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Heterosis studies of fruit yield and its component traits in okra [*Abelmoschus esculentus* (L.) Moench]

Pravallika Poluru, MM Pandya, Amar A Sakure and Patel NA

Abstract
The present investigation in okra intended to examine and estimate the heterosis for fruit yield and its contributing characters. L × T mating design was used to create 48 cross combinations from 6 lines and 8 testers and enough F_1 seeds were produced in summer 2022. The F_1's along with their 14 parents and one standard check (GJOH 4) were evaluated during *kharif* 2022. The heterobeltiosis for fruit yield per plant varied from -28.22% (GAO 8 × AOL 20-05) to 19.40% (AOL 18-06 × AOL 19-12) for fruit yield per plant while for useful heterosis values varied from -24.87% (Phule Prajatika × AOL 21-14) to 90.81% (GAO 5 × AOL 20-03). GAO 5 × AOL 20-03, GAO 8 × AOL 20-03 and AOL 21-10 × AOL 20-03 were the top three crosses which had high *per se* performance as well as significant and higher estimates of standard heterosis for fruit yield per plant and its contributing traits.

Keywords: Heterobeltiosis, standard heterosis, okra, line × tester mating design

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] is one of the world's oldest and important vegetable and medicinal crop belonging to the family Malvaceae. The chromosome number varies greatly ranging from polyploid to diploid from 2n=66 to 144. The crop is often cross-pollinated with cross pollination ranging from 4 to 18 percent (Purewal and Randhawa, 1947) [5]. The fruit of okra is a capsule and is a highly nutritive vegetable which contains moisture of 90.19 g, protein 2.0 g, carbohydrates 7.45 g, vitamins (ascorbic acid 23 mg, niacin 1 mg, thiamine 0.2 mg), minerals (calcium 82 mg, potassium 299 mg, magnesium 57 mg, zinc 0.58 mg, iron 0.62 mg), sugars 1.48 g and fibres 3.2 g per 100 gm of edible portion (Kumar *et al.*, 2013) [8].

Heterosis breeding has been recognized as a practical tool in providing information to the breeders as mean of increasing yield and other economic traits. It is a result of the favourable combinations of genes from different parental lines, leading to increased yield, improved quality traits, enhanced disease resistance or other desirable attributes in the hybrid progeny. By studying heterosis, breeders can identify and select superior parental lines for developing high-performing hybrid varieties.

Material and Methods

The present investigation for heterosis studies in Okra (*Abelmoschus esculentus* (L.) Moench) was conducted at Main Vegetable Research Station (MVRS), Anand during summer 2022 (crossing) and *kharif* 2022 (evaluation). 6 lines and 8 testers were from MVRS in which Phule Prajatika was obtained from Mahatma Phule Krishi Vidyapeeth, Rahuri and standard check GJOH 4 was obtained from Vegetable Research Station, JAU, Junagadh. Total 63 genotypes comprising 48 crosses, 14 parents and one check was evaluated in randomized complete block design with three replications. All treatments were grown at 60 × 30 cm spacing and recommended practices was applied. Total 10 observations were recorded including yield and its contributing traits. Heterosis was calculated using the formula

$$\text{Heterobeltiosis (\%)} = \frac{\overline{F}_1 - \overline{BP}}{\overline{BP}} \times 100 \text{ (over better parent)}$$

$$\text{Standard heterosis (\%)} = \frac{\overline{F}_1 - \overline{SC}}{\overline{SC}} \times 100 \text{ (over standard check)}$$

Results and Discussion

The analysis of variance showed that the mean sum of squares due to genotypes were highly significant for fruit yield per plant and 9 other contributing traits. The mean sum of squares due to genotypes (Table 1) was further divided into different sources of variances which includes parents, hybrids, parents *vs* hybrids. The mean sum of squares for parents was further partitioned into females, males and females *vs* males. The variance attributed to parents was significant for all traits except fruit girth and fruit length. Variances were found to be significant for all traits except fruit length, fruit girth (both males and females), branches per plant (Females). 48 hybrids generated by crossing line × tester revealed that hybrids were significantly differing for all traits. The mean sum of squares due to parents *vs* hybrids were significant for all traits except days to 50 percent flowering, fruit length, fruit girth, plant height, internodal length, The analysis of variance for 10 characters were mentioned in Table 1.

