International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; 9(7): 1279-1284
www.biochemjournal.com
Received: 09-05-2025
Accepted: 13-06-2025

**Yogesh P Katariya**
M.Sc. Scholar, Department of Genetics and Plant Breeding, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

**RS Parmar**
Associate Professor & Head, Department of Genetics and Plant Breeding, College of Agriculture, Junagadh Agricultural University, Mota Bhandariya-Amreli, Gujarat, India

**Harsh M Badreshiya**
M.Sc. Scholar, Department of Genetics and Plant Breeding, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

**GK Sapara**
Assistant Research Scientist, Main Oilseed Research Station, Junagadh Agricultural University, Junagadh, Gujarat, India

**SA Hariyani**
Assistant Professor, College of Agriculture, Junagadh Agricultural University, Mota Bhandariya-Amreli, Gujarat, India

**Corresponding Author:**
**Yogesh P Katariya**
M.Sc. Scholar, Department of Genetics and Plant Breeding, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

# Study of heterosis for fruit yield and its yield components in okra [*Abelmoschus esculentus* (L.) Moench]

**Yogesh P Katariya, RS Parmar, Harsh M Badreshiya, GK Sapara and SA Hariyani**

**DOI:** https://www.doi.org/10.33545/26174693.2025.v9.i7p.4924

**Abstract**
The experimental material comprised of eight lines, four testers of okra, their 32 hybrids developed by line × tester design and one standard check hybrid (GJOH-4). They were evaluated in randomized block design with three replications at Instructional Farm, Krushigadh, Department of Agronomy, College of Agriculture, J.A.U., Junagadh during *kharif* 2024 for studies extent and magnitude of heterotic effects of hybrids over better parent and standard check. The analysis of experimental variance revealed highly significant differences among the genotypes, parents and hybrids for all the trait except fruit girth. The heterobeltiosis for fruit yield per plant was laid between-19.91% (JOL-23-03 × GJO-3) to 25.22% (JOL-23-16 × GAO-8), while, the standard heterosis ranged from-14.51% (JOL-23-13 × GJO-3) to 22.82% (JOL-23-16 × GAO-8). Further exploitation of these crosses could lead to the development of desirable hybrids of okra.

**Keywords:** Okra, line × tester analysis, heterosis

## Introduction
Okra [*Abelmoschus esculentus* (L.) Moench] is one of the most valuable vegetable crops of India, belongs to family Malvaceae or Malva and having chromosome number 2n = 130. Owes, its origin to Ethopia, from where it proliferated into Arabia down the Nile valley and was introduced into Europe by the Moors and further into Louisiana during the early l700's by the French Colonist (Woodruff, 1927) [27]. India is also considered its native place as various ancestral wild forms are met here (Yawalkar, 1965) [28]. Okra is also known as lady's finger, *bhindi*, *gumbo* etc., its tender green fruits are used as a vegetable and are generally marketed in the fresh state, but sometimes in canned or dehydrated form. The root and stem of okra are used for cleaning of gur, *khand* or raw sugar. Okra's sturdy character, dietary fiber content, unique seed protein balance of lysine and tryptophan amino acids have earned it is called "a perfect villager's vegetable." The important okra growing states in India are Gujarat, Maharashtra, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Karnataka, Haryana and Punjab. Okra is cultivated as a *Kharif* as well as summer season crop. The main okra growing districts in Gujarat are Vadodara, Junagadh, Surendranagar, Gandhinagar, Banaskantha, Surat, Kheda and Anand.

## Materials and Methods
The experimental material comprised of eight (Female) lines *viz*., JOL-22-12, JOL-23-01, JOL-23-03, JOL-23-07, JOL-23-08, JOL-23-11, JOL-23-13, JOL-23-16; four testers (male) of okra *viz*., GJO-3, GO-6, GAO-8, Pusa Sawani (Table 1) and their 32 $F_1$s hybrids developed by line × tester design and one standard check hybrid (GJOH-4). They were evaluated in randomized block design (RBD) with three replications at Instructional Farm, Krushigadh, Department of Agronomy, College of Agriculture, J.A.U., Junagadh. during *kharif* 2024. Row to row and plant to plant spacing was 60 cm × 30 cm. To produce a better crop, the region's recommended agronomic practices were followed. The observations were recorded on five randomly selected plants expect the plot basis from parents and crosses for 15 characters *viz*., nodal position for first flowering, days to first flowering, days to first

picking, fruit weight (g), fruit length (cm), fruit girth (cm), plant height (cm), number of branches per plant, number of nodes per plant, internode length (cm), number of fruits per plant, days to last picking, total pickings, fruit yield per plant (g) and 100 seed weight (g), and Mean data were used for statistical analysis. The variance analysis for each character was performed using the method described by Panse and Sukhatme (1995) [11]. Heterosis was estimated in term of two parameters, *i.e*. heterobeltiosis (heterosis over better parental value) as suggested by Fonseca and Patterson (1968) [3] and standard heterosis (heterosis over standard check) as suggested by Meredith and Bridge (1972) [9].

