



Combining Ability and Heterosis for Yield and its Contributing Characters in Okra (*Abelmoschus esculantus* (L.) Moench)

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Estimation of combining ability by line x tester analysis and magnitude of heterosis was conducted at Vegetable Research Farm, BHU, Varanasi, in a set of 8 parents (five lines and three testers) received from IIVR Varanasi by making 15 cross combinations evaluated during summer and kharif 2009 in RBD with three replications. The data on nine characters viz. plant height, number of primary branches, days to first flowering, total number of fruit plant⁻¹, fruit length, fruit girth, fresh fruit weight, internodal length and yield plant⁻¹ were utilized for the present study. On the basis of GCA effects across nine characters, Arka Abhay, VRO-6, Hissar Unnat and Punjab Padmini were identified as most promising parents for improving number of fruits plant⁻¹, fruit girth and days to 50% flowering. The most promising crosses showing significantly positive SCA effects and standard heterosis for fruit yield were Arka Abhay x Parbhani Kranti, Hissar Unnat x Punjab Padmini, VRO-6 x Parbhani Kranti and VRO-6 x Arka Anamika. These crosses should be exploited for further advancement in breeding programme for HYVs and early maturity, simultaneously.

Key words: Heterosis, Combining ability, GCA Variance, SCA Variance, Line x Testers and ANOVA.

Okra is a green vegetable with immense nutritive value being grown in tropical, subtropical and warm temperate region around the globe. India has emerged as second largest producer of vegetables after China, contributing about 133.73 mt from 7.98 mha having 16.7 t/ha productivity in 2009-10 (NHB database, 2010). India is the largest producer of okra having productivity 10.6 t/ha (NHB database, 2010). It is commonly known as Lady's finger, 'gumbo' or 'bhindi'. It originated from South Africa near Ethiopia in (De Condolle, 1883; Vavilov, 1951). It is extensively cultivated throughout India mainly in Indo-Gangetic plains during summer and rainy seasons for its large, slender and immature green fruit. Matured pods and stem containing crude fibres are used in paper industry and purifying sugarcane juice in preparation of jaggery in sugar industry (Singh, 1989; Akhtar *et al.*, 2010). It occupies good place in kitchen garden having two crops per year along with additional medicinal attributes e.g. anti-ulcer and relief in gastro-intestinal ulcer by neutralizing the digestive acids (Wammanda, 2010). In Mediterranean countries, the oil of okra seeds is used for cooking purpose. Okra is an often cross pollinated crop as the natural crossing occurs in this crop up to a range of 4-19% (Purewal and Randhawa, 1947 and Kumar *et al.* 2010). Emasculation and pollination events are easier due to large flower and monoadelphous stamens. It is essential to mitigate the future thrust of higher productivity by estimating the extent of combining

ability in lines and crosses for choosing lines of best general combining ability (GCA) and crosses of specific combining ability (SCA) (Sprague and Tatum 1942). GCA reveals the preponderance of additive gene effects while SCA reveals the intra-allelic (dominance) and inter-allelic interactions (epistasis).

For judicious application of heterotic vigour, it is imperative to assess the magnitude of genetic differences among the parents involved in the crosses, because high genetic diversity between parents shows maximum heterotic response (Moll and Stuber, 1976). Through Line x Tester analysis and heterosis estimation, our aim of current study was to identify best combiner genotypes and their crosses on the basis of GCA and SCA variances and effects on standard heterosis.

Materials and Methods

The present investigation was carried out during summer and kharif, 2009 at the Vegetable Research Farm, BHU, Varanasi (U.P.) which is situated at 25°15'2" N latitude and 83°03'0" E longitude, having elevation of 129.23 m above mean sea level. The genotypes under current study were procured from the germplasm collection of the Indian Institute of Vegetable Research, Varanasi, India and maintained through selfing. All the genotypes were grown in a crossing block during summer season 2009. Crosses were attempted in line x tester fashion involving five parents as male and three parents as females (Table 1). Seeds were harvested

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cross wise to raise next crop in kharif season. The seeds of 15 F₁s crosses were sown in Randomized Block Design with three replications. The parents and F₁s were shown in plots having rows of 20 plants with a spacing of 60x45cm. Recommended agronomic package and practices were applied to raise a healthy crop.

