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Estimation of heterosis and inbreeding depression in okra (*Abelmoschus esculentus*)

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ABSTRACT

All parental genotypes of okra [*Abelmoschus esculentus* (L.) Moench] were sown during the *zaid* season 2011 at Horticulture Research Centre, Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, for developed and maintained for using conventional agronomic practices to keep the crop in good conditions for morphological study. Twenty selected genetically diverse genotypes of okra along with their 51 F_1s and 51 F_2s population developed in next season through Line × Tester analysis. This experiment was conducted to study the heterosis and inbreeding depression between various economically important traits of okra for the purpose of genetic improvement and their effect in populations. Inbreeding depression was observed for different characters studied in number of crosses. In this best crosses showed 21 crosses early flowering, 40 crosses tallest plant, 29 crosses maximum number of branches, 21 crosses maximum number of nodes per plant, 21 crosses maximum length of first fruiting node, 34 crosses maximum length of internode, 26 crosses maximum length of fruits, 36 crosses maximum width, 39 crosses maximum number of fruits/plant and 32 crosses maximum yield/plant. According to this better fruit yield cross combination BO 2 × Azad Krishna showed maximum inbreeding depression.

Key words: Heterosis, Inbreeding depression, Line × Tester, Okra

India ranks first in the world with 6 350.2 thousand tonnes (72.9% of the total world production) of okra produced from over 530.7 thousand ton (Indian Horticulture Database 2013). In India, okra is grown throughout except in the mountain regions. The major producers are Andhra Pradesh, West Bengal, Bihar, Gujarat, and Odisha. While, Andhra Pradesh had first rank in production (1.11 million tonnes) and productivity (15.0 tonnes/h) of okra followed by West Bengal, Bihar, Gujarat, and Odisha. Uttar Pradesh has produced 0.15 million tonnes okra under 12.44 thousand hectare area with 12.8 tonnes/h productivity during 2012-13 (Indian Horticulture Database 2013). Okra is an important fruit vegetable grown for its tender pods in India. It is a power house of variable nutrients and a good source of vitamin A, B and C, protein and mineral elements. Singh *et al.* 2003 analyzed fruit and reported 6.60 to 10.40% crude fibbers, 84.60 to 90.50% edible protein. Among the vitamins, vitamin C providing 20% of daily value a 2000 calorie diet in 100 g. To start with an effective breeding procedure, it would be essential to have information on various genetic parameters mentioned above. This will help the breeder to choose a suitable breeding programme, characters for selection and relative importance of various yield components to make the selection for final product to be more effective. Among the vegetables, contribution of rainy and summer season cultivated crop okra is 5.4 % in area with 3.5 % share in production (Anonymous 2012 and Solankey *et al.* 2013).The attempt on okra breeding was not exhaustive and has been reviewed by scientists. The yield potential of okra is low. 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 the improvement of this crop (Singh *et al.* 2003, Yadav *et al.* 2002, Koundinya *et al.* 2013).

MATERIALS AND METHODS

The materials for the present investigation comprised twenty genotypes (17 Line × 3 Tester) of okra were collected from Indian Institute of Vegetable Research, Varanasi and Chandra Sekhra Azad University of Agriculture and Technology, Kanpur (UP). The collected germplasm stock maintained at Horticulture Research Centre, Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut, for agronomically practices to keep the crop in good condition.

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Table 1 Twenty parents of okra genotype

Genotype	Genotype
Line	IIHR 4
IC 218872	IC 69302
IC 306053	SKY/TD/RS 113
IC 11527	FB 10
EC 169367	Azad Bhindi 2
SC 108	VRO 1668
VRO 5	VRO 238
C 7801	*Tester*
BO 2	Parbhani Kranti (PK)
VRO 3	Azad bhindi 1 (AB 1)
KS 312	Azad Krishna (AK)

All the homozygous parents were sown during the *zaid* season 2011. All the possible 51 F_1 crosses, excluding reciprocals were made among these twenty parents. The heterosis and inbreeding depression analysis was carried out by the procedure suggested by (Griffing 1956). The experimental method-II and Model-I (Robinson 1966 and Robinson 1965) was taken to be the most appropriate for the material under study.