**Results and Discussion**

The analysis of variance showed highly significant differences among the genotypes for all the traits except fruit girth. The genotypic variance was further partitioned into parents (lines, testers and L. vs T.), hybrids and parents vs. hybrids. The differences among parents and hybrids were found highly significant for all the traits except fruit girth. Differences due to parents vs hybrids were also found highly significant for the fruit weight (g), fruit girth (cm), total picking and fruit yield per plant (g). The mean squares due to lines were significant for all the traits. The mean squares due to testers were significant for all the traits except Fruit length (cm), Plant height (cm), Number of nodes per plant and Internode length (cm). This indicated the presence of wide genetic variability in the material used. The mean squares due to lines vs testers were significant for all traits, indicating the significant difference between female and male parents for these traits. Magnitude of variability was higher with lines for days to first flowering, fruit length (cm), plant height (cm), number of nodes per plant, internode length (cm), days to last picking and 100 seed weight (g) in comparison to testers. This indicated that the more contribution of lines in total variance for these characters. Likewise, the magnitude of variability was equal with lines and testers for fruit girth (cm). While, the magnitude of variability was higher with testers for the rest of the traits under studied to the total variance (Table 2). Similar result observed by Patel and Patel (2016) [14], Punia *et al.* (2017) [19], Pithiya *et al.* (2019) [18], Patel *et al.* (2020) [12], Sidapara *et al.* (2021) [25], Shweta *et al.* (2022) [24], Chaudhary *et al.* (2023) [1], Sakriya *et al.* (2023) [22], Pathania *et al.* (2024) [17], Ranga *et al.* (2024) [21] and Vani *et al.* (2024) [26] for nodal position for first flowering, days to first flowering, days to first picking, fruit weight (g), fruit length (cm), fruit girth (cm), plant height (cm), number of branches per plant, number of nodes per plant, internode length (cm), number of fruits per plant, days to last picking, total pickings, fruit yield per plant (g) and 100 seed weight (g).

Many crosses depicted significant heterosis over better parent and standard check in favourable direction for nodal position for first flowering (16, 12) days to first flowering (11, 13), days to first picking (10, 11), fruit weight (g) (2, 2), fruit length (cm) (2, 0), fruit girth (cm) (5, 3), plant height (cm) (5, 5), number of branches per plant (6, 3), number of nodes per plant (6, 4), internode length (cm) (8, 13), number of fruits per plant (8, 8), days to last picking (7, 1), total picking (7, 5), fruit yield per plant (g) (8, 9) and 100 seed weight (g) (5, 0), respectively.

Prformance of crosses in respect of heterosis over better parent and standard check (GJOH-4) revealed that the high magnitudes of heterobeltiosis and standard heterosis in desirable direction were found for nodal position for first flowering, days to first flowering, days to first picking, internode length (cm), number of fruits per plant, days to last picking, total picking and fruit yield per plant (g). While, the low magnitude of heterobeltiosis and heterosis over standard check was noticed for fruit weight (g), fruit length (cm), fruit girth (cm), plant height (cm), number of branches per plant, number of nodes per plant and 100 seed weight (g). Similar observations were also made by Punia *et al.* (2017) [19], Pithiya *et al.* (2019) [18], Patel *et al.* (2020) [12], Sidapara *et al.* (2021) [25], Shweta *et al.* (2022) [24], Chaudhary *et al.* (2023) [1], Sakriya *et al.* (2023) [22], Pathania *et al.* (2024) [17], Ranga *et al.* (2024) [21].

