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GENETIC ANALYSIS OF HETEROSIS FOR FRUIT YIELD AND CONTRIBUTING TRAITS IN OKRA (*Abelmoschus esculentus* L. Moench)

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ABSTRACT

Okra is one of major tropical and sub-tropical vegetable crop of India. Hybrids in okra are very popular as ease in emasculation, desired pollination and commercial F_1 hybrid seed production. Present study intended to isolate a superior F_1 hybrids in terms of high yield with various 13 component characters. Therefore, 10 line and 4 tester was crossed in line × tester mating design. Total 40 F_1 crosses were produced which further evaluated in completely randomized block design with 3 replications. Observations for various 13 character were recorded and data was analyzed for estimation of heterobeltiosis (HB) and standard heterosis (SH) with comparing to commercial check 'GJOH-4'. Data revealed that number of cross combinations exhibits significant desirable SH was highest for plant height (6) followed by internodal length (4), fruit length (4), number of branches per plant (3), ten fruit weight (3), number of nodes per plant (2), fruit girth (2), fruit yield per plant (2) and 1 for rest of the characters. The experimental crosses, HRB-55 × JOL-2K-19 and IC 282238 × JOL-2K-19 exhibited significant desirable SH for highest number of characters (6) followed by JOL-12-12 × JOL-2K-19 (3), JOL-20-4 × VRO-6 (3), JOL-12-13 × JOL-2K-19 (2), IC 282238 × GAO-8 (2), EC 30563 × JOL-2K-19 92), JOL-12-10 × GAO-8 (1), JOL-12-13 × VRO-6 (1), NOL-L9-08 × JOL-2K-19 (1), NOL-L9-08 × GO-6 (1) and EC 30563 × GAO-8 (1). Two superior F_1 hybrids *viz.*, HRB-55 × JOL-2K-19 and IC 282238 × JOL-2K-19 were identified based on their standard heterosis, heterobeltiosis and mean value. Further, which recommended for multi-location testing for commercial release.

Keywords **:** Heterobeltiosis, standard heterosis, hybrids, okra, *Abelmoschus*

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] is one of the important vegetable crops grown extensively in tropics, sub tropics and warmers season of temperate areas in the world (Charrier, 1984; Thompson and Kelly, 1957). India is a major okra producing country in the world, comprising of 62.20 per cent of total production of okra. In India, okra is commercially grown in the states of Gujarat, West Bengal, Odisha, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Andhra Pradesh and Maharashtra as a kharif as well as summer season crop. The area under okra cultivation in India is 5.49 lakh ha with production of 71.58 lakh tonnes and productivity of 13.4 tonnes per hectare (Anon., 2025). It is also an important vegetable crop in Gujarat state and is occupies an area of 0.94 lakh hectares with a production of 11.48 lakh tonnes, having average productivity of 12.22 tonnes per hectare. Gujarat is a leading okra producing state with 16.03 per cent of production share, while Gujarat comprised of 17.11 per cent area share (Anon., 2025).

Although it is self-pollinated crop, outcrossing occurs up to an extent of 4-9 per cent with the maximum of 42.20 per cent was observed through

entomophilous pollination (Kumar, 2006). Its characteristics such as, short life span, ease in emasculation, high percent of fruit set and large number of seeds per fruit facilitates breeders to achieve quick genetic outcomes and make the commercial exploitation of hybrid vigour easy. Hybrid vigour in okra has been first reported by Vijayaraghavan and Warrier (1946). Heterosis empowers breeders to create hybrids that demonstrate heightened vigour and yield compared to their parent lines (Ranga *et al.*, 2024).

Hence, current investigation intended to the evaluate 40 experimental F_1 hybrids for different 13 traits for estimation of heterosis over better parent and over standard check for various traits and to identify the promising cross which may be considered for further testing across the various agro-climatic zones.

