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Genetic behaviour of earliness traits in okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract
Okra [*Abelmoschus esculentus* (L.) Moench] has a prominent position in vegetables due to its wider adaptability, year-round export potential and high nutritive value. Breeders and growers of okra would profit from robust genotypes with improved morphological and fruit yield-related characteristics. To escape from pest infestation and disease incidence, earliness from flowering to maturity is most desirable. The aim of this work is to determine the nature and magnitude of gene action on fruit yield, to define the best combinations of earliness and yield characters, develop hybrids that perform better on drought escape. During the year 2022, 10 different parents, namely Punjab Suhavani, GAO-8, GO-2, AOL-19-09, Pusa Sawani, Kashi Kranti, GAO-5, AOL-18-06, AOL-19-12 and AOL-18-08 were crossed using a 10×10 half-diallel set analysis without reciprocals to generate 45 F_1 crosses and evaluated in randomized complete block design (RCBD) with three replications. The results indicated significant entries, parents, hybrids mean squares suggesting that okra population was highly variable for all the traits under study. Appreciable heterosis was found over standard check for all characters. Significant combining ability SCA variance estimates were more considerable than general combining ability (GCA) variance for all characters indicated preponderance of non-additive gene action in governing the traits. The Parent Punjab Suhavani was recognized as the best general combiner for most earliness and fruit yield attributes. Among 45 hybrids, Punjab Suhavani × Pusa Sawani and AOL-19-12 × AOL-18-08 exhibited high, significant and desirable standard heterosis, *per se* performance and sca effect for most of the traits including fruit yield per plant (g). Heterosis breeding would be most efficient for qualities where high performance was determined by dominance and dominance gene effects.

Keywords: Half-diallel, heterobeltiosis, standard heterosis, combining ability and okra

Introduction

In India, okra is cultivated in the area of 5.32 lakh hectares with the annual production of 65.13 lakh tonnes with the productivity of 11.84 tonnes per hectare (Anon., 2022) [2]. Good nutritive value, popularity, medicinal value, good market value and high export potential are the key aspects in favour of okra. However, pests such as jassids and bollworms (*Earias vittella* and *Earias insulana*) and diseases like yellow vein mosaic, powdery mildew *etc*. pose problems in okra cultivation by reducing the quality of the produce and increasing the cost of cultivation. To escape from these incidence, earliness from flowering to maturity of marketable pod is most desirable.

Diallel analysis of earliness, fruit yield, and related attributes may reveal fascinating information about the kind of gene action involved in the expression of a trait. Conventional breeding between relevant varieties may be helpful in specific scenarios to understand the type of gene action involved in the expression of a trait. Additionally, it provides genetic information and enables breeders to select the most optimal breeding strategies for hybrid variety or cultivar development projects. In the early stages of breeding techniques, additive and non-additive gene action estimations are critical. Selection would be successful in the early generations when additive gene action is the dominating mode of action. Unless these effects are fixed in the homozygous line, selection will occur in later generations. This study aimed to assess heterosis, combining ability and genetic parameters for earliness and yield traits in okra.

Materials and Methods

The present study used 45 F_1 crosses generated by crossing the 10 okra genotypes (Punjab Suhavani, GAO-8, GO-2, AOL-19-09, Pusa Sawani, Kashi Kranti, GAO-5, AOL-18-06, AOL-19-12 and AOL-18-08) in a half-diallel fashion (excluding reciprocals) at the Vegetable Research Station, Junagadh Agricultural University, Junagadh, during the 2021 and 2022 seasons. Biometric data were recorded on 8 quantitative characters. Observation on fruit yield per plant (g), duration of harvest, percent infestation of fruit borer and percent YVMV incidence were recorded on five randomly selected competitive plants in each replication, while the observation on characters like days to first flowering, days to first picking, days to last picking and number of picking were recorded on whole plot basis in each entry in each replicate. Heterobeltiosis and standard heterosis were determined as percent increase (+) or decrease (-) of F_1 over mid parent (MP), better parent (BP) and standard hybrid check (SH) using the formulae (F_1-MP/MP × 100), (F_1-BP/BP × 100) and (F_1-SH/SH × 100), respectively (Singh, 1973). The statistical significance of heterosis, heterobeltiosis and standard heterosis was assessed by t-test (Wynne *et al.*, 1970) [50]. Data was analysed according to Model-I, Method-II proposed by Griffing (1956) [12] to study combining ability variances and effects.

Results and Discussions

The analysis of variance was done to test the significance of differences among the replications, genotypes and other partitioning sources of variation for different characters and is presented in Table 1. The analysis of variance revealed mean square due to genotypes was found significant for percent YVMV incidence and highly significant for all other remaining characters indicating that experimental materials had sufficient genetic variability for different characters under studied. The variance due to genotypes was further partitioned into variance due to parents, hybrids and parents *vs* hybrids (P *vs* H). The mean square due to parents was significant for days to last picking, number of picking, fruit yield per plant (g), duration of harvest and percent infestation of fruit borer (except days to first flowering, days to first picking and percent YVMV incidence) indicating substantial amount of genetic variability present among the parents. The mean square due to hybrids was found significant for percent YVMV incidence and highly significant for all other characters indicating substantial amount of genetic variation has present among the hybrids for the characters under studied. While mean square due to parents *vs* hybrids comparison was found significant only for days to last picking and fruit yield per plant (g) indicating that the performance of hybrids as a group was different than that of parents for these two traits only.

Table 1: Analysis of variance (mean squares) for earliness and fruit yield characters in okra

Source	DF	DFF	DFP	DLP	NP	FYP	DH	PIFB	PYI
Replications	2	25.89**	5.63**	5.58	12.77**	570.94	31.49*	2.77	5.36
Genotypes	54	19.53**	14.26**	33.31**	4.95**	2469.55**	51.29**	16.35**	49.27*
a) Parents	9	5.85	11.55	24.90**	3.48*	2278.72**	52.38**	9.54*	50.59
b) Hybrids	44	22.57**	14.66**	35.21**	5.31**	2515.08**	52.23**	18.11**	48.09*
c) Parent *vs* Hybrids	1	9.16	21.04	25.27*	2.20	2183.97*	0.19	0.34	89.24
Error	108	5.10	5.96	4.52	1.60	324.87	9.21	4.38	30.20

*, ** Significant at 5% and 1%, respectively. (Where, DFF = days to first flowering, DFP = days to first picking, DLP = days to last picking, NP = number of picking, FYP = fruit yield per plant, PIFB = percent infestation of fruit borer and PYI = percent YVMV incidence)

Estimation of heterobeltiosis and standard heterosis

The aim of estimation of heterosis in the present study was to find out the best combination of parents giving high degree of useful heterosis for fruit yield and earliness characters for its future use in the breeding programme. The measure of heterosis over better parent has relatively less practical value than standard heterosis. Therefore, it is important to measure heterosis in terms of superiority of hybrids over the standard hybrid as commercial check (GJOH-4), in addition to that over better parent. The character-wise results on heterosis over better parent (heterobeltiosis) and over standard hybrid, GJOH-4 (standard heterosis) are presented in Table 2 are described as under.

