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Estimation of heterosis in okra (*Abelmoschus esculentus*) for fruit yield and its components using line × tester mating design

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ABSTRACT

Okra [*Abelmoschus esculentus* (L.) Moench] cultivars were sown during the *kharif* season 2013-14 at Horticulture Research Centre, Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (UP), India, developed and maintained for using conventional agronomic practices to keep the crop in good condition. Fifty one F_1 hybrids developed from crossing between 20 okra parents using line × testers (17 Line × 3 Testers) mating design, evaluated during the *kharif* season 2013-14 at Horticulture Research Centre, Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (UP), India. Genetic material was developed and maintained by following standard conventional agronomic practices to keep the crop in good condition. Out of 51 cross combinations, some crosses showed the significant heterosis over better parent and mid parent. Seven and twenty six crosses were founded significant for early flowering twenty six and thirty three crosses were showed significant positive heterosis for higher yield over better parent and mid parent, respectively. It is pertinent to mention that the crop has potential to produce the heterotic cross combinations and such crosses can be use for further improvement of this crop. Six crosses, namely, VRO1668×AK, IC11527×AK, VRO3×AK, VRO5×AK, FB10×PK and BO2×AK were found potential for fruit yield and other desired characters. This indicates that the cross can be exploited commercially for high yield potential.

Key words: Better parents, Heterosis, Line×Testers, Mid parents heterosis, Okra

Okra [*Abelmoschus esculentus* (L.) Moench] is one often-cross pollinated vegetable crop where the presence of heterosis was demonstrated for the first time by Vijayaraghavan and Warrier (1946). Since then, heterosis for yield and its components were extensively studied. Several research workers have reported occurrence of heterosis in considerable quantities for fruit yield and its various components (Singh and Goswami 2014, Singh *et al*. 2015, Mehta *et al*. 2007, Joshi *et al*. 1958, Weerasekara *et al*. 2007, Jindal *et al*. 2009, Rashwan, 2011, Somashekhar, 2011, Goswami *et al*. 2015). The ease in emasculation and very high percentage of seed setting indicates the possibilities of exploitation of hybrid vigour in okra. The presence of sufficient hybrid vigour is an important prerequisite for successful production of hybrid varieties. Therefore, the heterotic studies can provide the basis for the exploitation of valuable hybrid combinations in the future breeding programmes and their commercial utilization. Variation in most of the agronomical and horticultural traits is available in the germplasm of cultivated okra (Singh *et al*. 2015, Goswami *et al*. 2014, Dhall *et al*. 2003, Singh *et al*. 2006, Dakahe *et al*. 2007, Mohapatra *et al*. 2007, Reddy 2010). The initial selection of parents to be involved in any effective hybridization programme depends upon the nature and magnitude of relative heterosis (heterosis over mid parent), heterobeltiosis (heterosis over better parent), and economic heterosis (heterosis over check) present in genetic stocks. Exploitation of heterosis is primarily dependent on the screening and selection of available germplasm that could be produced by better combinations of important agronomical and horticultural traits. Heterosis breeding based on the identification of the parents and their cross combinations is capable of producing the highest level of transgressive segregates (Falconer 1960). The choice of the best parental matings is crucial for the development of superior hybrids and because combinations of hybrids grow exponentially with the potential number of parents to be used, this is one of the most expensive and time-consuming steps in hybrid development programmes (Agrawal 1998). The magnitude of heterosis provides a guide for the choice of desirable parents for developing superior F1 hybrids, so as to exploit hybrid vigour. It also helps in choosing suitable crosses to be used for commercial exploitation as well as in

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Table 1 ANOVA for 10 characters of okra

Cluster	Df	Days to flowering	Plant height (cm)	Number of branches/ plant	No. of first fruiting node	Length of first fruiting node	Length of internode	Length of fruits	Width of fruits	No. of fruits/ plant	Yield/ plant (g)
Rep	2	0.02	3.63	0.05	0.02	0.05	0.02	0.03	0.02	0.12	0.00
Genotypes	19	29.17**	452.21**	0.77**	2.01**	32.89**	4.08**	8.42**	0.88**	30.78**	2218.90**
Error	38	1.74	1.63	0.23	0.37	0.73	0.28	0.48	0.07	0.40	2.02

component breeding programme. The investigation aims primarily to study the direction and extent of relative heterosis, heterobeltiosis and economic heterosis for yield and its associated traits in Line × Tester crosses for utilization of existing genetic diversity to develop heterotic F1 hybrids in okra. The productivity of this crop should be increased by improving the genetic architecture through hybridization and recombination. Indeed knowledge of heterosis of yield and its component characters should be placed greater emphasis for this improvement of this crop (Singh et al. 2013, Goswami and Singh 2014, Yadav et al. 2002, Koundinya et al. 2013).