In okra, negative heterosis is desirable for nodal position for first flowering. The heterobeltiosis was ranged from-31.02% (JOL-23-13 × Pusa Sawani) to 20.41% (JOL-23-08 × GAO-8). The standard heterosis varied from-28.25% (JOL-23-08 × GJO-3) to 19.00% (JOL-23-11 × Pusa Sawani) (Table 3). Similar findings were reported by Nagesh *et al.* (2014) [10], Patel *et al.* (2015) [16], Pithiya *et al.* (2019) [18], Sidapara *et al.* (2021) [25], Poluru *et al.* (2023) [20], Ranga *et al.* (2024) [21] and Vani *et al.* (2024) [26].

As earliness is desirable character in okra and days to first flowering is component which effects on earliness. Heterobeltiosis values for days to first flowering were between-14.37% (JOL-23-07 × GAO-8) to 8.84% (JOL-23-13 × GAO-8). The standard heterosis ranged from-13.29% (JOL-23-03 × GAO-8) to 2.53% (JOL-23-01 × Pusa Sawani). This result matched with finding of Sidapara *et al.* (2021) [25], Kharat *et al.* (2022) [5], Chaudhary *et al.* (2023) [1], Sakriya *et al.* (2023) [22] and Ranga *et al.* (2024) [21].

In okra, earliness in days to first picking is a desirable trait and the heterobeltiosis for this trait was ranged from-14.92% (JOL-23-07 × GAO-8) to 7.45% (JOL-23-13 × GAO-8). the standard heterosis showed wide range from-12.21% (JOL-23-03 × GAO-8) to 2.33% (JOL-23-01 × Pusa Sawani). There findings are akin to Mehta *et al.* (2007) [8], Patel *et al.* (2015) [16], Pithiya *et al.* (2019) [18], Sidapara *et al.* (2021) [25], Kharat *et al.* (2022) [5], Shweta *et al.* (2022) [24], Sakriya *et al.* (2023) [22] and Vani *et al.* (2024) [26].

The estimated heterosis over better parent varied from-15.75% (JOL-23-13 × GJO-3) to 22.89% (JOL-23-11 × Pusa Sawani) for fruit weight. The standard heterosis varied from -12.13% (JOL-23-07 × GJO-3) to 11.25% (JOL-23-01 × GJO-3). Positive estimation of heterosis in this trait was reported by Punia *et al.* (2017) [19], Sapavadiya *et al.* (2019) [23], Poluru *et al.* (2023) [20], Patel *et al.* (2024) [15] and Pathania *et al.* (2024) [17].

More fruit length generally directly responsible for high yield and hence, their positive values found beneficial in okra. The heterobeltiosis was ranged from-21.27% (JOL-23-03 × GJO-3) to 14.72% (JOL-23-07 × GO-6). None of the crosses showed positive and significant heterosis over standard check (GJOH-4) for fruit length. These results are agreed with the result obtained by Kumar and Pathania (2011) [7], Patel (2013) [13], Punia *et al.* (2017) [19], Sapavadiya *et al.* (2019) [23], Kharat *et al.* (2022) [5] and Chaudhary *et al.* (2023) [1].

In case of okra, negative heterosis is desirable for fruit girth. The heterobeltiosis was ranged from-9.03% (JOL-23-07 × GJO-3) to 6.63% (JOL-23-11 × Pusa Sawani). The range of standard heterosis was noted from-6.34% (JOL-23-07 × GJO-3) to 8.82% (JOL-23-11 × Pusa Sawani). There finding confined the result of those reported by Nagesh *et al.* (2014) [10], Patel *et al.* (2015) [16], Patel and Patel (2016) [14], Sidapara *et al.* (2021) [25], Poluru *et al.* (2023) [20] and Vani *et al.* (2024) [26].

The values of heterobeltiosis for plant height ranged from-22.24% (JOL-23-08 × GJO-3) to 19.17% (JOL-23-03 × GJO-3). The minimum and the maximum values of heterosis over standard check were-10.44% (JOL-22-12 × GJO-3) and 22.18% (JOL-23-08 × Pusa Sawani). These results are agreed with the result obtained by Khatik *et al.* (2012) [6], Nagesh *et al.* (2014) [10], Patel and Patel (2016) [14], Pithiya *et al.* (2019) [18], Kharat *et al.* (2022) [5], Poluru *et al.* (2023) [20] and Patel *et al.* (2024) [15].

For number of branches per plant, the estimates of heterobeltiosis ranged from-44.19% (JOL-23-01 × GJO-3) to 42.42% (JOL-23-03 × GAO-8). The range of standard heterosis was noted from-42.86% (JOL-23-13 × GO-6) to 16.67% (JOL-23-16 × GAO-8). Similar results were observed by Patel (2013) [13], Patel and Patel (2016) [17], Pithiya *et al.* (2019) [18], Shweta *et al.* (2022) [24] and Sakriya *et al.* (2023) [22].

