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# Heterosis for yield and yield components in Tomato (*Lycopersicon esculentum* L.)

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**Abstract**
The current study, "Heterosis for Yield and Yield Components in Tomato (*Lycopersicon esculentum* L.)," was carried out at the Department of Vegetable Science in Kalyanpur, Kanpur, during the Rabi season of 2022–2023. The experiment was set up using a randomized block design (RBD), with nine parents and eighteen hybrids making up the number of treatments, or genotypes.T1–6026 x Azad T-3, T2- 6026 x Azad T-6, T3–6026 x Azad ks–07, T4–6512 x Azad T-3, T5–6512 x Azad ks–07, T6–7039 x Azad T-3, T7–7039 x Azad T-6, T8–7039 x Azad ks–07, T9–7053 x Azad T-3, T10–7053 x Azad T-6, T11–7053 x Azad ks–07, T12–7048 x Azad T-3, and T13–7048 x Azad T-6. T15- 7202 x Azad T-3 T14- 7048 x Azad ks-07 T-6 T17 7202 x Azad ks-07 T167202 x Azad KS-03 x Azad T187202. The study's findings showed that the highest plant height measured was 103.19 cm (Azad T-6), and that the number of primary branches per plant among the parents ranged from 2.45 (7039) to 4.26 (7048). The parent with the longest fruit length was 6512 (5.45 cm), and the maximum fruit width was 6026 (5.24 cm). Among the crosses, the results varied to 10.66 (7053 × Azad ks-07) to 16.64 (7053 × Azad T-6). Azad ks-07 (15.92) was the parent deemed to be the best in terms of fruit clusters per plant. The other three top parents in terms of fruit production per plants was 7048 (48.70), 7053 (46.96), and 6512 (33.55). Fruit yield per plant was recorded to be 1874.36g (6512 × Azad ks-07), highest number of seeds per fruit were 7053 (148.66).

**Keywords:** Tomato, tester, variety, growth and yield

## Introduction
In decreasing order, the top tomato-producing nations are China, India, the United States, Turkey, Egypt, Iran, and Italy. An area of 5 million hectares is used for tomato cultivation worldwide, with a median yield of 36.97 tonnes ha-1 and an overall production of 186.82 million Metric tonnes (FAO, 2022). Tomato cultivation covers 0.84 million hectares in India, yielding an average of 20.69 million Cubic tonnes of production and 21.18 t ha-1 of productivity (PIB Report 2021-22). The province of Uttar Pradesh produced 9.02 million metric tons on 0.08 million hectares of common land (National Horticulture Board, 2021-22). Based on their growth habits, tomatoes may be divided into two main categories: determinate (also known as "bush" type) and indeterminate. Cultivars of the bush variety are frequently cultivated, either for fresh tomato consumption or to be processed into tomato puree, soup, juice, or ketchup. Determinate tomatoes have a fixed number of groupings, which is not particularly high, and require very little in the way of plant care. Although their inputs are relatively inexpensive, their yields and quality are often not particularly high. The primary purpose of cultivating indeterminate cultivars is for fresh consumption. They are seldom ever produced for processing since the processing industry has come to rely more and more on large volume output in short amounts of time a feature that is difficult to select for and breed from genotypes that grow indefinitely.

Other significant fruit quality attributes of tomatoes includes pH, titrable acidity, shelf life, and vitamin contents, in addition to economically significant features such fruit size, shape, total solids, color, firmness, nutritional quality, and flavor (Foolad, 2007). The fruit of tomatoes is composed of 5-6% organic components (solids) and 94-95% water. The solids are made up of different parts: About 50% of the solids are sugars (fructose, glucose, and sucrose, which are mainly found in fruit walls); 25% are pectins, cellulose, proteins, and polysaccharides (alcohol insoluble solids); 12% are organic acids like citrate and malate; the

remaining solids are made up of carotenoids and volatile compounds, amino acids, and inorganic compounds. Tomato output has significantly increased as a result of hybrids replacing inbred lines (Grandillo *et al*., 1999). The parents concerned must be superior genetically and have greater particular combining ability in order for superior hybrids to arise. The main benefit of hybrids over open-pollinated cultivars is their ability to effectively use the heterosis phenomenon. Most people agree that tomatoes with heterosis exhibit improved vigor, quicker growth and development, early maturity, higher production, and a higher level of resilience to biotic and abiotic challenges (Yordanov, 1983).