MATERIALS AND METHODS

Present investigation was carried out with a genetic material comprising 51 F_1 hybrids developed using 17 Line×3 Tester mating design excluding reciprocals from twenty diverse parents, i.e. IIHR4, IC218872, IC69302, IC306053, SKY/TD/RS113, IC11527, FB10, EC169367, Azad Bhindi 2, SC108, VRO1668, VRO5, VRO238, C7801, BO2, VRO3, KS312, Parbhani Kranti (PK), Azad bhindi 1 (AB 1) and Azad Krishna (AK) at Horticulture Research Centre, Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut, Uttar Pradesh. All standard agronomic practices were followed to keep the crop in good condition. Selection of parents for present investigation was based on better adaptation and desirable agronomical characters. Parents and F_1 hybrids were evaluated in three randomized block design (3 RBD). Observation were made on five randomly selected plants in parents, F_1 hybrids and check in each replication for ten characters, viz. Days to flowering, plant height (cm), number of branches/plant, no. of first fruiting node, length of first fruiting node, length of internode, length of fruits, width of fruits, no. of fruits per plant and fruit yield per plants (g). The heterosis analysis was carried out following the procedure as suggested by Griffing. (1956). Heterosis over mid parent (MP) and better parent (BP) were calculated as F1-MP/MP×100 and F1-BP/BP×100 respectively. The experimental method-II and Model-I (Robinson 1966, and Robinson 1965) was found to be the most appropriate for the material under study.

RESULTS AND DISCUSSION

Analysis of variance with respect to all ten traits under study in parents and F_1 hybrids revealed that mean sum of squares due to characters in parent and F_1 hybrids were highly significant for different characters (Table 1). Among 51 hybrids, some crosses showed the significant heterosis over better parent and mid parent (Table 2). Heterosis over better parent for days to flowering was estimated over earlier flowering parent of the crosses. Hence, Crosses with negative heterosis were considered as desirable attributes. Mid parent heterosis was calculated as increase or decrease in F_1 hybrid over its mid parent. Seven and 26 crosses showed significant negative and 44 and 25 crosses significant positive heterosis over batter parent and mid parent, respectively. Crosses VRO1668×Azad Krishna followed by IC11527×Azad Krishna, EC169367×Azad Krishna, SC108×Azad Krishna and FB10×Azad Krishna were found to be early in flowering over better parent and crosses IC 11527×Azad Krishna followed by VRO1668×Azad Krishna, EC169367×Azad Krishna, SC108×Azad Krishna and IC 218872×Azad Krishna showed early flowering over mid parent. In respect of plant height - the crosses with positive heterosis were considered as desirable for plant height. Nine and 15 crosses showed significant positive and 42 and 36 crosses significant negative heterosis over batter parent and mid parent, respectively. Crosses VRO5 × Azad Bhindi 1 followed by EC169367 × Azad Bhindi 1, IC 218872 × Azad Bhindi 1, EC169367 × Azad Krishna and VRO5 × Azad Krishna were found to be tallest for height of plant over better parent in order to merit Crosses VRO5 × Azad Bhindi 1 followed by VRO5 × Azad Krishna, EC169367 × Azad Krishna, IC 218872 × Azad Bhindi 1 and EC169367 × Azad Bhindi 1 were tallest for height of plant over mid parent. In respect of number of branches/plant- 19 and 24 crosses showed significant positive heterosis over better and mid parent, respectively, whereas 32 and 27 crosses showed significant negative heterosis over better and mid parent. Crosses IC 306053 × Parbhani Kranti followed by IC 218872 × Parbhani Kranti, SC108 × Parbhani Kranti, IIHR4 × Parbhani Kranti and SC108 × Azad Bhindi 1 exhibited maximum heterosis for more number of branches per plant over better parent. Crosses IC 306053 × Parbhani Kranti followed by IIHR4 × Parbhani Kranti, Azad Bhindi 2 × Parbhani Kranti, IIHR4 × Azad Bhindi 1 and SC108 × Parbhani Kranti showed maximum heterosis in order to merit for more number of branches per plant over mid parent. In respect of number of first fruiting node- nine and five crosses showed significant negative heterosis over better and mid parent, respectively. Forty two and 46 crosses showed significant positive heterosis over better and mid parent, respectively. Crosses IC 218872 × Azad Bhindi 1