Heterosis is considered positively significant for all the characters except days to 50 percent flowering as early flowering is desirable for this trait. The nature and magnitude of heterosis for fruit yield and its component traits over better parent and standard check (GJOH 4) for 10 characters were represented in Table 2 and 3.

Days to 50 percent flowering

In case of days to 50 percent flowering, heterobeltiosis values ranged from -6.30% (AOL 18-06 × AOL 19-12) to 14.55% (Phule Prajatika × AOL 20-03). Hybrid which flowered earlier was Phule Prajatika × AOL 20-05 (8.19%). Standard heterosis values for days to 50 percent flowering varied from -8.60% (Red One Long × AOL 21-09, AOL 21-10 × AOL 21-09) to 7.04% (GAO 5 × AOL 20-03). Significant negative heterobeltiosis was observed for earlier flowering in AOL 21-10 × AOL 21-09 and Red One Long × AOL 21-09 (-8.60%). Results for this character were desirable in negative direction. Similar observations for heterobeltiosis and standard heterosis were also reported by Jindal *et al.* (2010) [6], Kumar and Sreeparvathy (2010) [9], Solankey *et al.* (2011) [20], Reddy (2012) [16], Javia *et al.* (2013) [5], Kishor *et al.* (2013) [7], Tiwari *et al.* (2015) [21].

Fruits per plant

For fruits per plant, range of heterobeltiosis varied from -25.18% (GAO 8 × AOL 20-05) to 11.77% (Phule Prajatika × AOL 19-05). Standard heterosis for fruits per plant varied from -26.42% (AOL 18-06 × AOL 20-04) to 69.82% (AOL 21-10 × AOL 20-03). Hybrid AOL 21-10 × AOL 20-03 (69.82%) revealed high standard heterosis for fruits per plant. The results are in concordant for standard heterosis and dissimilar for better parent heterosis with the findings of Kumar and Sreeparvathy (2010) [9], Adiger *et al.* (2013a) [1], Neetu *et al.* (2015) [13], Hadiya *et al.* (2018) [2], Makdoomi *et al.* (2018) [10].

Fruit weight

Fruit weight was recorded and heterobeltiosis results varied from -14.63% (GAO 8 × AOL 21-14) to 13.04% (AOL 18-06 × AOL 20-03), the hybrid AOL 18-06 × AOL 20-04 (13.04%) had high heterobeltiosis for fruit weight and standard heterosis for fruit weight ranged from -7.95% (AOL 18-06 × AOL 19-07) to 17.06% (GAO 5 × AOL 19-12). GAO 5 × AOL 19-12 (17.06%) was the top cross exhibiting standard heterosis. Significant positive heterosis and heterobeltiosis were also reported by Jaiprakashnarayan (2008) [4], Medagam *et al.* (2012a) [11], Jagan (2013a) [3].

Fruit length

The heterobeltiosis results for fruit length in hybrids varied from -18.61% (Red One Long × AOL 20-04) to 11.86% (Red One Long × AOL 19-07). Standard heterosis for fruit length ranged from -20.91% (Red One Long × AOL 20-04) to 3.96% (Red One Long × AOL 19-07). No hybrid in the crosses had shown significant heterobeltiosis and standard heterosis. The results of present investigation revealed that both heterobeltiosis and standard heterosis had values in negative direction. The results were in disagreement with Medagam *et al.* (2012a) [11], Jagan (2013a) [3] and Kumar and Reddy (2016) [19].

