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HETEROSIS STUDIES IN BRINJAL (*SOLANUM MELONGENA* L.) FOR YIELD AND QUALITY ATTRIBUTES OVER DIFFERENT ENVIRONMENTS

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ABSTRACT

The present investigation was carried out during late *kharif* season of 2020-2021 to study the magnitude of heterosis, in brinjal (*Solanum melongena* L.). The evaluation of F_1 hybrids was done at three different locations *viz*., Hill Millet Research Station, Waghai (E_1), Fruit Research Station, Gandevi (E_2) and Regional Horticultural Research Station, Navsari (E_3). Line x tester mating design comprising of 7 lines, 4 testers, their resultant 28 hybrids and one standard check GNRB-1 was followed. The experiment was conducted in Randomized Complete Block Design (RBD) with three replications. Significant and positive standard heterosis for fruit yield plant^{-1} was obtained in all the environments. The estimates of standard heterosis varied from -24.89 (IC-110662 × GOB-1) to 28.25 per cent (NBL-117 × GOB-1) in E_1; -32.08 (GJB-3 × GOB-1) to 19.58 per cent (NBL-117 × Swarna Mani) in E_2 and-28.87 (IC-110662 × Swarna Mani) to 15.48 per cent (NBL-117 × Swarna Mani) in E_3. An overall view of all the top yielding crosses with respect to fruit yield contributing traits revealed that the higher fruit yield was mainly due the more number of fruits plant^{-1}. The current study demonstrates good potential for heterosis in brinjal commercial utilization and for separating purelines from the offspring of heterotic F_1s.

Key words : Evaluation, Line x tester, Purelines and Standard heterosis.

Introduction

Brinjal (*Solanum melongena* L. 2n = 24) is one of the most common popular and principal vegetable crop grown in India and other parts of the world belongs to the angiospermic family solanaceae. It's grown around the year in almost all parts of the country. It is highly productive and cosmopolitan. The demand will increase due to the burgeoning population of the country. So, brinjal as an important vegetable deserves a deep contemplation for improvement of locally preferred cultivars for high yield and adaptation or development of new hybrid combinations. It should be highly pragmatic by the fact that India being the centre of origin and diversity of brinjal, it should pave the way to bring about a kind of plant architecture, which could enhance its quality and productivity without losing the consumer's requirements. Brinjal continues to be a choice of breeders for exploitation of heterosis as it is a hardy plant with comparatively large sized flowers and large number of seeds can be obtained by a single act of pollination. The use of hybrid technology for exploitation of heterosis is considered as one of the desirable, sustainable and eco-friendly approach to develop high yielding varieties or hybrids which are location specific and disease resistant. Exploitation of hybrid vigour has become a potential tool for improvement in eggplant (Nalini *et al*., 2011). The estimation of heterosis for yield and its component characters would be useful in determining the best hybrid combination.

Materials and Methods

A total of 28 F_1 hybrids generated following Line x Tester mating design comparing of 7 lines and 4 testers were evaluated. The experimental material for this study comprised of 11 genotypes which were selected based on their diversity for various traits. Among the genotypes, seven *viz*., GJB-3, NBL-50, AB-8/5, IC-110662, GJB-2, BPG-3 and NBL-117 were used as female (lines) and four testers *viz*., GAOB-2, GOB-1, Swarna Mani and GNRB-1 were used as male parent (testers). All the genotypes were grown at Regional Horticulture Research Station, ASPEE College of Horticulture and Forestry, Navsari Agriculture University, Navsari and crossed in line x tester matting design for producing twenty-eight crosses. All crosses along with their parents were evaluated during late *kharif* season of 2020-2021 at three different locations *viz*., at Regional Horticultural Research Station, Navsari, Fruit Research Station, Gandevi and Hill Millet Research Station, Waghai in a randomized block design (RBD) with three replications with spacing of 90 × 60 cm. Standard package of practices were followed to raise the crop.

Data were recorded on five randomly selected plants in each treatment over replication for all fifteen characters *viz*., days to 50% flowering, plant height at final harvest, total number of branches plant^{-1}, fruit length (cm), fruit diameter (cm), fruit weight (g), number of fruits plant^{-1}, fruit yield plant^{-1} (kg), number of seeds fruit^{-1}, 100 seed weight (mg), total fruit yield (t ha^{-1}), vitamin-C (mg 100 g^{-1}), TSS (^{0} Brix), total phenol content (mg 100 g^{-1}) and total anthocyanin content (mg 100 g^{-1}).

Results and Discussion

Estimation of Heterosis

Heterosis is measured as mean superiority of F_1s over their better parents or mid parent or the best commercial variety and thus, it is rated to be an important parameter in such studies. This phenomenon has extensively been exploited in cross pollinated as well as self pollinated crops. The most important factor for determining the feasibility of hybrid is the nature and extent of heterosis and its exploitation. The goal of brinjal hybrid breeding is to identify and then reliably reproduce superior hybrid genotypes. The relative heterosis will only help to understand the genetic status of the characters. However, from the practical point of view, standard heterosis is the most important of the three types of heterosis because it is aimed at developing desirable hybrids superior to the existing high yielding commercial varieties and here standard heterosis over GNRB-1 was estimated. Heterosis was estimated for fifteen various characters. The results obtained for fruit yield and its attributing characters have been described below (Table 1).

Days to 50% flowering

Days to 50% flowering is an effective trait for earliness and negative heterosis is desirable for all the attributes of earliness. The estimates of heterosis ranged from -2.65 (NBL-117× GNRB-1) to 7.94 per cent (GJB-2 × GNRB-1) in E_1; -4.00(NBL-117 × GNRB-1) to 22.29 per cent (IC-110662 × GAOB-2) in E_2 and -1.14(NBL-117 × GAOB-2) to 22.73 per cent (AB-8/5 × GNRB-1, IC-110662×GAOB-2 and IC-110662 × Swarna Mani) in E_3. Out of the 28 F_1s, the number of F_1s which exhibited significant and negative estimate for standard heterosis was one in E_2, and none in $E_1$and E_3. The promising hybrid was NBL-117 × GNRB-1 in E_2.

