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Genetic Analysis for Yield and Yield Contributing Characters in Brinjal (*Solanum melongena* L.) Over Environments

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A B S T R A C T

With prime objective of developing season/region specific hybrid, the present investigation was undertaken to obtain the information on the *per se* performance, heterosis, combining ability, nature of gene action and stability parameters for fruit yield and its components in brinjal (*Solanum melongena* L.) using line x tester analysis at Navsari during 2014-15. Female parent, JBG-10-208 recorded the highest fruit yield per plant, while, PLR-1 was the highest yielding male parent. The best cross combination identified for fruit yield per plant based on pooled analysis was JB-12-6 ×PLR-1, which also displayed superior performance of other yield related attributes. The maximum standard heterosis for fruit yield per plant over both the checks was recorded by the cross combination JB-12-6 × PLR-1. Preponderance of additive gene actions for days to 50% flowering, plant height, primary branches per plant, fruit weight, fruit length, fruits per plant, fruit dry matter percentage, chlorophyll content, leaf area and total phenol. Non-additive gene actions were pre-dominant for secondary branches per plant, fruit yield per plant, photosynthesis rate, stomatal conductance and total soluble solids. It was recommended that *inter se* matings followed by pedigree method of breeding might prove useful for higher yield with better fruit quality. The cross combinations JBL-12-6-1-2 × Pant Rituraj and JB-12-6 × GJB-2 involving good x good general combining parents besides exhibiting favourable additive effect of good combiner parents, manifested complementary interaction effects for fruit yield and thus, resulted in higher *sca* effects. Hence, these crosses may be expected to yield transgressive segregants possessing enhanced yielding ability with stable performance.

Keywords

Brinjal, Combining ability, Heterosis, Stability

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Introduction

Vegetables are rightly called as natural source of protective food as they supply vitamins and minerals along with roughages. Brinjal (*Solanum melongena* L.) a self-pollinated crop (2n = 24) and perennial in nature is grown commercially is a good source of dietary fiber, micronutrients and bioactive compounds. Indo-Burma region is considered as center of origin (Vavilov, 1928) which offers plant breeders an opportunity to utilize huge genetic diversity for heterosis breeding, present in our country. Hybrid vigour is manifested by single cross hybrids. Exploitation of heterosis on a commercial scale in vegetable crops has resulted in the development of the several high yielding hybrid varieties. This technique has been proved to be the most important genetic tool for accelerating yield potential at an exponential rate, which depends mainly on the selection of the elite promising parents. A high yielding genotype may or may not always transmit its superiority to the progenies.

Thus, the outcome of a breeding program depends largely on useful gene combinations in the form of high combining efficient inbreds. For development of superior hybrids, information on combining ability is a pre-requisite which is helpful to plant breeders in selecting the elite parents and their desirable cross combinations to be used during varietal improvement on a commercial scale. Information regarding the nature of gene action governing various yield contributing traits is helpful in predicting the effectiveness of selection and formulating further sound crop improvement programme.

This study was, therefore, conducted in brinjal to identify high yielding possible single cross combinations which has elite parents. We also assessed whether there are any mode of gene action such as additive and dominant gene effects, non-allelic gene interaction (epistasis), for yield and its component traits in brinjal using line × tester analysis. Such information can provide a guideline reference to maximize germplasm potential useful for increasing heterosis in pearl millet hybrid breeding.

Materials and Methods

Plant materials: Experimental material for the present investigation were crossed in L × T fashion using 10 females from JAU, Junagadh (JBL-12-06-4-1, JB-12-06, JBL-12-06-1-2, JBCL-1, JBL-08-07, JBG-10-208 and JBL-12-08-1-1) and AAU, Anand (AB-08-6, AB-07-2 and AB-08-14) universities and 4 males procured from Vegetable Research Station, TNAU, Palur (PLR-1) GBPUAT, Pantnagar (Pant Rituraj) and JAU, Junagadh (GJB-2 and JBGR-1). These 40 F_1s, 14 parents (10 females, 4 males) and two checks ABH – 1 (commercial hybrid check) and Surati Ravaiya (local check) from AAU, Anand and RHRS, NAU, Navsari respectively, composed the material for the current study.