Material and Methods

The present study was conducted at Instructional farm, Jambuvadi, College of Horticulture, JAU, Junagadh during summer 2024 to make crosses and during late *kharif* 2024 for evaluation of crossing materials. The experimental site is situated at 21°50' North Latitude, 70° 45' East Longitude and 60 meter above mean sea level with sandy loam soil. The experiment consisted 10 lines *viz.*, JOL-20-4, JOL-12-8, JOL-12-9, JOL-12-10, JOL-12-12, JOL-12-13, HRB-55, NOL-L9-08, IC 282238, EC 30563 and 4 testers *viz.*, JOL-2K-19, VRO-6, GO-6, GAO-8. In current study, total 40 experimental hybrids were generated through crossing between line and testers in line × tester mating design during summer 2024 and all 40 F_1 hybrids with standard commercial check 'Gujarat Junagadh Okra Hybrid-4' were grown to evaluate during *kharif* 2024 using completely randomized block design with 3 replications. Ten plants per entry per replication were maintained. Plant to plant distance in a row was kept 30 cm and row to row distance was about 60 cm. The observations for attributes *viz.*, days to 50% flowering, days to first picking and days to last picking were recorded plot basis and for rest of the attributes *viz.*, number of pickings, plant height (cm), number of branches per plant, number of nodes per plant, internodal length (cm), number of fruits per plant, fruit length (cm), fruit length (cm), fruit girth (cm), ten fruit weight (g) and fruit yield per plant (g) were recorded by randomly selecting five competitive plants excluding border plants from each entries of each replication and their average values were used for further statistical analysis. Test of significance at 5% and 1% were conducted by estimating the analysis of variance (ANOVA) for experimental design using the replicated data of each attribute. Thereafter, heterobeltiosis (over better parent) as given by Fonseca and Petterson, 1968 and standard heterosis (over standard check) as given by Meredith and Bridge, 1972 were calculated in Microsoft excel using formula given below and tested for significance.

Heterobeltiosis (HB) % = $[(F_1\text{-BP})/BP] * 100$

Standard Heterosis (SH) % = $[(F_1\text{-SC})/SC] * 100$

Where, F_1 = mean value of F_1 hybrid,

BP = mean value of batter parent,

SC = mean value of standard check 'GJOH-4'

Results and Discussion

The replicated data were subjected to estimation of analysis of variance. It revealed that F_1 hybrids significantly differ to each other for characters studied. In okra, days to 50% flowering and days to first picking exhibits the earliness. The extent of heterosis for days to 50% flowering ranged from -19.11 to 12.86% for HB and -7.97 to 16.67% for SH and, for days to first picking ranged from -17.82 to 11.32% for HB and -8.33 to 13.46% for SH (Table 1). Total 11 F_1 hybrids exhibited significant negative heterobeltiosis for days to 50% flowering while in respect to days to first picking, 10 and 1 hybrids exhibited significant negative HB and SH (Table 1). The cross combination, JOL-12-10 × GAO-8 exhibited highest significant negative SH for days to first picking (Table 2). Similar findings for days to 50% flowering were done by Ranga *et al.* (2024), Patel *et al.* (2024), Poluru *et al.* (2023) and Sakriya *et al.* (2023). For days to first picking, Patel *et al.* (2024), Chaudhary *et al.* (2023), Sapavadiya *et al.* (2019) and Jindal *et al.* (2010) found similar magnitude of heterosis. Days to last picking and number of pickings directly related to the extent of time period for which crop yield. So, a greater number of pickings are desirable since it directly responsible for high yield. For days to last picking, heterosis ranged from -12.17 to 19.92% for HB and -8.87 to 7.17% for SH and for number of pickings heterosis ranged from -25.71 to 21.21% for HB and -30.56 to 11.11% for SH (Table 1). Total seven and one experimental hybrids showed significant desirable HB and SH for days to last picking and six and one crosses exhibited significant desirable HB and SH for number of pickings (Table 1). A cross combination *viz.*, JOL-12-9 × JOL-2K-19 showed significant positive magnitude of SH for days to last picking and cross combination, IC-282238 × GAO-8 exhibited significant highest positive magnitude of HB and SH for number of pickings (Table 2). For days to last picking, Patel *et al.* (2024), Sakriya *et al.* (2023), Karadi and Hanchinamani (2021) found similar results. Sakriya *et al.* (2023) and Sapavadiya *et al.* (2019) found similar results for number of pickings.

Table 1: Range of heterosis (%) and number of hybrids exhibiting significant heterosis in desirable direction for different characters in okra

Character	Heterobeltiosis (BH)		Standard heterosis (SH)	
	Range (%)	No. of heterotic hybrids in desirable direction	Range (%)	No. of heterotic hybrids in desirable direction
Days to 50% flowering	-19.11 to 12.86	11	-7.97 to 16.67	0
Days to first picking	-17.82 to 11.32	10	-8.33 to 13.46	1
Days to last picking	-12.17 to 19.92	7	-8.87 to 7.17	1
Number of pickings	-25.71 to 21.21	6	-30.56 to 11.11	1
Plant height (cm)	-26.9 to 12.97	2	-21.08 to 18.86	6
Number of nodes per plant	-21.79 to 29.32	11	-26.9 to 13.46	2
Internodal length (cm)	-52.56 to 36.89	19	-24.77 to 52.28	4
Number of branches per plant	-36.03 to 74.13	13	-48.28 to 20.69	3
Fruit length (cm)	-33.32 to 39.37	17	-30.80 to 13.2	4
Fruit girth (cm)	-8.34 to 19.28	1	-9.8 to 13.66	2
Number of fruits per plant	-27.16 to 29.13	5	-28.03 to 15.32	1
Ten fruit weight (g)	-27.89 to 39.32	10	-29.93 to 17.43	3
Fruit yield per plant (g)	-17.72 to 18.68	3	-16.08 to 17.3	2