Table 2 Estimation of Best parents heterosis, mid parents heterosis of 10 characters of okra

Cross combination	BPMP	Days to flowering	Plant height (cm)	Number of branches/plant	No. of first fruiting node	Length of first fruiting node (cm)	Length of internode (cm)	Length of fruits(cm)	Width of fruits(cm)	No. of fruits/plant	Green fruit yield/plant(g)
IC218872 × PK	BP	2.40*	-1.25	18.18**	8.70**	9.89**	-11.54**	-14.44**	-28.74**	-12.24**	7.31**
	MP	-1.92*	8.97**	18.18**	16.28**	21.95**	-9.80**	-8.63**	-16.78**	-7.53**	7.71**
IC218872 × AB1	BP	17.39**	10.23**	-16.67**	-29.17**	-30.21**	0	0	1.06**	-20.90**	-27.81**
	MP	12.50**	14.62**	-13.04**	-22.73**	-20.71**	4.00**	1.50*	21.79**	-4.50**	-19.93**
IC218872 × AK	BP	-4.00**	1.77*	-15.38**	0	-5.56**	3.85**	-0.99	-47.83**	0	6.04**
	MP	-9.43**	11.79**	-8.33**	6.98**	4.29**	20.00**	1.13*	-37.66**	9.28**	12.46**
IC306053 × PK	BP	3.31**	-6.75**	27.27**	4.17**	2.17*	0	-2.37**	-34.48**	38.78**	13.35**
	MP	-2.72**	10.85**	40.00**	6.38**	2.73*	19.05**	13.25**	-15.56**	58.14**	20.16**
IC306053 × AB1	BP	3.48**	-14.20**	0	25.00**	-16.67**	-8.33**	-7.12**	-12.77**	-19.40**	0.89
	MP	0.85	-3.36**	14.29**	25.00**	-14.89**	7.32**	0.14	15.49**	3.85**	17.48**
IC306053 × AK	BP	5.79**	-17.68**	-15.38**	25.00**	1.09	36.84**	-7.99**	-38.04**	-5.66**	-7.01**
	MP	-1.92*	-2.54**	0	27.66**	2.20*	44.44**	-1.38*	-18.57**	11.11**	3.83**
IC11527 × PK	BP	4.41**	-16.25**	-8.33**	26.09**	-13.19**	4.00**	-22.41**	-27.59**	-2.04*	1.65*
	MP	1.07	-7.97**	-4.35**	28.89**	-4.24**	13.04**	-17.71**	-15.44**	10.34**	3.54**
IC11527 × AB1	BP	13.04**	-9.94**	-8.33**	29.17**	6.25**	0	-2.68**	-46.81**	-38.81**	6.66**
	MP	0	-6.76**	-8.33**	34.78**	20.00**	6.67**	-0.5	-35.90**	-21.90**	19.87**
IC11527 × AK	BP	-15.71**	-22.22**	-23.08**	13.04**	-5.56**	19.05**	-9.00**	-46.74**	24.53**	0
	MP	-17.19**	-14.92**	-20.00**	15.56**	3.66**	25.00**	-6.38**	-36.36**	45.05**	7.54**
EC169367 × PK	BP	2.31*	-12.00**	0	13.04**	-25.00**	-20.00**	-21.01**	-38.71**	-24.49**	-1.1
	MP	0	-6.13**	0	26.83**	-20.00**	-16.67**	-20.00**	-36.67**	-22.11**	0.09
EC169367 × AB1	BP	5.22**	13.92**	-16.67**	25.00**	0.96	4.17**	-13.03**	-24.47**	-11.94**	5.92**
	MP	-1.22	14.25**	-13.04**	42.86**	5.00**	6.38**	-4.72**	-24.06**	4.42**	18.35**
EC169367 × AK	BP	-10.00**	8.33**	-30.77**	13.04**	2.88**	17.39**	-41.39**	-61.29**	-3.77**	24.96**
	MP	-13.33**	15.01**	-25.00**	26.83**	10.31**	28.57**	-35.42**	-61.08**	3.03**	33.57**
SC108 × PK	BP	2.94**	-9.50**	16.67**	-21.74**	-3.03**	-4.00**	-7.11**	-24.14**	40.82**	17.18**
	MP	2.56*	-3.08**	21.74**	-20.00**	1.05	2.13**	2.38*	-18.52**	51.65**	39.20**
SC108 × AB1	BP	10.43**	-4.83**	8.33**	12.50**	6.06**	0	9.16**	-38.30**	-2.99**	-7.54**
	MP	0.79	-4.15**	8.33**	17.39**	7.69**	4.35**	11.28**	-31.36**	19.27**	19.05**
SC108 × AK	BP	-8.76**	5.81**	-23.08**	0	-7.07**	4.55**	21.13**	-41.30**	-1.89**	13.05**
	MP	-9.75**	12.79**	-20.00**	2.22**	-2.65**	12.20**	22.72**	-35.33**	9.47**	40.43**
VRO5 × PK	BP	6.87**	-9.50**	-15.38**	21.74**	-15.38**	-16.00**	-15.73**	-40.23**	-12.24**	-10.69**
	MP	4.87**	9.86**	-8.33**	33.33**	-14.44**	2.44**	1.56*	-27.78**	-3.37**	-5.97**
VRO5 × AB1	BP	13.91**	14.20**	-23.08**	4.17**	-23.96**	29.17**	-17.30**	-42.55**	-13.43**	10.95**
	MP	6.50**	31.59**	-20.00**	16.28**	-21.08**	55.00**	-7.01**	-28.48**	8.41**	16.82**
VRO5 × AK	BP	6.11**	6.57**	-15.38**	-4.35**	0	36.84**	10.57**	-50.00**	56.60**	27.41**
	MP	2.58*	28.85**	-15.38**	4.76**	0.56	48.57**	23.63**	-38.26**	78.49**	27.93**