Fruit girth

Fruit girth results for heterobeltiosis varied from -16.67% (AOL 18-06 × AOL 20-04) to 9.03% (AOL 18-06 × AOL 19-07). Standard heterosis for fruit girth ranged from -14.90% (AOL 18-06 × AOL 20-04) to 11.35% (AOL 18-06 × AOL 19-07). No hybrid in the crosses had shown significant heterobeltiosis and standard heterosis. The results of present investigation revealed that both heterobeltiosis and standard heterosis were in negative direction. The results were found in disagreement with Medagam *et al.* (2012a) [11], Jagan (2013a) [3] and Kumar and Reddy (2016) [19].

Fruit yield per plant

The heterobeltiosis for fruit yield per plant varied from -28.22% (GAO 8 × AOL 20-05) to 19.40% (AOL 18-06 × AOL 19-12). The top performing hybrid for better parent heterosis based on fruit yield per plant was AOL 18-06 × AOL 19-12 (19.40%). Results showed that for fruit yield per plant values varied from -24.87% (Phule Prajatika × AOL 21-14) to 90.81% (GAO 5 × AOL 20-03). GAO 5 × AOL 20-03 (90.81%) recorded highest standard heterosis for fruit yield per plant. The heterobeltiosis and standard heterosis results were in congruent with the findings of Jaiprakashnarayan *et al.* (2008) [4], Kumar and Sreeparvathy (2010) [9], Solankey *et al.* (2011) [20], Neetu *et al.* (2015) [13], Hadiya *et al.* (2018) [2].

Plant height

The heterobeltiosis results for plant height ranged from -23.24% (Red One Long × AOL 20-03) to 10.86% (AOL 18-06 × AOL 19-07). Best significant cross combination over better parent for plant height was AOL 18-06 × AOL 19-07 (10.86%). Standard heterosis for plant height ranged between -22.68% (AOL 21-10 × AOL 21-14) to 6.69% (Red One Long × AOL 20-04). No hybrid in the crosses had shown significant heterobeltiosis and standard heterosis. The results for heterobeltiosis were in agreement and for standard heterosis were in disagreement with the findings of Kumar and Sreeparvathy (2010) [9], Medagam *et al.* (2012a) [11], Jagan *et al.* (2013a) [3], Tiwari *et al.* (2015) [21] and Patel and Patel (2016) [14]

Nodes per plant
Results for nodes per plant varied from -25.00% (Red One Long × AOL 20-05) to 17.40% (AOL 18-06 × AOL 21-09). The hybrid AOL 18-06 × AOL 21-09 (17.40%) recorded highest heterobeltiosis for number of nodes per plant. Standard heterosis for nodes per plant varied from –26.42% (Red One Long × AOL 20-05 and AOL 21-10 × AOL 21-14) to 64.16% (AOL 21-10 × AOL 20-03). High standard heterosis was observed in AOL 21-10 × AOL 20-03 (64.16%) for nodes per plant. More number of fruiting nodes with shorter distance would be helpful in increasing the number of fruits per plant, which in turn gives more yield per plant. The estimates for this trait were in concordance with Nama *et al.* (2017) [12], Satish *et al.* (2017a) [17], Makdoomi *et al.* (2018) [10].

Internodal length
The heterobeltiosis for internodal length varied from -56.61% (GAO 5 × AOL 20-03) to 15.00% (Red One Long × AOL 20-04). The hybrid Red One Long × AOL 20-04 (15.00%) recorded maximum internodal length. Standard heterosis for internodal length varied from –51.97% (Red One Long × AOL 20-04) to 23.73% (Red One Long × AOL 20-04). Top performing hybrid for standard heterosis was Red One Long × AOL 20-04 (23.73%). Positive results for heterobeltiosis and standard heterosis were in confirmity with reports of Jindal *et al.* (2010) [6], Solankey *et al.* (2011) [20], Medagam (2012a) [11], Javia *et al.* (2013) [5], Kumar and Reddy (2016) [19], Patel and Patel (2016) [14].

