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Estimation of heterosis for yield and its contributing traits in brinjal

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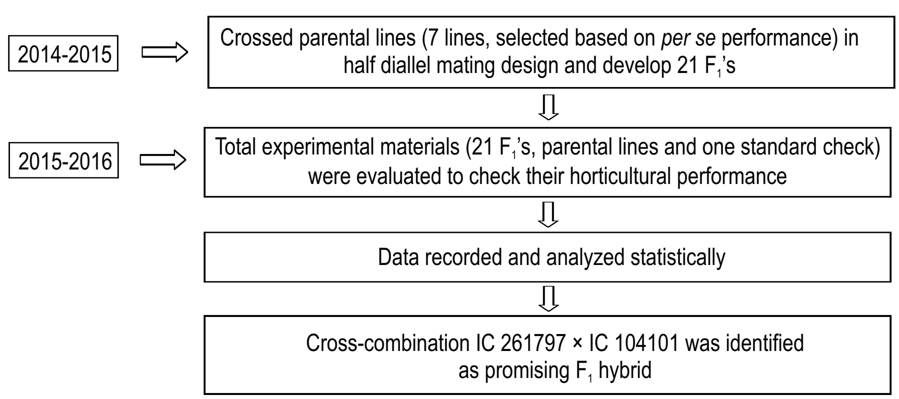
Abstract

Aim : The development of high yielding F_1 hybrids with superior fruit quality is important to increase the productivity as well as fulfill the demand of consumer and also increase the farmer's income. In view of this, the present study was undertaken to identify superior F_1 hybrids having desirable traits.

Methodology : Twenty one cross-combinations (excluding reciprocals) involving seven parents were made in a diallel fashion during 2014-2015. The parents were selected based on their *per se* performance. The experimental materials comprising twenty one F_1 hybrids, seven parents and one standard check were evaluated in randomized complete block design (RCBD) with three replications during the summer season of 2015-2016 at the experimental field of the Division of Vegetable Science and Floriculture, SKUAST-Jammu, India.

Results : Analysis of variance for experimental design indicated that the mean square (MS) due to genotypes, parents, hybrids and parents vs hybrids were significant for all the traits studied except days to first picking of parents and crosses, number of fruits per plant and primary branches per plant of parents and days to flowering of crosses, where the mean square was non-significant. For fruit yield per plant and total fruit yield (q ha^{-1}) twenty one and fourteen F_1 hybrids exhibited significant positive better parent and standard heterosis, respectively. The cross-combinations IC 354611 × IC 310886 and IC 261797 × IC 310886 exhibited highest heterosis over better parent for fruit yield per plant and total fruit yield, respectively, whereas over standard check, the hybrid IC 261797 × IC 104101 had shown the highest heterosis for both the traits. The F_1 hybrid IC 104101 × IC 310886 exhibited highest significant positive standard heterosis for number of fruits per plant and hybrid IC 261797 × IC 104101 for fruit weight. Some of the promising hybrids showed desirable heterosis for days to flowering, ascorbic acid and phenol content.

Interpretation : Cross-combination IC 261797 × IC 104101 was identified as promising F_1 hybrid for total fruit yield with other important fruit traits and this hybrid can be exploited at the commercial level.



Introduction

Brinjal (*Solanum melongena* L.; 2n=24) belongs to family Solanaceae, is an annual herbaceous versatile crop plant, which is well adapted to various agro-ecological zones and cultivated throughout the year. India is considered as the centre of origin/diversity of brinjal (Vavilov, 1931). Fruit extracts of brinjal have anti-oxidant (Lo Scalzo *et al.*, 2010), anti-carcinoma (Eleveld-Trancikova *et al.,* 2005), hepatoprotective (Akanitapichat *et al.,* 2010), anti-microbial, anti-LDL, anti-viral (Matsubara *et al.,* 2005) and cardio-protective properties. Due to its versatility use in Indian food, brinjal is often described as the *'king of vegetables'*. Based upon its year round production potential and availability, it is also termed as poor man's vegetable. In India, it occupies an area of about 0.71 million ha with the total production of 13.55 million tonnes and productivity of 19.06 tonnes ha^{-1} (FAO, 2014). To keep pace of increasing population, there is need to further increase the productivity level of this crop. In respect to local preferences for traits like color, size, shape and taste, there are specific germplasm suited for specific region. It is not possible to have a single cultivar to suit different localities and local preferences. It is therefore, required to improve the locally preferred varieties with high yield potential and adaptation (Akpan *et al.,* 2016). In India, brinjal has a huge amount of genetic diversity for agro-morphological characters (Sidhu *et al.,* 2005), which offers much scope for yield improvement through heterosis breeding. F_1 hybrids in India are more popular among farmers because of earliness, high yield potential, uniform maturity and high net return. The estimation of heterosis for fruit yield and quality parameters would, therefore, is useful to judge the best hybrid combination for their commercial exploitation (Prabhu *et al.,* 2005). The heterosis migh tbe due to factors such as heterozygosity, allelic interaction *viz.,* dominance or over-dominance, non-allelic interaction or epistasis and maternal interactions. Therefore, the present study was carried out to investigate the extent of heterosis in 21 F_1 hybrids (excluding reciprocals) over better parent and standard check hybrid in a diallel cross set of seven parents and to select suitable parents to develop F_1 hybrids, which can be evaluated further to enhance yield potential in brinjal.

