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Short communication

Manifestation of heterosis in relation to seasonal variation in Okra [*Abelmoschus esculentus* (L.) Monech]

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Okra [*Abelmoschus esculentus* (L.) Moench] is an important vegetable crop in the tropics and sub-tropical parts of the world. India ranks first in the world with 4.53 million tonnes of okra produced (70% of the total world production) from over 0.43 million ha land (FAOSTAT, 2009). West Bengal is the leading state in area and production, while Andhra Pradesh has maximum productivity of okra (Anonymous, 2009). Exploitation of heterosis has been attempted and hybrid vigour has been reported with as much as 86 per cent increase yield (Elmaksoud *et al*., 1986). In India, the major cultivation problem in okra is lack of high yielding varieties/ hybrids along with location specificity and disease tolerance. Various approaches are being used to overcome this bottleneck, one of these may be use of hybrid technology utilizing appropriate genotypes for specific traits. Present investigation was carried out to estimate the magnitude of heterosis for fruit yield and its attributing traits in okra during rainy and summer season of 2007-2008 in randomized block design with three replications.

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The experimental material consists of 51 F_1s, 17 lines and 3 testers in which VRO-6 was treated as standard check parent. F_1s were developed by crossing the parental lines with testers in line × tester matting design during summer season of 2006 and the resulting crosses were grown and evaluated in the rainy season of 2007 and the F_1s developed during the rainy season were evaluated in the next summer season, 2008. Observations were recorded for ten characters viz., plant height (cm), stem diameter (cm), number of branches/plant, number of nodes/plant, internodal length (cm), days to first flowering, days to 50 per cent flowering, number of fruits/plant, single fruit weight (g) and fruit yield/plant (g).

Heterosis, the increase of F_1 mean over the better parental value and standard parent value, was calculated. Standard error of difference and critical difference for heterosis over better and standard parent (VRO-6) were calculated as follows and same were used for comparing two means.

$$\text{Per cent heterosis over better parent} = \frac{\overline{F_1} - \overline{BP}}{BP} \times 100$$

$$\text{Per cent heterosis over standard parent} = \frac{\overline{F_1} - \overline{SP}}{SP} \times 100$$

Where,

F_1 = Mean value of F_1's $\overline{BP}$ = Better parent value,

$\overline{SP}$ = Standard parent value.

Heterosis was computed as per cent increase or decrease in F_1's value over better parent (heterobeltiosis) and over the commercial variety, VRO-6 (standard heterosis) for 10 characters in 51 F_1s.

Table 1: Extent of heterosis over better parent (BP) and standard parent (SP) in 15 best hybrids for 10 characters in okra during rainy season.

S.N.	Crosses	Plant height (cm)		Number of branches/ plant		Number of nodes/ plant		Internodal length (cm)	
		Better Parent	Standard Parent	Better Parent	Standard Parent	Better Parent	Standard Parent	Better Parent	Standard Parent
1	VRO - 5 × PS	-0.81	-1.88	-22.03**	22.10*	-15.23*	-32.65**	49.87**	22.96*
2	VRO - 6 × PS	-1.34	-1.34	-30.51**	9.75	-23.79**	-23.77**	4.10	4.10
3	AC - 108 × AA	2.22	1.58	-29.46**	6.05	8.65	-8.85	1.40	-11.63
4	AC - 108 × PS	-11.28*	-12.23**	-50.85**	-19.88	-31.49**	-42.53**	43.85**	25.36*
5	IC - 45806 × AA	4.85	4.20	-39.29**	-7.53	26.58**	-19.34**	-17.33	3.75
6	IC - 218844 × AA	-10.87*	-11.43**	-46.43**	-17.41	-20.22**	-40.31**	-16.93	-11.68
7	Arka Abhay × PK	-23.24**	-22.32**	-30.30**	-6.30	-42.14**	-48.78**	39.59**	25.36*
8	IC - 43720 × AA	-9.69*	-9.82*	-31.25**	3.58	-0.81	-25.59**	-11.03	-3.70
9	IIVR-342 × PS	6.30	13.07**	-25.42**	17.16	18.02**	-6.23	-6.85	-5.23
10	EC - 305612 × AA	7.67	11.61**	-4.46	40.62**	77.97**	2.64	-38.72**	-14.29
11	EC - 305612 × PS	-4.82	-1.34	-54.24**	-24.81*	-27.66**	-42.53**	44.03**	46.54**
12	IIVR-401 × AA	7.97*	18.51**	-45.54**	-16.17	9.46	-22.97**	-6.44	19.61
13	IIVR-401 × PS	-17.98**	-9.97*	-40.68**	-5.06	-24.62**	-40.11**	23.13*	25.27**
14	SA - 2 × AA	-15.32**	-13.13**	-18.75*	20.86*	-20.61*	-47.17**	7.21	34.81**
15	IC - 140934 × AA	-3.42	3.33	-36.61**	-3.83	7.94	-17.73**	-10.83	0.78

