27 |
| 33 | VRT-19 × Kashi Aman | 12.00 | 29.95 | 46.18 | 60.55 | 82.92 | 92.64 | 1.00 | 3.03 | 4.23 | 9.53 | 12.77 |
| 34 | VRT-19 × VRT-50 | 11.48 | 25.71 | 39.31 | 51.52 | 75.14 | 90.03 | 0.97 | 2.13 | 3.37 | 7.20 | 10.33 |
| 35 | VRT-19× VRT-30 | 11.66 | 32.69 | 42.57 | 58.94 | 83.49 | 94.12 | 1.03 | 2.77 | 4.23 | 9.53 | 11.88 |
| 36 | H-88-78-1 × Kashi Chaya | 15.19 | 34.33 | 49.68 | 63.60 | 88.53 | 98.11 | 1.00 | 3.60 | 3.90 | 7.23 | 11.92 |
| 37 | H-88-78-1 × Vaibhav | 12.11 | 29.66 | 47.00 | 59.55 | 81.12 | 92.63 | 1.00 | 2.27 | 4.03 | 7.87 | 11.26 |
| 38 | H-88-78-1 × Kashi Aman | 12.44 | 32.95 | 46.59 | 59.30 | 83.81 | 92.81 | 1.00 | 2.87 | 3.97 | 9.57 | 12.59 |
| 39 | H-88-78-1 ×VRT-50 | 11.38 | 25.18 | 39.18 | 51.89 | 78.75 | 89.81 | 0.90 | 2.20 | 3.20 | 6.83 | 11.16 |
| 40 | H-88-78-1 × VRT-30 | 12.87 | 31.02 | 42.83 | 57.29 | 82.46 | 94.39 | 1.00 | 2.73 | 3.87 | 9.50 | 11.78 |
| 41 | VRT-51 ×Kashi Chaya | 11.21 | 32.91 | 46.16 | 61.69 | 82.62 | 92.91 | 0.33 | 3.37 | 4.33 | 7.37 | 11.75 |
| 42 | VRT-51 × Vaibhav | 11.64 | 32.62 | 46.09 | 59.34 | 81.56 | 93.70 | 0.00 | 2.97 | 4.33 | 9.43 | 11.26 |
| 43 | VRT-51 ×Kashi Aman | 11.94 | 30.18 | 45.46 | 58.41 | 84.92 | 93.32 | 0.33 | 3.00 | 4.33 | 9.53 | 12.37 |
| 44 | VRT-51 ×VRT-50 | 11.99 | 24.32 | 38.62 | 52.05 | 79.01 | 89.22 | 0.50 | 2.17 | 3.30 | 6.97 | 10.24 |
| 45 | VRT-51 ×VRT-30 | 12.20 | 32.24 | 42.87 | 60.30 | 77.80 | 94.52 | 0.33 | 2.87 | 4.33 | 9.63 | 11.78 |
| 46 | Tolev-28 × Kashi Chaya | 14.31 | 30.11 | 46.09 | 61.40 | 76.11 | 91.66 | 0.33 | 3.43 | 4.27 | 7.40 | 11.67 |
| 47 | Tolev-28 × Vaibhav | 14.38 | 29.81 | 46.02 | 57.96 | 82.58 | 92.04 | 0.00 | 2.97 | 4.23 | 9.40 | 12.28 |
| 48 | Tolev-28 ×kashi Aman | 14.73 | 31.84 | 45.46 | 59.32 | 83.82 | 93.18 | 0.33 | 2.70 | 4.23 | 9.60 | 12.46 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 49 | Tolev-28 × VRT-50 | 14.44 | 31.48 | 45.71 | 60.52 | 81.29 | 92.99 | 0.33 | 2.87 | 4.23 | 8.80 | 11.14 |
| 50 | Tolev-28 ×VRT-30 | 13.85 | 30.20 | 42.98 | 62.68 | 76.56 | 94.54 | 0.67 | 2.83 | 4.23 | 9.37 | 12.04 |
| 51 | VRT-50 × Kashi Chaya | 14.39 | 31.59 | 44.04 | 59.95 | 75.22 | 92.11 | 1.00 | 3.30 | 4.33 | 7.40 | 11.48 |
| 52 | VRT-01 ×Vaibhav | 14.45 | 31.92 | 43.97 | 65.63 | 82.88 | 94.11 | 1.00 | 2.87 | 4.33 | 9.40 | 12.40 |
| 53 | VRT-01 ×Kashi Aman | 15.70 | 29.92 | 44.01 | 59.96 | 82.54 | 93.04 | 0.67 | 2.60 | 4.33 | 9.63 | 11.89 |
| 54 | VRT-01 ×VRT-50 | 14.61 | 29.85 | 43.63 | 61.95 | 80.70 | 92.56 | 1.00 | 2.93 | 4.33 | 8.83 | 12.18 |
| 55 | VRT-01 × VRT-30 | 14.66 | 29.81 | 42.59 | 62.17 | 77.20 | 92.59 | 1.00 | 2.67 | 4.27 | 8.40 | 12.10 |
| 56 | Tolev-32 × Kashi Chaya | 14.23 | 30.11 | 42.98 | 60.23 | 75.61 | 92.28 | 0.00 | 3.23 | 4.43 | 7.50 | 11.50 |
| 57 | Tolev-32 × Vaibhav | 14.67 | 29.66 | 42.76 | 62.98 | 84.42 | 93.92 | 0.00 | 3.20 | 4.43 | 9.43 | 12.17 |
| 58 | Tolev-32 ×Kashi Aman | 14.89 | 32.98 | 42.95 | 59.69 | 82.73 | 92.78 | 0.00 | 2.53 | 4.43 | 9.57 | 12.11 |
| 59 | Tolev-32 ×VRT-50 | 14.57 | 31.11 | 42.67 | 60.85 | 81.81 | 93.88 | 0.33 | 3.03 | 4.43 | 9.17 | 12.38 |
| 60 | Tolev-32 ×VRT-30 | 15.02 | 29.53 | 42.49 | 62.21 | 78.76 | 94.29 | 0.33 | 2.47 | 4.33 | 8.37 | 12.13 |
| | Mean F1 | **13.58** | **30.80** | **43.97** | **59.32** | **81.28** | **92.65** | **0.78** | **2.83** | **4.60** | **8.53** | **11.94** |
| | Min | 11.03 | 24.32 | 38.62 | 49.55 | 75.14 | 89.22 | 0.00 | 2.13 | 3.20 | 6.57 | 10.22 |
| | Max | 16.42 | 35.70 | 50.00 | 65.63 | 88.73 | 98.11 | 1.07 | 3.63 | 6.07 | 9.67 | 13.25 |
| | SE(d) ± | 0.15 | 0.50 | 0.48 | 0.50 | 0.61 | 0.52 | 0.29 | 0.16 | 0.09 | 0.18 | 0.09 |
| | C.D. at 5% | 0.29 | 1.00 | 0.95 | 0.99 | 1.20 | 1.03 | 0.57 | 0.32 | 0.18 | 0.36 | 0.18 |
| | C.V. (%) | 1.35 | 1.96 | 1.33 | 1.03 | 0.92 | 0.69 | 47.26 | 7.32 | 2.34 | 2.62 | 0.92 |