Materials and Methods

The present research was undertaken during 2014-2015 and 2015-2016 at the Vegetable Experimental Farm, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha, (SKUAST-J), Jammu, India. The experimental materials used in this study comprised of seven genetically diverse lines of brinjal namely, Pusa Purple Cluster (PPC), IC 261797, IC 261767, IC 354611, IC 203585, IC 104101 and IC 310886 (received from National Bureau of Plant Genetic Resources, New Delhi, India). The parental lines were crossed in a half diallel fashion (excluding reciprocals) to generate 21 F_1 hybrids during 2014-2015. The resultant 21 F_1 hybrids along with their 7 parents and one standard check (Pusa Hybrid-5) were evaluated for yield and quality parameters. The experiment was laid out in a randomized complete block design (RCBD) with three replications during 2015-2016. The seedlings were transplanted on ridges and row × plant spacing was maintained at 75 cm × 60 cm. Cultural practices, such as fertilization, irrigation, weeding, diseases and insect-pests control were performed whenever required.

Data were recorded from five randomly selected plants leaving the border plant at each side. Observations were recorded in each replication on fourteen fruit yield and quality parameters *i.e.,* plant height (cm), number of primary branches per plant, days to flowering, days to first picking, number of fruits per cluster, fruit length (cm), fruit girth (cm), number of fruits per plant, average fruit weight (g), crop duration (days from transplanting to final harvesting of fruits), fruit yield per plant (g), total fruit yield (q ha^{-1}), ascorbic acid content (mg 100 g^{-1}) and total phenols content (mg 100 g^{-1}). The data was subjected to diallel analysis as per the method suggested by Griffing (1956). The data collected were subjected to heterosis analysis using computer software WINDOSTAT (INDOSTAT services Ltd. Hyderabad, India).

Results and Discussion

The analysis of variance for experimental design indicated that the mean square due to genotypes, parents, hybrids and parents vs hybrids were significant for all the traits studied except days to first picking of parents and crosses, number of fruits per plant and primary branches per plant of parents and days to flowering of crosses, where the mean square was non-significant indicating considerable amount of variability in the material selected for study (Table 1).

The early flowering is positively associated with early yield in brinjal. Earliness also leads to early supply of the produce in the market and enables it to fetch a higher price. The mean performance of parents for days to flowering varied from 51.00 (IC 261797) to 55.67 (IC 203585), on the other hand, the hybrid means ranged from 48.00 (PPC × IC 261797) to 52.00 (PPC × IC 104101). The negative heterosis for days to flowering is desirable for breeding short statured cultivars or hybrids. In this study, not even a single F_1 hybrid expressed positively significant heterosis over better parent and standard check for this character. Seventeen hybrids exhibited significant negative heterosis over better parent and standard check (Pusa Hybrid-5). The magnitude of heterosis varied from - 11.98% (IC 203585 × IC 310886) to -1.92% (IC 261797 × IC 261767); and -10.56% (PPC × IC 261797) to -3.11% (PPC × IC 104101) over better parent and standard check, respectively. The line IC 261797 and F_1 hybrids PPC × IC 261797 and IC 261767 × IC 310886 were identified as early to flowering (Table 2, 3). Better parent heterosis ranging from -2.91 to -27.98% has also been reported by Galani *et al.* (2015). The significant negative heterosis for days to flowering was also recorded by Dubey *et al.* (2014); Venkata *et al.* (2014); Galani *et al.* (2015); Bhushan *et al.* (2016); Shahjahan *et al.*

(2016); Balwani *et al.* (2017); Sivakumar *et al.* (2017). For days to first picking, negative heterosis was considered as desirable because yield obtained from early picking is profitable to the producer to gets better price in the market. Out of 21 F_1's, 12 and 10 hybrids were significantly earlier to their respective better parents and standard check, respectively. The days to first picking among parents ranged from 79.00 (PPC and IC 261797) to 81.33 (IC 203585). Among F_1 hybrids, the minimum was observed in 77.00 (PPC × IC 261797), whereas maximum was taken by hybrid IC 261797 × IC 310886 (80.33). In case of better parent, the heterosis varied from -3.28% (PPC × IC 203585 and IC 203585 × IC 310886) to -0.82% (IC 261797 × IC 310886), while over standard check the magnitude of heterosis ranged from -4.94% (PPC × IC 261797) to -0.82% (IC 261797 × IC 310886). PPC × IC 261797, PPC × IC 261767, PPC × IC 203585, IC 261797 × IC 354611 and IC 203585 × IC 310886 were the top hybrids over standard check for early picking in brinjal. Number of fruits per cluster was positively associated with fruit yield because it helps to increase yield per plant. Perusal of mean performance revealed that among the parents, IC 104101 (2.16) had highest number of fruits per cluster followed by IC 310886 (2.11), whereas minimum was recorded in IC 354611 (1.40). Among hybrids, it ranged from 2.40 in IC 261767 × IC 310886 to 4.53 in IC 354611 × IC 104101. All the 21 F_1 hybrids observed significant positive better parent and standard heterosis except IC 261767 × IC 310886, which showed non-significant heterosis over better parent. The heterosis over better parent and standard check varied from 13.92% (IC 261767 × IC 310886) to 133.08% (IC 261797 × IC 354611) and from 46.34% in IC 261767 × IC 310886 to 176.02% in IC 354611 × IC 104101, respectively. Dubey *et al.* (2014) have reported better parent heterosis up to 45.05% for fruits per cluster.