The heterobeltiosis for days to first flowering ranged from -8.44 percent (Pusa Sawani × Kashi Kranti) to 11.54 percent (AOL-19-09 × Kashi Kranti) with an average heterobeltiosis of 2.78%. Similarly, for days to first picking, it lied between -2.92 percent (Pusa Sawani × Kashi Kranti) and 11.45 percent (GAO-8 × AOL-18-08) with an average heterobeltiosis of 3.68%; for days to last picking, minimum and the maximum value of heterosis over better parent was -3.92 (Pusa Sawani × AOL-18-08) and 6.37 percent (AOL-19-09 × AOL-18-06), respectively with an average heterobeltiosis of -0.66%; for number of picking, ranged from -18.18 (GAO-5 × AOL-18-08) to 14.29 percent (Kashi Kranti × AOL-18-06) with an average heterobeltiosis of -2.09%; for fruit yield per plant (g), varied from -57.60 (GO-2 × AOL-18-06) to 24.36 percent (AOL-19-12 × AOL-18-08) with mean heterobeltiosis of -11.11%; for duration of harvest, ranged from -17.93 (Kashi Kranti × AOL-19-12) to 12.32 percent (AOL-19-09 × AOL-18-06) with mean heterobeltiosis of -4.83%; between -17.29 percent (GO-2 × AOL-19-09) and 26.68 percent (GO-2 × AOL-19-12) with an average of 3.88% for percent infestation of fruit borer and between -21.74 percent (Punjab Suhavani × kashi kranti and GAO-8 × Pusa Sawani) and 36.35 percent (GO-2 × GAO-5) with an average of 2.08% for percent YVMV incidence.

The standard heterosis varied from -14.81 percent (Punjab Suhavani × AOL-18-08) to 7.41 percent (AOL-19-09 × Kashi Kranti) with an average standard heterosis of -2.14%; for days to first picking, ranged from -10.23 percent (Punjab Suhavani × AOL-18-08) to 5.11 percent (Kashi Kranti × AOL-19-12, GAO-5 × AOL-18-08 and AOL-18-06 × AOL-19-12) with an average standard heterosis of -0.70%; for days to last picking, minimum and the maximum value of heterosis over better parent was -3.92 (Pusa Sawani × AOL-18-08) and 6.37 percent (AOL-19-09 × AOL-18-06), respectively with an average heterobeltiosis of -0.66%; for number of picking, varied from -16.28 (Pusa Sawani × AOL-18-06 and GAO-5 × AOL-18-08) to 18.60 percent (Punjab Suhavani × GO-2, Punjab Suhavani × AOL-19-09 and Punjab Suhavani × GAO-5) with a mean standard heterosis of -1.86%; ranged from -43.67 (GO-2 × AOL-18-06) to 29.22 percent (Punjab Suhavani × GAO-8) with mean standard heterosis of -4.25% for fruit yield per plant (g); for duration of harvest, spectrum was from -12.59 (Pusa Sawani × AOL-18-06) to 22.22

percent (Punjab Suhavani × GAO-5) with an average of 0.64%; between 21.23 percent (GO-2 × AOL-18-08) to 27.58 percent (GO-2 × AOL-19-12) with an average of -0.35% for percent infestation of fruit borer and between -24.53 percent (AOL-18-06 × AOL-18-08) to 18.93 percent (Pusa Sawani × Kashi Kranti) with an average of -2.26% for percent YVMV incidence.

Table 2: Estimation of percent heterobeltiosis (HB) for earliness and fruit yield traits in okra