Branches per plant
The heterobeltiosis varied for branches per plant from -30.00% (GAO 8 × AOL 20-05) to 25.00% (AOL 21-10 × AOL 19-12). Standard heterosis for branches per plant varied from -12.50% (GAO 8 × AOL 20-05) to 50.00% (AOL 21-10 × AOL 20-03). Top performing hybrid for standard heterosis was to GAO 8 × AOL 20-03, GAO 8 × AOL 21-14, AOL 18-06 × AOL 20-03 and AOL 21-10 × AOL 20-03 (50.00%). The results for heterobeltiosis were dissimilar and standard heterosis were similar with findings of Kumar and Sreeparvathy (2010) [9], Kumar and Reddy (2016) [19], Patel and Patel (2016) [14].

Table 1: Analysis of variances (Mean squares) for various characters

Sr. No.	Sources of variation			df	Days to 50 percent flowering	Fruits per plant	Fruit weight	Fruit length	Fruit girth
1.	Replications			2	2.26	3.81	0.88	1.00	0.10
2.	Genotypes			62	9.46**	52.97**	1.60**	2.09**	0.20**
	a	Parents		13	14.81**	35.64**	1.38**	0.35	0.16
		1	Females	5	16.49**	6.36*	1.38*	0.66	0.12
		2	Males	7	12.55**	60.00**	1.22*	0.17	0.17
		3	Females *vs* Males	1	22.29**	11.46*	2.54*	0.03	0.35
	b	Hybrids		47	8.22**	59.68**	1.50**	2.62**	0.22**
	c	Parents *vs* Hybrids		1	4.60	16.10**	10.78**	0.68	0.25
3.	Error			124	3.15	2.14	0.56	1.06	0.12

Sr. No.	Sources of variation			df	Internodal length	Branches Per plant	Fruit yield Per plant	Plant height	Nodes per plant
1.	Replications			2	0.92	5.10**	396.28	12.77	6.56
2.	Genotypes			62	6.93**	0.77*	9556.14**	397.25**	47.12**
	a	Parents		13	7.55**	0.33*	7174.75**	602.45**	36.24**
		1	Females	5	5.07**	0.27	2266.22**	533.20**	7.02**
		2	Males	7	9.84**	0.42*	11677.34**	667.69**	60.33**
		3	Females *vs* Males	1	3.90*	0.02	199.33	492.07**	13.67*
	b	Hybrids		47	7.04**	0.89**	10416.41**	342.71**	51.91**
	c	Parents *vs* Hybrids		1	0.09	1.19*	9549.17**	135.67	10.63*
3.	Error			124	0.58	0.18	198.99	59.54	2.14

*, ** Significant at P = 0.05 and P = 0.01 levels of probability, respectively

Table 2: Estimate of heterobeltiosis (HB) and standard heterosis (SH) in percent for days to 50 percent flowering, fruits per plant, fruit weight, fruit length, fruit girth, fruit yield per plant, plant height and nodes per plant in okra