Field trials: The experiment was conducted at College Farm, NAU, Navsari which is situated in agro - climatic zone – III of Gujarat. Crossing program was carried out during *Rabi* 2013-14 in L × T mating design. Sufficient F_1's and self-seeds of parents were harvested and stored properly for sowing in the next season. The experiment was laid out in Randomized Block Design (RBD) with three replication during late *kharif*, *rabi* and early *summer* season of 2014-15. In each replication, parents, hybrids and checks were planted. Each entry was planted in 1 row of 6m length, spaced at 120cm between rows and 60cm between plants. Standard agronomic management practices were followed during all seasons (late *kharif*, *rabi* and early *summer*: 2014-15) for good crop growth.

Traits evaluated: Data were recorded on the five competitive plants for plant height, primary branches per plant, secondary branches per plant, fruit weight, fruit length, fruit length, fruit diameter, fruits per plant, fruit yield per plant, fruit dry matter, chlorophyll content, leaf area, photosynthesis rate, stomatal conductance, total soluble solids and total phenol. Days to 50 per cent flowering were calculated on population basis. Among the physiological traits the chlorophyll content was measured from five plants in each replication by chlorophyll meter, manufactured by Konica Minolta sensing Inc. Japan (Model no. SPAD 502 Plus).Leaf area was measured by leaf area meter (CID).The net photosynthetic rate was measured in each replication by photosynthetic system (CID).

Stomatal conductance was measured using CIRAS-IA photosynthetic system. An open system of narrow rectangular chamber with window was used. Every observation was recorded with leaf covering full window of the system. Observations were made on fully expanded green leaves from 3rd and 4th from top and measured between 8:30 to 10:30 am.

The percentage of total soluble sugars (T.S.S.) content in the juice of the brinjal fruit of each of five labeled plants were recorded with the help of Pocket Refractometer Pal-1, Atago (range 0 to 32). For the total phenol measurement freshly harvested fruits were peeled off and fleshes were dried in hot air oven at 80^0 C for 24 hours. The phenol content was then estimated by using Folin-Ciocalteu reagent as per the method suggested by Bray and Thorpe (1954).

Statistical analysis: All the data were analyzed for pooled analysis of variance over the three different environments was done as suggested by Gomez and Gomez (1984) to test the interaction of genotypes and their sub-divisions with environments. The mean values of the traits were subjected to combining ability analysis using the line x tester model as suggested by Kempthorne (1957) and heterosis by using Meredith and Bridge (1971).

Results and Discussion

In the present study, performance of 40 crosses was compared with one of the hybrid check ABH-1 (check-1) and local check Surati Ravaiya (check-2) which is widely cultivated. One of the male parents, PLR-1 was showing consistency in its performance for all the characters as it was involved in the top three performers for all traits, except for total phenol. A female AB-7-2 exhibited superior performer for many traits such as days to 50% flowering, plant height (cm), primary branches per plant, fruit weight (g), fruit length (cm), fruit diameter (cm), fruit yield per plant (g) and stomatal conductance (µM $m^{-2}s^{-1}$).

Analysis of variances revealed significant differences among genotypes, parents and hybrids for all the traits under all individual environments as well as over the environments indicating presence of substantial amount of genetic variability among the genotypes, parents and hybrids. The average performance of hybrids differed significantly than that of parents suggesting the presence of average heterosis, which was evident from the significance of parents vs. hybrids comparison for most of the characters in individual environments and also over environments. Perusal of analysis of variance over the environments revealed significant differences among the environments for all the characters, indicating variable environmental conditions.