Data were recorded for nine yield and its contributing characters in okra viz. plant height (cm), number of primary branches plant⁻¹, days to first flowering, total number of fruits plants⁻¹, fruit length, fruit girth, fresh fruit weight, internodal length and Yield plant⁻¹. Data of ten plants of each genotype and its crosses were averaged replication wise and mean data was used for statistical analysis. The analysis of variance (ANOVA) for RBD was estimated crosswise according to Panse and Sukhtame (1989) and ANOVA for line x tester analysis was done according to Kempthorne (1957) and Singh and Chaudhary (1985). Heterosis over better parent and standard/check variety (VRO-6) was estimated

$$\text{Heterobeltiosis} = \frac{F_1 - BP}{BP} \quad \text{Standard Heterosis} = \frac{F_1 - \text{Check}}{\text{Check}}$$

Where, F₁ = mean performance of cross, BP = mean performance of better parent and Check = mean performance of standard variety and significance of heterosis is tested with the help of standard error using 't' test.

Table 2. ANOVA of combining ability by Line x Tester analysis for yield & its contributing characters in okra.

Source	Df	Plant height (cm)	No. of primary branches	Days to first flowering (days)	Total no. of fruits plant ⁻¹	Fruit Length (cm)	Fruit girth (cm)	Fruit Weight (gm)	Internodal length (cm)	Yield plant ⁻¹ (kg)
Replication	2	0.11	0.06	1.15	0.16	0.10**	0.03	0.02	0.01	0.04
Treatment	22	204.44**	0.08**	43.02**	11.31**	7.18**	0.01*	0.16**	0.41**	1000.99**
Parent	7	50.41**	0.02*	12.04**	6.86**	3.96**	0.02	0.59**	0.19**	221.08**
Parent vs cross	1	482.85**	0.82**	364.72**	23.80**	32.90**	0.04	7.68**	0.59**	9711.00**
Cross	14	261.5**	0.07**	35.53**	12.64**	6.96**	0.02*	1.80**	0.51**	768.80**
Line	4	166.23	0.05	29.42	14.18	10.19	0.03	0.58	0.31	1345.00*
Tester	2	338.36	0.01	35.90	10.85	13.61	0.02	4.05	0.66	1483.40*
Line x tester	8	290.03**	0.09**	38.50**	12.32**	3.68**	0.02	1.86**	0.57**	301.90**
Error	44	0.85	0.01	0.83	0.2820	0.01	0.01	0.01	0.01	1.67

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

Variances due to line x tester were significant for all the characters. There were no significant variances due to male and female for all the characters except yield plant⁻¹. Further, variances due to female x male were significant for all the characters, except fruit girth.

Estimate of GCA effect of Parents

The GCA effect reveals genetic worth of each parent. Negative significant GCA effect for plant height and days to first flowering are well exploited for further increment in yield and earliness (Table 3). The line VRO-5 and among testers Parbhani Kranti and Arka Anamika showed negative significant GCA effects for plant height. Among lines, Arka Abhay showed positive significant GCA effects for number of primary branches. Lines Arka Abhay and VRO-6 showed negative significant GCA effect for days to

Results and Discussion

ANOVA of combining ability analysis for yield and its contributing characters

Highly significant variances due to treatment were obtained for all the characters studied, except fruit girth that showed significant deviation (Table 2). Further, treatment variance was partitioned into **Table 1. Parents and their crosses involved in Line X Tester analysis.**

