ISSN Print: 2664-6064
ISSN Online: 2664-6072
NAAS Rating (2025): 4.69
IJAN 2025; 7(10): 37-41
www.agriculturejournal.net
Received: 23-07-2025
Accepted: 26-08-2025

DN Savdhariya
Ph.D. Student, Department of Genetics and Plant Breeding, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

LJ Raval
Professor, Department of Genetics and Plant Breeding, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

Corresponding Author:
DN Savdhariya
Ph.D. Student, Department of Genetics and Plant Breeding, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

Studies on heterosis and inbreeding depresion for fruit yield and yield contributing traits in okra [*Abelmoschus esculentus* (L). Moench]

DN Savdhariya and LJ Raval

DOI: https://www.doi.org/10.33545/26646064.2025.v7.i10a.301

Abstract
Fruit production per plant had the highest heterobeltiosis (32.67% in JOL-2K-19 × EC-30563) mean, whereas heterosis over midparent ranged from -24.38% to 48.63%. The heterosis over better parent (heterobeltiosis) for various attributes ranged from -44.44% to 32.27%. Plant height showed the greatest heterosis over midparent (48.63% in JOL-2K-19 × EC-30563). Higher levels of inbreeding depression were seen in plant height (-18.37% in JOL-2K-19 × EC-30563) and internodal length (-19.39% in VRO-6 × IC-282248). Fruit yield per plant showed a significant and favourable inbreeding depression (7.43% in VRO-6 × IC- 282248, 7.50% in JOL-2K-19 × EC-30563, and 8.80% in GO-2 × EC- 30563).

Keywords: Heterosis, inbreeding depression, okra

Introduction
The cultivated species, *Abelmoschus esculentus* (L.) Moench, belongs to the Malvaceae family, which is a subfamily of the Malvales order; the genus *Abelmoschus* has been distinguished from the genus Hibiscus. There are a lot of names for okra. Gumbo is the name given to it in the United States, lady's finger in England, and gumbo in Spain. It's called guino-gombo in Portugal, guibeiro in India, and bhindi in India. By the 12th century B.C., the ancient Egyptians were cultivating okra, which had its origins in Ethiopia. Its cultivation expanded over North Africa and the Middle East. The chromosomal counts and ploidy levels of the many species in the genus Abelmoschus vary significantly. For *A. angulosus*, the lowest recorded chromosome number was 2n=56, whereas for *A. manihot* var. caillei, the highest recorded chromosome number was about 2n=200. A. esculentus has a regular series of polyploids with n = 12 with chromosome numbers of 2n = 72, 108, 120, 132, and 144 (Zate, 2019) [7]. Gujarat's main okra-growing regions include Surat, Tapi, Navsari, Banaskantha, Vadodara, Kheda, Bharuch, Anand, and Mahesana. Gujarat has an area of 557 hectares, a production of 7305 tonnes, and a productivity of 13115 kg per hectare (Anon., 2024) [1]. One of the key factors in choosing the appropriate parents for crosses is the type and degree of heterosis. This helps identify superior cross combinations that could result in desirable transgressive segregants in later generations. Since okra is a crop that is frequently cross-pollinated, heterosis has long been recognised as having good potential for higher fruit yield. Conversely, a decline in vigour, fertility, and yield is a result of inbreeding depression. For plant breeders, the percentage of inbreeding depression in each generation becomes crucial.

Materials and Methods
The experimental material consisted of six generations, namely P_1, P_2, F_1, F_2, B_1 and B_2 of three crosses in okra *viz*., VRO - 6 × IC - 282248 (cross 1), GO - 2 × EC - 30563 (cross 2) and JOL - 2K - 19 (cross 3). Experiment was laid-out in Compact Family Block Design (CFBD) with three replications during *kharif* 2021-12 at Instructional Farm, Junagadh Agricultural University, Junagadh. The observation were recorded on five randomly selected plants of P_1, P_2 and F_1, twenty plants from F_2 and ten plants from B_1 and B_2 generations in each replication for thirteen characters *viz*., days to first flowering, days to

first picking, plant height, number of primary branches per plant, number of nodes per plant, internodal length (cm), number of fruits per plant, fruit length (cm), fruit girth (mm), ten fruit weight (g), days to last picking, number of pickings and fruit yield per plant (g).