Sr. no.	Crosses	DTF	DFP	DLP	NP	FYP	DH	PIFB	PYI
1	Punjab Suhavani × GAO-8	-1.34	1.25	-1.88	4.35	4.55	-5.00	13.91	0.00
2	Punjab Suhavani × GO-2	1.34	3.75	2.19	10.87	-10.79	0.62	10.82	-9.12
3	Punjab Suhavani × AOL-19-09	6.71	8.75*	5.94**	10.87	-5.10	3.13	17.39*	14.95
4	Punjab Suhavani × Pusa Sawani	-3.36	0.00	-3.44*	-2.17	3.84	-6.88	23.65**	-8.55
5	Punjab Suhavani × Kashi Kranti	0.00	2.50	-2.81	0.00	-6.54	-8.13	14.50*	-21.74*
6	Punjab Suhavani × GAO-5	3.36	3.75	4.06*	10.87	-12.26	4.37	24.22**	18.62
7	Punjab Suhavani × AOL-18-06	4.70	10.00**	-1.88	-6.52	-16.77*	-13.75**	14.37*	-13.59
8	Punjab Suhavani × AOL-19-12	3.36	6.87	-1.88	-4.35	-16.48*	-10.63*	20.54**	0.00
9	Punjab Suhavani × AOL-18-08	-7.38*	-1.25	-1.25	6.52	-11.33	-1.25	14.76*	-14.25
10	GAO-8 × GO-2	4.49	5.29	-2.83	-11.63	-26.38**	-9.72	0.35	0.00
11	GAO-8 × AOL-19-09	3.80	1.15	-2.20	-4.65	-1.81	-6.25	-4.88	-15.16
12	GAO-8 × Pusa Sawani	0.65	1.17	-4.40**	-2.33	-10.24	-9.03	-5.79	-21.74*
13	GAO-8 × Kashi Kranti	2.56	1.75	-0.63	2.33	1.73	-2.07	-8.94	-17.28
14	GAO-8 × GAO-5	2.48	2.87	-0.63	-2.33	-6.28	-4.86	-2.85	12.79
15	GAO-8 × AOL-18-06	1.86	4.02	-2.20	-9.30	18.60*	-9.72	14.33*	-0.20
16	GAO-8 × AOL-19-12	5.70	5.17	4.72**	9.30	0.94	4.17	7.87	5.13
17	GAO-8 × AOL-18-08	6.58	6.02	-2.20	-6.82	0.33	-6.25	4.13	-9.36
18	GO-2 × AOL-19-09	10.9**	7.65*	0.00	-6.98	-30.04**	-5.07	-17.29**	0.00
19	GO-2 × Pusa Sawani	6.49	5.88	0.00	-4.88	-32.31**	-6.92	-6.91	-13.59
20	GO-2 × Kashi Kranti	8.33*	7.65*	-1.58	-7.14	-48.24**	-11.72*	-17.07**	-18.24
21	GO-2 × GAO-5	0.00	5.29	0.00	-7.32	-39.53**	-3.10	0.13	36.35**
22	GO-2 × AOL-18-06	5.13	4.71	2.68	-4.88	-57.60**	0.00	-1.70	0.00
23	GO-2 × AOL-19-12	5.13	3.53	0.66	-2.44	-55.27**	-0.78	26.68**	5.13
24	GO-2 × AOL-18-08	5.92	6.02	-0.65	-9.09	-45.87**	-8.57	-12.50	0.00
25	AOL-19-09 × Pusa Sawani	1.30	0.58	0.64	2.33	-11.94	4.35	-12.37	14.74
26	AOL-19-09 × Kashi Kranti	11.54**	1.17	-3.80*	-4.65	-5.48	-9.66	7.73	0.21
27	AOL-19-09 × GAO-5	3.16	1.14	-0.96	-4.65	-11.69	-2.90	9.13	18.87
28	AOL-19-09 × AOL-18-06	3.80	1.70	6.37**	9.30	-14.73	12.32*	-5.36	24.99*
29	AOL-19-09 × AOL-19-12	-0.63	-1.14	-2.23	-2.33	-1.17	-3.62	5.56	4.91
30	AOL-19-09 × AOL-18-08	5.26	7.23*	-2.55	-13.64	-6.55	-8.57	8.79	20.08
31	Pusa Sawani × Kashi Kranti	-8.44*	-2.92	-3.16	4.76	-14.20	-3.45	-5.37	8.55
32	Pusa Sawani × GAO-5	-1.30	-1.17	-1.64	2.50	-9.18	0.00	-8.08	30.53*
33	Pusa Sawani × AOL-18-06	4.55	2.92	-2.33	-10.00	-12.76	-9.23	9.17	4.46
34	Pusa Sawani × AOL-19-12	1.95	0.00	1.66	5.00	-22.84**	4.62	-8.65	-5.13
35	Pusa Sawani × AOL-18-08	0.66	0.60	-3.92*	-6.82	-9.74	-9.29	5.24	-9.36
36	Kashi Kranti × GAO-5	3.85	4.09	-2.85	-2.38	2.40	-11.03*	7.16	18.62
37	Kashi Kranti × AOL-18-06	0.64	2.92	3.48*	14.29	3.28	4.14	-8.41	-4.66
38	Kashi Kranti × AOL-19-12	7.05*	8.19*	-3.80*	-11.90	3.98	-17.93 **	-11.90	10.04
39	Kashi Kranti × AOL-18-08	-3.29	10.24**	-1.58	-9.09	-2.64	-11.72 *	14.55*	0.00
40	GAO-5 × AOL-18-06	-3.73	-1.71	-1.64	-2.50	18.94*	-1.55	-9.44	30.27*
41	GAO-5 × AOL-19-12	-3.16	-0.57	0.00	7.50	-7.75	0.78	-9.90	18.62
42	GAO-5 × AOL-18-08	10.53**	11.45**	-0.65	-18.18*	24.24**	-15.00**	17.35*	12.79
43	AOL-18-06 × AOL-19-12	7.59*	5.11	2.98	0.00	-27.39**	0.00	2.19	0.00
44	AOL-18-06 × AOL-18-08	9.87**	7.23*	-2.94	-15.91*	-16.68	-15.00**	19.97**	-14.25
45	AOL-19-12 × AOL-18-08	-3.29	4.82	-0.65	0.00	24.36**	-7.14	17.56*	-20.82
	S. E. ±	1.84	1.99	1.73	1.03	14.72	2.48	1.71	4.49
Number of significant and positive crosses		7	9	5	0	4	1	13	4
Number of significant and negative crosses		2	0	5	2	12	8	2	2
Correlation between *per se* and heterobeltiosis		0.90**	0.63**	0.74**	0.87**	0.79**	0.60**	0.84**	0.68**

*, ** significant at 5% and 1%, respectively. (Where, DFF = days to first flowering, DFP = days to first picking, DLP = days to last picking, NP = number of picking, FYP = fruit yield per plant, PIFB = percent infestation of fruit borer and PYI = percent YVMV incidence)

In case of days to first flowering, two namely Pusa Sawani × Kashi Kranti (-8.44%) and Punjab Suhavani × AOL-18-08 (-7.38%) and eight crosses *viz.*, Punjab Suhavani × AOL-18-08 (-14.81), Pusa Sawani × Kashi Kranti (-12.96%), Punjab Suhavani × Pusa Sawani (-11.11%), Punjab Suhavani × GAO-8 (-9.26%), Kashi Kranti × AOL-18-08 (-9.26%), AOL-19-12 × AOL-18-08 (-9.26), Punjab Suhavani × Kashi Kranti (-8.02%) and Punjab Suhavani × GO-2 (-6.79%) exhibited desirable heterosis over better parental value and standard check, respectively. Significant and negative heterosis for this trait was also reported by Poshiya and Vashi (1995) [29]; Khanorkar and Kathiria (2010) [16]; Tiwari *et al.* (2015) [45]; Rameshkumar *et al.* (2017) [31]; Chowdhury and Kumar (2019) [8]; Javiya *et al.* (2020) [14]; Rynjah *et al.* (2020) [37] and Nanthakumar *et al.* (2021) [25]. Whereas, for days to first picking, none of the crosses exhibited heterobeltiosis in the desired direction and four crosses in the order of merit Punjab Suhavani × AOL-18-08 (-10.23), Punjab Suhavani × Pusa Sawani (-9.09%), Punjab Suhavani × GAO-8 (-7.95%) and Punjab Suhavani × Kashi Kranti (-6.82%) showed standard heterosis for earliness. This result agrees with the results of Khanorkar and Kathiria (2010) [16]; Tiwari *et al.* (2015) [45]; Sapavadiya *et al.* (2019) [38]; Javiya *et al.* (2020) [14]; Chavan *et al.* (2021) [7]; Panchal *et al.* (2021) [26] and Mundhe *et al.* (2022) [24].