Table 1. Continued

S.N.	Crosses	Days to 50% flowering		Number of fruits/plant		Fruit yield/plant (g)	
		Better Parent	Standard Parent	Better Parent	Standard Parent	Better Parent	Standard Parent
1	VRO - 5 × PS	12.50**	12.50**	5.73	-17.62**	8.33	-2.80*
2	VRO - 6 × PS	11.81**	11.81**	-14.96*	-14.94*	-10.13	4.98**
3	AC - 108 × AA	5.07*	0.69	-4.95	-14.27*	-30.35**	-3.74**
4	AC - 108 × PS	15.94**	11.11**	2.08	-23.42**	-6.70	-3.12*
5	IC - 45806 × AA	4.00	8.33**	-10.64	-19.40**	-23.05**	-1.87
6	IC - 218844 × AA	10.14**	5.56*	-38.86**	-44.85**	-36.45**	16.82**
7	Arka Abhay × PK	-4.61*	0.69	13.99	-12.70*	-14.78*	-3.24**
8	IC - 43720 × AA	-10.00**	-6.25**	-35.89**	-42.17**	-52.34**	-4.67**
9	IIVR-342 × PS	4.00	8.33**	3.27	-22.53**	11.68	-23.71**
10	EC - 305612 × AA	3.40	5.56*	-14.85*	-23.20**	13.78	-28.04**
11	EC - 305612 × PS	10.20**	12.50**	26.10**	-4.00	35.01**	-7.78
12	IIVR-401 × AA	3.33	7.64**	-9.16	-18.06**	27.13**	-25.98**
13	IIVR-401 × PS	4.00	8.33**	-15.26*	-28.11**	16.19	-20.63**
14	SA - 2 × AA	2.67	6.94**	-13.86*	-22.30**	14.53	-24.97**
15	IC - 140934 × AA	24.00**	29.17**	-1.49	-11.14	13.93	-21.31**

*, ** Significant at 5% and 1% probability levels, respectively. Where, AA = Arka Anamika, PS = Pusa Sawani, PK = Prabhani Kranti.

For plant height, out of 51 F_1 hybrids, only IIVR-198 × Arka Anamika showed maximum positively significant heterosis over both, better parent and standard variety during both the seasons. Many researchers including Singh and Syamal (2006) and Pitchaimuthu and Dutta (2002) has reported the similar pattern of heterosis for plant height in okra.

The heterosis for number of branches per plant was higher for IIVR-435 × Pusa Sawani (57.90 %) over standard parent during rainy season. Singh and Syamal

Table 2: Extent of heterosis over better parent (BP) and standard parent (SP) in 15 best hybrids for 10 characters in okra during summer season.

S.N.	Crosses	Plant height (cm)		Number of branches/ plant		Number of nodes/ plant		Internodal length (cm)	
		Better Parent	Standard Parent	Better Parent	Standard Parent	Better Parent	Standard Parent	Better Parent	Standard Parent
1	VRO - 5 × AA	-33.47**	-33.02**	-37.50**	2.25	-21.23**	-41.18**	-2.50	-7.14
2	VRO - 6 × AA	-8.30	-7.68	-47.50**	-14.11	-39.71**	-39.71**	133.33**	133.33**
3	AC - 108 × AA	-10.83	-10.23	-26.25**	20.65	-16.33*	-31.37**	14.18	82.14**
4	AC - 108 × PS	-8.40	-10.62	-33.90**	-20.25	-21.31**	-35.46**	33.58**	113.10**
5	IC - 45806 × AA	-5.94	-5.29	-50.00**	-18.20**	-8.40	-42.97**	10.31	154.76**
6	IC - 218844 × PK	-8.93	-5.72	-47.27**	-40.70**	-23.53**	-38.40**	27.52**	126.19**
7	Arka Abhay × AA	5.09	5.81	-43.75**	-7.98	17.91*	-17.16**	-0.64	85.71**
8	Arka Abhay × PK	-21.95**	-24.04**	-9.09	2.25	-23.95**	-46.57**	27.39**	138.10**
9	IIVR-342 × PS	2.65	3.62	21.95	2.25	16.41*	-14.22*	-8.02	77.38**
10	IC - 140906 × AA	-12.13*	-11.53*	-38.75**	0.20	-0.79	-38.24**	38.81**	121.43**
11	IIVR-435 × AA	-14.96**	-9.38	-36.44**	53.37**	-11.88*	-10.29	0.80	50.00**
12	IIVR-401 × AA	4.83	5.55	-73.75**	-57.06**	22.05*	-24.02**	-5.67	117.86**
13	IIVR-401 × PS	-14.21*	-13.82*	-29.27*	-40.70**	-11.75	-34.97**	6.79	105.95**
14	SA - 2 × AA	-9.47	-8.85	-28.75**	16.56	12.29	-25.33**	-10.00	82.14**
15	IC - 140934 × PS	-14.59*	-16.66**	-58.82**	-57.06**	-15.96*	-38.07**	-0.62	91.67**