The estimated heterosis over better parent varied from-21.46% (JOL-23-11 × Pusa Sawani) to 15.22% (JOL-23-16 × GAO-8) for number of nodes per plant. The standard heterosis varied from-13.87% (JOL-23-11 × Pusa Sawani) to 20.17% (JOL-23-08 × GO-6). These finding are akin to Dabhi *et al.* (2009) [2], Patel (2013) [13], Patel and Patel (2016) [14], Pithiya *et al.* (2019) [18], Shweta *et al.* (2022) [24], Chaudhary *et al.* (2023) [1] and Ranga *et al.* (2024) [21].

In okra, negative heterosis is desirable for internode length. The heterobeltiosis for this trait was varied from-26.26% (JOL-22-12 × Pusa Sawani) to 35.01% (JOL-23-01 × GO-6). The estimated heterosis over standard check (GJOH-4) varied from-32.09% (JOL-22-12 × Pusa Sawani) to 13.03% (JOL-23-01 × GO-6). Similar findings were also reported by Dabhi *et al.* (2009) [2], Patel *et al.* (2015) [16], Sidapara *et al.* (2021) [25], Chaudhary *et al.* (2023) [1] and Pathania *et al.* (2024) [17].

Considering heterosis over better parent, the variation for number of fruits per plant was from-34.20% (JOL-23-16 × GJO-3) to 22.64% (JOL-23-07 × GO-6). Estimations of standard heterosis was ranged from-23.49% (JOL-23-16 × GJO-3) to 19.88% (JOL-23-13 × GAO-8). These results are agreed with the result obtained by Nagesh *et al.* (2014) [10], Punia *et al.* (2017) [19], Patel *et al.* (2020) [12], Kharat *et al.* (2022) [5] and Patel *et al.* (2024) [15].

The values of heterobeltiosis for days to last picking ranged from-13.54% (JOL-23-08 × GJO-3) to 15.11% (JOL-23-13 × GAO-8). The standard heterosis was noted from-11.04% (JOL-23-07 × GJO-3) to 4.87% (JOL-23-08 × Pusa Sawani). These results also resemble to finding reported by Khanpara *et al.* (2009) [4], Khatik *et al.* (2012) [6], [14]Patel and Patel (2016) [14], Pithiya *et al.* (2019) [18] and Sakriya *et al.* (2023) [22].

The estimated heterosis over better parent varied from-30.77% (JOL-23-01 × GAO-8) to 57.69% (JOL-23-16 × GAO-8) for total picking. The standard heterosis varied from-19.35% (JOL-23-13 × GJO-3) to 32.26% (JOL-23-16 × GAO-8). These findings are akin to those of results reported by Kumar and Pathania (2011) [7], Nagesh *et al.* (2014) [10], Pithiya *et al.* (2019) [18], Patel *et al.* (2020) [12], Shweta *et al.* (2022) [24] and Ranga *et al.* (2024) [21].

The heterobeltiosis for this trait was ranged from-19.91% (JOL-23-03 × GJO-3) to 25.22% (JOL-23-16 × GAO-8) for fruit yield per plant. The highest desirable heterobeltiosis was recorded in cross JOL-23-16 × GAO-8 (25.22%) followed by JOL-22-12 × GAO-8 (23.65%), JOL-23-13 × GAO-8 (22.41%) and JOL-23-11 × GJO-3 (19.19%). The standard heterosis varied from-14.51% (JOL-23-13 × GJO-3) to 22.82% (JOL-23-16 × GAO-8). The hybrid JOL-23-16 × GAO-8 exhibited the highest magnitude of standard heterosis (22.82%) in desirable direction followed by JOL-22-12 × GAO-8 (21.93%) and JOL-23-13 × GAO-8 (20.47%). These results were also agreed with the result obtained by Punia *et al.* (2017) [19], Pithiya *et al.* (2019) [18], Patel *et al.* (2020) [12], Sidapara *et al.* (2021) [25], Shweta *et al.* (2022) [24], Chaudhary *et al.* (2023) [1], Sakriya *et al.* (2023) [22], Pathania *et al.* (2024) [17], Ranga *et al.* (2024) [21] and Vani *et al.* (2024) [26].