S. No. Parents used as line	Parents used as tester
A. Parents	
1. Arka Abhay	1. Parbhani Kranti
2. VRO-5	2. Punjab Padmini
3. VRO-6	3. Arka Anamika
4. Pusa Makhmali	
5. Hissar Unnat	
B. Crosses	
1. Arka Abhay x Parbhani Kranti	9. VRO-6 x Punjab Padmini
2. Arka Abhay x Punjab Padmini	10. Pusa Makhmali x Parbhani Kranti
3. Arka Abhay x Arka Anamika	11. Pusa Makhmali x Punjab Padmini
4. VRO-5 x Parbhani Kranti	12. Pusa Makhmali x Arka Anamika
5. VRO-5 x Punjab Padmini	13. Hissar Unnat x Parbhani Kranti
6. VRO-5 x Arka Anamika	14. Hissar Unnat x Punjab Padmini
7. VRO-6 x Parbhani Kranti	15. Hissar Unnat x Arka Anamika
8. VRO-6 x Punjab Padmini	

parent, cross and parent vs cross. Variance due to parent and crosses were significant for all the characters. Variances due to parent vs. cross were also significant for all the characters except fruit girth.

first flowering whereas among testers Punjab Padmini. Arka Abhay and Hissar Unnat exhibited significant positive GCA effect for total number of fruits plant⁻¹ while among testers, Punjab Padmini.

Fruit length is an important yield trait, which is directly valuable from marketing point of view. Three lines, namely Arka Abhay, VRO-5 and VRO-6 represented significant positive GCA effect while among testers Parbhani Kranti. The line VRO-6 showed significant positive GCA effect for fruit weight and among testers Parbhani Kranti. Three lines Arka Abhay, Hissar Unnat and VRO-6 represented positive significant GCA effect for yield plant⁻¹, however among testers Parbhani Kranti and Punjab Padmini. The lines, Arka Abhay and VRO-6 emerged as good general combiner for yield plant⁻¹, average

Table 3. GCA effect for various yield and its contributing characters in Line x Tester analysis in okra.

S. No.	Parents	Plant height (cm)	No. of primary branches	Days to first flowering (days)	Total no. of fruits plant ⁻¹	Fruit Length (cm)	Fruit girth (cm)	Fruit Weight (gm)	Internodal length (cm)	Yield plant ⁻¹ (kg)
1.	Aab	1.76**	0.11**	-2.09**	1.40**	1.06**	-0.07*	-0.047	-0.14**	12.80**
2.	VRO-5	-7.03**	-0.02	2.10**	-1.20**	0.90**	0.09*	0.05	0.32**	-13.86**
3.	VRO-6	2.43**	0.01	-1.67**	-0.40*	1.23**	-0.07	0.38**	-0.11**	2.46**
4.	PMk	-0.96**	-0.08*	1.02**	-1.06**	-0.90**	-0.07	-0.08	-0.01	-11.53**
5.	HU	3.80**	-0.02	0.66*	1.26**	-0.50**	-0.07	-0.31**	-0.04	10.13**
	SE	0.30	0.03	0.30	0.17	0.03	0.03	0.04	0.03	0.43
	CD at 95%	0.63	0.06	0.62	0.36	0.07	0.06	0.08	0.08	0.88
	CD at 99%	0.85	0.09	0.83	0.48	0.05	0.09	0.11	1.10	1.19
1.	PK	-2.53**	-0.01	1.66**	-0.33*	1.10**	0.07	0.60**	-0.20**	7.26**
2.	PP	5.46**	0.02	-1.39**	0.96**	-0.56**	-0.01	-0.28**	-0.02	4.06**
3.	A A	-3.11**	-0.01	-0.26	-0.63**	-0.54**	0.07	-0.32**	0.22**	-11.33**
	SE	0.23	0.02	0.23	0.13	0.02	0.02	0.031	0.03	0.33
	CD at 95%	0.48	0.05	0.48	0.28	0.05	0.05	0.06	0.06	0.68
	CD at 99%	0.65	0.07	0.64	0.37	0.07	0.07	0.08	0.08	0.92

** , * Significant at 1% and 5%, respectively. Lines: (1) Arka Abhay (AAb), (2) VRO-5, (3) VRO-6, (4) Pusa Makhmali (PMk), and (5) Hissar Unnat (HU); Testers: (1) Parbhani Kranti (PK), (2) Punjab Padmini (PP), and (3) Arka Anamika (AA)

combiner for plant height, total number of fruit plant⁻¹ and fruit length expressing significant additive gene effect as similar reported by Randhwa *et al.* (1989),

Sivakumar *et al.* (1995), Nichal *et al.* (2000), Khanpara *et al.* (2009), Javia *et al.* (2009), kumar *et al.* (2010) and Mitra and Das (2003). Punjab Padmini

Table 4. SCA effect for various yield and its contributing characters in Line x Tester analysis in okra.