Contd.

Table 2 *Contd.*

Cross combination	BPMP	Days to flowering	Plant height (cm)	Number of branches/plant	No. of first fruiting node	Length of first fruiting node (cm)	Length of internode (cm)	Length of fruits(cm)	Width of fruits(cm)	No. of fruits/plant	Green fruit yield/plant(g)
C7801 × PK	BP	0.75	-4.25**	-27.27**	-13.04**	-19.78**	-14.81**	-19.18**	-19.54**	-18.37**	-9.58**
	MP	-0.37	-0.26	-20.00**	-11.11**	-15.12**	-11.54**	-13.79**	-4.76**	-16.67**	-5.78**
C7801 × AB1	BP	3.48**	-14.67**	-25.00**	29.17**	8.33**	-11.11**	0.25	-44.68**	-2.99*	4.59**
	MP	-4.03**	-12.78**	-14.29**	34.78**	17.51**	-5.88**	1.88*	-32.47**	14.04**	11.25**
C7801 × AK	BP	-3.76**	-11.36**	0	34.78**	4.44**	-7.41**	-2.96**	-39.13**	28.30**	23.33**
	MP	-6.23**	-8.12**	18.18**	37.78**	9.94**	8.70**	-0.76	-26.32**	36.00**	25.17**
BO2 × PK	BP	4.27**	-6.75**	0	-8.70**	2.15*	-8.00**	-17.03**	-28.74**	-5.36**	13.16**
	MP	-3.56**	-3.37**	12.00**	5.00**	3.26**	-4.17**	-12.50**	-16.22**	0.95	15.70**
BO2 × AB1	BP	0.87	-17.20**	-21.43**	29.17**	10.42**	8.33**	-18.99**	-42.55**	11.94**	-16.42**
	MP	0	-14.92**	-15.38**	51.22**	12.17**	10.64**	-16.69**	-30.32**	21.95**	-5.75**
BO2 × AK	BP	11.97**	-7.58**	-14.29**	21.74**	2.15*	-8.70**	7.93**	-28.26**	35.71**	31.81**
	MP	1.95*	-4.69**	-11.11**	40.00**	3.83**	0	11.69**	-13.73**	39.45**	42.25
VRO3 × PK	BP	1.53	-8.75**	-8.33**	-8.70**	-18.68**	-20.00**	-16.16**	-24.14**	-6.12**	-0.7
	MP	-0.37	-3.69**	-4.35**	2.44**	-16.85**	-18.37**	-15.16**	-5.04**	-2.13*	1.52
VRO3 × AB1	BP	0.87	-15.64**	-16.67**	8.33**	-9.38**	12.50**	-24.28**	-51.06**	0	5.03**
	MP	-5.69**	-14.93**	-16.67**	23.81**	-4.92**	12.50**	-18.91**	-36.99**	19.64**	13.78**