RESULTS AND DISCUSSION

Significant increase or decrease in the performance in F_1 hybrids over better and mid parents and inbreeding depression in F_2 population for all the characters under study are being presented in Table 2. In the preset study the degree of heterosis is measured as mean superiority crosses over better and mid parental value. Days to flowering, heterosis over better parent for days to flowering was estimated over earlier flowering parent of the crosses. Hence, negative heterosis was considered as desirable trait. Mid parent heterosis was calculated as increase or decrease in F_1 hybrid over its mid parent. Heterosis ranged from -17.14 (VRO 1668 × Azad Krishna) to 26.09 (IC 69302 × Azad Bhindi 1) per cent over better parent and from -17.19 (IC 11527 × Azad Krishna) to 21.85 (IC 69302 × Azad Bhindi 1) per cent over mid parent inbreeding depression ranged from 2.13 (IIHR 4 × Azad Krishna) to 12.14 (SC 108 × Parbhani Kranti) per cent. Twenty one F_2 populations flowered earlier than their corresponding F_1s, crosses. In plant height crosses with positive heterosis were considered as desirable for plant height. Hybrid vigour range -27.75 (VRO 1668 × Parbhani Kranti) to 14.20 (VRO 5 × Azad Bhindi 1) over better parent and from -23.14 (VRO 1668 × Parbhani Kranti) to 31.59 (VRO 5 × Azad Bhindi 1) over mid parent. Some crosses VRO 5 × Azad Bhindi 1 followed by EC 169367 × Azad Bhindi 1 and other were tallest for height of plant over mid parent. Inbreeding depression in F_2 ranged 4.18(SC 108 × Azad Bhindi 1) to 23.63 (VRO 5 × Azad Bhindi 1) per cent. Forty F_2 populations exhibited depression over F1 dwarfness, whereas eight F_2 populations showed no inbreeding depression. Crosses SC 108 × Azad Bhindi 1 followed by FB 10 × Azad Bhindi 1 etc. showed significant increase in tallness in F_2 population. In number of branches per plant heterosis ranged from -30.77 (EC 169367 × Azad Krishna) to 27.27 (IC 306053 × Parbhani Kranti) per cent over better parent and -25.93 (FB 10 × FB 10 × Azad Krishna) to 40.00 (IC 306053 × Parbhani Kranti) per cent our mid parent. Inbreeding depression ranged from 7.69 (IC 69302 × Azad Krishna) to 46.15 (FB 10 × Azad Bhindi 1) per cent. Crosses IC 69302 × Azad Krishna followed by EC 169367 × Azad Krishna etc. showed significant increase in more number of branches per plant in F2 population in order to merit. In number of nodes per plant heterosis ranged from -32.94 (VRO 1668 × Parbhani Kranti) to 1.27 (FB 10 × Azad Bhindi 1) per cent over better parent and from -20.28 (VRO 1668 × Parbhani Kranti) to 7.14 (KS 312 × Azad Krishna) per cent over mid parent. Inbreeding depression ranged 1.30 (IC-218872 × Parbhani Kranti) to 16.00 (KS 312 × Azad Krishna) per cent. Length of first fruiting node heterosis ranged from -37.14 (VRO 238 × Parbhani Kranti) to 20.00 (SKY/TD/RS 113 × Azad Krishna) per cent over better parent and from -32.65 (VRO 238 × Parbhani Kranti) to 26.32 (SKY/TD/RS 113 × Azad Krishna) per cent over mid parent. Crosses SKY/TD/RS 113 × Azad Krishna followed by FB 10 × Parbhani Kranti etc. exhibited maximum heterosis in order to merit for length of first fruiting node over mid parent. Inbreeding depression ranged from 2.11 (BO 2 × Azad Krishna) to 25.96 (C 7801 × Azad Bhindi 1) per cent. Cross combinations C-7801 × Azad Bhindi 1 followed by IC 69302 × Azad etc. exhibited the lowest length of first fruiting node in F_2 population in order to merit. In length of internodes, heterosis ranged from -20.83 (VRO 1668 × Azad Bhindi 1) to 63.16 (FB-10 × Azad Krishna) per cent over better parent and from -18.37 (VRO-3 × Parbhani Kranti) to 76.47 (VRO-1668 × Azad Krishna) per cent over mid parent. Inbreeding depression ranged from 3.85 (IC 306053 × Azad Krishna) to 45.16 (IIHR 4 × Parbhani Kranti) per cent. In length of fruit heterosis effect in hybrid, involving long fruited type, was estimated over both parents. Heterosis ranged from -41.39 (EC 169367 × Azad Krishna) to 21.13 (SC 108 × Azad Krishna) per cent and from -35.42 (EC 169367 × Azad Krishna) to 23.63 (VRO 5 × Azad Krishna) per cent over better and mid parent, respectively. Inbreeding depression ranged from 1.78 (SKY/TD/RS 113 × Parbhani Kranti) to 36.62 (Azad Bhindi 2 × Azad Krishna) per cent. In width of fruit, heterosis ranged from -61.98 (EC 169367 × Azad Krishna) to 11.49 (VRO 1668 × Azad Krishna) per cent over better parent and from -61.08 (EC 169367 × Azad Krishna) to 49.23 (VRO 1668 × Azad Krishna) per cent over mid parent. Inbreeding depression ranged from 1.13 (SC 108 × Azad Krishna) to 50.77 (VRO 1668 × Parbhani Kranti) per cent. In number of fruit per plant, heterosis ranged from -38.81 (IC 11527 × Azad Bhindi 1) to 60.38 (VRO 3 × Azad Krishna) per cent over better parent and -26.05 (Azad Bhindi 2 × Azad Bhindi 1) to 78.49 (VRO 5 × Azad Krishna) per cent over mid parent. Inbreeding depression ranged 1.89 (IC 218872 × Azad Bhindi 1) to 42.11 (BO 2 × Azad Krishna) per cent. In green fruit yield per plant, heterosis range from -27.81 (IC 218872 × Azad