For days to last picking, in the order of merit, five hybrids namely AOL-19-09 × AOL-18-06 (6.37%), Punjab Suhavani × AOL-19-09 (5.94%), Punjab Suhavani × AOL-19-09 (5.94%), GAO-8 × AOL-19-12 (4.72%) and Kashi Kranti × AOL-18-06 (4.33%) recorded significant and positive heterobeltiosis while, six hybrids *i.e.*, Punjab Suhavani × AOL-19-09 (9.00%), AOL-19-09 × AOL-18-06 (7.40%), Punjab Suhavani × GAO-5 (7.07%), GAO-8 × AOL-19-12 (7.07%), Punjab Suhavani × GO-2 (5.14%) and Kashi Kranti × AOL-18-06 (5.14%) depicted significant and desirable (positive) standard heterosis over check (GJOH-4). On the other hand, for number of picking three crosses *viz.*, Punjab Suhavani × GO-2, Punjab Suhavani × AOL-19-09 and Punjab Suhavani × GAO-5 showed standard heterosis for earliness and is in agreement with the results of Javiya *et al.* (2020) [14] and Mundhe *et al.* (2022) [24].

Out of forty-five hybrids, only one of the hybrids (AOL-19-09 × AOL-18-06) recorded significant and positive heterosis over better parent for duration of harvest while, seven hybrids revealed significant and positive heterosis over check which were at maximum. The best three cross combinations Punjab Suhavani × GAO-5 (23.70%), Punjab Suhavani × AOL-19-09 (22.22%) and Punjab Suhavani × GO-2 (19.26%).

In the present study, out of forty-five crosses studied for fruit yield per plant, four namely AOL-19-12 × AOL-18-08 (24.36%), GAO-5 × AOL-18-08 (24.24%), GAO-8 × AOL-18-06 (18.60%) and GAO-5 × AOL-18-06 (17.78%) and seven crosses *viz.*, Punjab Suhavani × GAO-8 (29.22%), Punjab Suhavani × Pusa Sawani (28.34%), AOL-19-12 × AOL-18-08 (21.88%), Punjab Suhavani × GO-2 (18.51%), Punjab Suhavani × AOL-19-09 (17.28%), GAO-5 × AOL-18-08 (17.07%) and GAO-8 × AOL-18-06 (16.96%) depicted significant and positive heterosis over better parent and standard check, respectively. These findings were similar to that of Poshiya and Vashi (1995) [29]; Singh *et al.* (1996) [42]; Dhaduk *et al.* (2003) [10]; Borgaonkar *et al.* (2006) [6]; Desai *et al.* (2007) [9]; Ramya and Senthil (2010) [33]; Khanorkar and Kathiria (2010) [16]; Reddy *et al.* (2013) [35]; Aware *et al.* (2014) [4]; Tiwari *et al.* (2015) [45]; Kumar *et al.* (2017) [19]; Hadiya *et al.* (2018) [13]; Mulge and Khot (2018) [23]; Chowdhury and Kumar (2019) [8]; Kavya *et al.* (2019) [15]; Javiya *et al.* (2020) [14]; Koli *et al.* (2020) [17]; Patel *et al.* (2020) [17]; Chavan *et al.* (2021) [7]; Sidapara *et al.* (2021) [41] and Mundhe *et al.* (2022) [24].

Fruit yield per plant in okra is highly influenced by incidence of YVMV and shoot and fruit borer. The incidence of YVMV was observed among all the hybrids. Two hybrids *i.e.*, GO-2 × AOL-19-09 and GO-2 × Kashi Kranti documented significant and negative heterobeltiosis and standard heterosis for percent fruit borer infestation. This finding was in line with that of Verma and Sood (2015) [46]. In case of percent YVMV incidence, two hybrids namely Punjab Suhavani × Kashi Kranti and GAO-8 × Pusa Sawani and one (AOL-19-12 × AOL-18-08) cross exhibited heterobeltiosis and standard heterosis in the desired direction and is in agreement with the results of Mundhe *et al.* (2022) [24] and Shinde *et al.* (2023) [39].

In the present investigation, all the characters expressed moderate range of heterosis which showed wide range of heterosis. Comparatively, moderate estimates of heterotic effect for various traits were mainly due to inclusion of well adapted parental lines of different states. The manifestation of heterosis observed in undesirable direction in some of crosses for different traits may be due to the combination of the unfavourable genes of the parents.

The most desirable cross combinations based on comparisons among *per se*, heterobeltiosis and standard heterosis were Pusa Sawani × Kashi Kranti and Punjab Suhavani × AOL-18-08 for days to first flowering; AOL-19-09 × AOL-18-06, Punjab Suhavani × AOL-19-09, GAO-8 × AOL-19-12 and Punjab Suhavani × GAO-5 for days to last picking; AOL-19-12 × AOL-18-08 for fruit yield per plant and GO-2 × AOL-19-09 and GO-2 × Kashi Kranti for percent fruit borer infestation. Therefore, it was noted that top ranking crosses based on *per se* performance, heterobeltiosis and standard heterosis were same. In general, the hybrids which gave the best *per se* performance were also the best heterotic crosses indicating a positive association between these two parameters. This result suggested that the selection of parents that to be included in hybridization could also be judged on the basis of *per se* performance besides its combining ability effects.

Combining ability

The analysis of variance for combining ability revealed that the mean square due to both general combining ability (GCA) and specific combining ability (SCA) were significant/highly significant for all the characters (except GCA for percent YVMV incidence and SCA for days to first picking). This indicated that both additive as well as non-additive genetic variances played a vital role in the inheritance of all these traits under studied. The results are in accordance with the findings of Weerasekara *et al.* (2008) [49]; Mistry (2013) [20]; Patil *et al.* (2016) [28]; Wakode *et al.* (2016) [48]; Sugani *et al.* (2017) [44]; Hadiya *et al.* (2018) [13]; Reddy and Sridevi (2018) [36]; Shwetha *et al.* (2018) [40]; Kousalya *et al.* (2021) [18]; Rajani *et al.* (2021) [30] and Anyaoha *et al.* (2022) [3].