The heterobeltiosis ranged from-32.17% (JOL-23-11 × GJO-3) to 24.68% (JOL-22-12 × Pusa Sawani) for this trait. None of the crosses showed positive and significant heterosis over standard check (GJOH-4) for 100 seed weight. Similar results for this trait in okra were observed by Mehta *et al.* (2007) [7], Punia *et al.* (2017) [19], Pithiya *et al.* (2019) [18], Chaudhary *et al.* (2023) [1] and Ranga *et al.* (2024) [21].

The superior cross JOL-23-16 × GAO-8 was exhibited significant standard heterosis in desired direction for the characters, viz., nodal position for first flowering, number of branches per plant, internode length, number of fruits per plant and total of pickings suggesting the greater role of these traits towards the fruit yield per plant. This cross had also registered significant heterobeltiosis in desirable direction for fruit yield per plant, nodal position for first flowering, fruit length, number of branches per plant, number of nodes per plant, internode length, number of fruits per plant, days last picking and total pickings. (Table 4).

The second highest heterotic cross JOL-22-12 × GAO-8 was recorded significant standard heterosis in desired direction for nodal position for first flowering, days first flowering, days first picking, internode length, number of fruits per plant and fruit yield per plant. This cross had also exhibited significant heterobeltiosis in desired direction for nodal position for first flowering, plant height, number of branches per plant, number of nodes per plant, number of fruits per plant and fruit yield per plant. (Table 4).

The third highest heterotic cross JOL-23-13 × GAO-8 was recorded significant and positive heterosis over standard check for number of fruits per plant, total pickings and fruit yield per plant. This cross had also exhibited significant heterobeltiosis in desired direction for number of fruits per plant, days last picking, total pickings and fruit yield per plant (Table 4).

It is interesting to note that the high heterotic crosses for fruit yield per plant did not show high heterosis for all the yield component traits (Table 4). However, the current study found that significant and positive heterosis for fruit yield was associated with significantly desirable heterosis for two or more yield-contribute traits. A similar cumulative heterotic effect of two or more yield components on fruit yield per plant was previously reported by Sidapara *et al.* (2021) [25], Shweta *et al.* (2022) [24], Chaudhary *et al.* (2023) [1], Pathania *et al.* (2024) [17] and Ranga *et al.* (2024) [21]

**Table 1:** Detailed description of parental lines used in crossing programme

| Sr. No. | Parents | Salient features |
|---|---|---|
| **Females (Lines)** | | |
| 1 | JOL-22-12 | Medium to tall height, long internode, broad leaf, dark green pod |
| 2 | JOL-23-01 | Tall height, long internode, broad leaf, light green pod |
| 3 | JOL-23-03 | Tall height, long internode, good branches with broad leaf, light green pod |
| 4 | JOL-23-07 | Tall height, good branches with strip leaf, light green pod |
| 5 | JOL-23-08 | Tall height, long internode, fully broad leaf, dark green pod |
| 6 | JOL-23-11 | Tall height, strip leaf, broad and dark green pod |
| 7 | JOL-23-13 | Tall height, long internode, broad leaf, light green pod |
| 8 | JOL-23-16 | Tall height, variegated red stem with strip leaf, light green pod |
| **Males (Tester)** | | |
| 1 | GJO-3 | Tall height, long internode, broad leaf, light green pod |
| 2 | GO-6 | Tall height, long internode, broad leaf, long, shine and dark green pod |
| 3 | GAO-8 | Tall height, short internode, broad leaf, dark green pod |
| 4 | Pusa Sawani | Medium to tall plant height, short internode, Green slender and attractive pod |
| **Standard check** | | |
| 1 | GJOH-4 | Tall, Pods are dark green, tender, long and attractive, Tolerant against YVMV |