S. No.	Crosses	Plant height (cm)	No. of primary branches	Days to first flowering (days)	Total no. of fruits plant ⁻¹	Fruit Length (cm)	Fruit girth (cm)	Fruit Weight (gm)	Internodal length (cm)	Yield plant ⁻¹ (kg)
1.	AAb x PK	-6.84**	0.04	1.13*	-0.30	1.33**	-0.07	-0.03	0.16*	-2.60**
2.	AAb x PP	11.13**	-0.19**	3.49**	2.40**	-0.60**	-0.08	-0.65**	0.08	11.60**
3.	AAb x AA	-4.28**	0.14*	-4.64**	-2.10**	-0.72**	0.093	0.06**	-0.25**	-9.00**
4.	VRO-5 x PK	1.75**	-0.02	-0.46	-1.20**	0.00	0.02	0.86**	-0.40**	0.06
5.	VRO-5 x PP	-1.76**	-0.16**	-2.70**	0.50	-0.94**	0.047	-0.65**	0.22**	-5.73**
6.	VRO-5 x AA	0.01	0.18**	3.16**	0.70*	0.94**	-0.07	-0.21**	0.18*	5.66
7.	VRO-6 x PK	3.48**	0.04	-3.68**	1.60**	0.16*	0.027	-0.76**	0.033	4.73**
8.	VRO-6 x PP	-13.53**	0.07	0.07	-3.20**	-0.17*	-0.05	1.21**	-0.04	-14.06**
9.	VRO-6 x AA	10.04**	-0.05	3.60**	1.60**	0.07	0.02	-0.44**	0.01	9.33**
10.	PMk x PK	5.68**	-0.05	3.33**	0.46	0.20**	-0.07	-0.20**	-0.66**	1.73*
11.	PMk x PP	-7.13**	0.10	-2.60**	-1.13**	0.36**	0.14*	0.48**	0.35**	-3.06**
12.	PMk x AA	1.44*	-0.053	-0.736	0.66*	-0.56**	-0.07	-0.28**	0.11	1.33
13.	HU x PK	-4.08**	-0.02**	-0.33	-0.56	-1.70**	0.02	0.13	0.66**	-3.93**
14.	HU x PP	11.30**	0.24**	1.73**	1.43**	1.36**	-0.05	-0.38**	-0.61**	11.27**
15.	HU x AA	-7.22**	-0.22**	-1.40*	-0.86**	0.34**	0.02	0.25**	-0.05	-7.333**

** , * Significant at 1% and 5%, respectively. Lines: (1) Arka Abhay (AAb), (2) VRO-5, (3) VRO-6, (4) Pusa Makhmali (PMk), and (5) Hissar Unnat (HU); Testers: (1) Parbhani Kranti (PK), (2) Punjab Padmini (PP), and (3) Arka Anamika (AA)

emerged as good general combiner for plant height, yield plant⁻¹ and having desirable significant negative GCA effect for days to first flowering for earliness as

similar reported by Pawar *et al.* (1999), Dhanker and Dhanker (2001), Singh *et al.* (2006), Weerasekara *et al.* (2008) and Singh *et al.* (2009).

Table 5. Estimation of average per cent of heterosis over better parent.