Fruit length is an important parameter which decides consumer preference. The fruit length of parents ranged from 8.46 cm (IC 354611) to 12.18 cm (IC 104101), whereas for hybrids it varied from 11.08 cm (PPC × IC 261797) to 16.86 cm (IC 261797 × IC 104101). The magnitude of heterosis ranged from 12.13% (IC 203585 × IC 104101) to 88.95% (PPC × IC 310886) over better parent and from 8.87% (PPC × IC 261797) to 65.65% (IC 261797 × IC 104101) over standard check. All the twenty one F_1 hybrids showed significant positive heterosis over their respective better parent and over standard check. The fruit girth of parents and hybrids varied from 14.66 cm (IC 310886) to 21.79 cm (IC 104101) and 14.41 cm (IC 354611 × IC 104101) to 20.89 cm (IC 261797 × IC 203585). The heterosis over better parent and standard check ranged from -33.91% in IC 354611 × IC 104101 to 11.32% in PPC × IC 310886; and from -11.28% (IC 354611 × IC 104101) to 28.56% (IC 261797 × IC 203585), respectively. None of the hybrid was better than their respective better parent. 7 hybrids namely, PPC × IC 261797, PPC × IC 203585, IC 261797 × IC 203585, IC 261797 × IC 104101, IC 261797 × IC 310886, IC 354611 × IC 203585 and IC 104101 × IC 310886 exhibited significant positive standard heterosis. Standard heterosis for fruit length and fruit diameter has been observed up to 134.09 and 104.48% by Nagar *et al.* (2016). Significant positive heterosis for fruit length and fruit girth was also earlier reported by Makani *et al.* (2013); Galani *et al.* (2015); Bhushan *et al.* (2016); Balwani *et al.* (2017); Sivakumar *et al.* (2017). Fruit weight is one of the most important characters which directly influence the total fruit yield. Perusal of data revealed that among parents, maximum fruit weight was recorded in IC 203585 (92.93 g) and minimum in PPC (71.55 g), whereas among hybrids it ranged from 80.23 g in PPC × IC 261767 to 115.25 g in IC 261767 × IC 104101. Out of 21 F_1 hybrids, fourteen and none of the hybrids showed significant positive better parent and standard heterosis. The hybrids IC 261797 × IC 354611 and IC 261767 × IC 104101 exhibited maximum heterosis over better parent and standard check, respectively, ranging from -11.88% to 46.68% over better parent, whereas from-22.02% to 12.02% over standard check. Standard heterosis up to 36.63% has been reported by Nagar *et al.* (2016) and better parent heterosis from -39.79 to 77.57% reported by Balwani *et al.* (2017). Venkata *et al.* (2014); Galani *et al.* (2015); Shahjahan *et al.* (2016) also reported positive heterosis for fruit weight.

Number of fruits per plant is economically important characterto get moreyields. Heterosis for fruit yield per plant is positively associated with heterosis for number of fruits per plant. The number of fruits per plant can be increased by utilizing variable parents lines and progenies in breeding programme. The mean value of parents for number of fruits per plant ranged from 22.16 in IC 261797 to 30.93 in IC 104101, whereas from 33.66 in PPC × IC 261767 to 83.62 in IC 104101 × IC 310886 among the hybrids. Heterobeltiosis ranged from 37.43% (PPC × IC 261767) to 221.87% (IC 203585 × IC 310886) and standard heterosis varied from 33.05% (PPC × IC 261767) to 230.57% (IC 104101 × IC 310886). All the 21 F_1 hybrids exhibited significant positive heterosis over their respective better parent and over standard check. IC 104101 × IC 310886, IC 203585 × IC 310886, IC 354611 × IC 310886 and IC 261767 × IC 104101 were the top 4 hybrids over standard check for number of fruits per plant. In brinjal, heterosis over standard check for number of fruits per plant has been observed up to 92.15% by Nagar *et al.* (2016), up to 69.36% by Balwani *et al.* (2017) and up to 92.12% by Sivakumar *et al.* (2017).