The magnitude of GCA and SCA variances revealed that the SCA variances were higher than their respective GCA variances for all the characters (except days to first picking). This was further supported by the potent ratio ($\sigma^2_{GCA}/\sigma^2_{SCA}$) less than unity confirmed the preponderance of non-additive gene action for characters under studied and emphasized the utility of hybrid breeding approach to exploit existing heterosis in okra genotypes. The predominance of non-additive gene action for fruit yield and its component traits were also reported by Rani *et al.* (2002) [34]; Mitra and Das (2003) [21]; El-Gendy *et al.* (2012) [11]; Mrinmoy *et al.* (2013) [22]; Akotkar *et al.* (2014) [1]; Bhatt *et al.* (2015) [5]; Verma and Sood (2015) [46]; Verma *et al.* (2016) [47]; Rameshkumar *et al.* (2017) [31]; Shwetha *et al.* (2018) [40] and Rajani *et al.* (2021) [30].

Table 3: Estimation of percent standard heterosis (SH) for earliness and fruit yield traits in okra

Sr. no.	Crosses	DTF	DFP	DLP	NP	FYP	DH	PIFB	PYI
1	Punjab Suhavani × GAO-8	-9.26**	-7.95*	0.96	11.63	29.22**	12.59*	0.31	9.57
2	Punjab Suhavani × GO-2	-6.79*	-5.68	5.14**	18.60*	18.51*	19.26**	-2.41	-4.68
3	Punjab Suhavani × AOL-19-09	-1.85	-1.14	9.00**	18.60*	17.28*	22.22**	3.38	9.57
4	Punjab Suhavani × Pusa Sawani	-11.11**	-9.09**	-0.64	4.65	28.34**	10.37	8.89	0.20
5	Punjab Suhavani × Kashi Kranti	-8.02*	-6.82*	0.00	6.98	15.51	8.89	0.83	-14.25
6	Punjab Suhavani × GAO-5	-4.94	-5.68	7.07**	18.60*	8.44	23.70**	9.39	-4.68
7	Punjab Suhavani × AOL-18-06	-3.70	0.00	0.96	0.00	2.87	2.22	0.72	-9.36
8	Punjab Suhavani × AOL-19-12	-4.94	-2.84	0.96	2.33	3.23	5.93	6.15	-4.68
9	Punjab Suhavani × AOL-18-08	-14.81**	-10.23**	1.61	13.95	9.59	17.04**	1.06	-14.25
10	GAO-8 × GO-2	0.62	1.70	-0.64	-11.63	-2.19	-3.70	1.90	4.89
11	GAO-8 × AOL-19-09	1.23	0.00	0.00	-4.65	-3.17	0.00	-4.59	-19.14
12	GAO-8 × Pusa Sawani	-4.32	-1.70	-2.25	-2.33	-6.39	-2.96	-6.06	-14.25
13	GAO-8 × Kashi Kranti	-1.23	-1.14	1.61	2.33	0.32	5.19	-7.54	-9.36
14	GAO-8 × GAO-5	1.85	1.70	1.61	-2.33	-7.58	1.48	-1.35	-9.36
15	GAO-8 × AOL-18-06	1.23	2.84	0.00	-9.30	16.96*	-3.70	14.89*	4.68
16	GAO-8 × AOL-19-12	3.09	3.98	7.07**	9.30	-0.46	11.11	8.64	0.20
17	GAO-8 × AOL-18-08	0.00	0.00	0.00	-4.65	-1.06	0.00	-6.25	-9.36
18	GO-2 × AOL-19-09	6.79*	3.98	0.96	-6.98	-7.05	-2.96	-17.04**	-4.68
19	GO-2 × Pusa Sawani	1.23	2.27	-3.22	-9.30	-10.07	-10.37	-7.17	-9.36
20	GO-2 × Kashi Kranti	4.32	3.98	0.00	-9.30	-31.24**	-5.19	-14.13*	-14.25
21	GO-2 × GAO-5	-3.70	1.70	-2.25	-11.63	-19.67*	-7.41	6.02	9.57
22	GO-2 × AOL-18-06	1.23	1.14	-1.29	-9.30	-43.67**	-4.44	-1.22	4.89
23	GO-2 × AOL-19-12	1.23	0.00	-2.25	-6.98	-40.58**	-5.19	27.58**	0.20
24	GO-2 × AOL-18-08	-0.62	0.00	-2.25	-6.98	-28.08**	-5.19	-21.23**	0.00
25	AOL-19-09 × Pusa Sawani	-3.70	-2.27	1.61	2.33	-8.15	6.67	-12.62*	9.36
26	AOL-19-09 × Kashi Kranti	7.41*	-1.70	-2.25	-4.65	-10.21	-2.96	8.06	-4.48
27	AOL-19-09 × GAO-5	0.62	0.57	0.00	-4.65	-16.79*	-0.74	9.46	-4.48
28	AOL-19-09 × AOL-18-06	1.23	1.70	7.40**	9.30	-19.73*	14.81*	-5.07	19.14
29	AOL-19-09 × AOL-19-12	-3.09	-1.14	-1.29	-2.33	-3.15	-1.48	5.88	0.00
30	AOL-19-09 × AOL-18-08	-1.23	1.14	-1.61	-11.63	-12.03	-5.19	-2.06	14.45
31	Pusa Sawani × Kashi Kranti	-12.96**	-5.68	-1.61	2.33	-10.51	3.70	-5.63	18.93
32	Pusa Sawani × GAO-5	-6.17	-3.98	-3.86*	-4.65	-5.28	-3.70	-8.34	4.89
33	Pusa Sawani × AOL-18-06	-0.62	0.00	-5.47**	-16.28*	-9.01	-12.59*	8.86	9.57
34	Pusa Sawani × AOL-19-12	-3.09	-2.84	-1.29	-2.33	-19.52*	0.74	-8.91	-9.57
35	Pusa Sawani × AOL-18-08	-5.56	-5.11	-5.47**	-4.65	-5.86	-5.93	-5.26	-9.36
36	Kashi Kranti × GAO-5	0.00	1.14	-1.29	-4.65	-2.73	-4.44	10.97	-4.68
37	Kashi Kranti × AOL-18-06	-3.09	0.00	5.14**	11.63	-1.89	11.85*	-7.96	0.00
38	Kashi Kranti × AOL-19-12	3.09	5.11	-2.25	-13.95	1.90	-11.85*	-11.27	4.89
39	Kashi Kranti × AOL-18-08	-9.26**	3.98	0.00	-6.98	-7.52	-5.19	3.12	0.00
40	GAO-5 × AOL-18-06	-4.32	-2.27	-3.86*	-9.30	12.07	-5.93	-9.00	4.68
41	GAO-5 × AOL-19-12	-5.56	-1.14	-2.25	0.00	-9.60	-3.70	-9.26	-4.68
42	GAO-5 × AOL-18-08	3.70	5.11	-2.25	-16.28*	17.07*	-11.85*	5.64	-9.36
43	AOL-18-06 × AOL-19-12	4.94	5.11	0.00	-6.98	-28.84**	-6.67	2.69	-4.68
44	AOL-18-06 × AOL-18-08	3.09	1.14	-4.50**	-13.95	-22.68**	-11.85*	8.00	-14.25
45	AOL-19-12 × AOL-18-08	-9.26**	-1.14	-2.25	2.33	21.88**	-3.70	5.84	-24.53*
	S. E. ±	1.84	1.99	1.73	1.03	14.72	2.48	1.71	4.49
Number of significant and positive crosses		2	0	6	3	7	7	2	0
Number of significant and negative crosses		8	4	5	2	10	4	4	1
Correlation between standard heterosis and heterobeltiosis		0.90**	0.63**	0.74**	0.87**	0.79**	0.60**	0.84**	0.68**