Results

Heterosis in the negative direction is preferred and indicates early blossoming for the number of days until first flowering. The range of the heterosis over midparent was 1.69% (cross 1) to -2.81% (cross 3). Heterobeltiosis ranged from 0.16% (cross 3) to 7.14% (cross 1) and was determined to be significant and positive in cross 1, whereas it was found to be significant in the desired direction in cross 3. The inbreeding depression was considerable and negative in cross 3, with a range of -3.59% (cross 3) to 2.80% (cross 2). Cross 3 revealed a large negative inbreeding depression for this trait, which is undesirable and should be avoided in order to improve the trait. (Table 1).

Heterosis over midparent in days to first picking varied from -2.57% (cross 3) to 1.56% (cross 1). Heterobeltiosis varied from 0.14% (cross 3) to 6.53% (cross 1) and was found to be significant and positive in cross 1, whereas it was found to be significant and negative in cross 3. Heterosis in the negative direction is preferred for this attribute and indicates early choosing. The inbreeding depression was considerable and negative in cross 3, with a range of -3.28% (cross 3) to 2.57% (cross 2). Cross 3 revealed a large negative inbreeding depression for this trait, which is undesirable and should be avoided in order to improve the trait. (Table 1).

The range of plant height heterosis across midparent was 11.64% (cross 1) to -24.38 (cross 3). Heterobeltiosis ranged from -25.42% (cross 3) to 10.70% (cross 1), and was found to be significant and negative in cross 3 and significant and positive in cross 1, whereas it was found to be significant and negative in cross 3 and significant in the desired direction in cross 1. Positive heterosis is preferred for this characteristic. The inbreeding depression was significant and negative in cross 3 and significant and positive in cross 1, with a range of -18.37% (cross 3) to 7.19% (cross 1). The outcome also implied that in subsequent generations, negative ID would cause the plant to grow taller through selfing. (Table 1).

Heterosis over midparent for the number of branches per plant varied from -22.08 (cross 2) to 23.81% (cross 3). In contrast to heterobeltiosis, which varied from -44.44% (cross 2) to 2.63% (cross 3), it was determined to be significant and negative in cross 2 and significant and positive in cross 3. Positive heterosis is preferred for this characteristic. The inbreeding depression was non-significant and positive in all three crosses, ranging from 6.41% (cross 3) to 11.05% (cross 1). (Table 1).

Heterosis over midparent for the number of nodes per plant varied from 18.60% (cross 3) to 37.72% (cross 1). In contrast, heterobeltiosis ranged from -6.56% (cross 2) to 32.27% (cross 1), was determined to be non-significant and unfavourable in cross 2, and was shown to be significant and desired in both cross 1 and cross 3. Positive heterosis is preferred for this characteristic. The inbreeding depression was found to be substantial and positive in cross 1 and non-significant and negative in cross 2, with a range of -2.41% (cross 2) to 9.45% (cross 1). (Table 1).

For the midparent, the range of internodal length heterosis was 3.05% (cross 1) to 16.51% (cross 2). While heterobeltiosis ranged from 2.09% (cross 1) to 13.56% (cross 2) and was found to be significant and positive in cross 2, it was also found to be significant and positive in cross 3 mean. Positive heterosis is preferred for this characteristic. The inbreeding depression was considerable and negative in cross 1, with a range of -19.39% (cross 1) to 2.82% (cross 2). (Table 1).

Heterosis in a positive direction is preferred for the number of fruits per plant. The range of the heterosis over midparent was 9.79% (cross 3) to -4.35% (cross 1). While heterobeltiosis ranged from -7.60% (cross 1) to 9.32% (cross 3) and was determined to be non-significant and negative in cross 1, it was shown to be significant and positive in cross 2 and cross 3. The inbreeding depression was found to be non-significant and negative in cross 1 and significant and positive in cross 2 and cross 3, with a range of -8.01% (cross 1) to 5.33% (cross 3). (Table 1).