Hybrids	Days to 50 percent flowering		Fruits per plant		Fruit weight		Fruit length		Fruit girth		Fruit yield per plant		Plant height		Nodes per plant	
	BP	SH	BP	SH	BP	SH	BP	SH	BP	SH	BP	SH	BP	SH	BP	SH
GAO 8 × AOL 19-05	-1.63	-5.47	10.55	22.65**	-4.33	4.12	-3.50	-6.50	4.35	2.13	5.88	27.85**	6.88	-3.58	9.10	13.21
GAO 8 × AOL 19-07	-0.81	-3.91	-16.67**	-7.55	5.55	14.86**	5.25	1.98	1.48	-2.13	-12.45*	5.73	2.95	-8.12	-18.19**	-15.10*
GAO 8 × AOL 19-12	4.84	1.57	2.05	13.21	-6.49	1.77	-0.30	-3.39	0.69	3.55	-4.42	15.43**	2.87	-14.32**	5.46	9.44
GAO 8 × AOL 20-03	6.46	3.13	1.17	64.16**	3.79	12.95*	2.05	-1.13	0.70	2.13	7.35*	85.55**	-3.44	-19.58**	-7.06	49.06**
GAO 8 × AOL 20-04	-1.62	-4.69	-16.67**	-7.55	5.33	14.62**	-4.07	-6.78	-1.43	-2.13	-12.81**	5.30	-9.17	-17.19**	-12.73	-9.44
GAO 8 × AOL 20-05	-0.81	-3.91	-25.18**	-16.99*	-2.25	6.39	2.63	-0.57	2.12	2.84	-28.22**	-13.31*	-2.64	-3.11	-14.55*	-11.33
GAO 8 × AOL 21-09	2.48	-3.13	2.05	13.21	-1.63	7.06	2.63	-0.57	-8.83	-12.06*	0.50	21.36**	4.88	-12.65**	-1.82	1.89
GAO 8 × AOL 21-14	-1.62	-4.69	-11.57	-1.89	-14.63**	-7.09	-11.67	-14.41*	2.88	1.42	-25.11**	-9.57	-14.81**	-16.23**	-9.10	-5.67
GAO 5 × AOL 19-05	-1.63	-5.47	5.89	1.89	3.39	7.65	-3.94	-3.39	2.90	0.71	11.63*	9.70	-19.17**	-16.47**	-2.05	-9.44
GAO 5 × AOL 19-07	1.57	1.57	4.00	-1.89	0.57	4.71	-1.13	-0.57	4.35	2.13	4.65	2.84	0.70	4.06	11.12	-5.67
GAO 5 × AOL 19-12	-1.58	-2.35	-21.16**	-22.65**	12.43*	17.06**	-3.38	-2.83	-4.14	-1.42	-8.95	-10.53	-18.25**	-15.52**	-9.81	-13.21
GAO 5 × AOL 20-03	6.21	7.04*	3.49	67.93**	6.63	13.53*	-7.31	-6.78	2.10	3.55	10.39**	90.81**	-17.33**	-14.56**	1.18	62.27**
GAO 5 × AOL 20-04	-3.13	-3.13	8.00	1.89	-8.48	-4.71	-18.54*	-18.08*	1.43	0.71	-1.26	-2.97	-20.10**	-17.43**	8.89	-7.55
GAO 5 × AOL 20-05	2.33	3.13	-10.00	-15.10*	-3.03	0.98	-7.31	-6.78	1.41	2.13	-14.07*	-15.56**	-2.78	0.48	6.13	-1.89
GAO 5 × AOL 21-09	3.31	-2.35	4.00	-1.89	-4.75	-0.83	0.57	1.13	2.90	0.71	0.84	-0.92	-20.33**	-17.67**	4.35	-9.44