S. No.	Crosses	Plant height (cm)	No. of primary branches	Days to first flowering (days)	Total no. of fruits plant ⁻¹	Fruit Length (cm)	Fruit girth (cm)	Fruit Weight (gm)	Internodal length (cm)	Yield plant ⁻¹ (kg)
1.	AAb x PK	-4.25**	18.75**	-12.33**	2.13	27.01**	-6.25	5.66**	-9.52**	17.68**
2.	AAb x PP	23.83**	13.33*	-12.53**	23.40**	0.73	-12.50*	-6.73**	-13.33**	23.76**
3.	AAb x AA	-6.86**	25.00**	-29.08**	-9.04**	0.00	-5.88	10.00**	-11.63**	3.87**
4.	VRO-5 x PK	-4.45**	6.25	-9.09**	-12.29**	0.71	6.25	15.09**	-11.90**	13.86**
5.	VRO-5 x PP	1.35	0.00	-20.99**	4.47	-17.86**	6.25	-5.77**	0.00	8.43**
6.	VRO-5 x AA	-11.26**	18.75**	-5.19**	-4.95*	-4.29**	-5.88	2.00	9.30**	-2.76**
7.	VRO-6 x PK	7.05**	12.50*	-24.32**	25.32**	23.31**	6.67	2.83**	-11.90**	28.05**
8.	VRO-6 x PP	1.06	20.00**	-22.73**	0.64	8.27**	-6.25	15.83**	-15.56**	13.25**
9.	VRO-6 x AA	7.84**	6.25	-12.12**	4.40	9.77**	-5.88	-0.96	-4.65*	8.29**
10.	PMk x PK	5.82**	0.00	0.00	1.74	19.17**	0.00	3.77**	-26.67**	15.57**
11.	PMk x PP	4.26**	12.50*	-19.05**	0.00	5.79**	6.25	3.85**	-4.44*	10.78**
12.	PMk x AA	-3.92**	0.00	-11.90**	-4.40	-4.80**	-11.76*	0.00	-4.44*	-3.87**
13.	HU x PK	0.68	6.25	-9.30**	-1.05	15.32**	0.00	4.72**	4.76*	16.11**
14.	HU x PP	26.25**	33.33**	-6.63**	16.32**	17.36**	-6.25	-6.73**	-26.67**	22.78**
15.	HU x AA	-7.75**	-6.25	-8.40**	-4.21	5.60**	-5.88	3.00**	-4.65*	3.31**

** , * Significant at 1% and 5%, respectively. Lines : (1) Arka Abhay(AAb), (2) VRO-5,(3) VRO-6, (4) Pusa Makhmali (PMk), and (5) Hissar Unnat (HU); Testers : (1) Parbhani Kranti (PK), (2) Punjab Padmini (PP) and (3) Arka Anamika (AA).

Estimation of SCA effect of crosses

The ideal cross combination to be exploited is one where high magnitude of SCA effect is present in addition to high GCA effect in both or at least one

of the parents. The SCA effects of 15 F₁ hybrids with respect to nine yield contributing characters are represented in Table 4. Out of fifteen F₁ hybrids, seven cross combinations displayed negative

Table 6. Performance of standard heterosis over check parent VRO-6.

S. No.	Crosses	Plant height (cm)	No. of primary branches	Days to first flowering (days)	Total no. of fruits plant ⁻¹	Fruit Length (cm)	Fruit girth (cm)	Fruit Weight (gm)	Internodal length (cm)	Yield plant ⁻¹ (kg)
1.	AAb x PK	4.72**	26.67**	-14.32**	24.68**	30.83**	0.00	7.69**	-2.56	33.13**
2.	AAb x PP	33.71**	13.33*	-15.91**	50.68**	3.76**	-6.67	-6.73**	0.00	40.00**
3.	AAb x AA	6.74**	33.33**	-31.82**	11.04**	3.01**	6.67	5.77**	-2.56	17.50**
4.	VRO-5 x PK	4.49**	13.33*	-8.41**	1.95	6.02**	13.33*	17.31**	-5.13*	18.13**
5.	VRO-5 x PP	9.33**	6.67	-20.45**	21.43**	-13.53**	13.33*	-5.77**	15.38**	12.50**
6.	VRO-5 x AA	1.69	26.67**	-4.55*	12.34**	0.75	6.67	-1.92	20.51**	10.00**
7.	VRO-6 x PK	17.08**	20.00**	-24.32**	25.32**	23.31**	6.67	4.81**	-5.13*	31.25**
8.	VRO-6 x PP	6.74**	20.00**	-22.73**	2.60	8.27**	0.00	15.38**	-2.56	17.50**
9.	VRO-6 x AA	23.60**	13.33*	-12.12**	23.38**	9.77**	6.67	-0.96	5.13*	22.5**
10.	PMk xPK	15.73**	6.67	-2.27	13.64**	7.52**	0.00	5.77**	-15.38**	20.63**
11.	PMk x PP	10.11**	20.00**	-22.73**	11.69**	-3.76**	13.33*	3.85**	10.26**	15.63**
12.	PMk x AA	10.11**	6.67	-15.91**	12.99**	-10.53**	0.00	-3.85**	10.26**	8.75**
13.	HU x PK	10.11**	13.33*	-11.86**	22.08**	-3.76**	6.67	6.73**	12.82**	30.63**
14.	HU x PP	36.18**	33.33**	-13.64**	43.51**	6.77**	0.00	-6.73**	-15.38**	38.13**
15.	HU x AA	5.73**	0.00	-18.18**	18.18**	-0.75	6.67	-0.96	5.13*	16.88**