The number of primary branches per plant is also one of the major contributing traits for fruit yield per plant. Mean performance of parents for number of primary branches per plant varied from 6.07 (IC 310886) to 7.00 (PPC) and for hybrids, it ranged from 9.76 (PPC × IC 354611) to 12.62 (IC 104101 × IC 310886). The better parent heterosis ranged from 39.48% in PPC × IC 354611 to 99.95% in IC 203585 × IC 310886, and from -12.85% in PPC × IC 354611 to 12.65% in IC 104101 × IC 310886 over standard check hybrid. All the 21 F_1 hybrids had shown significant and positive heterosis over better parent but over standard check only 1 hybrid namely IC 104101 × IC 310886 exhibited significant positive heterosis. Significant and positive heterosis for number of primary branches per plant has also been reported by Venkata *et al.* (2014); Galani *et al.* (2015); Bhushan *et al.* (2016); Shahjahan *et al.* (2016); Sivakumar *et al.* (2017). The ideal plant type is one which is long and acts as source trait to

Table 1 : Analysis of variance of diallel hybrids among seven parents evaluated for 14 traits in brinjal

Source of variations	df	Days to flowering	Days to first picking	No. of fruits/ cluster	Fruit length (cm)	Fruit girth (cm)	Average fruit weight (g)	No. of fruits/ plant	No. of primary branches/ plant	Plant height (cm)	Crop duration	Fruit yield/ plant (g)	Fruit yield (q ha^{-1})	Ascorbic acid content (mg 100 g^{-1})	Total phenol content (mg 100 g^{-1})
Replications	2	1.94	1.27	0.02	0.06	0.12	59.94	1.22	0.31	16.45	4.75	9518.53	98.68	0.59	0.02
Treatments	27	11.42*	2.67*	2.41*	24.39*	1.59*	616.24*	1330.03*	12.43*	303.81*	202.74*	3795639.25*	39342.34*	16.53*	0.05*
Parents	6	8.75*	2.94	0.28*	5.41*	2.03*	245.19*	24.81	0.79	472.48*	57.92*	42125.19*	436.62*	3.07*	0.04*
Hybrids	20	2.93	1.39	1.45*	12.65*	1.38*	436.79*	694.31*	1.47*	71.54*	65.18*	3135749.25*	32502.57*	5.20*	0.05*
Parent *vs* Hybrids	1	197.33*	26.69*	34.35*	373.03*	3.25*	6431.48*	21875.72*	301.39*	3937.28*	3822.79*	39514520.00*	409572.19*	324.04*	0.02
Error	54	3.40	1.36	0.04	0.06	0.15	53.17	13.21	0.37	10.13	5.85	4403.54	45.65	0.56	0.01

*Significant at 5 percent level of significance

Table 2 : Mean performance of 7 parents and their 21 F_1 hybrids for 14 traits of brinjal