VRO3 × AK	BP	2.29*	-10.35**	0	39.13**	3.33**	29.17**	-29.80**	-29.35**	60.38**	-10.60**
	MP	-1.11	-5.84**	4.00**	56.10**	5.08**	44.19**	-24.38**	-9.72**	73.47**	-7.51**
KS312 × PK	BP	0.85	-12.75**	0	17.39**	0	-8.00**	-19.83**	-27.59**	-4.08**	-13.70**
	MP	-6.30**	-5.42**	0	35.00**	7.06**	-4.17**	-3.88**	-11.89**	1.08*	-9.28**
KS312 × AB1	BP	16.52**	-9.94**	-25.00**	8.33**	-5.21**	-8.33**	-3.82**	-42.55**	-31.34**	-18.20**
	MP	15.02**	-8.12**	-21.74**	26.83**	4.00**	-6.38**	7.54**	-28.00**	-17.12**	-13.73**
KS312 × AK	BP	22.03**	-11.87**	-7.69**	39.13**	7.78**	-4.35**	-19.33**	-28.26**	56.60**	9.46**
	MP	11.63**	-4.90**	0	60.00**	14.79**	4.76**	-10.32**	-10.81**	71.13**	10.09**
IIHR4 × PK	BP	2.42*	-12.25**	27.27**	13.04**	4.40**	24.00**	-13.58**	3.45**	5.66**	13.16**
	MP	-2.31*	0.57	33.33**	20.93**	11.11**	34.78**	-0.25	20.81**	9.80**	16.46**
IIHR4 × AB1	BP	21.74**	-13.92**	16.67**	8.33**	-23.96**	16.67**	3.05**	-48.94**	1.49*	-9.17**
	MP	17.15**	-6.77**	27.27**	18.18**	-17.05**	24.44**	10.50**	-38.46**	13.33**	3.02**
IIHR4 × AK	BP	13.71**	-12.37**	-15.38**	21.74**	-10.00**	14.29**	-11.86**	-25.00**	-7.55**	-8.32**
	MP	6.82**	0	-4.35**	30.23**	-4.71**	20.00**	-6.04**	-10.39**	-7.55**	-0.44
IC69302 × PK	BP	3.25**	-7.25**	0	21.74**	-11.34**	-20.00**	-12.50**	-11.49**	-2.00*	-9.80**
	MP	-1.93*	-1.46	10.00**	30.23**	-8.51**	-16.67**	-11.93**	5.48**	-1.01	-1.83*
IC69302 × AB1	BP	26.09**	4.53**	-16.67**	8.33**	5.15**	4.17**	-7.42**	-57.45**	-25.37**	9.62**
	MP	21.85**	4.68**	-4.76**	18.18**	5.70**	6.38**	-0.35	-47.71**	-14.53**	11.51**
IC69302 × AK	BP	13.01**	-6.31**	0	13.04**	8.25**	0	-12.01**	-9.78**	39.62**	9.04**
	MP	5.70**	-0.93	18.18**	20.93**	12.30**	9.52**	-4.73**	9.93**	43.69**	12.48**

Contd.