Table 2 Estimation of best parents heterosis, mid parents heterosis and inbreeding depression of 10 characters of okra

Cross combination	BP MP IBP	Days to 50% flowering	Plant height (cm)	Number of branches/ plant	Number of nodes/ plant	Length of first fruiting node (cm)	Internodal length (cm)	Fruit length (cm)	Fruits width (cm)	No. of fruits/ plant	Green fruit yield/plants (g)
IC 218872 × PK	BP	2.40*	–1.25	18.18**	–9.41**	9.89**	–11.54**	–14.44**	–28.74**	–12.24**	7.31**
	MP	–1.92*	8.97**	18.18**	2.67**	21.95**	–9.80**	–8.63**	–16.78**	–7.53**	7.71**
	IBP	2.34*	18.99**	0	1.30*	–13.00**	8.70**	13.60**	–3.41**	0	–0.85
IC 218872 × AB-1	BP	17.39**	10.23**	–16.67**	–10.13**	–30.21**	0	0	1.06**	–20.90**	–27.81**
	MP	12.50**	14.62**	–13.04**	–1.39*	–20.71**	4.00**	1.50*	21.79**	–4.50**	–19.93**
	IBP	0	18.30**	–10.00**	2.82**	–11.94**	–3.85**	–0.12	19.85**	1.89**	–20.29**
IC 218872 × AK	BP	–4.00**	1.77*	–15.38**	–7.79**	–5.56**	3.85**	–0.99	–47.83**	0	6.04**
	MP	–9.43**	11.79**	–8.33**	0	4.29**	20.00**	1.13*	–37.66**	9.28**	12.46**
	IBP	–1.67	23.57**	–9.09**	7.04**	18.82**	14.81**	3.84**	–16.53**	–5.66**	17.69**
IC 306053 × PK	BP	3.31**	–6.75**	27.27**	–9.41**	2.17*	0	–2.37**	–34.48**	38.78**	13.35**
	MP	–2.72**	10.85**	40.00**	6.21**	2.73*	19.05**	13.25**	–15.56**	58.14**	20.16**
	IBP	0	29.76**	21.43**	0	0	12.00**	24.00**	29.23**	26.47**	10.16**
IC 306053 × AB-1	BP	3.48**	–14.20**	0	–15.19**	–16.67**	–8.33**	–7.12**	–12.77**	–19.40**	0.89
	MP	0.85	–3.36**	14.29**	–3.60**	–14.89**	7.32**	0.14	15.49**	3.85**	17.48**
	IBP	3.36**	–5.30**	–16.67**	–8.96**	5.00**	9.09**	–13.26**	43.54**	0	17.30**
IC 306053 × AK	BP	5.79**	–17.68**	–15.38**	–15.58**	1.09	36.84**	–7.99**	–38.04**	–5.66**	–7.01**
	MP	–1.92*	–2.54**	0	–5.11**	2.20*	44.44**	–1.38*	–18.57**	11.11**	3.83**
	IBP	0	7.67**	45.45**	–7.69**	–2.15*	3.85**	13.68**	25.09**	–14.00**	–0.35
IC 11527 × PK	BP	4.41**	–16.25**	–8.33**	–27.06**	–13.19**	4.00**	–22.41**	–27.59**	–2.04*	1.65*
	MP	1.07	–7.97**	–4.35**	–16.78**	–4.24**	13.04**	–17.71**	–15.44**	10.34**	3.54**
	IBP	1.41	25.67**	–27.27**	–11.29**	–6.33**	15.38**	–17.71**	–9.18**	12.50**	–0.9
IC 11527 × AB-1	BP	13.04**	–9.94**	–8.33**	–11.39**	6.25**	0	–2.68**	–46.81**	–38.81**	6.66**
	MP	0	–6.76**	–8.33**	–2.10**	20.00**	6.67**	–0.5	–35.90**	–21.90**	19.87**
	IBP	0.77	16.40**	18.18**	–1.43*	15.69**	12.50**	16.42**	–16.36**	–7.32**	22.88**
IC 11527 × AK	BP	–15.71**	–22.22**	–23.08**	–16.88**	–5.56**	19.05**	–9.00**	–46.74**	24.53**	0
	MP	–17.19**	–14.92**	–20.00**	–9.22**	3.66**	25.00**	–6.38**	–36.36**	45.05**	7.54**
	IBP	1.69	–8.77**	0	–6.25**	–12.94**	–4.00**	–4.60**	–35.50**	21.21**	1.79
EC 169367 × PK	BP	2.31*	–12.00**	0	–16.47**	–25.00**	–20.00**	–21.01**	–38.71**	–24.49**	–1.1
	MP	0	–6.13**	0	–7.79**	–20.00**	–16.67**	–20.00**	–36.67**	–22.11**	0.09
	IBP	3.76**	13.92**	–18.18**	4.23**	–16.67**	–10.00**	–14.35**	20.32**	–29.73**	–5.36**
EC 169367 × AB-1	BP	5.22**	13.92**	–16.67**	–3.80**	0.96	4.17**	–13.03**	–24.47**	–11.94**	5.92**
	MP	–1.22	14.25**	–13.04**	2.70**	5.00**	6.38**	–4.72**	–24.06**	4.42**	18.35**
	IBP	1.65	16.96**	20.00**	0	11.43**	12.00**	0.82	6.05**	13.56**	20.67**