GAO 5 × AOL 21-14	1.62	-1.57	-10.00	-15.10*	0.77	4.92	0.29	0.85	-6.48	-7.81	-9.41	-10.98	-12.48**	-9.55*	8.09	-4.16
AOL 18-06 × AOL 19-05	-0.82	-4.69	-7.85	-11.33	-1.20	-2.36	1.85	-6.22	0.70	2.84	-9.01	-13.50*	4.91	-3.11	-10.21	-16.99*
AOL 18-06 × AOL 19-07	5.52	4.69	2.00	-3.78	-5.16	-7.95	2.13	-5.09	9.03	11.35	-1.28	-11.35	10.86*	2.39	6.67	-9.44
AOL 18-06 × AOL 19-12	-6.30	-7.04*	6.54	4.53	9.70	6.48	1.86	-6.78	2.76	5.68	19.40**	11.33	1.04	-6.69	-1.97	-5.67
AOL 18-06 × AOL 20-03	6.30	5.47	-15.12**	37.74**	-4.84	1.33	1.20	-4.24	1.39	3.55	-19.62**	38.95**	5.69	-2.39	-16.48**	33.97**
AOL 18-06 × AOL 20-04	-0.79	-1.57	-20.41**	-26.42**	13.04*	9.71	-17.16*	-19.5**	-16.67**	-14.90*	-10.95	-20.02**	2.59	-5.26	6.67	-9.44
AOL 18-06 × AOL 20-05	-3.15	-3.91	2.05	-5.67	1.22	-1.77	8.19	0.85	2.09	4.26	2.97	-7.53	-4.08	-4.54	-6.13	-13.21
AOL 18-06 × AOL 21-09	0.83	-4.69	3.20	-2.65	1.22	-1.77	2.49	-6.78	-0.7	1.42	6.61	-4.27	1.04	-6.69	17.40*	1.89
AOL 18-06 × AOL 21-14	0.81	-2.35	-16.33*	-22.65**	8.43	5.24	2.09	-3.39	4.87	7.10	-9.76	-18.96**	5.59	3.82	6.39	-5.67
Phule Prajatika × AOL 19-05	10.00*	-5.47	11.77	7.55	-1.79	-2.95	2.46	-5.65	1.38	4.26	9.92	4.50	-0.27	-10.03*	5.89	1.89
Phule Prajatika × AOL 19-07	7.28	-7.82*	-4.01	-9.44	-2.23	-6.83	0.92	-6.22	-10.35	-7.81	-1.53	-16.62**	0.27	-10.51*	-14.51*	-17.74**
Phule Prajatika × AOL 19-12	11.82**	-3.91	3.85	1.89	12.97*	7.65	4.94	-3.96	-6.90	-4.26	15.51*	7.70	2.71	-18.38**	-1.97	-5.67
Phule Prajatika × AOL 20-03	14.55**	-1.57	3.49	67.93**	-2.21	4.12	-6.87	-11.87	2.76	5.68	1.27	75.04**	3.31	-17.9**	1.18	62.27**
Phule Prajatika × AOL 20-04	9.10*	-6.25	-4.17	-13.21	-2.75	-7.33	-6.40	-9.04	-6.21	-3.55	-3.18	-19.86**	9.95*	0.24	-5.89	-9.44
Phule Prajatika × AOL 20-05	8.19*	-7.04*	8.70	-5.67	5.83	1.48	9.10	1.70	2.07	4.97	15.70*	-4.24	-9.84*	-10.27*	-7.85	-11.33
Phule Prajatika × AOL 21-09	10.00*	-5.47	4.00	-1.89	0.93	-3.83	2.47	-6.22	2.07	4.97	7.83	-5.43	3.21	-15.52**	-3.93	-7.55
Phule Prajatika × AOL 21-14	10.00*	-5.47	-14.59	-22.65**	1.80	-3.01	6.27	0.57	0.69	3.55	-10.96	-24.87**	-13.84	-15.28**	-23.14**	-26.04**