Heterosis in a negative orientation is preferred for fruit length. The range of the heterosis across midparent was -13.78% (cross 2) to -17.12% (cross 3). In contrast, heterobeltiosis varied from 21.31% (cross 3) to -14.44% (cross 1) and was also shown to be substantial and unfavourable in all three crossings. The inbreeding depression was severe and negative in crosses two and three, with values ranging from -13.69% (cross 2) to 4.02% (cross 1). (Table 1).

Over mid-parent, fruit girth heterosis varied from -12.29 (cross 1) to 5.43% (cross 3). In contrast, heterobeltiosis varied from -15.84% (cross 1) to 3.81% (cross 3), and it was shown to be significant and negative in cross 1 and significant and positive in cross 3. Positive heterosis is preferred for this characteristic. The inbreeding depression was considerable and positive in crosses two and three, with values ranging from 1.77% (cross 1) to 5.14% (cross 2). (Table 1).

Heterosis over midparent for ten fruit weights varied from 3.42% (cross 3) to -3.09 (cross 3). Heterobeltiosis varied from -8.32% (cross 3) to 0.01% (cross 1) and was found to be significant and negative in cross 3, whereas it was discovered to be significant and positive in cross 1. Positive heterosis is preferred for this characteristic. The inbreeding depression was considerable and positive in both crosses 1 and 2, with a range of -0.70% (cross 3) to 5.19% (cross 2). (Table 1).

Heterosis over midparent for days to last picking varied from -2.85% (cross 3) to 0.87% (cross 1). While heterobeltiosis ranged from -4.57% (cross 3) to 4.00% (cross 2) and was found to be significant and positive in cross 2, it was found to be significant and negative in cross 3 and significant and positive in cross 1. Positive heterosis is preferred for this characteristic. The inbreeding depression was significant and negative in cross 1 and significant and positive in cross 3, with ranges of -0.81% (cross 1) to 4.99% (cross 3). (Table 1).

For Number of pickings heterosis over mid parent ranged from 7.08 (cross 1) to 14.29% (cross 2). It was found significant and positive in all the three crosses, mean while heterobeltiosis was ranged from 6.18% (cross 1) to 12.57% (cross 3) and found significant and positive in all the three crosses. For this trait, heterosis in positive direction is desirable. The inbreeding depression ranged from 1.60% (cross 2) to 4.39% (cross 3) and was recorded non-significant and positive in all the three crosses. (Table 1).

Heterosis in a positive orientation is preferred for fruit yield per plant. Cross 1 showed a heterosis of 19.00, whereas Cross 3 showed a heterosis of 48.63%. In contrast, heterobeltiosis ranged from 15.00% (cross 1) to 32.67% (cross 3) and was shown to be significant and desirable in all three crossings. It was also found to be favourable and significant in all three crosses. In all three crosses, the inbreeding depression was found to be significant and positive, ranging from 7.43% (cross 1) to 8.80% (cross 2). (Table 1).

Several research workers have also reported heterosis in desirable direction for various traits of okra *viz.*, days to first flowering by Jogi et al. (2018), Makdoomi et al. (2018); days to first picking by Makdoomi et al. (2018); plant height by Makdoomi et al. (2018) and Sabesan et al. (2016); number of primary branches per plant by Shrikanth et al. (2019); number of nodes per plant by Makdoomi et al. (2018) and Shrikanth et al. (2019); internodal length by Dhankar et al. (2015), Makdoomi et al. (2018) and Shrikanth et al. (2019); number of fruits per plant by Sabesan et al. (2016), Jogi et al. (2018) and Shrikanth et al. (2019); fruit length by Sabesan et al. (2016) and Shrikanth et al. (2019); fruit girth by Jogi et al. (2018) and Shrikanth et al. (2019); fruit yield per plant by Dhankar et al. (2015), Sabesan et al. (2016), Makdoomi et al. (2018) and Shrikanth et al. (2019) [2, 3, 4, 5, 6].