Significant and negative standard heterosis for this trait was obtained by Reddy and Patel (2014), Biswas *et al*. (2016), Desai *et al*. (2016), Balwani *et al*. (2017), Khapte *et al*. (2017), Kumar *et al*. (2017), Pramila *et al*. (2017), Kalaiyarasi *et al*. (2018), Zeal *et al*. (2019), Chaudhari *et al*. (2020), Deshmukh *et al*. (2020) and Makasare *et al*. (2020).

Plant height at Final harvest

The extent of standard heterosis ranged from -14.27 (NBL-117 × GNRB-1) to 11.00 per cent (BPG-3 × GAOB-2) in E_1; -19.86 (GJB-3 × GOB-1) to 9.75 per cent (BPG-3 × GAOB-2) in E_2 and -24.70 (GJB-3 × GOB-1) to 26.51 per cent (BPG-3 × GAOB-2) in E_3. Out of the 28 F_1s, the number of F_1s, which exhibited significant and positive estimate for standard heterosis were six in E_1, seven in E_2 and thirteen in E_3. The promising hybrid was BPG-3 × GAOB-2 in all three locations.

For this trait significant and positive standard heterosis was earlier reported by Reddy and Patel (2014), Biswas *et al*. (2016), Desai *et al*. (2016), Sharma *et al*. (2016), Ansari (2017), Balwani *et al*. (2017), Khapte *et al*. (2017), Kumar *et al*. (2017), Pramila *et al*. (2017), Kalaiyarasi*et al*. (2018), Sujin*et al*. (2018), Zeal *et al*. (2019), Chaudhari *et al*. (2020) and Makasare *et al*. (2020).

Total number of Branches plant^{-1}

Perusual of the data suggest that the per cent standard heterosis was in the range of-20.66 (GJB-2 × GNRB-1) to 4.96 per cent (GJB-3× GAOB-2) in E_1; -35.36 (GJB-2 × GNRB-1) to 3.04 per cent (NBL-117 × GAOB-2) in E_2 and -45.55 (GJB-2 × GAOB-2) to -13.17 per cent (NBL-50 × Swarna Mani) in E_3. Out of the 28 F_1s, none

Table 1 : Estimates of standard heterosis in individual environments for days to 50% flowering and plant height at final harvest (cm).

Hybrids		Days to 50% flowering			Plant height at final harvest(cm)			Total number of branches plant^{-1}		
		E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
GJB-3 × GAOB-2		3.17*	15.43**	14.20**	-4.66**	1.80*	7.81**	4.96	0.38	-29.18**
GJB-3 × GOB-1		5.82**	13.14**	14.77**	-4.52**	-19.86**	-24.70**	0.83	-8.37	-21.35**
GJB-3 × Swarna Mani		4.76**	13.71**	14.20**	-2.30*	3.63**	12.73**	-1.65	-8.75*	-15.66**
GJB-3 × GNRB-1		3.70**	10.86**	17.05**	-3.90**	-5.33**	1.45	-7.44	-1.52	-22.06**
NBL-50 × GAOB-2		2.12	10.29**	14.77**	-1.88*	-5.30**	3.80**	-19.01**	- 25.86**	-28.11**
NBL-50× GOB-1		-1.06	14.86**	17.61**	-5.01**	-8.79**	-6.37**	-9.92	-14.83**	-29.89**
NBL-50 × Swarna Mani		2.12	16.00**	20.45**	-0.56	-0.44	5.28**	-1.65	-7.22	-13.17**
NBL-50 × GNRB-1		5.29**	2.86	2.27	-1.74	-7.33**	-1.37	1.65	-1.90	-15.30**
AB-8/5 × GAOB-2		3.17*	19.43**	21.02**	-11.06**	-15.55**	-8.32**	-10.74	-22.05**	-45.20**
AB-8/5 × GOB-1		0.00	17.71**	22.16**	-15.03**	-18.40**	-13.02**	-9.92	-17.49**	-39.15**
AB-8/5 × Swarna Mani		4.76**	19.43**	22.16**	-10.58**	-13.11**	-12.59**	-10.74	-11.41**	-29.89**
AB-8/5 × GNRB-1		4.23**	19.43**	22.73**	-2.92**	-8.49**	-2.03*	-9.09	-14.07**	-18.51**
IC-110662 × GAOB-2		3.70**	22.29**	22.73**	-12.53**	-17.39**	-9.51**	-3.31	-6.08	-27.05**
IC-110662 × GOB-1		4.23**	17.71**	21.59**	6.68**	2.48**	13.49**	-2.48	0.00	-25.27**
IC-110662 × Swarna Mani		1.59	18.86**	22.73**	-11.00**	-16.71**	-11.32**	-15.70**	-19.77**	-25.27**
IC-110662 × GNRB-1		4.23**	19.43**	19.89**	-10.93**	-15.38**	-8.68**	-1.65	-9.51*	-15.30**
GJB-2 × GAOB-2		5.82**	17.14**	21.02**	-1.25	-3.29**	3.87**	-9.09	-25.48**	-45.55**
GJB-2 × GOB-1		7.41**	17.14**	18.18**	-2.05*	-3.19**	1.77*	-14.88**	-17.49**	-40.21**
GJB-2 × Swarna Mani		5.82**	17.14**	20.45**	5.78**	3.84**	21.45**	-9.09	-17.87**	-38.08**
GJB-2 × GNRB-1		7.94**	13.71**	17.61**	5.71**	1.26	9.66**	-20.66**	-35.36**	-40.93**
BPG-3 × GAOB-2		6.35**	11.43**	12.50**	11.00**	9.75**	26.51**	-7.44	-6.08	-16.73**
BPG-3 × GOB-1		7.41**	15.43**	14.20**	-4.52**	-8.79**	0.72	-6.61	-7.22	-23.49**
BPG-3 × Swarna Mani		6.88**	14.29**	13.64**	6.05**	4.31**	18.70**	-3.31	-9.89*	-19.57**
BPG-3 × GNRB-1		3.70**	12.00**	13.64**	5.29**	2.07**	10.02**	-0.83	-6.08	-21.00**
NBL-117 × GAOB-2		4.76**	4.57**	-1.14	0.21	-2.82**	5.17**	-2.48	3.04	-23.13**
NBL-117 × GOB-1		4.23**	9.14**	9.09**	-2.71**	-13.11**	-11.21**	-7.44	-11.41**	-21.71**
NBL-117 × Swarna Mani		1.06	-0.57	1.70	-8.35**	-13.38**	-9.15**	-13.22*	-10.65*	-21.71**
NBL-117 × GNRB-1		-2.65	-4.00*	1.70	-14.27**	-15.72**	-10.85**	-9.92	-14.45**	-24.56**
Range	Minimum	-2.65	-4.00	-1.14	-14.27	-19.86	-24.70	-20.66	-35.36	-45.55
	Maximum	7.94	22.29	22.73	6.68	9.75	26.51	4.96	3.04	-13.17
Significant crosses	Positive crosses	21	25	24	6	7	13	0	0	0
	Negative crosses	0	1	0	18	19	12	5	17	28
	Total crosses	21	26	24	24	26	25	5	17	28