(*Continued*)

Table 2 (*Continued*)

Cross combination	BP MP IBP	Days to 50% flowering	Plant height (cm)	Number of branches/ plant	Number of nodes/ plant	Length of first fruiting node (cm)	Internodal length (cm)	Fruit length (cm)	Fruits width (cm)	No. of fruits/ plant	Green fruit yield/plants (g)
EC 169367 × AK	BP	–10.00**	8.33**	–30.77**	–2.60**	2.88**	17.39**	–41.39**	–61.29**	–3.77**	24.96**
	MP	–13.33**	15.01**	–25.00**	2.74**	10.31**	28.57**	–35.42**	–61.08**	3.03**	33.57**
	IBP	0	33.10**	–44.44**	–2.67**	14.95**	14.81**	–36.98**	–36.61**	13.73**	19.84**
SC 108 × PK	BP	2.94**	–9.50**	16.67**	–9.41**	–3.03**	–4.00**	–7.11**	–24.14**	40.82**	17.18**
	MP	2.56*	–3.08**	21.74**	6.21**	1.05	2.13**	2.38*	–18.52**	51.65**	39.20**
	IBP	12.14**	18.23**	28.57**	14.29**	3.13**	12.50**	5.93**	28.79**	27.54**	8.58**
SC 108 × AB-1	BP	10.43**	–4.83**	8.33**	–7.59**	6.06**	0	9.16**	–38.30**	–2.99**	–7.54**
	MP	0.79	–4.15**	8.33**	5.04**	7.69**	4.35**	11.28**	–31.36**	19.27**	19.05**
	IBP	1.57	4.18**	23.08**	12.33**	11.43**	12.50**	4.92**	19.30**	18.46**	10.40**
SC 108 × AK	BP	–8.76**	5.81**	–23.08**	–15.58**	–7.07**	4.55**	21.13**	–41.30**	–1.89**	13.05**
	MP	–9.75**	12.79**	–20.00**	–5.11**	–2.65**	12.20**	22.72**	–35.33**	9.47**	40.43**
	IBP	2.40*	23.39**	–10.00**	9.23**	2.17*	–21.74**	19.49**	1.13**	3.85**	8.66**
VRO 5 × PK	BP	6.87**	–9.50**	–15.38**	–21.18**	–15.38**	–16.00**	–15.73**	–40.23**	–12.24**	–10.69**
	MP	4.87**	9.86**	–8.33**	–13.55**	–14.44**	2.44**	1.56*	–27.78**	–3.37**	–5.97**
	IBP	2.86*	21.82**	18.18**	–7.46**	–1.3	–9.52**	7.88**	12.31**	–9.30**	2.39*
VRO 5 × AB-1	BP	13.91**	14.20**	–23.08**	–6.33**	–23.96**	29.17**	–17.30**	–42.55**	–13.43**	10.95**
	MP	6.50**	31.59**	–20.00**	–0.67	–21.08**	55.00**	–7.01**	–28.48**	8.41**	16.82**
	IBP	2.29*	23.63**	–10.00**	8.11**	–54.79**	12.90**	–14.89**	22.96**	15.52**	23.73**
VRO 5 × AK	BP	6.11**	6.57**	–15.38**	–7.79**	0	36.84**	10.57**	–50.00**	56.60**	27.41**
	MP	2.58*	28.85**	–15.38**	–3.40**	0.56	48.57**	23.63**	–38.26**	78.49**	27.93**
	IBP	3.60**	32.70**	18.18**	5.63**	–21.11**	11.54**	11.17**	–17.65**	32.53**	18.82**
C 7801 × PK	BP	0.75	–4.25**	–27.27**	–15.29**	–19.78**	–14.81**	–19.18**	–19.54**	–18.37**	–9.58**
	MP	–0.37	–0.26	–20.00**	–2.04**	–15.12**	–11.54**	–13.79**	–4.76**	–16.67**	–5.78**
	IBP	2.24*	26.37**	–25.00**	11.11**	–16.44**	0	–2.32**	19.71**	5.00**	–12.27**
C 7801 × AB-1	BP	3.48**	–14.67**	–25.00**	–11.39**	8.33**	–11.11**	0.25	–44.68**	–2.99*	4.59**
	MP	–4.03**	–12.78**	–14.29**	–0.71	17.51**	–5.88**	1.88*	–32.47**	14.04**	11.25**
	IBP	2.52*	–4.14**	–11.11**	–2.86**	25.96**	25.00**	7.87**	–11.45**	18.46**	16.27**
C 7801 × AK	BP	–3.76**	–11.36**	0	–16.88**	4.44**	–7.41**	–2.96**	–39.13**	28.30**	23.33**
	MP	–6.23**	–8.12**	18.18**	–7.91**	9.94**	8.70**	–0.76	–26.32**	36.00**	25.17**
	IBP	–2.34*	13.68**	38.46**	–6.25**	4.26**	–4.00**	11.08**	19.00**	30.88**	12.30**
BO 2 × PK	BP	4.27**	–6.75**	0	–10.59**	2.15*	–8.00**	–17.03**	–28.74**	–5.36**	13.16**
	MP	–3.56**	–3.37**	12.00**	–4.40**	3.26**	–4.17**	–12.50**	–16.22**	0.95	15.70**
	IBP	4.92**	20.11**	42.86**	–10.53**	1.05	17.39**	9.35**	18.84**	11.32**	6.46**