*, ** significant at 5% and 1%, respectively. (Where, DFF = days to first flowering, DFP = days to first picking, DLP = days to last picking, NP = number of picking, FYP = fruit yield per plant, PIFB = percent infestation of fruit borer and PYI = percent YVMV incidence)

Table 4: Analysis of variance (mean squares) for combining ability in half-diallel design for fruit yield earliness characters in okra

Source	df	DTF	DFP	DLP	NP	FYP	DH	PIFB	PYI
GCA	9	18.39**	16.50**	30.01**	4.78**	1906.39**	61.96**	3.389*	15.12
SCA	45	4.13**	2.41	7.32**	1.02**	606.54**	8.12**	5.863**	16.68*
Error	108	1.70	1.98	1.51	0.53	108.29	3.07	1.461	10.07
σ^2_{GCA}		1.39	1.21	2.37	0.35	149.84	4.90	0.16	0.42
σ^2_{SCA}		2.43	0.42	5.81	0.48	498.25	5.05	4.40	6.62
$\sigma^2_{GCA} / \sigma^2_{SCA}$		0.57	2.89	0.41	0.72	0.30	0.97	0.04	0.06

General combining ability effects

The data revealed that gca effects varied from -2.51 (Punjab Suhavani) to 1.27 (AOL-19-09). Estimates of gca effects indicated that three parents *i.e.,* Punjab Suhavani, Pusa Sawani and AOL-18-08 had significant and negative gca effects and were found to be good general combiners for earliness in flowering. On the other hand, the gca effect varied from -2.78 (Punjab Suhavani) to 1.28 (AOL-18-06). Two parents *viz.,* Punjab Suhavani and Pusa Sawani showed significant and negative gca effect; hence they were considered as good general combiners for earliness to first picking.

For days to last picking, gca effects ranged from -2.20 (Pusa Sawani) to 2.94 (Punjab Suhavani). Among parents, three parents namely GAO-8 (1.38), Punjab Suhavani (2.94) and AOL-19-09 (1.64) had significant and positive gca effect and seemed to be good combiners for this trait. On the other hand, only one parent (Punjab Suhavani) was observed as good combiner for number of picking.

The range of gca effects was observed from -14.69 (AOL-18-06) to 31.29 (Punjab Suhavani). The gca effects revealed that two parents Punjab Suhavani (31.29) and GAO-8 (8.52) had significant and positive gca effect and were found to be good combiners for fruit yield per plant. On the other hand, three parents Punjab Suhavani (5.72), AOL-19-09 (1.06) and GAO-8 (1.00) had significant and positive gca effect and were found to be good combiners for duration of harvest.

Table 5: General combining ability effects for fruit yield and earliness traits in okra

Sr. no.	Parents	Days to first flowering	Days to first picking	Days to last picking	Number of picking	Fruit yield per plant (g)	Duration of harvest	Percent infestation of fruit borer	Percent YVMV incidence
1	Punjab Suhavani	-2.51**	-2.78**	2.94**	1.60**	31.29**	5.72**	0.16	0.39
2	GAO-8	0.86*	0.39	1.39**	0.16	8.52**	1.00*	0.13	-0.25
3	GO-2	1.02**	0.64	-0.89**	-0.46*	-9.03**	-1.53**	-0.29	0.41
4	AOL-19-09	1.27**	0.58	1.64**	0.24	-5.61*	1.06*	-0.24	0.89
5	Pusa Sawani	-1.37**	-1.14**	-2.20**	-0.23	-0.27	-1.06*	-0.75*	1.21
6	Kashi Kranti	-0.06	0.19	0.50	0.04	-2.96	0.31	-0.30	0.39
7	GAO-5	0.27	0.33	-0.72*	-0.29	0.05	-1.06*	0.84*	-1.43
8	AOL-18-06	1.11**	1.28**	-0.69*	-0.73**	-14.69**	-1.97**	0.35	1.37
9	AOL-19-12	0.33	0.78*	-0.53	-0.09	-6.25*	-1.31**	0.70*	-1.25
10	AOL-18-08	-0.92*	-0.28	-1.44**	-0.23	-1.03	-1.17*	-0.62	-1.75*
$SE(g_i) \pm$		0.36	0.39	0.34	0.20	2.85	0.48	0.33	0.87
$SE(g_i - g_j) \pm$		0.53	0.58	0.50	0.30	4.25	0.72	0.49	1.29
Correlation between *per se* and gca effects		0.84**	0.86**	0.84**	0.76**	0.45	-0.08	0.35	0.43

*, ** significant at 5% and 1%, respectively

For percent infestation of fruit borer, gca effects ranged from -0.75 (AOL-19-12) to 0.70 (Pusa Sawani). Among parents, only one parent (Pusa Sawani) had significant and negative (desirable) gca effect and seemed to be good combiner for this trait while, for percent YVMV incidence, gca effects varied from -1.75 (AOL-18-08) to 0.89 (AOL-19-09). Out of ten parents, only one parent (AOL-18-08) had significant and negative (desirable) gca effect and seemed to be good combiner for this trait.