**Table 2:** Analysis of variance showing mean square for experimental design for different characters in okra

| Source | d. f. | Nodal position for first flowering | Days to first flowering | Days to first picking | Fruit weight (g) | Fruit length (cm) | Fruit girth (cm) | Plant height (cm) | Number of branches per plant |
|---|---|---|---|---|---|---|---|---|---|
| Replications | 2 | 0.24 | 3.36 | 3.02 | 74.39 | 1.41 | 7.13** | 0.38 | 0.14* |
| Genotypes | 43 | 2.15** | 18.10** | 19.56** | 337.51** | 2.44** | 0.09 | 130** | 0.63** |
| Parents | 11 | 2.36** | 29.81** | 31.48** | 435.59** | 2.44** | 0.06 | 144.05** | 0.68** |
| Lines | 7 | 1.30** | 20.27** | 19.43** | 271.70** | 4.20** | 0.20** | 156.55** | 0.81** |
| Testers | 3 | 2.78** | 19.04** | 21.34** | 889.66** | 1.10 | 0.20** | 72.13 | 1.54** |
| L. *vs* T. | 1 | 2.29** | 11.95** | 14.02** | 223.34** | 2.08** | 0.03** | 127.95** | 0.45** |
| P. *vs* H. | 1 | 0.89 | 0.27 | 0.20 | 460.50** | 1.89 | 0.71** | 6.16 | 0.04 |
| Hybrids | 31 | 2.12** | 14.52** | 15.95** | 298.75** | 2.46** | 0.08 | 129.01** | 0.64** |
| Error | 86 | 0.22 | 2.87 | 2.93 | 53.56 | 0.54 | 0.08 | 30.98 | 0.04 |

| Source | d. f. | Number of nodes per plant | Internode length (cm) | Number of fruits per plant | Days to last picking | Total pickings | Fruit yield per plant (g) | 100 seed weight (g) |
|---|---|---|---|---|---|---|---|---|
| Replications | 2 | 6.57** | 0.31 | 5.06** | 1.46 | 1.64 | 117.11 | 1.12** |
| Genotypes | 43 | 4.93** | 1.38** | 5.26** | 72.12** | 8.24** | 858.19** | 1.53** |
| Parents | 11 | 3.73** | 0.99** | 5.05** | 108.79** | 7.42** | 346.2* | 1.73** |
| Lines | 7 | 3.03* | 1.29** | 2.79** | 119.33** | 11.55** | 1022.74** | 0.83** |
| Testers | 3 | 0.53 | 0.26 | 7.28** | 107.85** | 14.54** | 2200.24** | 0.66** |
| L. *vs* T. | 1 | 7.04** | 1.81** | 6.08** | 35.36** | 6.18** | 822.78** | 1.85** |
| P. *vs* H. | 1 | 0.46 | 0.61 | 1.63 | 3.28 | 18.33** | 2055.73** | 0.09 |
| Hybrids | 31 | 5.5** | 1.54** | 5.45** | 61.33** | 8.20** | 1001.24** | 1.50** |
| Error | 86 | 1.02 | 0.19 | 0.70 | 5.73 | 2.41 | 175.08 | 0.16 |

*, ** Significant at 5% and 1% levels, respectively

**Table 3:** Range of heterobeltiosis (H1) and standard heterosis (H2) as well as number of crosses with specific heterotic effects for various traits in okra

| Sr. No. | Characters | Range of heterosis (%) | | | | | | Number of crosses with significant heterosis | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Heterobeltiosis ($H_1$) | | | Standard heterosis ($H_2$) | | | $H_1$ | | $H_2$ | |
| | | | | | | | | + Ve | -Ve | + Ve | -Ve |
| 1 | Nodal position for first flowering | -31.02 | to | 20.41 | -28.25 | to | 19.00 | 5 | 16 | 5 | 12 |
| 2 | Days to first flowering | -14.37 | to | 8.84 | -13.29 | to | 2.53 | 3 | 11 | 0 | 13 |
| 3 | Days to first picking | -14.92 | to | 7.45 | -12.21 | to | 2.33 | 2 | 10 | 0 | 11 |
| 4 | Fruit weight (g) | -15.75 | to | 22.89 | -12.13 | to | 11.25 | 2 | 5 | 2 | 5 |
| 5 | Fruit length (cm) | -21.27 | to | 14.72 | -19.36 | to | 8.56 | 2 | 6 | 0 | 7 |
| 6 | Fruit girth (cm) | -9.03 | to | 6.63 | -6.34 | to | 8.82 | 16 | 5 | 16 | 3 |
| 7 | Plant height (cm) | -22.24 | to | 19.17 | -10.44 | to | 22.18 | 5 | 6 | 5 | 0 |
| 8 | Number of branches per plant | -44.19 | to | 42.42 | -42.86 | to | 16.67 | 6 | 13 | 3 | 17 |
| 9 | Number of nodes per plant | -21.46 | to | 15.22 | -13.87 | to | 20.17 | 6 | 7 | 4 | 3 |
| 10 | Internode length (cm) | -26.26 | to | 35.01 | -32.09 | to | 13.03 | 7 | 8 | 2 | 13 |
| 11 | Number of fruits per plant | -34.20 | to | 22.64 | -23.49 | to | 19.88 | 8 | 10 | 8 | 6 |
| 12 | Days to last picking | -13.54 | to | 15.11 | -11.04 | to | 4.87 | 7 | 12 | 1 | 20 |
| 13 | Total pickings | -30.77 | to | 57.69 | -19.35 | to | 32.26 | 7 | 5 | 5 | 0 |
| 14 | Fruit yield per plant (g) | -19.91 | to | 25.22 | -14.51 | to | 22.82 | 8 | 2 | 9 | 0 |
| 15 | 100 seed weight (g) | -32.17 | to | 24.68 | -39.72 | to | 0.92 | 5 | 13 | 0 | 24 |