In order to create hybrids, this design uses one-to-one hybrid between lines and wide-based tests. Unlike topcross, which only produces half-sibs, this mating pattern is the simplest and simultaneously produces both full- and half-sibs. It offers SCA for every cross and, as line and testers have distinct sets of genotypes, it also offers GCA for the testers in addition to the lines (Sharma, 2006). Furthermore, it is employed in the estimation of diverse gene activities that are crucial for the development of quantitative features (Rashid *et al*., 2007) [9]. One biometrical approach called generation mean analysis uses six independent generations P1, P2, F1, F2, B1, and B2 to estimate the genetic components of variance. In addition to estimating additive and dominant variances and effects, this method gives information regarding the existence or absence of epistasis. In terms of gene effects and other data like potence ratio, degrees of authority, number of effective factors, etc., it also identifies the components of heterosis. The current study aims to comprehend the genetics of the yield and quality attributes that S. lycopersicum possesses.

## Materials and methods

The current study was carried out at the vegetable science department at Chandra shekhar Azad University of Agriculture and Technology in Kalyanpur, Kanpur, during the Zaidseason of 2022-2023. Analysis of the studies was done using Randomized Block Design (RBD). The experiment was set up in three replications and included the following eighteen treatments: three test sets (Azad T-3, T-6, and KS-07) and six lines (6026, 6512, 7039, 7053, 7048, and 722). The gross plot measured 3 by 3 meters, with rows spaced 60 by 60 centimeters apart.In every experiment, the specified standard cultural practices were adhered to.

**Table 1:** Comparison of various crossbreeds in terms of plant height, branch count, fruit dimensions, yield, and seed count

| Crosses | Plant height (cm) | No. of primary branches per plant | Fruit length (cm) | Fruit width (cm) | No. of fruit clusters per plant | No. of fruits per cluster | No. of fruits per plant | Fruit yield per plant (g) | Fruit yield (q/ha) | No. of seeds per fruit |
|---|---|---|---|---|---|---|---|---|---|---|
| 6026 x Azad T-3 | 85.74 | 3.3 | 4.51 | 5.53 | 12.02 | 3.43 | 30.62 | 1640.66 | 442.94 | 70.15 |
| 6026 x Azad T-6 | 142.65 | 4.9 | 4.46 | 5.02 | 14.35 | 3.88 | 26.07 | 1733.64 | 468.04 | 104.35 |
| 6026 x Azad ks-07 | 78.53 | 2.86 | 5.05 | 5.68 | 11.72 | 4.43 | 23.57 | 1406.01 | 379.64 | 91.02 |
| 6512 x Azad T-3 | 77.89 | 3.41 | 4.26 | 4.74 | 13.75 | 5.35 | 30.12 | 1353.68 | 365.45 | 83.35 |
| 6512 x Azad T-6 | 150.22 | 3.26 | 5.22 | 5.35 | 14.97 | 4.46 | 27.17 | 1588.14 | 428.74 | 102.65 |
| 6512 x Azad ks-07 | 95.59 | 4.7 | 4.52 | 4.98 | 16.27 | 4.83 | 27.32 | 1874.36 | 506.04 | 78.75 |
| 7039 x Azad T-3 | 90.28 | 3.3 | 4.37 | 4.93 | 14.56 | 5.48 | 33.77 | 1696.84 | 458.14 | 101.54 |
| 7039 x Azad T-6 | 89.51 | 3.27 | 4.22 | 4.82 | 13.86 | 3.49 | 21.32 | 1519.76 | 410.38 | 112.25 |
| 7039 x Azad ks-07 | 109.04 | 2.53 | 3.84 | 5.12 | 15.79 | 4.22 | 27.97 | 1577 | 425.74 | 61.25 |
| 7053 x Azad T-3 | 85.08 | 2.23 | 4.05 | 4.73 | 13.66 | 6.47 | 20.62 | 1538.61 | 415.44 | 100.53 |
| 7053 x Azad T-6 | 112.03 | 3.63 | 4.12 | 4.52 | 16.64 | 4.95 | 24.67 | 1675.28 | 452.34 | 148.59 |
| 7053 x Azad ks-07 | 77.52 | 2.23 | 4.34 | 5.23 | 10.66 | 5.67 | 20.04 | 1104.74 | 298.24 | 81.35 |
| 7048 x Azad T-3 | 120.48 | 3.63 | 3.46 | 3.63 | 15.04 | 5.54 | 31.15 | 1210.51 | 326.88 | 34.35 |
| 7048 x Azad T-6 | 140.78 | 4.43 | 4.32 | 3.93 | 13.87 | 5 | 38.42 | 1537.34 | 415.05 | 58.69 |
| 7048 x Azad ks-07 | 113.25 | 4.4 | 4.56 | 4.15 | 15.17 | 5.42 | 36.22 | 1455.78 | 393.02 | 52.85 |
| 7202 x Azad T-3 | 79.52 | 3.2 | 4.63 | 5.12 | 14.51 | 4.57 | 21 | 1193.34 | 322.24 | 82.55 |
| 7202 x Azad T-6 | 125.88 | 3.61 | 4.17 | 4.78 | 16.63 | 3.62 | 26.92 | 1754.94 | 473.84 | 92.75 |
| 7202 x Azad ks-07 | 82.54 | 2.43 | 4.23 | 4.77 | 15.91 | 4.07 | 18.67 | 1245.21 | 336.27 | 91.55 |
| S. E. m ± | 0.78 | 0.14 | 0.09 | 0.03 | 0.31 | 0.12 | 0.42 | 12.68 | 3.44 | 0.93 |
| C.D 5% | 3 | 0.38 | 0.23 | 0.22 | 0.87 | 0.37 | 1.27 | 36.14 | 9.74 | 2.77 |