Parents/ Hybrids	Days to flowering	Days to first picking	No. of fruits/ cluster	Fruit length (cm)	Fruit girth (cm)	Average fruit weight (g)	No. of fruits/ plant	No. of primary branches/ plant	Plant height (cm)	Crop duration	Fruit yield/ plant (g)	Fruit yield (q ha^{-1})	Ascorbic acid content (mg 100 g^{-1})	Total phenol content mg 100 g^{-1})
Pusa Purple Cluster (PPC)	51.67	79.00	2.05	8.75	16.35	71.55	23.69	7.00	96.24	156.22	1968.13	200.37	9.73	0.86
IC 261797	51.00	79.00	1.76	8.48	19.31	73.96	22.16	6.93	68.14	156.89	1803.19	183.58	8.03	0.93
IC 261767	52.00	80.33	1.53	8.83	17.14	76.88	24.49	5.79	96.26	157.65	1995.65	203.17	9.14	0.87
IC 354611	53.67	81.00	1.40	8.46	19.62	71.87	23.19	6.83	94.65	158.26	1785.39	181.77	8.32	0.87
IC 203585	55.67	81.33	1.60	8.86	20.97	92.93	24.02	6.10	71.83	156.42	1864.84	189.85	7.30	0.72
IC 104101	54.33	81.00	2.16	12.18	21.79	91.50	30.93	6.93	85.94	162.19	2096.20	213.41	9.23	1.12
IC 310886	54.33	81.00	2.11	8.54	14.66	76.83	25.56	6.07	72.67	168.26	1808.93	184.17	7.07	0.86
PPC × IC 261797	48.00	77.00	3.15	11.08	19.53	87.32	34.72	10.05	97.67	171.19	2200.57	224.04	11.60	0.85
PPC × IC 261767	49.67	78.00	2.96	12.07	16.89	80.23	33.66	9.87	100.16	161.82	2115.96	215.42	14.44	0.87
PPC × IC 354611	51.33	79.33	2.83	11.10	16.51	90.87	44.42	9.76	92.60	172.89	2163.78	220.29	10.76	0.80
PPC × IC 203585	49.67	78.67	2.89	12.96	19.56	84.91	42.49	10.02	103.53	167.73	2276.71	231.79	15.17	0.84
PPC × IC 104101	52.00	79.33	4.02	14.80	17.92	80.63	53.22	11.27	103.06	174.79	4261.65	433.87	12.30	1.17
PPC × IC 310886	50.33	79.33	3.88	16.53	18.21	106.42	56.19	10.83	103.53	171.06	3889.65	396.00	12.27	0.82
IC 261797 × IC 261767	51.00	79.67	2.53	11.58	14.85	85.21	53.35	11.33	102.79	174.56	2238.02	227.85	10.64	0.79
IC 261797 × IC 354611	49.00	78.67	4.11	13.85	15.67	108.49	56.66	11.20	104.11	172.70	4416.99	449.69	13.38	0.85
IC 261797 × IC 203585	50.00	79.33	2.76	12.82	20.89	105.93	55.22	10.53	102.76	173.76	3141.26	319.81	12.43	1.07
IC 261797 × IC 104101	49.00	79.00	3.96	16.86	19.28	112.25	58.52	10.53	102.10	175.73	4827.12	491.45	13.22	1.09
IC 261797 × IC 310886	51.00	80.33	2.47	11.68	20.00	93.74	59.89	10.39	100.56	176.83	3877.03	394.72	12.22	0.98
IC 261767 × IC 354611	49.00	79.33	3.05	14.08	15.32	110.18	67.49	11.06	100.22	179.16	4551.39	463.38	11.39	0.84
IC 261767 × IC 203585	49.33	80.00	3.18	15.61	14.88	109.09	69.16	11.17	100.66	179.72	4681.55	476.62	12.41	0.81
IC 261767 × IC 104101	49.00	79.33	2.60	16.06	14.63	115.25	75.85	10.86	100.62	176.59	3963.22	403.49	14.12	0.76
IC 261767 × IC 310886	48.67	79.00	2.40	12.78	15.70	88.30	74.52	11.03	83.25	179.42	2352.76	239.53	13.49	0.84
IC 354611 × IC 203585	49.33	79.00	2.47	11.79	19.18	103.59	71.94	10.93	91.96	171.56	2265.35	230.63	15.23	0.72
IC 354611 × IC 104101	49.00	79.00	4.53	16.14	14.41	111.90	75.82	10.67	101.35	178.46	4134.19	420.90	13.09	0.67
IC 354611 × IC 310886	49.67	79.33	4.13	16.05	14.47	106.85	80.56	11.20	98.96	179.53	4746.39	483.22	13.30	0.77
IC 203585 × IC 104101	50.33	79.33	2.83	13.65	18.09	88.42	75.16	11.27	100.52	177.12	2851.42	290.30	14.79	0.87
IC 203585 × IC 310886	49.00	78.67	4.14	16.11	15.04	111.85	82.26	12.19	98.66	180.26	3937.73	400.90	12.27	0.74
IC 104101 × IC 310886	49.33	79.00	3.98	16.85	18.56	109.48	83.62	12.62	100.19	179.95	4336.93	441.54	13.17	0.77

support yield and its component traits. Among the parents and hybrids, plant height varied from 68.14 cm (IC 261797) to 96.26 cm (IC 261767) and from 83.25 cm (IC 261767 × IC 310886) to 104.11 cm (IC 261797 × IC 354611), respectively. Out of 21 F_1 hybrids, 12 and 21 hybrids exhibited significant positive heterosis over better parent and standard check, respectively. The range of heterosis over better parent varied from -13.52% in IC 261767 × IC 310886 to 43.06% in IC 261797 × IC 203585, whereas from 30.06% in IC 261767 × IC 310886 to 62.64% in IC 261797 × IC 354611 over standard check. Better parent heterosis for plant height has been observed up to 24.82% by Balwani *et al.* (2017), and standard heterosis up to 53.12% reported by Nagar *et al.* (2016). Perusal of data for crop duration revealed that among parents, it ranged from 156.22 days (PPC) to 168.26 days (IC 310886) and among hybrids it varied from 161.82 days (PPC × IC 261767) to 180.26 days (IC 203585 × IC 310886). Percent heterosis over better parent ranged from 1.67% (PPC × IC 310886) to 14.00% (IC 261767 × IC 203585) and from -2.55% (PPC × IC 261767) to 8.56% (IC 203585 × IC 310886) over standard check hybrid. Heterosis study depicted that all the 21 F_1 hybrids showed significant and positive heterosis over better parent except PPC × IC 310886 and over standard check except PPC × IC 261767 and PPC × IC 203585.