AOL 21-10 × AOL 19-05	-0.82	-5.47	-21.57**	-24.53**	2.98	1.77	3.07	-5.09	-3.29	4.26	-19.77**	-23.72**	6.81	-2.63	-6.13	-13.21
AOL 21-10 × AOL 19-07	0.82	-3.91	10.00	3.78	5.36	4.12	3.35	-3.96	-5.27	2.13	18.18**	8.07	-6.29	-14.56**	15.56	-1.89
AOL 21-10 × AOL 19-12	2.46	-2.35	-7.70	-9.44	1.79	0.59	9.57	0.29	1.98	9.93	-2.40	-9.00	10.21*	0.48	-11.77	-15.10*
AOL 21-10 × AOL 20-03	9.84**	4.69	4.66	69.82**	0.56	7.06	5.08	-0.57	-8.56	-1.42	5.15	81.75**	-6.03	-14.32**	2.36	64.16**
AOL 21-10 × AOL 20-04	-1.64	-6.25	6.94	-1.14	0.30	-0.89	-4.07	-6.78	0.66	8.52	7.16	-2.03	5.24	-4.06	6.67	-9.44
AOL 21-10 x AOL 20-05	9.02*	3.91	1.64	-6.04	-5.36	-6.48	8.49	1.13	-13.16*	-6.39	-3.76	-12.00*	-14.87**	-15.28**	-2.05	-9.44
AOL 21-10 x AOL 21-09	-3.31	-8.60*	-6.01	-11.33	-0.27	-1.45	3.73	-5.65	-7.90	-0.71	-4.88	-13.02*	1.31	-7.64	4.35	-9.44
AOL 21-10 x AOL 21-14	2.46	-2.35	-10.21	-16.99*	5.60	4.36	8.66	2.83	1.98	9.93	-7.60	-15.51**	-21.36**	-22.68**	-17.03*	-26.42**
Red One Long x AOL19-05	0.82	-3.13	7.85	3.78	1.79	0.59	-5.20	-12.43	2.73	7.10	7.92	2.60	2.12	3.82	-1.93	-3.78
Red One Long x AOL19-07	-3.91	-3.91	-12.00	-16.99*	6.67	-1.18	11.86	3.96	2.05	6.39	-2.03	-15.69**	-8.69	-7.16	-18.08**	-19.63**
Red One Long x AOL19-12	-2.37	-3.13	8.08	6.04	8.36	2.95	2.15	-5.65	-2.73	1.42	17.05**	9.14	-17.38**	-16.00**	3.85	1.89
Red One Long x AOL20-03	4.69	4.69	1.17	64.16**	-2.21	4.12	2.99	-2.55	-4.77	-0.71	-1.14	70.89**	-23.24**	-21.96**	1.18	62.27**
Red One Long x AOL 20-04	-3.13	-3.13	4.48	-3.02	4.77	-2.95	-18.61*	-20.91**	5.45	9.93	9.24	-5.99	4.93	6.69	-11.54	-13.21
Red One Long x AOL20-05	-1.57	-1.57	-6.51	-13.21	2.15	-2.06	7.58	0.29	-14.97*	-11.35	-1.13	-14.91*	-12.92**	-11.46*	-25.00**	-26.42**
Red One Long x AOL 21-09	-3.31	-8.60*	0.80	-4.91	2.85	-4.42	5.82	-2.26	2.05	6.39	3.79	-8.98	-12.21**	-10.74*	-17.31*	-18.87**
Red One Long x AOL21-14	0.81	-2.35	-8.54	-15.10*	2.54	-4.71	0.90	-4.52	-2.05	2.13	-5.87	-18.99**	-17.61**	-16.23**	-23.08**	-24.53**