**Table 4:** Comparative study of three most heterotic crosses for fruit yield per plant and their heterotic effect for component characters in okra

| Heterotic crosses | Fruit yield per plant (g) | Percent heterosis for fruit yield per plant over | | sca effect for fruit yield per plant | Significant and desirable heterosis for component traits over | |
|---|---|---|---|---|---|---|
| | | Better parent | Standard check (GJOH-4) | | Better parent | Standard check (GJOH-4) |
| JOL-23-16 × GAO-8 | 193.94 | 25.22** | 22.82** | 13.36 | 1, 5, 8, 9, 10, 11, 12, 13, 14 | 1, 8, 10, 11, 13, 14 |
| JOL-22-12 × GAO-8 | 192.53 | 23.65** | 21.93** | 19.88* | 1, 7, 8, 9, 11, 14 | 1, 2, 3, 10, 11, 14 |
| JOL-23-13 × GAO-8 | 190.22 | 22.41** | 20.47** | 21.94* | 11, 12, 13, 14 | 11, 13, 14 |

**Where,** *, ** Significant at 5% and 1% levels, respectively

1 = Nodal position for first flowering; 2 = Days to first flowering; 3 = Days first picking; 4 = Fruit weight (g); 5 = Fruit length (cm); 6 = Fruit girth (cm); 7 = Plant height (cm); 8 = Number of branches per plant; 9 = Number of nodes per plant; 10 = Internode length (cm); 11 = Number of fruits per plant; 12 = Days to last picking; 13 = Total pickings; 14 = Fruit yield per plant (g) and 15 = 100 seed weight (g)

## Conclusion

From ongoing discussion, it could be concluded that the best three promising crosses namely JOL-23-16 × GAO-8, JOL-22-12 × GAO-8 and JOL-23-13 × GAO-8 exhibited high *per se* performance, significant and positive heterobeltiosis as well as standard heterosis in desired direction for fruit yield per plant and some other yield attributing traits. Therefore, these three best crosses could be further evaluated over years and locations to exploit for commercial cultivation through heterosis breeding or utilized in future breeding programme to obtain desirable transgressive segregants and to identify high yielding superior inbreds.