The fruit yield per plant is one of the most important characters, which deserves maximum consideration in any crop improvement programme. Fruit yield per plant of parents and F1 hybrids ranged from 1785.39 g in IC 354611 to 2096.20 g in IC 104101 and from 2115.96 g (PPC × IC 261767) to 4827.12 g (IC 261797 × IC 104101), respectively. Out of 21 F_1's, 14 and 21 hybrids showed significant and positive heterosis over standard check and better parent, respectively. The better parent and standard heterosis varied from 6.03% in PPC × IC 261767 to 162.39% in IC 354611 × IC 310886 and from -6.73% (PPC × IC 261767) to 112.78% (IC 261797 × IC 104101), respectively. The fruit yield (q ha^{-1}) of parents ranged from 181.77 (IC 354611) to 213.41 (IC 104101) and among hybrids, it varied from 215.42 (PPC × IC 261767) to 491.45 (IC 261797 × IC 104101). The heterosis over better parent varied from 6.03% in PPC × IC 261767 to 162.38% in IC 354611 × IC 310886 and from -6.73% in PPC × IC 261767 to 112.78% in IC 261797 × IC 104101 over standard check hybrid. In the present study, the hybrids IC 261797 × IC 104101, IC 354611 × IC 310886, IC 261767 × IC 203585 and IC 261767 × IC 354611 showed > 100% standard heterosis for fruit yield per plant and fruit yield (q ha^{-1}). Out of twenty one F_1 hybrids, fourteen and twenty one exhibited significant positive heterosis over standard check and better parent, respectively. Patel *et al.* (2017) have reported standard heterosis in the range of - 45.63 to 48.28% for fruit yield per plant. Standard heterosis to the extent of 22.98% has been observed by Galani *et al.* (2015), up to 67.12% by Palli *et al.* (2016). The significant positive heterosis for fruit yield per plant has also been reported by Bhushan *et al.* (2016); Shahjahan *et al.* (2016); Sivakumar *et al.* (2017).

The ascorbic acid content is important quality traits. Mean performance of parents ranged from 7.07 mg 100 g^{-1} (IC 310886) to 9.73 mg 100 g^{-1} (PPC) and for the hybrids it varied from 10.64 mg 100g^{-1} in IC 261797 × IC 261767 to 15.23 mg 100 g^{-1} in IC 354611 × IC 203585. The heterosis over better parent varied from 10.55% in PPC × IC 354611 to 83.17% in IC 354611 × IC 203585, while from 11.60% in IC 261797 × IC 261767 to 59.73% in IC 354611 × IC 203585 over standard check hybrid. All the hybrids exhibited significant and positive heterosis over better parent and standard check except PPC × IC 354611 (over better parent and standard check) and IC 261797 × IC 261767 (over standard check), which showed non-significant positive heterosis. The heterobeltiosis and standard heterosis ranging from-42.37 to 22.39% and -41.27 to 24.74% has been observed by Patel *et al.* (2017) and up to 40.37% and 44.96% by Balwani *et al.* (2017).

Phenols are the extremely abundant plant allelochemicals, often associated with feeding deterrence of growth inhibition of herbivores. Phenol content is also an important character as it helps to reduce the shoot and fruit borer incidence (Kumar *et al.*, 2012). If the phenol content is high borer infestation will be less. Improvement of phenol content can be achieved by utilizing variable parents and progenies. Mean value for phenol content ranged from 0.72 mg 100 g^{-1} in IC 203585 to 1.12 mg 100 g^{-1} in IC 104101 among parents, whereas from 0.67 mg 100 g^{-1} (IC 354611 × IC 104101) to 1.17 mg 100 g^{-1} (PPC × IC 104101) among hybrids. The heterobeltiosis ranged from -39.88% in IC 354611 × IC 104101 to 15.41% in IC 261797 × IC 203585, while standard heterosis ranged from - 5.51% in IC 203585 × IC 310886 to 48.31% in PPC × IC 104101. In the present study, the line IC 104101 among the parents had maximum total phenol content and PPC × IC 104101 among the hybrids recorded maximum value for phenol content. For processing purposes, the fruit should have low level of phenolic content (Dhruve *et al.,* 2014). The negative heterosis for phenol content is desirable for breeding hybrids suitable for processing. The F_1 hybrid IC 354611 × IC 104101 (-39.88%) showed the highest negative and significant better parent heterosis followed by IC 261767 × IC 104101 (-32.44%) and IC 104101 × IC 310886 (-30.95%). Out of 21 F_1 hybrids, 4 and none of the F_1 hybrids exhibited significant positive heterosis over standard check and better parent, respectively. Significant positive and negative heterosis for phenol content was also reported by Patel *et al.* (2017).