Table 1 continued...

S.Ed.±	0.83	1.04	1.05	0.88	0.73	0.75	0.44	0.37	0.30
C.D. at 5%	1.67	2.09	2.10	1.76	1.46	1.50	0.88	0.74	0.59
C.D. at 1%	2.22	2.78	2.80	2.34	1.94	1.99	1.18	0.98	0.78

Table 1 continued..

Hybrids		Fruit length (cm)			Fruit diameter (cm)			Fruit weight (g)		
		E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
GJB-3 × GAOB-2		27.75**	23.80**	25.51**	5.37**	6.21**	-1.21	-17.93**	-20.44**	-19.52**
GJB-3 × GOB-1		33.26**	33.97**	36.38**	-1.94	-1.05*	1.61	-8.13**	-12.80**	-12.07**
GJB-3 × Swarna Mani		35.37**	34.19**	37.70**	-1.42	0.13	5.36**	19.84**	13.48**	14.97**
GJB-3 × GNRB-1		34.26**	37.09**	39.93**	3.36*	4.12**	11.99**	16.54**	11.72**	12.65**
NBL-50 × GAOB-2		-20.24**	-18.38**	-17.11**	-11.58**	-13.27**	-16.14**	-55.98**	-58.50**	-58.68**
NBL-50× GOB-1		-15.35**	-13.46**	-11.56**	-15.65**	-14.25**	-10.38**	-55.52**	-57.74**	-56.95**
NBL-50 × Swarna Mani		-18.46**	-17.21**	-14.70**	-14.10**	-13.20**	-14.47**	-55.49**	-57.42**	-56.98**
NBL-50 × GNRB-1		-10.62**	-8.38**	-8.35**	-12.68**	-13.07**	-13.26**	-51.90**	-53.07**	-52.11**
AB-8/5 × GAOB-2		-10.40**	-11.68**	-5.38**	-24.64**	-22.61**	-23.38**	-52.63**	-54.50**	-53.37**
AB-8/5 × GOB-1		-5.73**	-5.14**	0.00	-16.56**	-15.75**	-16.28**	-52.40**	-54.38**	-53.79**
AB-8/5 × Swarna Mani		-7.01**	-8.27**	-7.15**	-17.21**	-15.75**	-20.29**	-57.14**	-59.18**	-58.23**
AB-8/5 × GNRB-1		1.00	1.23	1.37*	-5.30**	-16.08**	-18.69**	-49.90**	-53.11**	-53.05**
IC-110662 × GAOB-2		0.17	0.00	0.00	-6.02**	-3.73**	-3.08**	-35.03**	-36.56**	-35.51**
IC-110662 × GOB-1		1.00	1.90*	-0.69	-4.20**	-3.20**	-4.22**	-6.72**	-8.88**	-7.39**
IC-110662 × Swarna Mani		-1.11	-0.61	-1.89**	-3.56*	-2.94**	-1.00	-20.78**	-24.13**	-24.32**
IC-110662 × GNRB-1		-0.33	0.28	-1.32*	-4.27**	-1.63**	2.28**	-15.98**	-18.87**	-19.38**
GJB-2 × GAOB-2		26.47**	30.78**	33.47**	-4.14*	-3.07**	-5.16**	-11.10**	-13.15**	-12.57**
GJB-2 × GOB-1		29.53**	32.40**	34.55**	-4.85**	-3.79**	-6.43**	-13.53**	-13.86**	-14.22**
GJB-2 × Swarna Mani		26.75**	29.83**	34.90**	-4.59**	-2.75**	-7.84**	-16.64**	-17.62**	-17.25**
GJB-2 × GNRB-1		28.98**	32.46**	31.41**	-4.92**	-3.14**	-5.16**	-17.97**	-20.04**	-19.33**
BPG-3 × GAOB-2		19.47**	19.66**	27.17**	-5.63**	-5.10**	-6.36**	-14.67**	-17.19**	-17.06**
BPG-3 × GOB-1		-1.28	-0.45	-2.97**	-14.23**	-14.64**	-18.15**	-51.95**	-54.50**	-56.44**
BPG-3 × Swarna Mani		-4.67**	-4.25**	-3.66**	-17.46**	-19.02**	-15.54**	-50.48**	-54.18**	-53.65**
BPG-3 × GNRB-1		-1.61*	-1.68*	3.38**	-19.15**	-19.48**	-11.25**	-42.72**	-46.32**	-46.73**
NBL-117 × GAOB-2		-3.67**	-3.52**	-3.55**	-7.37**	-7.12**	-6.23**	-26.42**	-29.62**	-29.16**
NBL-117 × GOB-1		-1.84*	-1.84*	-0.06	-4.27**	-3.92**	-1.74*	-20.79**	-24.05**	-24.47**
NBL-117 × Swarna Mani		8.68**	10.00**	9.90**	-10.41**	-9.93**	-10.52**	-22.76**	-26.28**	-26.65**
NBL-117 × GNRB-1		-7.95**	-5.98**	-1.77**	-5.43**	-4.97**	1.00	-26.61**	-31.06**	-31.39**
Range	Minimum	-20.24	-18.38	-14.70	-24.64	-22.61	-23.38	-57.14	-59.18	-58.68
	Maximum	35.37	37.09	39.93	5.37	6.21	11.99	19.84	13.48	14.97
Significant crosses	Positive crosses	10	11	12	2	2	3	2	2	2
	Negative crosses	12	11	12	24	25	21	26	26	26
	Total crosses	22	22	24	26	27	24	28	28	28

S.Ed.±	0.04	0.04	0.03	0.08	0.02	0.04	0.27	0.37	0.44
C.D. at 5%	0.09	0.09	0.06	0.16	0.04	0.08	0.55	0.75	0.88
C.D. at 1%	0.12	0.12	0.08	0.21	0.06	0.11	0.73	0.10	1.17

Table 1 continued...