** , * Significant at 1% and 5%, respectively. Lines : (1) Arka Abhay(AAb), (2) VRO-5,(3) VRO-6, (4) Pusa Makhmali (PMk), and (5) Hissar Unnat (HU); Testers : (1) Parbhani Kranti (PK), (2) Punjab Padmini (PP) and (3) Arka Anamika (AA).

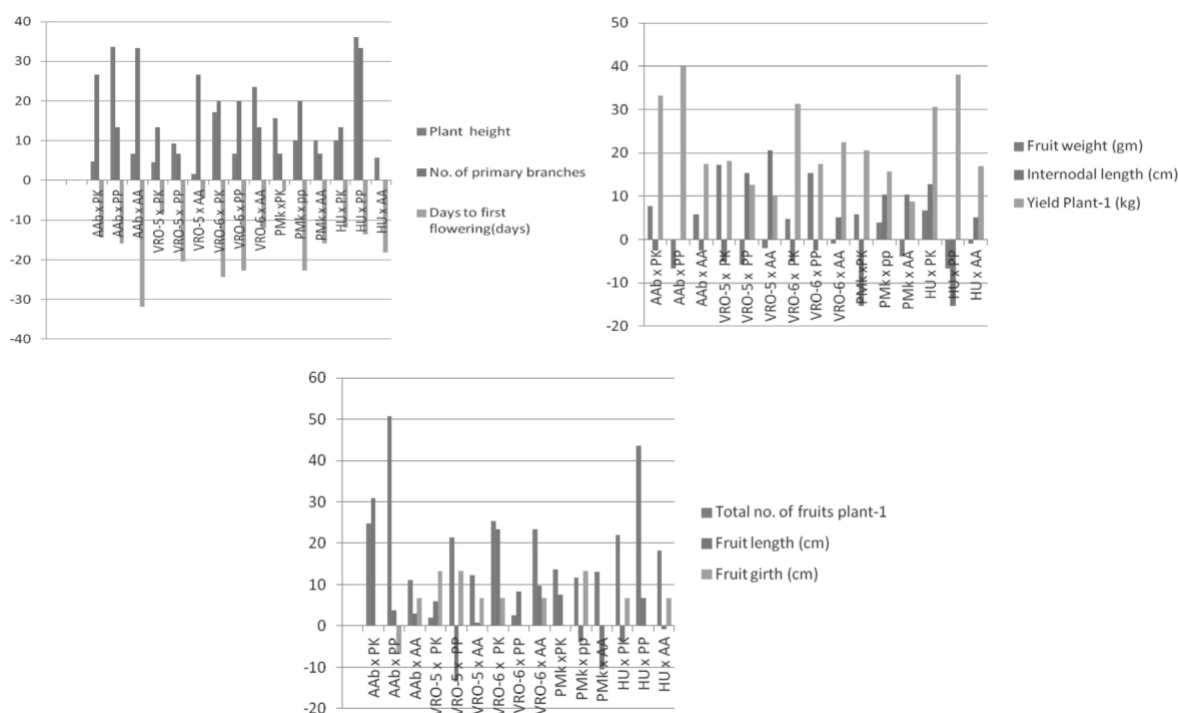


Fig.1. Graphical representation of Standard heterosis (Check variety VRO-6). Lines: (1) Arka Abhay (AAb), (2) VRO-5, (3) VRO-6, (4) Pusa Makhmali (PMk), and (5) Hissar Unnat (HU); Testers : (1) Parbhani Kranti (PK), (2) Punjab Padmini (PP), and (3) Arka Anamika (AA).