The maximum standard heterosis for fruit yield per plant over check-1 was recorded by the cross combination JB-12-6 × PLR-1 (44.27 %) followed by AB-7-2 × PLR-1 (40.86 %) and JBL-12-8-1-1 × Pant Rituraj (40.44 %). Whereas, over check-2, the maximum standard heterosis for fruit yield per plant was recorded by the cross combination JB-12-6 × PLR-1 (79.79 %) followed by AB-7-2 × PLR-1 (75.25 %) and JBL-12-8-1-1 × Pant Rituraj (74.73 %) (Table 1). The present findings were in close association with results reported by Deshmukh *et al.,* (2015) and Ramani *et al.,* (2015). The ten best crosses showing high standard heterosis and their performance for yield and related parameters have been summarized in Table 1.

Among the ten promising hybrids for fruit yield per plant over both the checks exhibited negative standard heterosis for days to 50 % flowering which is desirable character that most of the promising hybrids depicted significant negative heterosis for days to 50 %

flowering thereby suggesting that high yield in brinjal can be achieved along with early flowering. The results are in akin with the findings of Reddy and Patel (2014) and Deshmukh *et al.,* (2015).

The perusal of results revealed that all the top ten crosses for fruit yield per plant reported positive heterosis for plant height over the check-2 *i.e*., Surati Ravaiya. While, over check-1, among the top ten crosses only four *viz*., AB-7-2 × PLR-1, JBL-12-8-1-1 × Pant Rituraj, AB-7-2 × Pant Rituraj and JBL-12-8-1-1 × PLR-1 were showing positive Heterosis for plant height. These results indicate over dominance, as reported earlier in brinjal byReddy and Patel (2014); Deshmukh *et al.*, (2015) and Ramani *et al.,* (2015).

In case of total phenol among these hybrids, JB-12-6 × PLR-1, JBL-12-8-1-1 × Pant Rituraj, JBL-12-8-1-1 × PLR-1 and JB-12-6 × GJB-2 showed negative heterosis over only check-1. Total phenol imparts bitterness to the fruits hence it is undesirable character and is taken under negative direction for quality parameters. The significant positive heterosis for total soluble solids was reported by the promising hybrids for fruit yield *viz*., JB-12-6 × PLR-1, AB-8-6 × PLR-1, JBL-12-8-1-1 × PLR-1 and JB-12-6 × GJB-2 over both the checks and AB-7-2 × Pant Rituraj over only check-1 thus giving the importance of total soluble solids as quality parameter in obtained along with higher fruit yield. Sao and Mehta (2010) and Biswas *et al.*, (2013) reported similar findings.

The mean squares due to females and males were significant for all the characters (in males except for plant height in E_1) under individual environments as well as across the environments, signifying that both females and males had considerable general combining ability (gca) and contributed towards additive genetic variance. Highly significant mean squares due to females x males were manifested by all the characters (except fruit dry matter percentage in pooled analysis) in all the three environments as well as in pooled analysis, suggesting its significant contribution in favour of specific combining ability (sca) variances. The variance estimate, σ^2gca was highly significant for all the characters in each and over the environments except plant height and primary branches per plant over the environments.

Likewise, σ^2sca was found significant for all characters except days to 50 % flowering, plant height, primary branches per plant, fruit dry matter percentage, total soluble solids and total phenol. This emphasizes the importance of additive and non-additive gene actions in inheritance of these characters. However, perusal of σ^2gca / σ^2sca ratio revealed preponderance of additive gene action for days to 50% flowering, plant height, primary branches per plant, fruit weight, fruit length, fruits per plant, fruit dry matter percentage, chlorophyll content, leaf area and total phenol.

An estimate of combining ability is known to be greatly influenced by the environment. Among female parents, JB-12-6, JBCL-1, JBL-12-8-1-1, AB-8-6 and AB-7-2 were found to be good general combiners for fruit yield per plant, thereby classifying these parents as good sources of favourable genes for increasing production of fruit yield per plant. The female parents JBL-8-7, JBL-12-8-1-1, AB-7-2 and AB-8-14 showed desirable (positive) gca effects for plant height and hence, can be a good source of genes for the development of tall plant types in brinjal. The best hybrids on the basis of significant positive sca effect for fruit yield per plant were JBL-12-6-1-2 × Pant Rituraj, AB-8-14 × GJB-2, AB-7-2 × PLR-1, JBL-12-8-1-1 × Pant Rituraj, JBG-10-208 × JBGR-1, JB-12-6 × PLR-1, JBL-8-7 × JBGR-1 and JBL 12-6-4-1 × JBGR-1.