Discussion

The heterosis over better parent (heterobeltiosis) for different traits was ranging from -44.44% to 32.27% and highest heterobeltiosis was recorded in fruit yield per plant (32.67% in JOL-2K-19 × EC- 30563) mean, while heterosis over mid parent range from -24.38% to 48.63% The highest heterosis over mid parent recorded in plant height (48.63% in JOL-2K-19 × EC- 30563).

The degree of heterosis over better parent and mid parent varied from cross to cross for all the thirteen characters. Significant and positive heterosis over better parent observed for days to first flowering (7.14% in VRO-6 × IC-282248), for days to first picking (6.53% in VRO-6 × IC-282248), for plant height (10.70% in VRO-6 × IC282248), for number of nodes per plant (32.27% in VRO-6 × IC-282248 and 11.59% in JOL-2K-19 × EC- 30563), for internodal length (13.56% in GO-2 × EC- 30563), for number of fruits per plant (9.32% in JOL-2K-19 × EC-30563 and 5.33% in GO-2 × EC- 30563), for days to last picking (4% in GO-2 × EC- 30563), for number of pickings (12.57% in JOL-2K-19 × EC- 30563 and 9.30% in GO-2 × EC- 30563 and 6.18% in VRO-6 × IC- 282248), for fruit yield per plant (32.67% in JOL-2K-19 × EC- 30563 and 18.90% in GO-2 × EC- 30563 and 15% in VRO-6 × IC-282248).

Similarly significant and positive heterosis over mid parent observed in plant height (11.64% in VRO-6 × IC- 282248), for number of nodes per plant (34.72% in VRO-6 × IC-282248 and 18.60% in JOL-2K-19 × EC- 30563), for internodal length (16.51% in GO-2 × EC- 30563 and 5.75% in JOL-2K-19 × EC- 30563), for number of fruits per plant (9.79% in JOL-2K-19 × EC- 30563 and 7.08 in GO-2 × EC-30563), for fruit girth (5.43% in JOL-2K-19 × EC- 30563), for ten fruit weight (4.42% in VRO-6 × IC- 282248), for days to last picking (5.17% in GO-2 × EC- 30563), for number of pickings (14.29% in GO-2 × EC- 30563 and 13.25% in JOL-2K-19 × EC30563 and 7.08% in VRO-6 × IC- 282248), for fruit yield per plant (48.63% in JOL2K-19 × EC- 30563 and 24.40% in GO-2 × EC- 30563 and 19% in VRO-6 × IC282248).

Significant and negative heterosis over better parent observed in plant height (- 25.42% in JOL-2K-19 × EC-30563), for number of primary branches per plant (-44.44% in GO-2 × EC- 30563), for fruit length (-14.44% in VRO-6 × IC- 282248 and -16.31% in GO-2 × EC- 30563 and -21.31% in JOL-2K-19 × EC- 30563), for fruit girth (-15.84% in VRO-6 × IC- 282248), for ten fruit weight (-8.32% in JOL-2K-19 × EC30563), for days to last picking (-4.57% in JOL-2K-19 × EC- 30563).

Similarly, significant and negative heterosis over mid parent observed in days to first flowering (-2.81% in JOL-2K-19 × EC- 30563), for days to first picking (-2.57% in JOL-2K-19 × EC- 30563), for plant height (-24.38% in JOL-2K-19 × EC- 30563), for number of primary branches per plant (-22.08% in GO-2 × EC- 30563), for fruit length (-13.78% in GO-2 × EC- 30563 and -14.20% in VRO-6 × IC- 282248 and - 17.12% in JOL-2K-19 × EC- 30563), for fruit girth (-12.29% in VRO-6 × IC- 282248), for days to last picking (-2.87% in JOL-2K-19 × EC- 30563).