Hybrids	Number of fruits plant^{-1}			Fruit yield plant^{-1} (kg)			Number of seeds fruit^{-1}		
	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
GJB-3 × GAOB-2	7.87**	11.41**	-7.08**	-18.39**	-23.75**	-23.01**	-16.62**	-20.50**	-23.70**
GJB-3 × GOB-1	-2.51	-5.96	-6.44**	-17.49**	-32.08**	-27.82**	-26.64**	-29.54**	-28.44**
GJB-3 × Swarna Mani	-16.25**	-15.67**	-27.84**	-8.07*	-23.33**	-23.85**	-24.90**	-25.73**	-27.65**
GJB-3 × GNRB-1	-22.45**	-24.19**	-28.21**	-15.92**	-23.54**	-24.48**	-20.07**	-23.49**	-26.02**
NBL-50 × GAOB-2	134.84**	120.44**	93.23**	-2.69	-14.17**	-16.11**	-12.58**	-15.92**	-18.60**
NBL-50× GOB-1	113.40**	111.75**	90.56**	-11.21**	-14.79**	-19.04**	-14.52**	-19.16**	-18.73**
NBL-50 × Swarna Mani	116.75**	118.06**	106.73**	-9.64**	-13.13**	-14.44**	-13.28**	-15.74**	-18.94**
NBL-50 × GNRB-1	89.75**	99.83**	67.14**	-10.76**	-16.25**	-18.20**	-16.05**	-19.22**	-19.30**
AB-8/5 × GAOB-2	79.90**	76.32**	63.08**	-20.40**	-23.96**	-25.31**	-22.66**	-26.84**	-28.99**
AB-8/5 × GOB-1	81.74**	95.06**	56.90**	-17.71**	-24.58**	-24.06**	-20.17**	-24.17**	-27.61**
AB-8/5 × Swarna Mani	121.61**	110.39**	86.89**	-11.21**	-23.33**	-21.34**	-18.18**	-22.33**	-23.93**
AB-8/5 × GNRB-1	81.91**	79.22**	69.75**	-15.02**	-22.92**	-23.85**	-17.48**	-18.54**	-22.42**
IC-110662 × GAOB-2	28.81**	25.21**	18.70**	-20.85**	-22.92**	-25.10**	-14.84**	-16.03**	-21.00**
IC-110662 × GOB-1	-9.55**	-3.41	-6.44**	-24.89**	-23.75**	-23.64**	-11.90**	-18.13**	-20.27**
IC-110662 × Swarna Mani	13.07**	15.84**	-1.42	-16.59**	-24.38**	-28.87**	-18.31**	-20.52**	-22.49**
IC-110662 × GNRB-1	17.92**	15.50**	-1.15	-6.73	-17.92**	-19.67**	-12.67**	-17.16**	-21.26**
GJB-2 × GAOB-2	10.72**	6.64	-1.17	-6.28	-18.54**	-24.48**	-12.19**	-16.09**	-17.81**
GJB-2 × GOB-1	4.69	2.04	6.73**	-14.13**	-23.75**	-24.90**	-13.13**	-15.35**	-18.23**
GJB-2 × Swarna Mani	10.89**	13.46**	1.74	-13.68**	-23.75**	-25.94**	-18.20**	-18.53**	-19.24**
GJB-2 × GNRB-1	13.90**	8.52*	4.17**	-12.33**	-22.50**	-24.48**	-12.75**	-15.46**	-19.52**
BPG-3 × GAOB-2	14.07**	18.40**	-0.48	-8.74*	-18.33**	-22.38**	-15.68**	-18.98**	-20.32**
BPG-3 × GOB-1	119.77**	114.65**	72.28**	-1.12	-17.50**	-24.06**	-16.57**	-19.93**	-20.99**
BPG-3 × Swarna Mani	81.07**	80.92**	73.51**	-16.82**	-20.21**	-24.90**	-20.15**	-24.16**	-23.68**
BPG-3 × GNRB-1	60.13**	61.33**	42.60**	-13.23**	-21.04**	-23.85**	-21.39**	-24.35**	-24.86**
NBL-117 × GAOB-2	83.25**	79.05**	77.37**	24.89**	13.33**	11.72**	6.33**	0.45	-1.24
NBL-117 × GOB-1	72.86**	70.70**	40.01**	28.25**	6.67**	1.05	1.80**	-0.33	-1.21
NBL-117 × Swarna Mani	82.58**	79.73**	61.49**	23.32**	19.58**	15.48**	-2.96**	-2.97**	0.53
NBL-117 × GNRB-1	89.11**	86.03**	55.58**	28.25**	13.96**	7.95**	0.21	-0.86	-2.07
Range Minimum	-2.51	-24.19	-28.21	-20.85	-32.08	-27.82	-26.64	-29.54	-28.99
Range Maximum	134.84	120.44	106.73	28.25	19.58	15.48	6.33	0.45	0.53
Significant crosses Positive crosses	23	21	18	4	4	3	2	0	0
Significant crosses Negative crosses	3	2	5	20	24	24	25	25	24
Significant crosses Total crosses	26	23	23	24	28	27	28	25	24

S.Ed.±	0.54	0.66	0.29	0.05	0.01	0.02	2.03	3.16	5.34
C.D. at 5%	1.08	1.32	0.58	0.10	0.02	0.03	4.07	6.34	10.73
C.D. at 1%	1.44	1.76	0.77	0.14	0.03	0.04	5.42	8.45	14.28

Table 1 continued..