(*Continued*)

Table 2 (*Continued*)

Cross combination	BP MP IBP	Days to 50% flowering	Plant height (cm)	Number of branches/ plant	Number of nodes/ plant	Length of first fruiting node (cm)	Internodal length (cm)	Fruit length (cm)	Fruits width (cm)	No. of fruits/ plant	Green fruit yield/plants (g)
BO 2 × AB-1	BP	0.87	–17.20**	–21.43**	–10.13**	10.42**	8.33**	–18.99**	–42.55**	11.94**	–16.42**
	MP	0	–14.92**	–15.38**	–7.19**	12.17**	10.64**	–16.69**	–30.32**	21.95**	–5.75**
	IBP	0.86	–1.3	9.09**	–11.27**	13.21**	11.54**	–25.25**	1.28**	18.67**	1.59
BO 2 × AK	BP	11.97**	–7.58**	–14.29**	–14.29**	2.15*	–8.70**	7.93**	–28.26**	35.71**	31.81**
	MP	1.95*	–4.69**	–11.11**	–12.58**	3.83**	0	11.69**	–13.73**	39.45**	42.25
	IBP	1.53	19.95**	25.00**	–10.61**	2.11*	–38.10**	18.24**	20.00**	42.11**	19.55**
VRO 3 × PK	BP	1.53	–8.75**	–8.33**	–27.06**	–18.68**	–20.00**	–16.16**	–24.14**	–6.12**	–0.7
	MP	–0.37	–3.69**	–4.35**	–15.65**	–16.85**	–18.37**	–15.16**	–5.04**	–2.13*	1.52
	IBP	6.77**	18.63**	9.09**	–1.61*	–31.08**	15.00**	–6.98**	13.75**	–8.70**	11.44**
VRO 3 × AB-1	BP	0.87	–15.64**	–16.67**	–6.33**	–9.38**	12.50**	–24.28**	–51.06**	0	5.03**
	MP	–5.69**	–14.93**	–16.67**	4.96**	–4.92**	12.50**	–18.91**	–36.99**	19.64**	13.78**
	IBP	0	0	–10.00**	8.11**	–21.84**	7.41**	–29.63**	–18.97**	22.39**	21.41**
VRO 3 × AK	BP	2.29*	–10.35**	0	–9.09**	3.33**	29.17**	–29.80**	–29.35**	60.38**	–10.60**
	MP	–1.11	–5.84**	4.00**	0.72	5.08**	44.19**	–24.38**	–9.72**	73.47**	–7.51**
	IBP	–6.72**	20.85**	38.46**	–2.86**	3.23**	35.48**	–22.05**	16.54**	28.24**	3.28**
KS 312 × PK	BP	0.85	–12.75**	0	–20.00**	0	–8.00**	–19.83**	–27.59**	–4.08**	–13.70**
	MP	–6.30**	–5.42**	0	–8.11**	7.06**	–4.17**	–3.88**	–11.89**	1.08*	–9.28**
	IBP	0.84	19.77**	27.27**	–4.41**	16.48**	–21.74**	–1.05*	15.56**	–4.26**	–16.06**
KS 312 × AB-1	BP	16.52**	–9.94**	–25.00**	–6.33**	–5.21**	–8.33**	–3.82**	–42.55**	–31.34**	–18.20**
	MP	15.02**	–8.12**	–21.74**	4.23**	4.00**	–6.38**	7.54**	–28.00**	–17.12**	–13.73**
	IBP	5.97**	0.95	–22.22**	–8.11**	–2.20*	4.55**	–1.53*	–5.22**	4.35**	–5.61**
KS 312 × AK	BP	22.03**	–11.87**	–7.69**	–2.60**	7.78**	–4.35**	–19.33**	–28.26**	56.60**	9.46**
	MP	11.63**	–4.90**	0	7.14**	14.79**	4.76**	–10.32**	–10.81**	71.13**	10.09**
	IBP	4.17**	13.47**	8.33**	16.00**	–3.09**	9.09**	–33.80**	13.01**	27.71**	9.99**
IIHR 4 × PK	BP	2.42*	–12.25**	27.27**	–5.88**	4.40**	24.00**	–13.58**	3.45**	5.66**	13.16**
	MP	–2.31*	0.57	33.33**	0.63	11.11**	34.78**	–0.25	20.81**	9.80**	16.46**
	IBP	4.72**	12.54**	21.43**	–3.75**	1.05	45.16**	–5.81**	32.63**	7.14**	7.59**
IIHR 4 × AB-1	BP	21.74**	–13.92**	16.67**	–1.27*	–23.96**	16.67**	3.05**	–48.94**	1.49*	–9.17**
	MP	17.15**	–6.77**	27.27**	1.96*	–17.05**	24.44**	10.50**	–38.46**	13.33**	3.02**
	IBP	2.14*	–8.58**	0	–2.56**	–34.25**	17.86**	6.61**	–24.58**	13.24**	1.79
IIHR 4 × AK	BP	13.71**	–12.37**	–15.38**	–3.90**	–10.00**	14.29**	–11.86**	–25.00**	–7.55**	–8.32**
	MP	6.82**	0	–4.35**	–1.99*	–4.71**	20.00**	–6.04**	–10.39**	–7.55**	–0.44
	IBP	2.13*	17.58**	–27.27**	1.35*	–11.11**	12.50**	–18.86**	31.37**	2.04**	–2.14*