Specific combining ability effects

Specific combining ability effects helps in the identification of superior cross combinations for development of promising hybrids. The spectrum of variation in hybrids varied from -5.00 (Punjab Suhavani × Kashi Kranti) to 4.06 (AOL-19-09 × Kashi Kranti). Six cross combinations *viz.*, Punjab Suhavani × Kashi Kranti (-5.00), Pusa Sawani × Kashi Kranti (-4.31), AOL-19-12 × AOL-18-08 (-3.32), Punjab Suhavani × AOL-18-08 (-3.31), Kashi Kranti × AOL-18-08 (-2.75) and GAO-5 × AOL-18-06 (-2.44) were identified as the best specific cross combinations by exhibiting significant and negative (desirable) sca effects for days to first flowering. On the other hand, for days to first picking, the magnitude of variation in hybrids varied from -2.37 (Punjab Suhavani × AOL-18-08 and GAO-5 × AOL-18-06) to 3.35 (GAO-5 × AOL-18-08) but none of the crosses exhibited significant and negative (desirable) sca effects.

Seven crosses possessed significant and positive sca effects and identified as best cross combinations for days to last picking. The maximum magnitude of sca effect was observed in AOL-19-09 × AOL-18-06 (7.02) followed by GAO-8 × AOL-19-12 (6.78) and Kashi Kranti × AOL-18-06 (5.83). On the other hand, for number of picking sca effects varied between -1.63 (Kashi Kranti × AOL-19-12) and 2.68 (Kashi Kranti × AOL-18-06). Five crosses *viz.*, Kashi Kranti × AOL-18-06 (2.68), AOL-19-09 × AOL-18-06 (2.15), Punjab Suhavani × GO-2 (1.84), Punjab Suhavani × GAO-5 (1.68) and GAO-8 × AOL-19-12 (1.59) identified as the best specific cross combinations by exhibiting significant and positive sca effects.

The estimates of sca effects in hybrids ranged from -49.54 (GO-2 × AOL-19-12) to 50.97 (AOL-19-12 × AOL-18-08). Among forty-five hybrids, six hybrids namely AOL-19-12 × AOL-18-08 (50.97), GAO-8 × AOL-18-06 (41.32), GAO-5 × AOL-18-06 (41.30), GAO-5 × AOL-18-08 (36.32), Punjab Suhavani × Pusa Sawani (23.90) and Kashi Kranti × AOL-18-06 (20.05) identified as the best specific cross combiners by exhibiting significant and positive (desirable) sca effects for fruit yield per plant. For duration of harvest, five crosses *viz.*, AOL-19-09 × AOL-18-06 (7.31), Kashi Kranti × AOL-18-06 (6.73), Punjab Suhavani × GAO-5 (5.73), GAO-8 × AOL-19-12 (5.03) and Punjab Suhavani × GO-2 (4.20) identified as the best specific cross combinations by exhibiting significant and positive sca effects.

Foe percent infestation of fruit borer, nine crosses showed significant and negative sca effects which is desirable. Among negative estimates the cross GO-2 × AOL-18-08 (-4.67) depicted the highest sca effect followed by GAO-5 × AOL-

18-06 (-3.51) and GO-2 × AOL-19-09 (-3.93) revealing them as good specific combiners. For percent YVMV incidence, five crosses *viz.*, GAO-8 × AOL-19-09 (-7.92), AOL-19-12 × AOL-18-08 (-6.50), GAO-8 × Pusa Sawani (-6.23), GO-2 × Kashi Kranti (-6.08) and Punjab Suhavani × Kashi Kranti (-6.06) identified as the best specific cross combinations by exhibiting significant and positive sca effects.

Table 6: Specific combining ability effects for fruit yield and earliness characters in okra