Hybrids		100-seed weight (mg)			Total fruit yield (t ha^{-1})			Total phenol content (mg 100 g^{-1})		
		E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
GJB-3 × GAOB-2		-4.80**	0.41	1.64	-18.39**	-23.75**	-22.07**	0.48	3.21**	1.25
GJB-3 × GOB-1		-5.37**	-4.70**	-1.88	-17.50**	-32.09**	-23.93**	0.19	0.93	2.34
GJB-3 × Swarna Mani		-2.11	0.08	0.65	-8.08	-23.33**	-23.26**	-2.64*	-1.86	-1.52
GJB-3 × GNRB-1		-4.39**	-2.48**	-1.15	-15.94*	-23.55**	-25.12**	-6.21**	-5.07**	-4.57
NBL-50 × GAOB-2		-6.34**	-5.03**	-2.62	-2.70	-14.17**	-14.16**	1.48	2.47*	1.17
NBL-50× GOB-1		-2.11	-0.25	6.14**	-11.21	-14.80**	-18.16**	0.90	1.75	-29.03**
NBL-50 × Swarna Mani		-4.23**	-3.38**	-1.55	-9.64	-13.13**	-12.71**	-5.63**	-5.55**	-8.03
NBL-50 × GNRB-1		-6.50**	-5.20**	-7.61**	-10.77	-16.25**	-17.17**	1.16	2.04*	0.85
AB-8/5 × GAOB-2		-11.63**	-3.14**	-2.95*	-44.62**	-23.96**	-23.91**	-4.42**	-4.28**	-5.13
AB-8/5 × GOB-1		-0.89	0.00	-0.98	-17.72**	-24.59**	-24.23**	-1.22	-1.06	-3.06
AB-8/5 × Swarna Mani		-0.81	-0.17	-0.57	-11.23	-23.35**	-19.91**	-1.96	-1.06	-1.68
AB-8/5 × GNRB-1		0.49	0.99	1.72	-15.03*	-22.93**	-22.69**	-2.19*	-1.91*	-1.28
IC-110662 × GAOB-2		0.41	0.99	1.64	-20.85**	-22.92**	-22.90**	3.62**	2.50*	1.94
IC-110662 × GOB-1		0.57	1.90**	1.23	-24.90**	-23.75**	-22.91**	2.25*	4.22**	4.65
IC-110662 × Swarna Mani		0.49	1.07	1.88	-16.60*	-24.38**	-28.41**	0.29	1.59	-0.45
IC-110662 × GNRB-1		1.14	3.38**	2.05	-6.73	-17.93**	-18.18**	1.98	-0.66	-2.23
GJB-2 × GAOB-2		0.65	2.15**	2.37	-6.28	-18.56**	-22.51**	-0.87	-0.11	-0.82
GJB-2 × GOB-1		0.57	1.32*	1.47	-14.13*	-23.75**	-23.71**	-1.59	-2.12*	-3.30
GJB-2 × Swarna Mani		0.16	1.32*	1.64	-13.68*	-23.75**	-24.78**	1.03	-0.74	0.51
GJB-2 × GNRB-1		0.57	2.56**	1.72	-12.34	-22.51**	-23.57**	1.35	2.12*	0.74
BPG-3 × GAOB-2		3.50*	6.02**	5.16**	-8.74	-18.35**	-21.49**	13.38**	14.18**	12.82
BPG-3 × GOB-1		0.65	2.89**	6.79**	-1.13	-17.50**	-22.69**	12.67**	11.90**	11.65
BPG-3 × Swarna Mani		2.85	3.22**	4.91**	-16.83*	-20.22**	-23.84**	15.86**	14.13**	10.13
BPG-3 × GNRB-1		3.25*	4.79**	5.97**	-13.24*	-21.05**	-23.39**	11.42**	11.10**	5.29
NBL-117 × GAOB-2		-1.22	0.08	-1.06	24.90**	13.32**	12.81**	3.41**	3.00**	2.07
NBL-117 × GOB-1		0.08	1.57**	-0.41	28.26**	6.66**	2.35**	2.64*	2.97**	1.62
NBL-117 × Swarna Mani		0.98	1.40*	-0.49	23.31**	19.59**	16.85**	1.80	1.41	1.91
NBL-117 × GNRB-1		0.73	1.24*	0.25	28.25**	13.94**	9.26**	3.89**	4.43**	4.68
Range	Minimum	-11.63	-5.20	-7.61	-44.62	-32.09	-28.41	-6.21	-5.55	-29.03
	Maximum	3.50	6.02	6.79	28.26	19.59	16.85	15.86	14.18	12.82
Significant crosses	Positive crosses	2	13	5	4	4	4	9	13	0
	Negative crosses	7	6	2	13	24	24	5	5	1
	Total crosses	9	19	7	17	28	28	14	18	1

S.Ed.±	0.06	0.02	0.05	1.76	0.18	0.22	0.14	0.11	0.86
C.D. at 5%	0.12	0.04	0.11	3.54	0.36	0.44	0.28	0.24	1.73
C.D. at 1%	0.17	0.06	0.15	4.71	0.49	0.59	0.37	0.31	2.30

Table 1 continued...