The results of present investigation revealed that some genotypes had strong heterotic capacity as compared to rest of the genotypes during the hybridization. The performance of F_1's also largely depends on the genetic diversity of the parental lines involved in the crossing programme. The hybrids exhibited desirable better parent heterosis and standard heterosis for fruit yield per plant and other characters could be further evaluated to exploit the heterosis or utilized in future breeding programme to obtain desirable segregants for the development of superior genotypes. Based on results obtained from this study, the parents IC 261797 and IC 104101 can be used as donors for specific traits in breeding hybrids. On the basis of better parent and standard

Table 3 : Heterosis percentage over better parent (BP) and standard check (SC) of 21 hybrids for 14 traits of brinjal

Hybrids	Days to flowering		Days to first picking		No. of fruits/cluster		Fruit length (cm)		Fruit girth (cm)		Average fruit weight (g)		No. of fruits/ plant	
	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC
PPC × IC 261797	-7.10*	-10.56*	-2.53*	-4.94*	53.91*	92.07*	26.67*	8.87*	1.14	20.25*	18.06*	-15.13*	46.57*	37.26*
PPC × IC 261767	-4.49	-7.45*	-2.90*	-3.70*	44.46*	80.28*	36.74*	18.57*	-1.41	4.06	4.36	-22.02*	37.43*	33.05*
PPC × IC 354611	-4.35	-4.35	-2.06	-2.06	38.11*	72.36*	26.82*	9.00*	-15.74*	1.81	26.44*	-11.68	87.51*	75.60*
PPC × IC 203585	-10.78*	-7.45*	-3.28*	-2.88*	41.04*	76.02*	46.37*	27.34*	-6.78	20.50*	-8.63	-17.47*	76.92*	67.97*
PPC × IC 104101	-4.29	-3.11	-2.06	-2.06	86.27*	145.33*	21.57*	45.42*	-17.77*	10.38	-11.88	-21.63*	72.07*	110.37*
PPC × IC 310886	-7.36*	-6.21*	-2.06	-2.06	84.18*	136.59*	88.95*	62.41*	11.32	12.19	38.52*	3.44	119.86*	122.12*
IC 261797 × IC 261767	-1.92	-4.97	-0.83	-1.65	43.67*	54.47*	31.16*	13.72*	-23.10*	-8.58	10.83	-17.18*	117.84*	110.90*
IC 261797 × IC 354611	-8.70*	-8.70*	-2.88*	-2.88*	133.08*	150.61*	63.29*	36.02*	-20.12*	-3.48	46.68*	5.45	144.35*	123.97*
IC 261797 × IC 203585	-10.18*	-6.83*	-2.46*	-2.06	56.33*	68.09*	44.79*	25.97*	-0.55	28.56*	13.99*	2.96	129.92*	118.29*
IC 261797 × IC 104101	-9.82*	-8.70*	-2.47*	-2.47*	83.33*	141.46*	38.49*	65.65*	-11.48*	18.83*	22.68*	9.10	89.22*	131.33*
IC 261797 × IC 310886	-6.13*	-4.97	-0.82	-0.82	17.09*	50.41*	36.81*	14.77*	3.69	23.28*	22.02*	-8.89	134.36*	136.76*
IC 261767 × IC 354611	-8.70*	-8.70*	-2.06	-2.06	98.70*	85.77*	59.52*	38.31*	-21.93*	-5.67	43.30*	7.09	175.57*	166.78*
IC 261767 × IC 203585	-11.38*	-8.07*	-1.64	-1.23	98.54*	93.70*	76.21*	53.31*	-29.03*	-8.25	17.38*	6.03	182.39*	173.38*
IC 261767 × IC 104101	-9.82*	-8.70*	-2.06	-2.06	20.37*	58.54*	31.86*	57.73*	-32.80*	-9.80	25.96*	12.02	145.26*	199.84*
IC 261767 × IC 310886	-10.43*	-9.32*	-2.47*	-2.47*	13.92	46.34*	44.83*	25.57*	-8.43	-3.35	14.85	-14.18*	191.57*	194.57*
IC 354611 × IC 203585	-11.38*	-8.07*	-2.87*	-2.47*	54.17*	50.41*	33.08*	15.78*	-8.53	18.25*	11.47	0.69	199.54*	184.39*
IC 354611 × IC 104101	-9.82*	-8.70*	-2.47*	-2.47*	109.57*	176.02*	32.52*	58.51*	-33.91*	-11.28	22.30*	8.76	145.16*	199.72*
IC 354611 × IC 310886	-8.59*	-7.45*	-2.06	-2.06	95.89*	151.63*	87.94*	57.66*	-26.25*	-10.90	39.08*	3.86	215.22*	218.46*
IC 203585 × IC 104101	-9.58*	-6.21*	-2.46*	-2.06	31.17*	72.76*	12.13*	34.12*	-17.00*	11.41	-4.85	-14.06*	143.02*	197.10*
IC 203585 × IC 310886	-11.98*	-8.70*	-3.28*	-2.88*	96.52*	152.44*	81.90*	58.25*	-28.33*	-7.35	20.36*	8.72	221.87*	225.18*
IC 104101 × IC 310886	-9.20*	-8.07*	-2.47*	-2.47*	84.10*	142.48*	38.41*	65.55*	-14.79*	14.38*	19.65*	6.41	170.39*	230.57*

Table 3 : (Cont'd.)