Table 2 *Contd.*

Cross combination	BPMP	Days to flowering	Plant height (cm)	Number of branches/plant	No. of first fruiting node	Length of first fruiting node (cm)	Length of internode (cm)	Length of fruits(cm)	Width of fruits(cm)	No. of fruits/plant	Green fruit yield/plant(g)
SKY/TD/RS113	BP	0	-12.75**	-9.09	-13.04**	9.89**	-8.00**	-7.76**	-21.84**	-27.69**	-22.43**
× PK	MP	-5.84**	-8.40**	-9.09**	-2.44**	16.28**	4.55**	-1.50*	2.26**	-17.54**	-12.91**
SKY/TD/RS113	BP	6.09**	-14.09**	0	4.17**	-3.12**	-12.50**	5.93**	-55.32**	-17.91**	-17.14**
× AB1	MP	3.39**	-12.89**	4.35**	19.05**	5.08**	-2.33**	7.52**	-40.00**	-16.67**	-15.70**
SKY/TD/RS113	BP	14.88**	-9.09**	-15.38**	13.04**	20.00**	52.63**	5.68**	-7.61**	-16.92**	-7.29**
× AK	MP	6.51**	-5.01**	-8.33**	26.83**	26.32**	52.63**	7.94**	23.19**	-8.47**	-1.14
FB10 × PK	BP	0	-25.25**	-28.57**	4.35**	16.48**	28.00**	-18.75**	-41.38**	-10.00**	32.54**
	MP	0	-14.33**	-20.00**	9.09**	26.19**	45.45**	-14.32**	-21.54**	5.88**	32.91**
FB10 × AB-1	BP	8.70**	-13.92**	-7.14**	8.33**	-21.88**	37.50**	-8.41**	-34.04**	-2.86**	-10.95**
	MP	-0.4	-6.77**	0	15.56**	-13.29**	53.49**	-5.81**	-9.49**	-0.73	-1.31
FB10 × AK	BP	-8.09**	-11.11**	-28.57**	4.35**	4.44**	63.16**	4.81**	-35.87**	2.86**	9.30**
	MP	-9.42**	1.44	-25.93**	9.09**	12.57**	63.16**	8.46**	-12.59**	17.07**	15.82**
Azad Bhindi 2	BP	8.04**	-18.75**	27.27**	8.70**	5.00**	-18.52**	-9.48**	-4.60**	-9.62**	-21.90**
× PK	MP	-2.42**	-15.58**	33.33**	28.21**	9.95**	-15.38**	-3.78**	11.41**	-6.93**	-10.45**
Azad Bhindi 2	BP	14.29**	-13.78**	-8.33**	-4.17**	4.00**	22.22**	-8.56**	-51.06**	-34.33**	-1.9
× AB1	MP	12.78**	-11.63**	0	15.00**	6.12**	29.41**	-6.73**	-41.03**	-26.05**	2.20*
Azad Bhindi 2	BP	8.04**	-12.63**	0	17.39**	-9.00**	18.52**	12.71**	-31.52**	28.30**	-15.24**
× AK	MP	-3.97**	-9.66**	13.04**	38.46**	-4.21**	39.13**	15.68**	-18.18**	29.52**	-7.57**
VRO1668 × PK	BP	0	-27.75**	0	21.74**	-31.87**	-8.00**	-13.58**	11.49**	-16.33**	-25.78**
	MP	-1.45	-23.14**	0	27.27**	-27.06**	15.00**	-12.06**	49.23**	-3.53**	-23.83**
VRO1668 × AB1	BP	20.00**	0.57	0	8.33**	-11.46**	-20.83**	-16.07**	-9.57**	-29.85**	-6.66**
	MP	8.24**	0.57	4.35**	15.56**	-2.86*	-2.56**	-10.58**	24.09**	-8.74**	5.61**
VRO1668 × AK	BP	-17.14**	-6.57**	-23.08**	26.09**	-5.56**	57.89**	-4.02**	-20.65**	20.75**	14.85**
	MP	-17.14**	-1.07	-16.67**	31.82**	0.59	76.47**	2.87**	8.15**	43.82**	24.38**
VRO238 × PK	BP	3.28**	-11.25**	0	-13.04**	-37.14**	0	-17.24**	-18.39**	10.20**	-7.31**
	MP	-2.33*	-3.40**	4.76**	-2.44**	-32.65**	13.64**	-17.06**	-10.69**	10.20**	-7.23**
VRO238 × AB1	BP	7.83**	-13.64**	-8.33**	4.17**	-33.33**	-12.50**	-0.65	-9.57**	8.96**	-18.49**
	MP	4.64**	-11.50**	0	19.05**	-30.35**	-2.33**	7.37**	2.41**	25.86**	-9.82**
VRO238 × AK	BP	8.20**	-11.36**	-15.38**	39.13**	-16.19**	42.11**	-4.76**	-9.78**	41.51**	1.79
	MP	0.76	-3.97**	-4.35**	56.10**	-9.74**	42.11**	3.53**	1.22**	47.06**	7.68**
SE	BP	0.78	0.84	0.42	0.51	0.63	0.5	0.34	0.14	0.52	1.04
	MP	0.67	0.73	0.37	0.44	0.54	0.43	0.34	0.12	0.46	1.09
CD (P = 0.05)	BP	1.55	1.68	0.84	1.01	1.25	0.99	0.68	0.28	1.05	2.08
	MP	1.34	1.46	0.73	0.88	1.08	0.86	0.67	0.25	0.92	2.18