significant SCA effects for plant height, ranging from -13.53 (VRO-6 x Punjab Padmini) to -1.76 (VRO-5 x Punjab Padmini). Five crosses displayed negative significant SCA effect for days to first flowering that was highest for Arka Abhay x Arka Anamika (-4.64) and lowest for Hissar Unnat x Arka Anamika (-1.40). Six cross combinations exhibited positive significant

SCA effect for total number of fruits ranging from 0.66 (Pusa Makhmali x Arka Anamika) to 2.40 (Arka Abhay x Punjab Padmini). Hissar Unnat x Punjab Padmini cross (1.36) exhibits highest positive significant SCA effects for fruit length. Only cross combination, Pusa Makhmali x Punjab Padmini (0.14) exhibited positive significant SCA effect for

Fruit girth. Highest positive significant SCA effect for fruit weight was displayed by VRO-6 x Punjab Padmini (1.21), followed by VRO-5 x Parbhani Kranti (0.86). Out of fifteen crosses, five showed positive significant SCA effect for Yield plant⁻¹ ranging from 1.73 (Pusa Makhamali x Parbhani Kranti) to 11.60 (Arka Abhay x Punjab Padmini) as similar reported by Dhanker and Dhanker (2001) Kumar *et al.*(2006) and Weeraseskara *et al.*(2008). For all the nine characters studied, the crosses with significant SCA effects involved parents with high x high, high x low, low x high or low x low GCA effects. The SCA effects are found to be significant for seed yield and yield components. Five cross combinations, Arka Abhay x Punjab Padmini, VRO-6 x Parbhani Kranti, VRO-6 x Arka Anamika, Pusa Makhamali x Parbhani Kranti and Hissar Unnat x Punjab Padmini were recorded as good specific combiner for fresh fruit yield plant⁻¹ due to positive significant SCA effect as well as negative significant SCA effect for days to first flowering and plant height which is desirable for earliness and may be important for yield as well. On the basis of specific combining ability effect across nine characters, Hissar Unnat x Punjab Padmini could be considered as most promising parent, as it was good specific combiner for plant height, yield plant⁻¹, total number of pickings, total number of fruit plant⁻¹ and fruit length. Of the fifteen crosses, Hissar Unnat x Punjab Padmini appeared as specific combiner for six characters, whereas VRO-6 x Parbhani Kranti for five and Arka Abhay x Punjab Padmini for four characters. The specific combining

ability of parental combination is most valuable information to a plant breeder to develop a successful hybrid. In present investigation VRO-6 x Parbhani Kranti and Arka Abhay x Punjab Padmini, appeared to be cross combination with better SCA, therefore, these combination could be exploited in hybrid breeding programme.

Estimation of heterosis

Heterosis estimated among F₁ was calculated with respect to better parent value (Table 5), standard variety VRO-6 (Table 6), mid parent value (Table 7) and graphical representation of standard heterosis in Fig.1 for nine characters. Out of 15 crosses, five displayed significant and negative heterosis over mid parent for plant height viz. VRO-5 x Arka Anamika (-8.59 %), Hissar Unnat x Arka anamika (-4.95 %) and Arka Abhay x Arka Anamika (-4.09 %). Significant and negative heterosis for days to first flowering over mid parent ranged from -4.88 % (Hissar unnat x Parbhani Kranti) to -26.67 % (Arka abhay x Arka anamika) (Table 7). Six cross combinations exhibited negative and significant heterobeltiosis for plant height (Table 5) as similar reported by Rawale *et al.* (2003). The range of standard and significant heterosis for plant height varied from 4.49

% (VRO-5 x Parbhani Kranti) to 36.18 % (Hissar Unnat x Punjab Padmini) (Table 6). Out of 15, eleven crosses exhibit significant and positive standard heterosis for the number of primary branches ranged from 13.33 % (Arka Abhay x Punjab Padmini) to 33.33 % (Arka Abhay x Arka Anamika).

Table 7. Estimation of average per cent of heterosis over mid parent.