Table 1. Continued

S.N.	Crosses	Days to 50% flowering		Number of fruits/plant		Fruit yield/plant (g)	
		Better Parent	Standard Parent	Better Parent	Standard Parent	Better Parent	Standard Parent
1	VRO - 5 × AA	4.08	6.25**	-4.23	-15.05**	18.91**	0.93
2	VRO - 6 × AA	0.00	0.00	-13.99**	-14.02**	1.31	1.31
3	AC - 108 × AA	7.43**	10.42**	11.92*	-0.72	37.76**	-0.47
4	AC - 108 × PS	4.17	4.17**	0.95	-27.33**	10.43	-23.06**
5	IC - 45806 × AA	4.08	6.25**	-10.77*	-20.85**	12.38	-18.81**
6	IC - 218844 × PK	10.42**	10.42**	-0.97	-30.40**	2.12	-16.64**
7	Arka Abhay × AA	6.94**	6.94**	14.23**	1.33	55.00**	11.98*
8	Arka Abhay × PK	2.08	2.08**	-15.42**	-30.74**	-13.19*	-29.13**
9	IIVR-342 × PS	4.26	2.08**	-9.56	-16.07**	0.14	-27.34**
10	IC - 140906 × AA	-2.78	-2.78**	-0.38	-11.63*	-16.73*	-32.02**
11	IIVR-435 × AA	-2.10	-2.78**	-17.69**	-26.99**	-18.74**	-33.66**
12	IIVR-401 × AA	-7.84**	-2.08**	-6.54	-17.09**	17.72**	-3.89
13	IIVR-401 × PS	4.17	4.17**	-17.45**	-33.81**	23.13**	-11.05*
14	SA - 2 × AA	-0.70	-1.39**	-13.46*	-23.23**	3.75	-15.30**
15	IC - 140934 × PS	4.17	4.17**	-0.95	-28.69**	4.04	-24.84**

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

(2006) and Desai *et al*. (2007) have also found heterosis for number of branches per plant.

For number of nodes per plant, the maximum heterosis over better parent and standard variety was 121.33 per cent (IIVR-198 × Prabhani Kranti) and 33.90 per cent (IIVR-198 × Prabhani Kranti), respectively for rainy season crop. However, the highest heterosis over better parent and standard parent for summer season crop was 86.45 per cent (IIVR-401 × Prabhani Kranti) and

57.37 per cent (IIVR-435 x Arka Anamika), respectively. Desai *et al*. (2007) have also reported similar seasonal variation in heterosis for number of nodes per plant.

Negative estimates were considered desirable for internodal length, days to first and 50 per cent flowering. Minimum heterosis of -44.93 per cent (IIVR-198 × Prabhani Kranti) and -32.98 per cent (VRO-5 × Arka Anamika) for better and standard parent, respectively during rainy season was recorded for intermodal length. However, during summer season crop the maximum negative heterosis over better parent was - 42.67 (IIVR-401 × Pusa Sawani).

The minimum heterosis over better parents and standard variety, respectively days to 50 per cent flowering was -10.00 and -6.25 per cent (IC-43720 × Arka Anamika) during rainy season. During summer season the minimum heterosis over better and standard parent was -7.84 per cent (IC-128883 × Arka Anamika) -6.25 per cent (SA-2 × Prabhani Kranti), respectively. The findings of this study are in accordance with those of Pitchaimuthu and Dutta (2002) and Singh and Syamal (2006) was reported negative heterosis for earliness.

Number of fruits per plant is one of the most important component of yield. The highest positive significant heterosis was found in EC-305612 × Pusa Sawani (26.10%) over better parent during rainy season and the hybrid EC-305612 × Arka Anamika (15.32%) showed maximum positively significant standard parent heterosis. The F_1 hybrid EC-305612 × Arka Anamika (15.32%) showed maximum positive significant standard parent heterosis, while the cross IIVR-198 × Prabhani Kranti (61.27%) had maximum positive significant better parent heterosis during summer season. In general, the hybrid with highest yield also expressed high heterosis for this trait. The work of Borgaonkar *et al.* (2005) and Desai *et al.* (2007) also supported the present findings that heterosis in yield was due to increased number of fruits per plant.

Fruit yield per plant being a complex trait and is a multiplicative product of several component traits of yield. Maximum heterosis for fruit yield was 37.80 per cent (VRO-5 × Pusa Sawani) over better parent during rainy season. Maximum heterosis for summer season was 55.00 per cent and 11.98 per cent in the hybrid Arka Abhay × Arka Anamika over better parent and standard variety (VRO-6), respectively.

On the basis of experiment, the outstanding hybrids for fruit yield was VRO-5 × Pusa Sawani during rainy season and Arka Abhay × Arka Anamika during summer season considering both the seasons together, the crosses IC - 218844 × Prabhani Kranti and VRO-5 × Pusa Sawani were the better performer for most of traits during the two seasons which can be exploited for commercial hybrid breeding.

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