## References


1. Chaudhary PL, Kumar B, Kumar R. Analysis of heterosis and heterobeltiosis for earliness, yield and its contributing traits in okra [*Abelmoschus esculentus* (L.) Moench]. International Journal of Plant and Soil Science. 2023;35(11):84-98.
2. Dabhi KH, Vachhani JH, Poshiya VK, Jivani LL, Vekariya DH, Shekhati HG. Heterosis for fruit yield and its components over environments in okra [*Abelmoschus esculentus* (L.) Moench]. International Journal of Agricultural Sciences. 2009;5(2):572-576.
3. Fonseca S, Patterson F. Hybrid vigour in a seven-parent diallel cross in common winter wheat (*Triticum aestivum* L.). Crop Science. 1968;8(1):85-88.
4. Khanpara MD, Jivani LL, Vachhani JH, Kachhadia VH, Madaria RB. Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. International Journal of Agricultural Sciences. 2009;5(2):497-500.
5. Kharat MA, Bhalerao RV, Bhise DR, Sasane PA. Heterosis studies for yield and yield component in okra [*Abelmoschus esculentus* (L.) Moench]. The Pharma Innovation Journal. 2022;11(12):2251-2258.
6. Khatik KR, Chaudhary R, Khatik CL. Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. Annals of Horticulture. 2012;5(2):213-218.
7. Kumar S, Pathania NP. Combining ability and gene action studies in okra [*Abelmoschus esculentus* (L.) Moench]. Journal of Research Punjab Agricultural University. 2011;48(1&2):43-47.
8. Mehta N, Asati BS, Mamidwar SR. Heterosis and gene action in okra. Bangladesh Journal of Agriculture Research. 2007;32(3):421-432.
9. Meredith WR, Bridge RR. Heterosis and gene action in cotton, *Gossypium hirsutum* L. Crop Science. 1972;12(3):304-310.
10. Nagesh GC, Mulge R, Rathod V, Basavaraj LB, Mahaveer SM. Heterosis and combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench] for yield and quality parameters. The Bioscan. 2014;9(4):1717-1723.
11. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. 4th rev ed. New Delhi: ICAR; 1995. p. 1-381.
12. Patel AA, Patel AI, Parekh VB, Patel RK, Mali SC, Vekariya RD. Estimation of standard heterosis over environments for fruit yield and its attributes in okra [*Abelmoschus esculentus* (L.) Moench]. International Journal of Chemical Studies. 2020;8(6):2542-2547.
13. Patel BG. Genetic analysis of yield and yield attributing characters in okra [*Abelmoschus esculentus* (L.) Moench) [MSc thesis]. Navsari: Navsari Agricultural University; 2013.
14. Patel BG, Patel AI. Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. Annals of Agricultural and Environmental Medicine. 2016;1(1):15-20.
15. Patel DD, Delvadiya IR, Kumar R. Analysis of heterotic potential for earliness, yield and its attributing traits in okra (*Abelmoschus esculentus* L. Moench). International Journal of Bio-resource and Stress Management. 2024;15(2):1-9.
16. Patel HB, Bhanderi DR, Patel AI, Tank RV, Kumar A. Magnitude of heterosis for pod yield and its contributing characters in okra [*Abelmoschus esculentus* (L.) Moench]. The Bioscan Journal. 2015;10(2):939-942.
17. Pathania R, Mehta DK, Bhardwaj RK, Dogra RK, Singh K, Kaplex A, *et al.* Exploitation of heterosis, combining ability and gene action potential for improvement in okra [*Abelmoschus esculentus* (L.) Moench]. The Indian Journal of Agricultural Sciences. 2024;94(12):1340-1348.
18. Pithiya DJ, Pithiya KR, Jethava AS, Sapovadiya MH, Vachhani JH. Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. The Pharma Innovation Journal. 2019;8(12):461-465.
19. Punia M, Garg DK, Burdak A. Heterosis for fruit yield and its contributing traits in okra [*Abelmoschus esculentus* (L.) Moench]. International Journal of Chemical Studies. 2017;5(5):2238-2242.
20. Poluru P, Pandya MM, Sakure AA, Patel NA. Heterosis studies of fruit yield and its component traits in okra [*Abelmoschus esculentus* (L.) Moench]. The Pharma Innovation Journal. 2023;12(10):1194-1199.
21. Ranga AD, Vikram A, Kumar R, Dogra RK, Sharma R, Sharma HR. Exploitation of heterosis and combining ability potential for improvement in okra (*Abelmoschus esculentus* L.). Scientific Reports. 2024;90(1):25-31.

22. Sakriya SG, Vaja SJ, Patel S, Vaghela K, Mahesha KN, Saravaiya SN. Exploitation of heterosis for yield and yield attributes in okra [*Abelmoschus esculentus* (L.) Moench]. The Pharma Innovation Journal. 2023;12(6):4008-4013.
23. Sapavadiya SB, Kachhadia VH, Savaliya JJ, Sapovadiya MH, Singh SV. Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. The Pharma Innovation Journal. 2019;8(6):408-411.
24. Shweta, Sood S, Sood VK, Chadha S. Heterotic expression for fruit yield and component traits in inter-varietal hybrids of okra [*Abelmoschus esculentus* (L.) Moench]. Himachal Journal of Agricultural Research. 2022;48(2):225-233.
25. Sidapara MP, Gohil DP, Patel PU, Sharma DD. Heterosis studies for yield and yield components in okra [*Abelmoschus esculentus* (L.) Moench]. Journal of Pharmacognosy and Phytochemistry. 2021;10(1):1268-1275.
26. Vani VM, Singh BK, Raju SVS, Singh AK, Jaiswal DK. Genomic expression of heterosis for yield and seed parameters of okra [*Abelmoschus esculentus* (L.) Moench]. Plant Archives. 2024;24(2):2273-2281.
27. Woodruff JG. Okra. Georgia Bulletin. 1927;145.
28. Yawalkar KS. Vegetable crops of India. 3rd ed. Nagpur: Agri Horticultural Publishing House; 1965.