Table.1 Promising hybrids for fruit yield per plant with standard heterosis, GCA effects, SCA effects and component traits showing significant desired heterosis based on pooled over environments

Sr. No.	Hybrid	Fruit yield per plant (g)	Standard heterosis-1 (%)	Standard heterosis-2 (%)	GCA effects	SCA effects	Useful and significant for component traits	
							Standard heterosis-1 (%)	Standard heterosis-2 (%)
1.	JB-12-6 × PLR-1	3687.80	44.27**	79.79**	G × G	319.18*	DF, PB, SB, FW, FD, FPP, PR, SC, TSS, TP	DF, PH, PB, SB, FW, FD, FPP, ChC, PR, SC, TSS
2.	AB-7-2 × PLR-1	3600.65	40.86**	75.25**	G × G	437.70**	DF, PH, PB, SB, FW, FL, FPP	DF, PH, PB, SB, FW, FL, FPP, FDM
3	JBL-12-8-1-1 × Pant Rituraj	3589.82	40.44**	74.73**	G × G	406.10**	DF, PH, FW, FD, FDM, PR, SC, TP	DF, PH, FW, FL, FD, FPP, FDM, PR, SC
4	JBCL-1 × PLR-1	3481.46	36.20**	69.45**	G × G	230.37	DF, PB, FL, FD, FPP, SC	DF, PH, PB, FW, FL, FD, FPP, SC
5	AB-7-2 × Pant Rituraj	3372.02	31.92**	64.12**	G × G	120.23	DF, PH, PB, FW, FL, TSS	DF, PH, PB, FW, FL, FD, FDM
6	JBL-12-6-1-2 × Pant Rituraj	3363.87	31.60**	63.73**	P × G	524.09**	DF, FW, FD, FPP, FDM	DF, PH, FW, FL, FD, FPP, FDM, SC
7	AB-8-6 × PLR-1	3298.13	29.02**	60.53**	G × G	189.14	DF, PB, SB, FW, FD, FPP, TSS	DF, PH, PB, SB, FW, FL, FD, FPP, TSS
8	JBL-12-8-1-1 × PLR-1	3289.29	28.68**	60.10**	G × G	194.41	DF, PH, SB, FD, FPP, SC, TSS, TP	DF, PH, SB, FW, FD, FPP, FDM, PR, SC, TSS
9	JBCL-1 × Pant Rituraj	3273.29	28.05**	59.32**	G × G	-66.64	DF, PB, FW, FL, FD, FPP, SC	DF, PH, PB, FW, FL, FD, FPP, FDM, SC
10	JB-12-6 × GJB-2	3250.39	27.16**	58.20**	G × P	92.51	SB, FW, FPP, SC, TSS, TP	DF, PH, SB, FW, FL, FPP, SC, TSS

*, ** Significant at 5 and 1 per cent probability levels, respectively; G = Good parent having significant gca effect in desired direction; A = Average parent having either positive or negative but non-significant gca effects. DF=Days to 50% flowering, FY=Fruit yield per plant (g), PH=Plant height (cm), FDM=Fruit dry matter (%), PB=Primary branches per plant, ChC=Chlorophyll content (SPAD value), SB=Secondary branches per plant, LA=Leaf area (cm^2), FW=Fruit weight (g), PR=Photosynthesis rate ($\mu M\ m^{-2s-1}$), FL=Fruit length (cm), SC=Stomatal conductance ($\mu M\ m^{-2s-1}$), FD=Fruit diameter (cm), TSS=Total soluble solids (%), FPP=Fruits per plant and TP=Total phenol ($mg\ g^{-1}$)