*Significant at 5%,**significant at 1%

followed by SC108 × Parbhani Kranti, C7801 × Parbhani Kranti, SKY/TD/RS113 × Parbhani Kranti and VRO238 × Parbhani Kranti were found to be for minimum number of first fruiting node over better parent in order to merit. Crosses IC218872 × Azad Bhindi 1 followed by SC108 × Parbhani Kranti, C7801 × Parbhani Kranti, SKY/TD/RS 113 × Parbhani Kranti and VRO238 × Parbhani Kranti showed minimum number of first fruiting node over mid parent. In respect of length of first fruiting node- 25 and 31 crosses showed significant positive heterosis over better parent and mid parent, respectively, whereas 26 and 20 crosses showed significant negative heterosis over better and mid parent, respectively. Cross combinations SKY/TD/RS 113 × Azad Krishna followed by BO2 × Azad Bhindi 1, SKY/TD/RS 113 × Parbhani Kranti, C7801 × Azad Bhindi 1 and IC69302 × Azad Krishna exhibited maximum heterosis for length of first fruiting node over better parent. Crosses SKY/TD/RS 113 × Azad Krishna followed by FB10 × Parbhani Kranti, IC218872 × Parbhani Kranti, IC11527 × Azad Bhindi 1 and C7801 × Azad Bhindi 1 exhibited maximum heterosis in order to merit for length of first fruiting node over mid parent. In respect of length of internodes- positive heterosis was considered desirable for length of internodes. Thirty and 38 crosses showed significant positive heterosis, whereas 21 and 13 crosses exhibited significant negative heterosis over better and mid parent, respectively. Crosses FB10 × Azad Krishna followed by VRO1668 × Azad Krishna, SKY/TD/RS113 × Azad Krishna, VRO238 × Azad Krishna and IC306053 × Azad Krishna showed the maximum heterosis for the length of internodes over better parent in order to merit. Crosses VRO1668 × Azad Krishna followed by FB10 × Azad Krishna, VRO5 × Azad Bhindi 1, FB 10 × Azad Bhindi 1 and SKY/TD/RS113 × Azad Krishna showed the longest length of internodes over mid parent. In respect of length of fruit- a heterosis effect in hybrid, involving long fruited type, was estimated over both parents. Significant positive heterosis was observed in eleven crosses and significant negative heterosis in crosses 40 over better parent. Twenty and 31 crosses showed significant positive and negative heterosis in crosses over mid parent, respectively. Crosses SC108 × Azad Krishna followed by Azad Bhindi2 × Azad Krishna, VRO5 × Azad Krishna, SC108 × Parbhani Kranti and BO2 × Azad Krishna showed the maximum heterosis over better parent and crosses VRO5×Azad Krishna followed by SC108×Azad Krishna, Azad Bhindi 2 × Azad Krishna, IC306053 × Parbhani Kranti and BO2 × Azad Krishna over mid parent in order of more length of fruit. In respect of width of fruit- three and 13 crosses showed significant positive and 48 and 38 crosses significant negative heterosis over better and mid parent, respectively. Crosses EC169367 × Azad Krishna followed by IC69302 × Azad Bhindi 1, SKY/TD/RS113 × Azad Bhindi 1, VRO3 × Azad Bhindi 1 and Azad Bhindi 2 × Azad Bhindi 1 were found to be good response over better parent. Crosses EC169367 × Azad Krishna followed by, IC69302 × Azad Bhindi 1, Azad Bhindi 2 × Azad Bhindi1, SKY/TD/RS113 × Azad Bhindi 1 and IIHR4 × Azad Bhindi 1 showed good response over mid parent. In respect of number of fruit per plant- significant positive heterosis was observed in 19 and significant negative heterosis was exhibited 32 crosses over better parent. Thirty two and 19 crosses showed significant positive and negative heterosis, respectively over mid parent. Maximum heterosis in descending order was observed in the crosses VRO3 × Azad Krishna followed by KS312 × Azad Krishna, VRO5 × Azad Krishna, VRO238 × Azad Krishna and SC108 × Parbhani Kranti over better parent and crosses VRO5 × Azad Krishna followed by VRO3 × Azad Krishna, KS312 × Azad Krishna, IC306053 × Parbhani Kranti and SC108 × Parbhani Kranti showed heterosis over mid parent for more number of fruit per plant. In respect of fruit yield per plant- 26 crosses showed significant positive heterosis and 25 crossed showed significant negative heterosis over better parent. Significant positive heterosis was observed in 33 crosses and 18 crosses showed significant negative heterosis over. Maximum yield was observed for the crosses FB10 × Parbhani Kranti followed by BO2 × Azad Krishna, VRO5 × Azad Krishna, EC169367 × Azad Krishna and C7801 × Azad Krishna over better parent and BO2 × Azad Krishna followed by SC108 × Azad Krishna, SC108 × Parbhani Kranti, EC169367 × Azad Krishna and FB10 × Parbhani Kranti over mid parent. Similar results were found by Singh and Goswami (2014), Singh *et al*. (2015), Mehta *et al*. (2007), Joshi *et al*. (1958) Weerasekara *et al*. (2007), Jindal *et al*. (2009), Rashwan (2011) Somashekhar (2011) Goswami *et al*. (2015).