*, ** Significant at P = 0.05 and P = 0.01 levels of probability, respectively.

Table 3: Estimate of heterobeltiosis (HB) and standard heterosis (SH) in percent for internodal length, branches per plant

Hybrids	Internodal length		Branches per plant		Hybrids	Internodal length		Branches per plant	
	BP	SH	BP	SH		BP	SH	BP	SH
Phule Prajatika × AOL 19-05	-10.53	-11.86	-10.00	12.50	GAO 8 × AOL 19-05	-13.61	-14.90	-10.00	12.50
Phule Prajatika × AOL 19-07	3.83	9.03	**-30.00****	-12.50	GAO 8 × AOL 19-07	3.33	8.51	10.00	37.50**
Phule Prajatika × AOL 19-12	4.85	-13.23	10.00	37.50**	GAO 8 × AOL 19-12	-2.47	-21.74**	-10.00	12.50
Phule Prajatika × AOL 20-03	-38.83**	-49.38**	9.10	50.00**	GAO 8 × AOL 20-03	-32.71**	-46.01**	9.10	50.00**
Phule Prajatika × AOL 20-04	3.49	11.34	10.00	37.50**	GAO 8 × AOL 20-04	-14.83*	-8.37	-10.00	12.50
Phule Prajatika × AOL 20-05	-6.18	1.16	10.00	37.50**	GAO 8 × AOL 20-05	1.97	9.93	-30.00**	-12.50
Phule Prajatika × AOL 21-09	-3.10	-8.32	10.00	37.50**	GAO 8 × AOL 21-09	-8.99	-13.89	10.00	37.50**
Phule Prajatika × AOL 21-14	2.50	14.39	-30.00**	-12.50	GAO 8 × AOL 21-14	-20.08**	-10.80	20.00	50.00**
AOL 21-10 × AOL 19-05	2.10	12.26	12.50	12.50	GAO 5 × AOL 19-05	-24.12**	-7.54	11.12	25.00
AOL 21-10 × AOL 19-07	-20.47**	-12.55	10.00	37.50**	GAO 5 × AOL 19-07	-9.30	10.52	10.00	37.50**
AOL 21-10 × AOL 19-12	7.55	18.25*	25.00	25.00	GAO 5 × AOL 19-12	-23.33**	-6.57	11.12	25.00
AOL 21-10 × AOL 20-03	-52.12**	-47.35**	9.10	50.00**	GAO 5 × AOL 20-03	-56.61**	-47.12**	-9.10	25.00
AOL 21-10 × AOL 20-04	-3.52	6.09	25.00	25.00	GAO 5 × AOL 20-04	-26.13**	-9.99	-22.23	-12.50
AOL 21-10 x AOL 20-05	-14.08	-5.53	-22.23	-12.50	GAO 5 × AOL 20-05	-12.40	6.75	11.12	25.00
AOL 21-10 x AOL 21-09	-6.40	2.92	11.12	25.00	GAO 5 × AOL 21-09	-25.62**	-9.37	11.12	25.00
AOL 21-10 x AOL 21-14	-5.67	5.28	10.00	37.50**	GAO 5 × AOL 21-14	-18.72**	-0.96	-10.00	12.50
Red One Long x AOL19-05	4.05	7.94	-22.23	-12.50	AOL 18-06 × AOL 19-05	7.26	16.75*	12.50	12.50
Red One Long x AOL19-07	10.13	15.65*	10.00	37.50**	AOL 18-06 × AOL 19-07	4.86	14.14	10.00	37.50**
Red One Long x AOL19-12	-20.38**	-17.41*	22.23	37.50**	AOL 18-06 × AOL 19-12	-9.18	-1.14	25.00	25.00
Red One Long x AOL20-03	-53.70**	-51.97**	-18.19	12.50	AOL 18-06 × AOL 20-03	-33.10**	-27.18**	9.10	50.00**
Red One Long x AOL 20-04	15.00*	23.73**	11.12	25.00	AOL 18-06 × AOL 20-04	-3.09	5.50	12.50	12.50
Red One Long x AOL20-05	12.10	20.84**	-22.23	-12.50	AOL 18-06 × AOL 20-05	1.54	10.52	-22.23	-12.50
Red One Long x AOL 21-09	6.88	10.87	11.12	25.00	AOL 18-06 × AOL 21-09	-15.18*	-7.67	11.12	25.00
Red One Long x AOL21-14	-0.23	11.36	-30.00**	-12.50	AOL 18-06 × AOL 21-14	-1.24	10.23	-30.00**	-12.50

*, ** Significant at P = 0.05 and P = 0.01 levels of probability, respectively.

Conclusions

Significant levels of desirable heterobeltiosis and standard heterosis was registered in the current investigation for fruit yield per plant and its component traits. These suggests the possibility for improvement of okra through heterosis breeding. Out of 48 hybrids developed, superior hybrids based on heterobeltiosis for fruit yield per plant were AOL 18-06 × AOL 19-12 (19.40%) followed by AOL 21-10 × AOL 19-07 (18.18%) and Red One Long × AOL 19-12 (17.05%). Most promising hybrids based on the magnitude of useful heterosis were GAO 5 × AOL 20-03 (90.81%) followed by GAO 8 × AOL 20-03 (85.55%) and AOL 21-10 × AOL 20-03 (81.75%). Therefore, these cross combinations may be favoured for commercial cultivation as hybrids after critical evaluation in varied environments or over locations. These hybrids may also be further advanced for development of superior desirable recombinants as improved varieties.

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