Table 4.1 showed that the mean values for hybrids varied from 77.09 (7053 × Azad ks-07) to 150.22 cm (6512 × Azad T-6), with the smallest plant height reported among the parents being 71.87 cm (6512) and the greatest being 103.19 cm (Azad T-6). The hybrid cross 6512 × Azad T-6 had the highest plant height of 150.22 cm, next to 6026 × Azad T-6 (142.65 cm) and 7048 × Azad T-6 (140.78 cm). The maximum plant height among the parental lines was recorded for Azad T-6 (103.19 cm), followed by 7048 (101.78 cm) and 7039 (90.56 cm). The comparable outcome reported by Joshi and Kohli (2006).

The range of primary branch counts per plant for the parents was 2.45 (7039) to 4.26 (7048), and for the crosses, it was 2.23 (7053 x Azad T-3 and 7053 x Azad ks-07) to 4.9 (6026 × Azad T-6). Out of the parental genotypes, 7048 (4.26) had the highest number of primary branches per plant, followed by 7202 (3.57) and 6512 (3.27). In the hybrids, the cross 6026 × Azad T-6 (4.9) had the highest value for this trait, accompanied by 6512 × Azad ks-07 (4.7) and 7048 × Azad ks-07 (4.4). The comparable outcome presented by Salim *et al*. (2019) [9].

Fruit length measurements ranged from 2.73 (7048) to 5.45 cm (6512) for the parents and 3.46 (7048 × Azad T-3) to 5.22 cm (6512 × Azad T-6) for the crosses. In terms of longest fruit length, the best-performing parent was 6512 (5.45 cm), which was followed by 6026 (5.29 cm) and 7039 (4.78 cm). In terms of hybrids, the best-performing ones were 6512 × Azad T-6 (5.22 cm), 6026 × Azad ks-07 (5.05 cm), and 7202 × Azad T-6 (4.63 cm). Similar findings were reported by Kumar *et al*. (2016) [6].

The mean fruit width values among the parental lines varied from 2.73 (7048) to 5.24 cm (6026), but for the hybrids, the range was 3.63 (7048 × Azad T-3) to 5.63 cm (6026 × Azad ks-07). The hybrid cross 6026 × Azad ks-07 (5.63 cm) had the highest fruit width of any recorded hybrid, followed by 6026 × Azad T-3 (5.53 cm) and 6512 × Azad T-6 (5.35 cm).

The three best parents in terms of maximum fruit width were 6026 (5.24 cm), Azad T-6 (5.04 cm), and 6512 (4.74 cm). The comparable outcome reported by Meena *et al*. (2015) [5].