Component attributes *viz.*, plant height, number of nodes per plant and internodal length indirectly contribute to fruit yield. Heterosis ranged from -26.90 to 12.97% for HB and -21.08 to 18.86% recorded for plant height whereas -21.79 to 29.32% for HB and -26.90 to 13.46% for SH exhibited for number of nodes per plant (Table 1). Two and six F_1 hybrids showed significant positive HB and SH respectively for plant height. While 11 and 2 F_1 hybrids exhibited significant positive HB and SH for number of nodes per plant (Table 1). The cross combinations *viz.*, EC 30563 × JOL-2K-19, IC 282238 × JOL-2K-19 exhibited significant highest positive magnitude of HB and SH for plant height and number of nodes per plant and cross, HRB-55 × JOL-2K-19 exhibited significant positive SH for plant height (Table 2). Similar magnitude of heterosis were found by Ranga *et al.* (2024), Patel *et al.* (2024), Yadav *et al.* (2023) and Poluru *et al.* (2023) for plant height. While Ranga *et al.* (2024), Sakriya *et al.* (2023), Kharat *et al.* (2022) and Sapavadiya *et al.* (2019) found similar results for number of nodes per plant. The less internodal length is desirable as a greater number of nodes can be accommodated. Heterosis ranged from -52.56 to 36.89% for HB and -24.77 to 52.28% for SH exhibited for internodal length. For internodal length, nineteen and four F_1 hybrids manifested significant negative HB and SH respectively (Table 1). The cross combinations *viz.*, JOL-12-13 × VRO-6, NOL-L9-08 × GO-6, JOL-20-4 × VRO-6 showed significant highest negative HB and SH for internodal length (Table 2). For internodal length, Patel *et al.* (2024), Kharat *et al.* (2022), Karadi and Hanchinamani (2021) and Sapavadiya *et al.* (2019) found similar results.

Number of branches also positively contributes to fruit yield. Heterosis for number of branches per plant ranged from -36.03 to 74.13% for HB and -48.28 to 20.69% for SH. Thirteen and three F_1 hybrids manifested significant positive HB and SH for number of branches per plant (Table 1). The F_1 hybrids *viz.*, IC 282238 × GAO-8, EC 30563 × GAO-8, JOL-12-13 × JOL-2K-19 exhibited highest significant positive magnitude HB and SH for number of branches per plant (Table 2). Patel *et al.* (2024), Sakriya *et al.* (2023), Koli *et al.* (2020), Sapavadiya *et al.* (2019) and Jindal *et al.* (2010) found similar magnitude of heterosis for number of branches per plant. More fruit length is desirable in okra. Heterosis ranged from -33.32 to 39.37% for HB and from -30.80 to 13.20% for SH manifested for fruit length. Significant positive HB and SH were manifested in 17 and 4 crosses respectively for fruit length (Table 1). The cross combinations *viz.*, HRB-55 × JOL-2K-19, IC 282238 × JOL-2K-19, JOL-12-12 × JOL-2K-19 exhibited highest significant positive magnitude of HB and SH for fruit length (Table 2). Similar results were found by Ranga *et al.* (2024), Patel *et al.* (2024), Yadav *et al.* (2023) Sapavadiya *et al.* (2019) for fruit length. Less fruit girth is desirable in okra. Heterosis for fruit girth ranged from -8.34 to 19.28% for HB and -9.80 to 13.66% for SH was noted for fruit girth. For fruit girth, significant negative HB and SH were manifested by one and two F_1 hybrids respectively (Table 1). The cross combinations *viz.*, HRB-55 × JOL-2K-19, HRB-55 × VRO-6 exhibited highest significant negative

magnitude of SH for fruit girth (Table 2). For fruit girth, similar findings were done by Patel *et al.* (2024), Poluru *et al.* (2023) and Sapavadiya *et al.* (2019). Number of fruits per plant and ten fruit weight directly influence the fruit yield per plant. For number of fruits per plant, heterosis ranged from -27.16 to 29.13% for HB and 28.03 to 15.32% for SH were observed. For ten fruit weight, extent of heterosis ranged from -27.89 to 39.32% for HB and -29.93 to 17.43% for SH were noted. For number of fruits per plant, 5 and 1 hybrids exhibited significant positive HB and SH respectively while for ten fruit weight, 10 and 3 hybrids manifested significant positive HB and SH (Table 1).