In the present study, either low or moderate amount of inbreeding depression (ID) in desirable direction was found in most of the traits. With few exceptions, the higher magnitude of inbreeding depression was noted in internodal length (-19.39% in VRO-6 × IC- 282248), and plant height (-18.37% in JOL-2K-19 × EC- 30563). The inbreeding depression in remaining crosses was within the range of -13.69% to 9.45%. The character which manifested low heterosis in F1 also showed low inbreeding depression in F2. The significant and negative heterosis found in days to first flowering (-3.59% in JOL-2K-19 × EC- 30563) and days to first picking (-3.28% in JOL-2K-19 × EC- 30563) indicating that F1s flowered and matured earlier than their respective F2's. Similar results negative and significant inbreeding depression was found in plant height (-13.56% in GO-2 × EC- 30563) and days to last picking (-0.81% in VRO-6 × IC- 282248).

Significant and positive inbreeding depression was found in plant height (7.19% in VRO-6 × IC- 282248), for number of nodes per plant (9.45% in VRO-6 × IC282248), for number of fruits per plant (4.96% in GO-2 × EC- 30563 and 5.33% in JOL-2K-19 × EC- 30563), for fruit girth (5.03% in JOL-2K-19 × EC- 30563 and 5.14% in GO-2 × EC- 30563), for ten fruit weight (4.33% in VRO-6 × IC- 282248 and 5.19% in GO-2 × EC- 30563), for days to last picking (4.99% in JOL-2K-19 × EC- 30563), for fruit yield per plant (7.43% in VRO-6 × IC- 282248 and 7.50% in JOL-2K-19 × EC-30563 and 8.80% in GO-2 × EC- 30563).

Table 1: Estimates of heterosis over mid parent (MP), heterosis over better parent (BP) and inbreeding depression (ID) for thirteen characters in three crosses of okra

Crosses	MP (%)±SE	BP (%)±SE	ID (%)±SE
Days to First Flowering			
VRO-6 × IC-282248	1.69±0.48	7.14**±0.57	0.58±0.54
GO-2 × EC-30563	-1.18±1.09	4.37±1.13	2.80±1.07
JOL-2K-19 × EC-30563	-2.81**±0.38	0.16±0.42	-3.59**±0.36
Days to First Picking			
VRO-6 × IC-282248	1.56±0.48	6.53**±0.57	0.53±0.54
GO-2 × EC-30563	-1.09±1.09	3.99±1.13	2.57±1.07
JOL-2K-19 × EC-30563	-2.57**±0.38	0.14±0.42	-3.28**±0.36
Plant Height (cm)			
VRO-6 × IC-282248	11.64**±2.44	10.70**±2.67	7.19**±2.48
GO-2 × EC-30563	-0.32±3.93	-1.19±4.83	-13.56**±3.28
JOL-2K-19 × EC-30563	-24.38**±2.59	-25.42**±2.95	-18.37**±2.52
Number of Branches per Plant			
VRO-6 × IC-282248	11.67±0.18	2.38±0.24	11.05±0.17
GO-2 × EC-30563	-22.08**±0.27	-44.44**±0.32	9.17±0.25
JOL-2K-19 × EC-30563	3.81**±0.16	2.63±0.19	6.41±0.15
Number of Nodes per Plant			
VRO-6 × IC-282248	34.72**±0.52	32.27**±0.58	9.45**±0.51
GO-2 × EC-30563	0.00±0.52	-6.56±0.76	-2.41±0.34
JOL-2K-19 × EC-30563	18.60**±0.34	11.59**±0.41	5.40*±0.34
Internodal Length (cm)			
VRO-6 × IC-282248	3.05±0.10	2.09±0.13	-19.39**±0.10
GO-2 × EC-30563	16.51**±0.13	13.56**±0.14	2.82±0.11
JOL-2K-19 × EC-30563	5.75*±0.12	2.68±0.16	-0.14±0.11
Number of Fruits per Plant			
VRO-6 × IC-282248	-4.35±0.86	-7.60±0.92	-8.01±0.84
GO-2 × EC-30563	7.08**±0.27	5.33*±0.33	4.96**±0.26
JOL-2K-19 × EC-30563	9.79**±0.39	9.32**±0.52	5.33*±0.35
Fruit Length (cm)			
VRO-6 × IC-282248	-14.20**±0.39	-14.44**±0.41	4.02±0.37
GO-2 × EC-30563	-13.78**±0.43	-16.31**±0.48	-13.69**±0.41
JOL-2K-19 × EC-30563	-17.12**±0.50	-21.31**±0.85	-11.15**±0.41
Fruits Girth (mm)			
VRO-6 × IC-282248	-12.29**±0.79	-15.84**±0.86	1.77±0.80
GO-2 × EC-30563	2.58±0.73	1.08±0.80	5.14**±0.76
JOL-2K-19 × EC-30563	5.43**±0.97	3.81±1.15	5.03**±0.90
Ten Fruit Weight (g)			
VRO-6 × IC-282248	4.42**±1.74	0.01±1.81	4.33**±1.80
GO-2 × EC-30563	0.14±1.79	-0.43±1.65	5.19**±2.42
JOL-2K-19 × EC-30563	-3.09±4.72	-8.32*±4.64	-0.70±5.08
Days to Last Picking			
VRO-6 × IC-282248	0.87±0.45	-0.55±0.43	-0.81*±0.34
GO-2 × EC-30563	5.17**±0.98	4.00*±1.24	1.76±3.99
JOL-2K-19 × EC-30563	-2.85**±0.69	-4.57**±0.71	4.99**±0.79
Number of Pickings			
VRO-6 × IC-282248	7.08**±0.26	6.18*±0.33	2.91±0.21
GO-2 × EC-30563	14.29**±0.24	9.30**±0.31	1.60±0.21
JOL-2K-19 × EC-30563	13.25**±0.25	12.57**±0.30	4.39±0.32
Fruit Yield per Plant (g)			
VRO-6 × IC-282248	19.00**±6.19	15.00**±7.48	7.43**±5.67
GO-2 × EC-30563	24.40**±4.90	18.90**±6.57	8.80**±3.99
JOL-2K-19 × EC-30563	48.63**±6.28	32.67**±7.61	7.50**±5.07