Fruit cluster counts per plant ranged from 9.33 (6512) to 15.92 (Azad ks-07) for the parents and 10.66 (7053 × Azad ks-07) to 16.64 (7053 × Azad T-6) for the crosses. The hybrid that performed best for this trait was 7053 × Azad T-6 (16.64), followed by 7202 × Azad T-6 (16.63) and 6512 × Azad ks-07 (16.27). The parent that was deemed best had the highest number of fruit clusters per plant, and that was Azad ks-07 (15.92), followed by 7053 (15.33) and 7048 (14.93). The comparable outcome reported by Kumar *et al*. (2017) [7].

For the parents, the range of average fruits per cluster was 3.57 (Azad T-6) to 6.03 (7053). Between 3.47 (6026 × Azad T-3) and 6.47 (7053 × Azad T-3), the hybrid displayed a range of variety. Out of all the parents, 7053 (6.03) was shown to be the best at producing the most fruits per cluster, followed by CO-3 (5.54) and 7039 (5.12). Out of all the cross combinations, 7053 × Azad T-3 (6.47) was the most successful in generating more fruits per cluster, followed by 7053 × Azad ks-07 (5.67) and 7048 × Azad T-3 (5.54).The comparable findings of Yadav *et al.* (2013) and Ahmad *et al*. (2011) [1, 11].

Based on the amount of fruits per plant, the mean value for the parents was 19.54 (7202) at the lowest, 48.74 (7048) at the highest, and 38.42 (7048 × Azad T-6) at the highest for the hybrids. 7048 (48.70), 7053 (46.96), and 6512 (33.55) were the three best parents with the most fruits per plant, while the hybrids 7048 × Azad T-6 (38.42), 7048 × Azad ks-07 (36.22), and 7039 × Azad T-3 (33.77) were reported to yield the most fruits per plant. Similar findings have been reported by Singh *et al*. (2007) and Reddy *et al*. (2013) [8, 10].

Based on the amount of fruits per plant, the mean value for the parents was 19.54 (7202) at the lowest, 48.74 (7048) at the highest, and 38.42 (7048 × Azad T-6) at the highest for the hybrids. 7048 (48.70), 7053 (46.96), and 6512 (33.55) were the three best parents with the most fruits per plant, while the hybrids 7048 × Azad T-6 (38.42), 7048 × Azad ks-07 (36.22), and 7039 × Azad T-3 (33.77) were reported to yield the most fruits per plant. Similar findings have been reported by Singh *et al*. (2007) and Reddy *et al*. (2013) [8, 10].

The fruit production variance recorded in the parents varied from 292.34 (7202) to 447.23 q/ha (6512), whereas the hybrids showed a variation between 298.24 (7053 × Azad ks-07) and 506.04 q/ha (6512 × Azad ks-07). The hybrids 6512 × Azad ks-07 (506.04 q/ha), 7202 × Azad T-6 (473.84 q/ha), and 6026 × Azad T-06 (468.04 q/ha) were found desirable for the same yield per hectare, while the parents 6512 (447.23 q/ha), Azad ks-07 (436.63 q/ha), and Azad T-6 (406.76 q/ha) were found better for higher yield per hectare. Reddy *et al*. (2013) and Chauhan *et al*. (2014) [3, 8] exhibit comparable results.

Parental performance ranged from 53.34 (Azad ks-07) to 148.66 (7053) in terms of seeds per fruit. The distribution of the hybrids ranged from 34.35 (7048 × Azad T-3) to 148.59 (7053 × Azad T-6). Out of all the hybrids, the cross 7053 × Azad T-6 (148.59) had the greatest number of seeds per fruit, followed by 7039 × Azad T-6 (112.25) and 6026 × Azad T-6 (104.35). The top three parents with the largest number of seeds per fruit were 7053 (148.66), Azad T-6 (125.05), and Azad T-3 (109.24).

## Conclusion

In terms of performance, certain crossings were judged to be better in terms of both their unique combining ability and mean performances. In terms of the amount of fruit clusters per plant, the cross 7053 × Azad T-6 was the best particular combiner and superior mean performance. Regarding fruit output per plant, the cross 6512 × Azad ks-07 was determined to be a superior particular combiner and mean performance.

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