Table 2: Promising hybrids exhibiting significant standard heterosis in desirable direction along with their mean performance and heterobeltiosis for different characters of okra

Characters	Hybrid	Mean	BH (%)	SH (%)
Days to 50% flowering	-	-	-	-
Days to first picking	JOL-12-10 × GAO-8	47.67	-17.82**	-8.33**
Days to last picking	JOL-12-9 × JOL-2K-19	104.67	4.67	7.17*
No of pickings	IC 282238 × GAO-8	13.33	21.21**	11.11*
Plant height (cm)	EC 30563 × JOL-2K-19	106.50	12.97**	18.86**
	IC 282238 × JOL-2K-19	104.28	10.62*	16.38**
	HRB-55 × JOL-2K-19	103.85	7.53	15.90**
Number of nodes per plant	IC 282238 × JOL-2K-19	19.40	22.80**	13.46**
	EC 30563 × JOL-2K-19	18.60	17.70**	8.75*
Internodal length (cm)	JOL-12-13 × VRO-6	3.85	-52.56**	-24.77**
	NOL-L9-08 × GO-6	3.98	-38.80**	-22.3**
	JOL-20-4 × VRO-6	4.35	-27.89**	-15.01**
Number of branches per plant	IC 282238 × GAO-8	2.33	74.13**	20.69**
	EC 30563 × GAO-8	2.27	69.58**	17.24**
	JOL-12-13 × JOL-2K-19	2.10	45.16**	8.62*
Fruit length (cm)	HRB-55 × JOL-2K-19	13.25	12.80**	13.20**
	IC 282238 × JOL-2K-19	13.15	26.37**	12.31**
	JOL-12-12 × JOL-2K-19	12.95	11.64*	10.63*
Fruit girth (cm)	HRB-55 × JOL-2K-19	5.24	-8.34*	-9.80*
	HRB-55 × VRO-6	5.26	-7.95	-9.41*
Number of fruits per plant	HRB-55 × JOL-2K-19	13.30	29.13**	15.32*
Ten fruit weight (g)	HRB-55 × JOL-2K-19	201.51	22.68**	17.43**
	IC 282238 × JOL-2K-19	199.50	39.32**	16.26**
	JOL-12-12 × JOL-2K-19	198.25	21.79**	15.53**
Fruit yield per plant (g)	HRB-55 × JOL-2K-19	232.26	15.86*	17.3
	IC 282238 × JOL-2K-19	225.60	18.68*	13.94*

For number of fruits per plant, the cross combination, HRB-55 × JOL-2K-19 showed significant positive magnitude of HB and SH. While the cross combinations *viz.*, HRB-55 × JOL-2K-19, IC 282238 × JOL-2K-19, JOL-12-12 × JOL-2K-19 exhibited highest positive magnitude of HB and SH for ten fruit weight (Table 2). Similar results were found for heterosis of number of fruits per plant and ten fruit weight by Poluru *et al.* (2023), Kharat *et al.* (2022) Sapavadiya *et al.* (2019) and Jindal *et al.* (2010). For fruit yield per plant, three and two crosses showed significant positive HB and SH. Extent of HB and SH for fruit yield per plant were observed ranged from -17.72 to 18.68% and from -16.08 to 17.30% respectively (Table 1). The cross combinations *viz.*, HRB-55 × JOL-2K-19 and IC 282238 × JOL-2K-19 exhibited significant positive HB and SH for number of fruits per plant (Table 2). Similar results were obtained by Ranga *et al.* (2024), Patel *et al.* (2024), Yadav *et al.* (2023), Poluru *et al.* (2023), Sakriya *et al.* (2023), Chaudhary *et al.* (2023), Kharat *et al.* (2023), Karadi and Hanchinamani (2021), Koli *et al.* (2020), Sapavadiya *et al.* (2019) and Jindal *et al.* (2010) for fruit yield per plant.