Table.2 Summary of three best performing parents, best general combining parents and best performing hybrids along with their GCA effects and SCA effects and per cent standard heterosis for various traits on pooled basis

Character	Best performing parents		Best general combiner		Best performing hybrids	GCA effect	SCA effect		Standard heterosis-1 (%)		Standard heterosis-2 (%)	
	Female	Male	Female	Male								
Days to 50% flowering	JBG-10-208	Pant Rituraj	AB-7-2	Pant Rituraj	AB-7-2 × Pant Rituraj	G × G	-0.13		-14.90	**	-16.73	**
	AB-7-2	JBGR-1	JBL-12-6-4-1	JBGR-1	AB-7-2 × JBGR-1	G × G	-0.51		-13.87	**	-15.72	**
	JBL-8-7	PLR-1	JBL-8-7		JBL-8-7 × JBGR-1	G ×G	-1.28	*	-10.95	**	-12.86	**
Plant height (cm)	AB-8-14	GJB-2	AB-8-14	Pant Rituraj	AB-8-14 × GJB-2	G × G	2.89		28.65	**	58.21	**
	JBL-8-7	Pant Rituraj	JBL-8-7	GJB-2	AB-8-14 × Pant Rituraj	G × G	2.19		28.32	**	57.80	**
	AB-7-2	PLR-1	AB-7-2		JBL-8-7 × Pant Rituraj	G × G	3.48	*	21.22	**	49.07	**
Primary branches per plant	JBL-8-7	GJB-2	JBL-8-7	GJB-2	JBL-8-7 × PLR-1	G × A	0.26		25.11	**	25.28	**
	AB-7-2	PLR-1	JBCL-1		JBCL-1 × GJB-2	G × G	0.06		19.90	**	20.06	**
	AB-8-6	Pant Rituraj	AB-8-6		AB-7-2 × GJB-2	G × G	0.08		18.90	**	19.06	**
					JB-12-6 × Pant Rituraj	A × A	0.64	**	19.06	**	19.21	**
Secondary branches per plant	JBL-8-7	GJB-2	AB-8-6	GJB-2	JBCL-1 × GJB-2	A × G	2.71	**	53.45	**	58.86	**
	AB-8-6	PLR-1	JBG-10-208	PLR-1	AB-8-6 × GJB-2	G × G	-0.87		51.92	**	57.27	**
	JBG-10-208	Pant Rituraj	JBL-8-7		AB-7-2 × PLR-1	G × G	2.18	**	50.98	**	56.30	*
Fruit weight (g)	JBG-10-208	Pant Rituraj	JBG-10-208	Pant Rituraj	JBG-10-208 × Pant Rituraj	G × G	51.62	**	199.34	**	228.16	**
	AB-8-6	JBGR-1	AB-8-6		JBG-10-208 × JBGR-1	G × P	-8.73	**	95.50	**	114.33	**
	AB-7-2	PLR-1	AB-7-2		JBG-10-208 × GJB-2	G × P	-12.05	**	88.60	**	106.76	**
Fruit length (cm)	AB-7-2	JBGR-1	AB-7-2	JBGR-1	AB-7-2 × JBGR-1	G × G	2.41	**	119.49	**	199.50	**
	JBCL-1	Pant Rituraj	AB-8-6	Pant Rituraj	AB-7-2 × Pant Rituraj	G × G	-0.16		80.46	**	146.25	**
	AB-8-6	PLR-1	JBCL-1		AB-8-6 × JBGR-1	G × G	2.21	**	78.34	**	143.35	**
Fruit diameter (cm)	JBG-10-208	Pant Rituraj	JBG-10-208	Pant Rituraj	JBG-10-208 × Pant Rituraj	G × G	1.80	**	187.77	**	231.57	**
	AB-7-2	JBGR-1	AB-8-6		JBG-10-208 × PLR-1	G × A	1.41	**	135.71	**	171.58	**
	AB-8-6	GJB-2	JBL-12-6-4-1		JBL 12-6-4-1 × Pant Rituraj	G × G	0.47	*	106.26	**	137.65	**
Fruits per plant	JBCL-1	PLR-1	JBL-8-7	PLR-1	JBCL-1 × PLR-1	G × G	-1.39		33.73	**	52.00	**
	JBL-8-7	GJB-2	JBCL-1	GJB-2	JBL-8-7 × PLR-1	G × G	-2.74	**	33.28	**	51.49	**
	JBL-12-8-1-1	Pant Rituraj	JBL-12-6-1-2		JBL-8-7 × JBGR-1	G × P	1.51	*	30.91	**	48.80	**
Fruit yield per plant (g)	JBG-10-208	PLR-1	JB-12-6	Pant Rituraj	JB-12-6 × PLR-1	G × G	319.18	*	44.27	**	79.49	**