Hybrids		TSS (^{0} Brix)			Vitamin-C (mg 100 g^{-1})			Total anthocyanin content (mg 100 g^{-1})		
		E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
GJB-3 × GAOB-2		-13.53**	-13.82**	-13.27**	-55.17**	-50.94**	-50.63**	-67.64**	-67.52**	-67.78**
GJB-3 × GOB-1		14.72**	14.20**	8.82**	-57.64**	-49.06**	-53.54**	-68.31**	-68.06**	-68.33**
GJB-3 × Swarna Mani		13.34**	13.32**	14.64**	-58.47**	-53.46**	-53.75**	-69.52**	-68.70**	-69.96**
GJB-3 × GNRB-1		-5.76**	-5.07**	-4.57**	-54.55**	-48.43**	-47.71**	-68.41**	-68.48**	-68.73**
NBL-50 × GAOB-2		-21.98**	-21.76**	-22.03**	5.99**	-7.13*	5.00**	10.84**	11.48**	10.52**
NBL-50× GOB-1		8.20**	7.32**	7.38**	-7.23*	3.56**	1.46**	15.19**	15.75**	14.62**
NBL-50 × Swarna Mani		-20.48**	-19.57**	-20.40**	-15.91**	-16.35**	-27.08**	7.53**	8.12**	6.26**
NBL-50 × GNRB-1		-12.96**	-12.70**	-12.89**	-15.70**	-10.69**	-11.88**	13.48**	14.00**	13.03**
AB-8/5 × GAOB-2		-8.64**	-8.94**	-9.20**	-56.20**	-51.99**	-51.04**	27.92**	28.33**	27.20**
AB-8/5 × GOB-1		3.13**	2.50**	3.13**	-58.06**	-50.10**	-43.96**	31.01**	31.91**	30.98**
AB-8/5 × Swarna Mani		-19.85**	-20.20**	-20.21**	-57.85**	-48.85**	-48.75**	23.85**	24.42**	23.46**
AB-8/5 × GNRB-1		-20.10**	-19.39**	-19.02**	-55.17**	-49.48**	-50.83**	23.04**	23.51**	22.45**
IC-110662 × GAOB-2		7.20**	1.56	6.76**	-53.93**	-48.01**	-44.79**	18.34**	19.06**	17.65**
IC-110662 × GOB-1		-11.71**	-12.45**	-12.83**	-49.79**	-48.43**	-46.25**	14.52**	15.12**	13.97**
IC-110662 × Swarna Mani		1.82*	1.31	1.56*	-56.61**	-49.48**	-49.58**	16.35**	16.16**	15.14**
IC-110662 × GNRB-1		-1.13	-1.19	-1.56*	-55.99**	-47.38**	-46.67**	18.35**	19.08**	18.01**
GJB-2 × GAOB-2		0.06	0.69	0.19	-20.04**	-19.50**	-15.42**	-13.75**	-13.39**	-14.63**
GJB-2 × GOB-1		-16.66**	-17.01**	-17.15**	-17.98**	-16.56**	-15.00**	-17.07**	-16.57**	-17.07**
GJB-2 × Swarna Mani		9.14**	8.38**	8.51**	-9.92**	-14.88**	-18.33**	-17.96**	-17.42**	-18.24**
GJB-2 × GNRB-1		9.58**	9.07**	9.20**	-19.42**	-19.71**	-19.58**	-11.35**	-10.79**	-11.98**
BPG-3 × GAOB-2		7.20**	5.57**	5.94**	-23.35**	-22.43**	-21.67**	24.83**	25.58**	24.63**
BPG-3 × GOB-1		-21.85**	-21.26**	-21.40**	-16.12**	-18.45**	-15.42**	22.70**	24.25**	23.32**
BPG-3 × Swarna Mani		-2.13*	-2.06*	-2.07**	-19.01**	-18.87**	-20.21**	22.56**	21.79**	20.79**
BPG-3 × GNRB-1		13.40**	13.95**	14.58**	-21.07**	-16.56**	-17.71**	25.22**	25.95**	24.18**
NBL-117 × GAOB-2		15.09**	14.45**	14.64**	-20.66**	-19.71**	-22.08**	17.04**	17.43**	16.23**
NBL-117 × GOB-1		-22.04**	-22.26**	-22.28**	-25.00**	-23.27**	-18.75**	17.62**	18.37**	17.45**
NBL-117 × Swarna Mani		-2.19*	-2.19*	-1.69*	-20.45**	-20.34**	-24.38**	13.52**	14.02**	13.07**
NBL-117 × GNRB-1		-20.29**	-20.64**	-20.90**	-19.63**	-18.66**	-21.88**	13.18**	13.54**	12.05**
Range	Minimum	-21.98	-22.26	-22.28	-58.47	-53.46	-53.75	-69.52	-68.70	-69.96
	Maximum	15.09	14.45	14.64	-5.99	-3.56	-1.46	31.01	31.91	30.98
Significant crosses	Positive crosses	11	9	11	1	1	2	20	20	20
	Negative crosses	14	15	16	27	27	26	8	8	8
	Total crosses	25	24	27	28	28	28	28	28	28

S.Ed.±	0.05	0.04	0.04	0.05	0.05	0.05	0.49	0.31	0.18
C.D. at 5%	0.09	0.09	0.08	0.10	0.11	0.09	0.98	0.62	0.37
C.D. at 1%	0.12	0.12	0.10	0.13	0.14	0.12	1.31	0.82	0.49

*, ** Significant at 5and 1 % level of probability, respectively.

of the F_1s exhibited significant and positive estimate for standard heterosis.

Significant and positive heterosis for this trait was previously reported by Khapte *et al*. (2017), Pramila *et al*. (2017), Kalaiyarasi *et al*. (2018), Khobragade *et al*. (2019), Zeal *et al*. (2019) and Deshmukh *et al*. (2020).

Fruit length (cm)

Significant positive heterosis for fruit length is desirable. The estimates of standard heterosis varied from -18.46 (NBL-50 × Swarna Mani) to 35.37 per cent (GJB-2× Swarna Mani) in E_1; -17.21 (NBL-50 × Swarna Mani) to 37.09 per cent (GJB-3 ×GNRB-1) in E_2 and -14.70 (NBL-50 × Swarna Mani) to 39.93 per cent (GJB-3 × GNRB-1) in E_3. The number of crosses, which exhibited significant positive estimate for standard heterosis were, ten, eleven and twelve in E_1, E_2 and E_3 respectively.

For this trait significant and positive standard heterosis was earlier reported by Reddy and Patel (2014), Ansari and Singh (2016), Biswas *et al*. (2016), Desai *et al*. (2016), Sharma *et al*. (2016), Balwani *et al*. (2017), Khapte *et al*. (2017), Kumar *et al*. (2017), Pramila *et al*. (2017), Kalaiyarasi *et al*. (2018), Sujin *et al*. (2018), Bhatt *et al*. (2019), Khobragade *et al*. (2019), Zeal *et al*. (2019), Chaudhari *et al*. (2020) and Makasare *et al*. (2020).