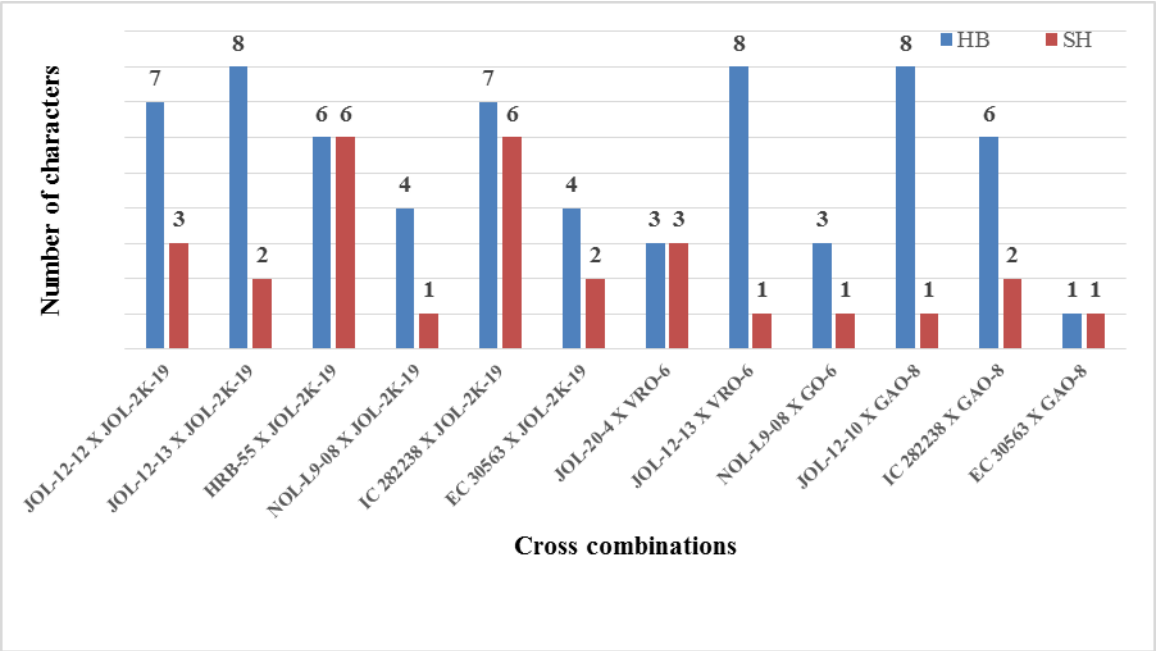

Fig. 1 : Number of characters for which significant desirable HB and SH exhibited by different 12 F_1 hybrids

The promising F_1 hybrids that exhibiting significant and desirable heterobeltiosis (HB) and standard heterosis (SH) for different characters have been identified (Fig. 1). Those cross combination manifesting significant desirable HB and SH included JOL-12-12 × JOL-2K-19, JOL-12-13 × JOL-2K-19, HRB-55 × JOL-2K-19, NOL-L9-08 × JOL-2K-19, IC 282238 × JOL-2K-19, EC 30563 × JOL-2K-19, JOL-20-4 × VRO-6, JOL-12-13 × VRO-6, NOL-L9-08 × GO-6, JOL-12-10 × GAO-8, IC 282238 × GAO-8, EC 30563 × GAO-8.

Table 3: Comparative study of standard heterotic crosses for fruit yield per plant (g) along with their heterotic effects for fruit yield component characters in okra

Heterotic crosses	Mean	Per cent heterosis for fruit yield per plant		Significant and desirable heterosis for component traits	
		HB	SH	Heterobeltiosis (HB)	Standard heterosis (SH)
HRB-55 × JOL-2K-19	232.26 g	15.86*	17.3*	Number of nodes per plant, Fruit length, Fruit girth, Number of fruits per plant, Ten fruit weight	Plant height, Fruit length, Fruit girth, Number of fruits per plant, Ten fruit weight
IC-282238 × JOL-2K-19	225.60 g	18.68*	13.94*	Plant height, Number of nodes per plant, Internodal length, Number of branches per plant, Fruit length, Ten fruit weight	Plant height, Number of nodes per plant, Internodal length, Fruit length, Ten fruit weight

Conclusion

From foregoing discussion, two outstanding F_1 hybrids have been identified *viz.*, HRB-55 × JOL-2K-19 and IC 282238 × JOL-2K-19. The cross combination, HRB-55 × JOL-2K-19 manifested significant desirable HB and SH for fruit yield per plant and other component traits *viz.*, plant height, fruit length, fruit girth, number of fruits per plant, ten fruit weight and the cross combination, IC 282238 × JOL-2K-19 exhibited significant positive HB and SH for fruit yield per plant and other component traits *viz.*, plant height, number of nodes per plant, internodal length, fruit length, ten fruit weight (Table 3). A prior to final release of hybrid for cultivation, it is essential to evaluate it across the diverse agro climatic zones of the state and country. Therefore, the two promising experimental hybrids are recommended for multi-location testing before commercial release.

Declaration

The authors declare that they do not have any conflict of research.

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