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

Conclusion

From ongoing discussion, it could be concluded that the heterosis over better parent (heterobeltiosis) for different traits was ranging from -44.44% to 32.67% and highest heterobeltiosis was recorded in fruit yield per plant (32.67% in JOL-2K-19 × EC- 30563. While heterosis over mid parent range from 24.40% to 48.63% was observed in fruit yield per plant. In the present study, either low or moderate amount of inbreeding depression (ID) in desirable direction was found in most of the traits. With few exceptions, the higher magnitude of inbreeding depression was noted in internodal length (-19.39% in VRO-6 × IC- 282248), and plant height (-18.37% in JOL-2K-19 × EC- 30563).

References

1. Anonymous. Ministry of Agricultural Cooperation and Farmer's Welfare, Govt. of India. Available from: www.agricoop.nic.in. Accessed 5 Sep 2024.
2. Dhankhar SK, Dahiya MS, Chandanshive AV. Generation means analysis for fruit yield and its

component traits in okra. Indian J Hort. 2015;72(4):571-573.
3. Jogi SR, Toprope VN, Jondhale AS. Generation mean analysis in okra (*Abelmoschus esculentus* (L.) Moench). J Pharmacogn Phytochem. 2018;7(1):2401-2404.
4. Makdoomi MI, Kouser P, Wani ZA, Dar K, Hussain A, Nabi FM, Mufti S. Heterosis studies in okra (*Abelmoschus esculentus* (L.) Moench). Int J Curr Microbiol Appl Sci. 2018;7(2):3297-3304.
5. Sabesan T, Saravanan K, Satheeshkumar P. Studies on heterosis, inbreeding depression and residual heterosis for fruit yield and its components in okra (*Abelmoschus esculentus* (L.) Moench). Plant Arch. 2016;16(2):669-674.
6. Shrikanth M, Dhankhar SK, Mamatha NC, Ravikumar T. Estimation of heterosis and inbreeding depression in okra (*Abelmoschus esculentus* L. Moench). Plant Arch. 2019;19(1):1195-1198.
7. Zate DK. Generation mean analysis studies in okra (*Abelmoschus esculentus* L. Moench). M.Sc. (Agri) thesis, unpublished. Parbhani: Vasantrao Naik Marathwada Krishi Vidyapith; 2019.