(*Continued*)

Table 2 (*Continued*)

Cross combination	BP MP IBP	Days to 50% flowering	Plant height (cm)	Number of branches/ plant	Number of nodes/ plant	Length of first fruiting node (cm)	Internodal length (cm)	Fruit length (cm)	Fruits width (cm)	No. of fruits/ plant	Green fruit yield/plants (g)
IC 69302 × PK	BP	3.25**	–7.25**	0	–23.53**	–11.34**	–20.00**	–12.50**	–11.49**	–2.00*	–9.80**
	MP	–1.93*	–1.46	10.00**	–12.75**	–8.51**	–16.67**	–11.93**	5.48**	–1.01	–1.83*
	IBP	2.36*	19.95**	0	9.23**	–22.09**	–25.00**	–8.73**	9.41**	6.12**	10.70**
IC 69302 × AB-1	BP	26.09**	4.53**	–16.67**	–10.13**	5.15**	4.17**	–7.42**	–57.45**	–25.37**	9.62**
	MP	21.85**	4.68**	–4.76**	–0.7	5.70**	6.38**	–0.35	–47.71**	–14.53**	11.51**
	IBP	2.76*	27.91**	10.00**	0	22.55**	–4.00**	–6.84**	–57.43**	2.00**	22.54**
IC 69302 × AK	BP	13.01**	–6.31**	0	–10.39**	8.25**	0	–12.01**	–9.78**	39.62**	9.04**
	MP	5.70**	–0.93	18.18**	–2.13**	12.30**	9.52**	–4.73**	9.93**	43.69**	12.48**
	IBP	0	17.25**	7.69**	5.80**	12.38**	–13.04**	2.63**	44.07**	14.86**	5.62**
SKY/TD/RS 113 × PK	BP	0	–12.75**	–9.09	–5.88**	9.89**	–8.00**	–7.76**	–21.84**	–27.69**	–22.43**
	MP	–5.84**	–8.40**	–9.09**	–0.62	16.28**	4.55**	–1.50*	2.26**	–17.54**	–12.91**
	IBP	2.48*	21.49**	20.00**	–6.25**	10.00**	13.04**	1.78**	22.69**	14.89**	–10.13**
SKY/TD/RS 113 × AB-1	BP	6.09**	–14.09**	0	–1.27*	–3.12**	–12.50**	5.93**	–55.32**	–17.91**	–17.14**
	MP	3.39**	–12.89**	4.35**	0.65	5.08**	–2.33**	7.52**	–40.00**	–16.67**	–15.70**
	IBP	0	–5.79**	25.00**	–2.56**	–2.15*	19.05**	7.08**	–46.98**	23.64**	–6.21**
SKY/TD/RS 113 × AK	BP	14.88**	–9.09**	–15.38**	–11.69**	20.00**	52.63**	5.68**	–7.61**	–16.92**	–7.29**
	MP	6.51**	–5.01**	–8.33**	–11.11**	26.32**	52.63**	7.94**	23.19**	–8.47**	–1.14
	IBP	–1.44	14.44**	0	–4.41**	9.26**	–6.90**	24.59**	38.35**	–5.56**	–5.08**
FB 10 × PK	BP	0	–25.25**	–28.57**	–10.59**	16.48**	28.00**	–18.75**	–41.38**	–10.00**	32.54**
	MP	0	–14.33**	–20.00**	–4.40**	26.19**	45.45**	–14.32**	–21.54**	5.88**	32.91**
	IBP	1.47	–8.03**	20.00**	–2.63**	11.32**	34.38**	–9.05**	0	31.75**	18.62**
FB 10 × AB-1	BP	8.70**	–13.92**	–7.14**	1.27*	–21.88**	37.50**	–8.41**	–34.04**	–2.86**	–10.95**
	MP	–0.4	–6.77**	0	4.58**	–13.29**	53.49**	–5.81**	–9.49**	–0.73	–1.31
	IBP	–1.6	–12.87**	46.15**	6.25**	–28.00**	12.12**	15.42**	39.77**	30.88**	4.49**
FB 10 × AK	BP	–8.09**	–11.11**	–28.57**	–7.79**	4.44**	63.16**	4.81**	–35.87**	2.86**	9.30**
	MP	–9.42**	1.44	–25.93**	–5.96**	12.57**	63.16**	8.46**	–12.59**	17.07**	15.82**
	IBP	0	13.92**	–30.00**	–12.68**	–14.89**	12.90**	12.80**	4.97**	12.50**	3.88**
Azad Bhindi 2 × PK	BP	8.04**	–18.75**	27.27**	–17.65**	5.00**	–18.52**	–9.48**	–4.60**	–9.62**	–21.90**
	MP	–2.42**	–15.58**	33.33**	–10.26**	9.95**	–15.38**	–3.78**	11.41**	–6.93**	–10.45**
	IBP	0.83	8.62**	50.00**	–10.00**	3.81**	–13.64**	2.12**	37.74**	4.26**	25.96**
Azad Bhindi 2 × AB-1	BP	14.29**	–13.78**	–8.33**	–7.59**	4.00**	22.22**	–8.56**	–51.06**	–34.33**	–1.9
	MP	12.78**	–11.63**	0	–2.67**	6.12**	29.41**	–6.73**	–41.03**	–26.05**	2.20*
	IBP	0.78	19.12**	0	6.85**	22.12**	33.33**	–7.45**	0.88	6.82**	18.59**

(*Continued*)

Table 2 (*Concluded*)