	AB-8-6	Pant Rituraj	JBCL-1	PLR-1	AB-7-2 × PLR-1	G × G	437.70	**	40.86	**	75.25	**
	AB-7-2	GJB-2	AB-7-2		JBL-12-8-1-1 × Pant Rituraj	G ×G	406.10	* *	40.44	**	74.73	**
Fruit dry matter (%)	JBL-8-7	Pant Rituraj	JBL-8-7	Pant Rituraj	JBL-8-7 × Pant Rituraj	G × G	-0.01		15.32	**	27.72	**
	JBL-12-6-1-2	GJB-2	JBL-12-6-1-2		JBL-8-7 × PLR-1	G × A	0.02		14.69	**	27.03	**
	JBL-12-8-1-1											
	JBL 12-6-4-1	PLR-1	JBL 12-6-4-1		JBL-12-6-1-2 × Pant Rituraj	G × G	-0.001		13.33	**	25.52	**
Chlorophyll content (SPAD value)	JBL-12-8-1-1	PLR-1	JBG-10-208	JBGR-1	JBG-10-208 × JBGR-1	G × G	2.92	*	12.71	**	22.90	**
	JB-12-6	JBGR-1	JBCL-1		JBG-10-208 × Pant Rituraj	G × A	4.76	**	7.44	*	17.16	**
	AB-8-6	Pant Rituraj	JB-12-6		JBCL-1 × JBGR-1	G × G	-1.19		2.07		11.30	**
Leaf area (cm^2)	JB-12-6	JBGR-1	AB-8-14	JBGR-1	AB-8-14 × JBGR-1	G × G	5.74	**	23.61	**	31.41	**
	JBG-10-208	PLR-1	JBG-10-208		JBG-10-208 × JBGR-1	G × G	3.51	**	17.52	**	24.94	**
	AB-8-14	GJB-2	AB-8-6		JBG-10-208 × GJB-2	G × A	2.13		11.64	**	18.68	**
Photosynthesis rate (μM $m^{-2}s^{-1}$)	JBL-12-8-1-1	JBGR-1	JBCL-1	JBGR-1	JBCL-1 × JBGR-1	G × G	1.33	*	48.46	**	59.06	**
	JB-12-6	PLR-1	JBL-12-6-1-2		JBL-12-6-1-2 × PLR-1	G × A	3.02	**	42.49	**	52.66	**
	AB-8-6	Pant Rituraj	JB-12-6		JBL-12-6-1-2 × JBGR-1	G × G	-0.41		33.31	**	42.82	**
					JB-12-6 × JBGR-1	G × G	0.06		33.28	**	42.79	**
Stomatal conductance (μM m-^{2}s^{-1})	JBL-12-8-1-1	Pant Rituraj	JBCL-1	JBGR-1	JBCL-1 × JBGR-1	G × G	0.03		65.17	**	72.92	**
	AB-8-6	PLR-1	JBG-10-208		JBG-10-208 × JBGR-1	G × G	0.04		59.20	**	66.67	**
			JBL-12-6-1-2									
	AB-7-2	JBGR-1	JB-12-6		JBL-12-6-1-2 × PLR-1	G × A	0.10	**	53.48	**	60.68	**
Total soluble solids (%)	AB-8-6	JBGR-1	AB-8-14	JBGR-1	AB-8-14 × GJB-2	G × A	0.60	**	67.21	**	56.14	**
	JBG-10-208	PLR-1	AB-8-6	PLR-1	AB-8-14 × JBGR-1	G × G	-0.27	*	48.12	**	38.31	**
	JB-12-6	Pant Rituraj	JB-12-6		AB-8-14 × PLR-1	G × G	-0.12		47.53	**	37.76	**
Total phenol (mg g^{-1})	JBG-10-208	JBGR-1	JB-12-6	JBGR-1	JBG-10-208 × JBGR-1	G × G	-0.06	**	-32.86	**	-21.41	**
	JB-12-6	GJB-2	JBL-12-8-1-1	GJB-2	JBG-10-208 × GJB-2	G × G	-0.05	*	-30.69	**	-18.86	**
	JBL-12-8-1-1	Pant Rituraj	JBG-10-208		JBL-12-8-1-1 × GJB-2	G × G	-0.03		-22.89	**	-9.73	*