S. No.	Crosses	Plant height (cm)	No. of primary branches	Days to first flowering (days)	Total no. of fruits plant ⁻¹	Fruit Length (cm)	Fruit girth (cm)	Fruit Weight (gm)	Internodal length (cm)	Yield plant ⁻¹ (kg)
1.	AAb x PK	-3.64**	26.67**	-11.61**	12.28**	40.32**	-3.23	10.34**	-8.43**	23.48**
2.	AAb x PP	25.20**	17.24**	-10.84**	34.49**	6.98**	-12.50**	-3.48**	-9.30**	29.11**
3.	AAb x AA	-4.09**	33.33*	-26.67**	-7.57**	4.58**	-3.03	11.68**	-9.52**	3.87**
4.	VRO-5 x PK	-3.79**	6.25	-7.67**	-5.71*	12.35**	9.68*	21.80**	-10.84**	14.55**
5.	VRO-5 x PP	2.42**	3.23	-17.65**	11.31**	-11.88**	6.25	-1.18	4.65*	8.43**
6.	VRO-5 x AA	-8.59**	18.75**	0.48	-4.16	1.13*	-3.03	4.97**	11.90**	1.44*
7.	VRO-6 x PK	11.84**	16.13**	-23.45**	25.32**	34.43**	6.67	3.81**	-8.64**	29.63**
8.	VRO-6 x PP	3.83**	20.00**	-19.72**	1.61	13.39**	-3.23	15.58**	-9.52**	15.34**
9.	VRO-6 x AA	15.18**	9.68*	-7.16**	13.10**	13.18**	0.00	0.98	0.00	14.96**
10.	PMk x PK	9.85**	0.00	1.18	7.36**	23.81**	0.00	7.84**	-24.14**	16.62**
11.	PMk x PP	6.41**	16.13**	-17.78**	4.56	6.22**	9.68*	6.93**	-4.44*	11.11**
12.	PMk x AA	1.98**	0.00	-8.98**	-1.69	-2.86**	-6.25	1.01	-2.27	0.00
13.	HU x PK	1.38	13.33**	-4.88**	9.30**	16.36**	3.23	10.45**	10.00**	21.51**
14.	HU x PP	27.58**	37.93**	-4.64	27.38**	23.48**	-6.23	-2.51**	-20.48**	27.75**
15.	HU x AA	-4.95**	0.00	-8.05	-2.15	12.82**	-3.03	5.64**	1.23	3.60**

**, *Significant at 1% and 5%, respectively. Lines : (1) Arka Abhay(AAb), (2) VRO-5,(3) VRO-6, (4) Pusa Makhamali (PMk), and (5) Hissar Unnat (HU); Testers : (1) Parbhani Kranti (PK), (2) Punjab Padmini (PP) and (3) Arka Anamika (AA).

Out of 15, 13 crosses represent highly significant and negative standard heterosis for days to first flowering ranged from -8.41 % (VRO-5 x Parbhani Kranti) to -31.82 % (Arka Abhay x Arka Anamika) while 14 crosses showed highly significant and negative heterobeltiosis for days to first flowering i.e. prerequisite for early maturity as similar finding

explained by Manivannan *et al.* (2007a), Hosamani *et al.* (2008) and Singh *et al.* (2008). Out of 15 crosses, 13 crosses showed highly significant and positive standard heterosis for total number of fruits plant⁻¹, ranging from 11.04% (Arka Abhay x Arka anamika) to 50.68% (Arka Abhay x Punjab padmini) (Table 6) as similar reported by Nichal *et al.* (2006)

and Manivannan et al. (2007a). Out of 15 crosses, VRO-6 x Prabhani Kranti (25.32%), Arka Abhay x Punjab Padmini (23.40%) and Hissar Unnat x Punjab Padmini (16.32%) displayed highly significant and positive heterobeltiosis for total number of fruits plant⁻¹ as similar reported by Hosamani et al. (2008), Singh et al. (2008) and Khanpara et al. (2009). Highest yield plant⁻¹ was found in cross Arka abhay x Parbhani kranti for heterobeltiosis and standard heterosis both.

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