Hybrids	No. of primary branches/ plant		Plant height (cm)		Crop duration		Fruit yield plant (g^{-1})		Fruit yield (q ha^{-1})		Ascorbic acid content (mg 100 g^{-1})		Total phenol content (mg 100 g^{-1})	
	BP	**SC**	**BP**	**SC**	**BP**	**SC**	**BP**	**SC**	**BP**	**SC**	**BP**	**SC**	**BP**	**SC**
PPC × IC 261797	43.62*	-10.26	1.48	52.58*	9.12*	3.10*	11.81*	-3.00	11.81*	-3.00	19.21*	21.67*	-8.60	8.05
PPC × IC 261767	40.95*	-11.93*	4.05	56.47*	2.65*	-2.55*	6.03*	-6.73*	6.03*	-6.73*	48.39*	51.45*	0.00	10.17
PPC × IC 354611	39.48*	-12.85*	-3.79	44.66*	9.25*	4.12*	9.94*	-4.62	9.94*	-4.62	10.55	12.83	-8.08	1.27
PPC × IC 203585	43.19*	-10.53	7.57*	61.73*	7.23*	1.01	15.68*	0.36	15.68*	0.36	55.89*	59.11*	-3.09	6.36
PPC × IC 104101	60.95*	0.57	7.08*	61.00*	7.77*	5.26*	103.30*	87.85*	103.30*	87.85*	26.37*	28.98*	4.17	48.31*
PPC × IC 310886	54.71*	-3.33	7.57*	61.73*	1.67	3.02*	97.63*	71.45*	97.63*	71.45*	26.10*	28.70*	-5.41	3.81
IC 261797 × IC 261767	63.62*	1.16	6.78*	60.58*	10.73*	5.12*	12.14*	-1.35	12.15*	-1.35	16.49*	11.60	-14.70	0.85
IC 261797 × IC 354611	61.69*	-0.03	9.99*	62.64*	9.12*	4.00*	144.95*	94.70*	144.95*	94.70*	60.84*	40.27*	-8.60	8.05
IC 261797 × IC 203585	52.07*	-5.98	43.06*	60.52*	10.75*	4.64*	68.45*	38.47*	68.45*	38.46*	54.82*	30.30*	15.41	36.44*
IC 261797 × IC 104101	52.07*	-5.98	18.80*	59.49*	8.35*	5.83*	130.28*	112.78*	130.28*	112.78*	43.19*	38.59*	-2.38	38.98*
IC 261797 × IC 310886	50.05*	-7.23	38.37*	57.09*	5.09*	6.49*	114.33*	70.90*	114.32*	70.90*	52.20*	28.10*	5.73	25.00*
IC 261767 × IC 354611	61.93*	-1.28	4.11	56.57*	13.21*	7.89*	128.07*	100.62*	128.07*	100.62*	24.66*	19.43*	-3.08	6.78
IC 261767 × IC 203585	83.16*	-0.33	4.56	57.24*	14.00*	8.23*	134.59*	106.36*	134.59*	106.36*	35.86*	30.16*	-6.54	2.97
IC 261767 × IC 104101	56.83*	-3.03	4.53	57.19*	8.88*	6.35*	89.07*	74.70*	89.07*	74.69*	52.94*	48.03*	-32.44*	-3.81
IC 261767 × IC 310886	81.76*	-1.58	-13.52*	30.06*	6.63*	8.05*	17.89*	3.71	17.90*	3.71	47.65*	41.45*	-3.46	6.36
IC 354611 × IC 203585	59.98*	-2.47	-2.85	43.66*	8.41*	3.32*	21.48*	-0.14	21.48*	-0.15	83.17*	59.73*	-16.54	-8.05
IC 354611 × IC 104101	53.99*	-4.79	7.07*	58.32*	10.03*	7.47*	97.22*	82.23*	97.22*	82.23*	41.82*	37.26*	-39.88*	-14.41
IC 354611 × IC 310886	63.98*	-0.03	4.55	54.59*	6.70*	8.12*	162.39*	109.22*	162.38*	109.21*	59.96*	39.50*	-11.15	-2.12
IC 203585 × IC 104101	62.66*	0.57	16.96*	57.03*	9.21*	6.66*	36.03*	25.69*	36.03*	25.69*	60.20*	55.05*	-22.32*	10.59
IC 203585 × IC 310886	99.95*	8.81	35.75*	54.12*	7.13*	8.56*	111.16*	73.57*	111.16*	73.57*	68.11*	28.63*	-13.23	-5.51
IC 104101 × IC 310886	82.19*	12.65*	16.58*	56.51*	6.95*	8.37*	106.89*	91.17*	106.89*	91.17*	42.69*	38.10*	-30.95*	-1.69

*Significant at 5 per cent level of significance heterosis, the cross-combination IC 354611 × IC 310886 and IC 261797 × IC 104101 have been identified as promising F_1 hybrids for total fruit yield with other important fruit traits and these hybrids can be exploited at the commercial level.

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