Out of 51 hybrids, some crosses showed the significant magnitude of heterosis over better parent and mid parent. Heterosis over better parent for days to flowering was estimated over earlier flowering parent of the crosses. Hence, Crosses with negative magnitude of heterosis were considered as desirable attributes. Mid parent heterosis was calculated as increase or decrease in F_1 hybrid over its mid parent. Seven and 26 crosses were showed significant negative and 44 and 25 crosses significant positive heterosis over batter parent and mid parent, respectively. In plant height positive heterosis were considered as desirable for plant height. Nine and 15 crosses were showed significant positive and 42 and 36 crosses significant negative heterosis over batter parent and mid parent, respectively. In number of branches per plant 19 and 24 crosses showed significant positive heterosis over better and mid parent, respectively, whereas 32 and 27 crosses showed significant negative heterosis over better and mid parent. Number of first fruiting node nine and five crosses showed significant negative heterosis over better and mid parent, respectively. Forty two and 46 crosses showed significant positive magnitude of heterosis over better and mid parent, respectively. Length of first fruiting node 25 and 31 crosses showed significant positive heterosis over better parent and mid parent, respectively, whereas 26 and 20 crosses showed significant negative heterosis over better and mid parent, respectively. In length of internodes positive heterosis was considered desirable for length of internodes. Thirty and 38 crosses showed significant positive heterosis, whereas 21 and 13 crosses exhibited significant negative heterosis over better and mid parent, respectively. Length of fruit, heterosis effect in hybrid, involving long fruited type, was estimated over both parents. Significant positive heterosis was observed in 11 crosses and significant negative heterosis in crosses 40 over better parent. Twenty and 31 crosses showed significant positive and negative heterosis in crosses over mid parent, respectively. Width of fruit 3 and 13 crosses showed significant positive and 48 and 38 crosses significant negative heterosis over better and mid parent, respectively. Number of fruit per plant significant positive heterosis was observed in nineteen and significant negative heterosis was exhibited 32 crosses over better parent. Thirty two and 19 crosses showed significant positive and negative heterosis, respectively over mid parent. For fruit yield per plant 26 crosses showed significant positive heterosis and 25 crossed showed significant negative heterosis over better parent. Predictions of heterosis through different breeding tools are important to know the inheritance pattern of morphological traits of hybrids along with their parents. Significant positive heterosis was observed in 33 crosses and 18 crosses showed significant negative heterosis over. Cross combinations VRO1668 × Azad Krishna and IC11527×Azad Krishna showed early flowering, VRO5 × Azad Bhindi1 and VRO5 × Azad Bhindi1 were found tallest for height of plant, number of branches per plant IC306053 × Parbhani Kranti and IC306053 × Parbhani Kranti showed maximum heterosis in order to merit for more number of branches per plant over mid parent, IC218872 × Azad Bhindi1 showed minimum number of first fruiting node. Cross combinations SKY/TD/RS113 × Azad Krishna exhibited maximum heterosis in order to merit for length of first fruiting node over mid parent. For length of internodes FB10 × Azad Krishna and VRO1668 × Azad Krishna showed the longest length of internodes over mid parent. Cross combinations SC-108 × Azad Krishna and VRO5 × Azad Krishna maximum length of fruit. EC169367 × Azad Krishna was found to be good response. Crosses viz., VRO3 × Azad Krishna and crosses VRO5 × Azad Krishna followed showed for more number of fruit per plant. For higher yield FB10 × Parbhani Kranti and C7801 × Azad Krishna showed significant heterosis over better parent and mid parent. In concluded that the crop has potential to produce the heterotic cross combinations and such crosses can be use for further improvement of this crop. Six crosses, namely, VRO1668 × AK, IC11527 × AK, VRO3 × AK, VRO5 × AK, FB10 × PK and BO2 × AK were found potential for fruit yield and other desired characters. This indicates that the cross can be exploited commercially.

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