Cross combination	BP MP IBP	Days to 50% flowering	Plant height (cm)	Number of branches/ plant	Number of nodes/ plant	Length of first fruiting node (cm)	Internodal length (cm)	Fruit length (cm)	Fruits width (cm)	No. of fruits/ plant	Green fruit yield/plants (g)
Azad Bhindi 2 × AK	BP	8.04**	–12.63**	0	–3.90**	–9.00**	18.52**	12.71**	–31.52**	28.30**	–15.24**
	MP	–3.97**	–9.66**	13.04**	0	–4.21**	39.13**	15.68**	–18.18**	29.52**	–7.57**
	IBP	0	17.63**	0	9.46**	–21.98**	31.25**	36.62**	10.13**	2.94**	–7.22**
VRO 1668 × PK	BP	0	–27.75**	0	–32.94**	–31.87**	–8.00**	–13.58**	11.49**	–16.33**	–25.78**
	MP	–1.45	–23.14**	0	–20.28**	–27.06**	15.00**	–12.06**	49.23**	–3.53**	–23.83**
	IBP	1.47	10.03**	9.09**	12.28**	–70.97**	4.35**	–3.47**	50.77**	–19.51**	–22.17**
VRO 1668 × AB-1	BP	20.00**	0.57	0	–22.78**	–11.46**	–20.83**	–16.07**	–9.57**	–29.85**	–6.66**
	MP	8.24**	0.57	4.35**	–10.95**	–2.86*	–2.56**	–10.58**	24.09**	–8.74**	5.61**
	IBP	1.45	8.47**	8.33**	4.92**	–14.12**	–26.32**	–9.79**	37.65**	–6.38**	5.86**
VRO 1668 × AK	BP	–17.14**	–6.57**	–23.08**	–12.99**	–5.56**	57.89**	–4.02**	–20.65**	20.75**	14.85**
	MP	–17.14**	–1.07	–16.67**	–0.74	0.59	76.47**	2.87**	8.15**	43.82**	24.38**
	IBP	0.86	21.35**	0	–11.94**	–10.59**	26.67**	2.32**	17.57**	7.81**	6.53**
VRO 238 × PK	BP	3.28**	–11.25**	0	–20.00**	–37.14**	0	–17.24**	–18.39**	10.20**	–7.31**
	MP	–2.33*	–3.40**	4.76**	–11.11**	–32.65**	13.64**	–17.06**	–10.69**	10.20**	–7.23**
	IBP	0.79	27.89**	9.09**	7.35**	–45.45**	32.00**	0.36	43.89**	29.63**	8.09**
VRO 238 × AB-1	BP	7.83**	–13.64**	–8.33**	–6.33**	–33.33**	–12.50**	–0.65	–9.57**	8.96**	–18.49**
	MP	4.64**	–11.50**	0	0.68	–30.35**	–2.33**	7.37**	2.41**	25.86**	–9.82**
	IBP	2.42*	–5.26**	18.18**	0	–30.00**	–19.05**	22.94**	50.00**	17.81**	–4.17**
VRO–238 × AK	BP	8.20**	–11.36**	–15.38**	–14.29**	–16.19**	42.11**	–4.76**	–9.78**	41.51**	1.79
	MP	0.76	–3.97**	–4.35**	–8.97*	–9.74**	42.11**	3.53**	1.22**	47.06**	7.68**
	IBP	0.76	16.81**	18.18**	–4.55**	–12.50**	–22.22**	4.56**	24.33**	18.67**	–8.65**
SE	BP	0.78	0.84	0.42	0.47	0.63	0.5	0.34	0.14	0.52	1.04
	MP	0.67	0.73	0.37	0.4	0.54	0.43	0.34	0.12	0.46	1.09
	IBP	0.78	0.71	0.35	0.5	0.54	0.39	0.3	0.1	0.42	1.17
CD (P = 0.05)	BP	1.55	1.68	0.84	0.95	1.25	0.99	0.68	0.28	1.05	2.08
	MP	1.34	1.46	0.73	0.85	1.08	0.86	0.67	0.25	0.92	2.18
	IBP	1.57	1.41	0.71	1.02	1.07	0.77	0.59	0.19	0.84	2.34

*Significant at P = 0.05, **significant at P = 0.01