*, ** Significant at 5 and 1 per cent probability levels, respectively; G = Good parent having significant GCA effect in desired direction; A = Average parent having either positive or negative but non-significant GCA effects; P = Poor parent having significant GCA effects in undesired direction.

Table.3 Character wise list of best three stable parents and hybrids for general and specific environments

Characters	Genotypes with average stability			Suitable for favourable environment		Suitable for unfavourable environment/ poor environment	
	Parents		Hybrids	Parents	Hybrids	Parents	Hybrids
	Female	Male					
Days to 50% flowering	AB-7-2	PLR-1	AB-7-2 × Pant Rituraj	--	--	JBG-10-208	JBCL-1 × JBGR-1
	JBL-8-7	Pant Rituraj	AB-8-6 × Pant Rituraj				
	--	JBGR-1	JBL 12-6-4-1 × Pant Rituraj				
Plant height (cm)	AB-8-14	GJB-2	AB-8-14 × GJB-2	--	--	--	--
	JBL-8-7	--	AB-8-14 × Pant Rituraj				
	AB-7-2	--	JBL-8-7 × Pant Rituraj				
Primary branches per plant	JBL-8-7	PLR-1	JBL-8-7 × PLR-1	--	--	--	--
	AB-7-2	--	JBCL-1 × GJB-2				
	AB-8-6	--	JB-12-6 × Pant Rituraj				
			AB-7-2 × GJB-2				
Secondary branches per plant	JBL-8-7	GJB-2	AB-8-6 × GJB-2	--	--	--	--
	AB-8-6	PLR-1	JB-12-6 × GJB-2				
	JBG-10-208	--	AB-8-6 × JBGR-1				
Fruit weight (g)	AB-8-6	--	JBG-10-208 × Pant Rituraj	--	--	--	AB-8-6 × Pant Rituraj
	JBL-12-6-4-1	--	JB-12-6 × Pant Rituraj				
	JB-12-6	--	AB-7-2 × Pant Rituraj				
Fruit length (cm)	JBCL-1	JBGR-1	AB-7-2 × JBGR-1	--	--	--	--
	--	Pant Rituraj	AB-7-2 × Pant Rituraj				
	--	PLR-1	AB-8-6 × JBGR-1				
Fruit diameter (cm)	JBG-10-208	Pant Rituraj	JBG-10-208 × Pant Rituraj	--	--	--	--
	AB-8-6	JBGR-1	JBL-12-6-4-1 × Pant Rituraj				
	JBL 12-6-4-1	--	JB-12-6 × Pant Rituraj				
Fruits per plant	JBCL-1	PLR-1	JBCL-1 × PLR-1	--	--	--	--
	JBL-8-7	GJB-2	JBL-8-7 × PLR-1				
	JBL-12-8-1-1	Pant Rituraj	JBL-8-7 × JBGR-1				