Fruit diameter (cm)

For fruit diameter significant positive heterosis is desirable. The estimates of standard heterosis varied from -24.64 (AB-8/5 × GAOB-2) to 5.37 per cent (GJB-3 × GAOB-2) in E_1; -22.61 (AB-8/5 × GAOB-2) to 6.21 per cent (GJB-3 × GAOB-2) in E_2 and -23.38 (AB-8/5 × GAOB-2) to 11.99 per cent (GJB-3 × GNRB-1) in E_3. The number of crosses, which exhibited significant positive estimate for standard heterosis were, two, two and three in E_1, E_2 and E_3, respectively.

For this trait significant and positive standard heterosis was earlier reported by Reddy and Patel (2014), Ansari and Singh (2016), Biswas *et al*. (2016), Desai *et al*. (2016), Sharma *et al*. (2016a), Balwani *et al*. (2017), Khapte *et al*. (2017), Kumar *et al*. (2017), Pramila *et al*. (2017), Kalaiyarasi *et al*. (2018), Sujin *et al*. (2018), Bhatt *et al*. (2019), Khobragade *et al*. (2019), Zeal *et al*. (2019), Chaudhari *et al*. (2020) and Makasare *et al*. (2020).

Fruit weight (g)

The heterosis for fruit weight is desirable in positive direction. The estimates of standard heterosis varied from -57.14 (AB-8/5 × Swarna Mani) to 19.84 per cent (GJB-3 × Swarna Mani) in E_1; -59.18 (AB-8/5 × GAOB-2) to 13.48 per cent (GJB-3 × GAOB-2) in E_2 and -58.23 (AB-8/5 × GAOB-2) to 14.97 per cent (GJB-3 × GNRB-1) in E_3. The number of crosses, which exhibited significant positive estimate for standard heterosis were, two in all three locations.

For this trait significant and positive standard heterosis was earlier reported by Deshmukh *et al*. (2020), Galani *et al*. (2015), Ansari and Singh (2016), Biswas *et al*. (2016), Sharma *et al*. (2016a), Balwani *et al*. (2017), Khapte *et al*. (2017), Kumar *et al*. (2017), Pramila *et al*. (2017), Kalaiyarasi *et al*. (2018), Modh*et al*. (2018), Sujin*et al*. (2018), Bhatt *et al*. (2019), Khobragade *et al*. (2019), Zeal *et al*. (2019), Chaudhari *et al*. (2020) and Makasare *et al*. (2020).

Number of fruits plant^{-1}

The heterosis for number of fruits plant^{-1} is desirable in positive direction. The estimates of standard heterosis varied from -22.45 (GJB-3 × GNRB-1) to 134.84 per cent (NBL-50 × GAOB-2) in E_1; -24.19 (GJB-3 × GNRB-1) to 120.44 per cent (NBL-50 × GAOB-2) in E_2 and -28.21 (GJB-3 × GNRB-1) to 106.73 per cent (NBL-50 × Swarna Mani) in E_3. The number of crosses, which exhibited significant positive estimate for standard heterosis were, twenty three, twenty one and eighteen in E_1, E_2 and E_3, respectively.

For this trait significant and positive standard heterosis was earlier reported by Singh *et al*. (2016), Chaudhari *et al*. (2015), Biswas *et al*. (2016), Sharma *et al*. (2016), Khapte *et al*. (2017), Kalaiyarasi *et al*. (2018), Modh *et al*. (2018), Sujin *et al*. (2018), Bhatt *et al*. (2019), Khobragade *et al*. (2019), Zeal *et al*. (2019) and Chaudhari *et al*. (2020).

Fruit yield Plant^{-1}

The heterosis for this trait is desirable in positive direction. The estimates of standard heterosis varied from -24.89 (IC-110662 × GOB-1) to 28.25 per cent (NBL-117 × GOB-1) in E_1; -32.08 (GJB-3 × GOB-1) to 19.58 per cent (NBL-117 × Swarna Mani) in E_2 and -28.87 (IC-110662 × Swarna Mani) to 15.48 per cent (NBL-117 × Swarna Mani) in E_3. The number of crosses, which exhibited significant positive estimate for standard

heterosis were, four in all three locations.

For this trait significant and positive standard heterosis was earlier reported by Nalini *et al*. (2011), Ansari and Singh (2016), Sharma *et al*. (2016), Balwani *et al*. (2017), Khapte *et al*. (2017), Patel *et al*. (2017), Kalaiyarasi *et al*. (2018), Modh *et al*. (2018), Khobragade *et al*. (2019), Zeal *et al*. (2019) and Chaudhari *et al*. (2020).

Number of seeds fruit^{-1}

For this trait the heterosis is desirable in negative direction. The estimates of standard heterosis varied from -26.64 (GJB-3 × GOB-1) to 6.33 per cent (NBL-117 × GAOB-2) in E_1; -29.54 (GJB-3 × GOB-1) to 0.45 per cent (NBL-117 × GAOB-2) in E_2 and -28.44 (GJB-3 × GOB-1) to 0.53 per cent (NBL-117 × Swarna Mani) in E_3. The number of crosses, which exhibited significant negative estimate for standard heterosis were, twenty-five in E_1 and E_2 respectively and 24 in E_3.

For this trait significant and negative standard heterosis was earlier reported by Khapte *et al*. (2017) and Chaudhari *et al*. (2020).

100 seed Weight (mg)

For this trait the heterosis is desirable in negative direction. The estimates of standard heterosis varied from -26.64 (GJB-3 × GOB-1) to 6.33 per cent (NBL-117 × GAOB-2) in E_1; -29.54 (GJB-3 × GOB-1) to 0.45 per cent (NBL-117 × GAOB-2) in E_2 and -28.44 (GJB-3 × GOB-1) to 0.53 per cent (NBL-117 × Swarna Mani)in E_3. The number of crosses, which exhibited significant negative estimate for standard heterosis were, two in E_1, thirteen in E_2 and five in E_3, respectively.

For this trait significant and negative standard heterosis was earlier reported by Khapte *et al*. (2017).

Total Fruit yield (t ha^{-1})

For this trait significant and positive standard heterosis is desirable. The estimates of standard heterosis varied from -44.62 (AB-8/5 × GAOB-2) to 28.26 per cent (NBL-117 × GOB-1) in E_1; -32.09 (GJB-3 × GOB-1) to 19.59 per cent (NBL-117 × Swarna Mani) in E_2 and -28.41 (IC-110662 × Swarna Mani) to 16.85 per cent (NBL-117 × Swarna Mani)in E_3. The number of crosses, which exhibited significant negative estimate for standard heterosis were, four in all three locations.