Bhindi 1) to 32.54 (FB 10 × Parbhani Kranti) per cent over better parent and -23.83 (VRO 1668 × Parbhani Kranti) to 42.25 (BO 2 × Azad Krishna) per cent over mid parent. Inbreeding depression ranged from 2.39 (VRO 5 × Parbhani Kranti) to 25.96 (Azad Bhindi 2 × Parbhani Kranti) per cent. Crosses Azad Bhindi 2 × Parbhani Kranti followed by VRO 5 × Azad Bhindi 1 etc. showed maximum significant negative inbreeding depression for high edible fruit yield per plant. Exploitation of hybrid vigour in any crop depends on magnitude and direction of heterosis. Amount of genetic diversity in the parents chosen for the development of hybrids also reflects magnitude of heterosis.

For maximum green fruit yield per plant twenty six crosses and thirty three crosses showed significant positive heterosis over better and mid parent, respectively. These are showed desirable heterosis for number of green fruit yield per plant over better parent and over mid parent. Inbreeding depression for this trait was observed in thirty two crosses show the maximum green fruit yield per plant. The heterotic response of these crosses was exhibited in most of the yield attributes also. The preponderant role of dominance in the magnitude of over dominance in these traits could be the reason for maximum heterosis for green fruit yield per plant. Similarly finding (Poshya and Shukla 1968) heterosis was highest yield/plant (Poshya and Vashi 1995) hybrids exhibiting significant heterosis for fruit yield. (Panwar *et al.* 1999) high heterosis for yield per plant (Yadav *et al.* 2003) inbreeding depression was observed in F_2 population with maximum depression (Thakar *et al.* 1981, Singh *et al.* 2002, Kumar *et al.* 2006, Vachhani *et al.* 2012, Medagam *et al.* 2012 and Hazem A *et al.* 2013).

CONCLUSION

The magnitude of heterosis was found in hybrid VRO 5 × Azad Krishna over better parent as well as mid parent for yield per plant indicating that this cross can be exploited for commercially. Inbreeding depression was observed for different characters studied in number of crosses. 21 crosses showed early flowering, 40 crosses tallest plant, 29 crosses maximum number of branches, 21 crosses maximum number of nodes per plant, 21 crosses maximum length of first fruiting node, 34 crosses maximum length of internode, 26 crosses maximum length of fruits, 36 crosses maximum width, 39 crosses maximum number of fruits per plant and 32 crosses maximum yield per plant. According to this, concluding that for fruit yield cross combination BO 2 × Azad Krishna show maximum inbreeding depression

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