Sr. No.	Crosses	Days to first flowering	Days to first picking	Days to last picking	Number of picking	Fruit yield per plant (g)	Duration of harvest	Percent infestation of fruit borer	Percent YVMV incidence
1	Punjab Suhavani × GAO-8	-2.08	-1.70	-3.03**	0.23	16.63	-1.32	-0.14	4.37
2	Punjab Suhavani × GO-2	-0.92	-0.62	3.58**	1.84**	15.59	4.20**	-0.45	-2.15
3	Punjab Suhavani × AOL-19-09	1.50	2.10	5.05**	1.15	10.03	2.95	1.05	3.23
4	Punjab Suhavani × Pusa Sawani	-0.86	-0.84	-1.11	-0.38	23.90*	-0.27	3.02**	-0.93
5	Punjab Suhavani × Kashi Kranti	-5.00**	-0.84	-3.14**	-0.32	4.29	-2.30	0.42	-6.06*
6	Punjab Suhavani × GAO-5	0.83	-0.31	5.41**	1.68*	-10.99	5.73**	1.57	-0.31
7	Punjab Suhavani × AOL-18-06	0.67	2.08	-0.95	-0.55	-5.93	-3.02	-0.25	-5.03
8	Punjab Suhavani × AOL-19-12	0.78	0.91	-1.11	-0.85	-13.76	-2.02	0.84	-0.48
9	Punjab Suhavani × AOL-18-08	-3.31**	-2.37	0.47	0.95	-7.91	2.84	0.81	-3.92
10	GAO-8 × GO-2	-0.28	0.55	-0.86	-1.04	2.39	-1.41	0.73	2.43
11	GAO-8 × AOL-19-09	-0.19	-0.39	-2.73*	-0.74	-2.73	-2.33	-1.04	-7.92**
12	GAO-8 × Pusa Sawani	-0.56	0.33	-1.22	0.07	-13.66	-1.55	-0.92	-6.23*
13	GAO-8 × Kashi Kranti	-0.19	-0.67	0.08	0.46	0.67	0.76	-1.77	-3.41
14	GAO-8 × GAO-5	1.14	0.85	1.30	0.12	-16.06	0.45	-1.26	-1.58
15	GAO-8 × AOL-18-06	-0.03	0.58	-0.39	-0.43	41.32**	-0.97	3.55**	1.39
16	GAO-8 × AOL-19-12	1.75	1.74	6.78**	1.59*	2.61	5.03**	1.53	2.17
17	GAO-8 × AOL-18-08	1.33	0.46	0.36	-0.27	-3.64	-0.11	-1.10	-1.27
18	GO-2 × AOL-19-09	2.64*	1.69	0.55	-0.46	8.07	-1.13	-3.93**	-2.64
19	GO-2 × Pusa Sawani	2.28	2.41	0.05	-0.32	-2.51	-2.36	-0.80	-4.88
20	GO-2 × Kashi Kranti	2.64*	2.08	0.69	-0.60	-36.61**	-1.38	-3.10**	-6.08*
21	GO-2 × GAO-5	-2.03	0.60	-0.42	-0.60	-19.51*	-1.02	1.12	5.53
22	GO-2 × AOL-18-06	-0.19	-0.67	0.55	0.18	-46.47**	1.23	-0.32	0.81
23	GO-2 × AOL-19-12	0.58	-0.84	-0.61	-0.13	-49.54**	0.23	6.99**	1.51
24	GO-2 × AOL-18-08	0.83	0.21	0.30	0.01	-33.04**	0.09	-4.67**	1.92
25	AOL-19-09 × Pusa Sawani	-0.64	-0.20	2.52*	0.65	-2.59	2.73	-2.29*	2.33
26	AOL-19-09 × Kashi Kranti	4.06*	-1.20	-4.17**	-0.63	-3.49	-2.97	2.76*	-2.54
27	AOL-19-09 × GAO-5	0.06	-0.01	-0.61	-0.29	-17.92	-0.60	1.99	-0.72
28	AOL-19-09 × AOL-18-06	-0.44	-0.28	7.02**	2.15**	-8.29	7.31**	-1.38	6.18*
29	AOL-19-09 × AOL-19-12	-2.00	-1.45	-2.14	-0.16	12.08	-0.69	1.18	0.94
30	AOL-19-09 × AOL-18-08	0.25	0.94	-1.56	-1.35*	-8.58	-2.49	0.39	7.38*
31	Pusa Sawani × Kashi Kranti	-4.31**	-1.81	0.33	0.84	-9.35	2.14	-0.38	6.76*
32	Pusa Sawani × GAO-5	-0.97	-0.95	-0.78	0.18	-3.26	0.17	-2.23*	2.82
33	Pusa Sawani × AOL-18-06	1.19	0.44	-2.47*	-1.04	4.99	-2.91	2.83*	1.94
34	Pusa Sawani × AOL-19-12	0.64	-0.73	1.69	0.32	-21.71*	2.42	-2.25*	-3.30
35	Pusa Sawani × AOL-18-08	0.56	-1.01	-1.72	0.12	-3.18	-0.72	0.04	-2.72
36	Kashi Kranti × GAO-5	1.06	0.71	-0.81	-0.10	3.85	-1.52	2.45*	-0.31
37	Kashi Kranti × AOL-18-06	-1.44	-0.89	5.83**	2.68**	20.05*	6.73**	-2.09	-1.19
38	Kashi Kranti × AOL-19-12	2.67*	2.60*	-2.00	-1.63*	18.19	-4.61**	-3.33**	3.45
39	Kashi Kranti × AOL-18-08	-2.75*	2.99*	1.25	-0.49	-3.39	-1.75	1.82	1.93
40	GAO-5 × AOL-18-06	-2.44*	-2.37	-2.28*	0.01	41.30**	0.09	-3.51**	2.56
41	GAO-5 × AOL-19-12	-2.33	-1.20	-0.78	0.71	-4.79	0.42	-3.93**	1.34
42	GAO-5 × AOL-18-08	3.92**	3.52**	0.14	-1.49*	36.32**	-3.38*	1.34	-0.09
43	AOL-18-06 × AOL-19-12	2.50*	1.52	1.52	0.15	-23.48*	0.01	-0.27	-1.46
44	AOL-18-06 × AOL-18-08	2.75*	0.24	-2.23*	-0.71	-17.99	-2.47	2.47*	-4.89
45	AOL-19-12 × AOL-18-08	-3.32**	-0.59	-0.06	0.98	50.97**	0.53	1.54	-6.50*
$SE(S_{ij})$ ±		1.20	1.30	1.13	0.67	9.58	1.61	1.11	2.92
$SE(S_{ij}-S_{ik})$ ±		1.77	1.90	1.66	0.99	14.09	2.37	1.64	4.29
$SE(S_{ij}-S_{kl})$ ±		1.68	1.82	1.58	0.94	13.43	2.26	1.56	4.09
Range of sca effect		-5.00 to 4.06	-2.37 to 3.52	-4.17 to 7.03	-1.63 to 2.68	-49.54 to 50.97	-4.61 to 7.31	-4.67 to 6.99	-7.92 to 7.38
Number of significant and positive crosses		6	3	7	5	6	5	7	3
Number of significant and negative crosses		6	0	7	3	6	2	9	5
Correlation between *per se* and sca effects		0.83**	0.74**	0.81**	0.80**	0.84**	0.72**	0.96**	0.93**

In majority of cases, the best specific combinations for different characters were good × poor, average × average or average × good and *vice versa* general combiners. This suggested that information on gca effects should be supplemented by sca effects and hybrid performance of cross combination to predict the transgressive type possibly made available in segregating generations to make their use in future breeding programme.

From Table 2 to 6 it can be seen that *per se* performance of hybrids with their sca effect and heterobeltiosis are highly significant and positively associated for all characters which means that increase in *per se* performance of one character will lead to increase in sca effect and heterobeltiosis of that character and *vice versa*. While, correlation between heterobeltiosis and sca effect as well as standard heterosis and sca effect are also found highly significant and positive which lead to better association of *per se* performance either with heterobeltiosis or standard heterosis in next generation. It is fact that *per se* performance is a realized value, whereas sca effect is an estimate value, measured as the deviation of F_1 over the parental performance. Therefore, for a given cross, performance of sca effect may or may not be high depending upon the performance of parental lines. There was significant and positive correlation between heterobeltiosis and standard heterosis for all the characters studied. The association between *per se* performance of parents and their gca effects suggested that while selecting the parents for hybridization programme, *per se* performance of parents should be given due consideration. If a cross combination showing high sca effects involving both the parents with good gca effects, the same is likely to be exploited rather more profitably in a varietal breeding programme.

Conclusion

From the data presented in this study, it could be concluded that both additive and non-additive gene actions played the major role with predominance of non-additive gene action in inheritance of various traits. Genotypes Punjab Suhavani exhibited good gca effects for fruit yield and earliness traits and could be exploited for future breeding programmes. Cross combinations Punjab Suhavani × Pusa Sawani and AOL-19-12 × AOL-18-08, appeared to be most superior in terms of fruit yield and some of earliness characters. These hybrids recorded 28.34 and 21.88 percent higher yield over standard check (GJOH-4), respectively in desirable direction for fruit yield and most of its attributing traits. Therefore, these two crosses could be exploited for heterosis breeding programme to boost the fruit yield in okra. Thus, breeding methods like reciprocal recurrent selection could be followed for improvement of okra.

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