For this trait significant and negative standard heterosis was earlier reported by Ansari (2017), Kumar *et al*. (2017) and Pramila *et al*. (2017).

Total Phenol content (mg 100 g^{-1})

For this trait significant and negative standard heterosis is desirable. The estimates of standard heterosis varied from -6.21 (GJB-3 × GNRB-1) to 15.86 per cent (BPG-3 × Swarna Mani) in E_1; -5.55 (NBL-50 × Swarna Mani) to 14.18 per cent (BPG-3 × GAOB-2) in E_2 and -29.03 (NBL-50 × GOB-1) to 12.82 per cent (BPG-3 × GAOB-2) in E_3. The number of crosses, which exhibited significant positive estimate for standard heterosis were five in $E_1$and E_2 and one E_3, respectively.

The results are concurrent with Makani *et al*. (2013) and Arpita *et al*. (2017).

TSS (^{0}Brix)

For this trait significant positive standard heterosis is desirable. The estimates of standard heterosis varied from -22.04 (NBL-117 × GOB-1) to 15.09 per cent (NBL-117 × GAOB-2) in E_1; -22.26 (NBL-117 × GOB-1) to 14.45 per cent (NBL-117 × GAOB-2) in E_2 and -22.28 (NBL-117 × GOB-1) to 14.64 per cent (NBL-117 × GAOB-2) in E_3. The number of crosses, which exhibited significant negative estimate for standard heterosis were eleven in E_1 and E_3 and 10 in E_2.

The results are agreement with Arpita *et al*. (2017) and Balwani *et al*. (2017).

Vitamin-C (mg 100 g^{-1})

For this trait positive heterosis was desirable. The estimates of standard heterosis varied from -58.47 (GJB-3 × Swarna Mani) to 5.99 per cent (NBL-50 × GAOB-2) in E_1; -53.46 (GJB-3 × Swarna Mani) to 3.56 per cent (NBL-50 × GOB-1) in E_2 and -53.75 (GJB-3 × Swarna Mani) to 5.00 per cent (NBL-50 × GAOB-2) in E_3. The number of crosses, which exhibited significant positive estimate for standard heterosis were, one in E_1 and E_2 and two in E_3. Similar results were found by Balwani*et al*. (2017) and Chaudhari *et al*. (2020).

Total Anthocyanin content (mg 100 g^{-1})

For this trait positive heterosis was desirable. The estimates of standard heterosis varied from -69.52 (GJB-3 × Swarna Mani) to 31.01 per cent (AB-8/5 × GOB-1) in E_1; -68.70 (GJB-3 × Swarna Mani) to 31.91 per cent (AB-8/5 × GOB-1) in E_2 and -69.96 (GJB-3 × Swarna Mani) to 30.98 per cent (AB-8/5 × GOB-1) in E_3. The number of crosses, which exhibited significant positive estimate for standard heterosis were, twenty in all three locations. Similar results were found by Balwani *et al*. (2017).

The top hybrids (crosses) showing standard heterosis and their performance for fruit yield and related parameters have been summarized in Table 2. A good number of hybrids had significant desired heterosis over the commercial check for various traits. The heterotic response of F_1 is an indicative of genetic diversity among

Table 2 : Promising hybrids for fruit yield plant^{-1} with standard heterosis and component traits showing significant and desired heterosis in all environments in brinjal.

	Hybrid	Fruit yield plant^{-1} (kg)	Standard Heterosis (%)	Useful and significant standard heterosis (%) for component traits
E_1				
1.	NBL-117 × GOB-1	1.90	28.25**	Number of fruits plant^{-1}, total fruit yield (t ha^{-1}), total anthocyanin content (mg 100 g^{-1}).
2.	NBL-117 × GNRB-1	1.90	28.25**	Number of fruits plant^{-1}, total fruit yield (t ha^{-1}), total anthocyanin content (mg 100 g^{-1})
3.	NBL-117 × GAOB-2	1.89	24.89**	Number of fruits plant^{-1}, total fruit yield (t ha^{-1}), total anthocyanin content (mg 100 g^{-1})
4.	NBL-117 × Swarna Mani	1.88	23.32**	Fruit length, number of fruits plant^{-1}, number seeds fruit^{-1} total fruit yield (t ha^{-1}), total anthocyanin content (mg 100 g^{-1})
E_2				
1.	NBL-117 × Swarna Mani	1.91	19.58**	Fruit length, number of fruits plant^{-1}, number seeds fruit^{-1}, total fruit yield (t ha^{-1}), total anthocyanin content.
2.	NBL-117 × GNRB-1	1.82	13.96**	Days to 50% flowering, number of fruits plant^{-1}, total fruit yield (t ha^{-1}), total anthocyanincontent.
3.	NBL-117 × GAOB-2	1.81	13.33**	Number of fruits plant^{-1}, total fruit yield ha, total anthocyanin content.
E_3				
1.	NBL-117 × Swarna Mani	1.84	15.48**	Fruit length, number of fruits plant^{-1}, total fruit yield (t ha^{-1}), total anthocyanin content.
2.	NBL-117 × GAOB-2	1.78	11.72**	Plant height, number of fruits plant^{-1}, total fruit yield (t ha^{-1}), total anthocyanin content.
3.	NBL-117 × GNRB-1	1.72	7.95**	Number of fruits plant^{-1}, total fruit yield (t ha^{-1}), total anthocyanin content.

the parents involved. Based on *per se* performance and standard heterosis for fruit yield and its attributes, four cross combinations *viz*., NBL-117 × GOB-1, NBL-117 × GNRB-1, NBL-117 × GAOB-2 and NBL-117 × Swarna Mani in E_1 and NBL-117 × GNRB-1, NBL-117 × GAOB-2 and NBL-117 × Swarna Mani in E_2 and E_3 proved to be promising heterotic cross for yield and its contributing traits. Similar kind of result was also found by Shanmughapriya *et al*. (2009). These hybrids may be further tested over locations, seasons and years and recommended for commercial release.

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