Fruit yield per plant (g)	JBG-10-208	PLR-1	JB-12-6 × PLR-1	--	--	--	JBL-12-6-1-2 × Pant Rituraj
	AB-8-6	Pant Rituraj	AB-7-2 × PLR-1				
	JB-12-6	--	JBL-12-8-1-1 × Pant Rituraj				
Fruit dry matter (%)	JBL-8-7	GJB-2	JBL-12-6-1-2 × Pant Rituraj	--	--	--	--
	JBL-12-6-1-2	Pant Rituraj	JBL-8-7 × GJB-2				
	JBL-12-8-1-1						
	AB-8-14	--	JBL-12-6-4-1 × PLR-1				
			JBL-12-6-1-2 × GJB-2				
			JBL-12-8-1-1 × Pant Rituraj				
Chlorophyll content (SPAD Value)	JBL-12-8-1-1	PLR-1	JBG-10-208 × JBGR-1	--	--	AB-7-2	JB-12-6 × PLR-1
	JB-12-6	--	JBG-10-208 × Pant Rituraj				
	JBL-8-7	--	JBCL-1 × JBGR-1				
Leaf area (cm^2)	JB-12-6	JBGR-1	JBG-10-208 × GJB-2	--	--	--	JBL-12-8-1-1 × JBGR-1
	JBG-10-208	PLR-1	AB-8-14 × GJB-2				
	AB-8-14	GJB-2	AB-8-14 × PLR-1				
Photosynthesis rate (µM $m^{-2}s^{-1}$)	JBL-12-8-1-1	--	JBCL-1 × JBGR-1	---	--	JBGR-1	--
	JB-12-6	--	JBL-12-6-1-2 × PLR-1				
	AB-8-6	--	JB-12-6 × JBGR-1				
			JBL-12-6-1-2 × JBGR-1				
Stomatal conductance (µM $m^{-2}s^{-1}$)	JBL-12-8-1-1	PLR-1	JBCL-1 × JBGR-1	--	--	Pant Rituraj	--
	AB-8-6	--	JBG-10-208 × JBGR-1				
	AB-7-2	--	JBL-12-6-1-2 ×× PLR-1				
Total soluble solids (%)	JB-12-6	--	AB-8-6 × GJB-2	--	--	--	--
	JBG-10-208	--	JBG-10-208 × JBGR-1				
	--	--	AB-8-14 × Pant Rituraj				
Total phenol (mg g^{-1})	JBG-10-208	Pant Rituraj	JBG-10-208 × JBGR-1	--	--	GJB-2	JB-12-6 × Pant Rituraj JB-12-6 × JBGR-1
	JB-12-6	--	JBG-10-208 × GJB-2				
	JBL-12-8-1-1	--	JBG-10-208 × Pant Rituraj				

The importance of sca particularly in crosses involving diverse germplasm was brought out by the studies of Dubey *et al.*, (2014) and Reddy and Patel (2014).Cross combinations JB-12-6 × PLR-1, AB-7-2 × PLR-1, JBL-12-8-1-1 × Pant Rituraj, JBCL-1 × PLR-1, AB-7-2 × Pant Rituraj, AB-8-6 × PLR-1, JBL-12-8-1-1 × PLR-1 and JBCL-1 × Pant Rituraj involving both good general combiners suggested still better possibilities of exploitation as it can be expected to yield stable segregants in the advanced generations and needs further exploitation in the breeding programme.

A summarized account of the best performing parents, the best general combiners, best performing hybrids and specific cross combinations (Table 2) revealed that for majority of the characters, the best performing parents were also found to be best general combiners though their relative ranking were different. The foregoing discussion and information clearly indicated that the hybrids JB-12-6 × PLR-1, AB-7-2 × PLR-1 and JBL-12-8-1-1 × Pant Rituraj were high yielding and heterotic along with desirable sca effect for fruit yield per plant over environments.

Environment plays an important role in the final phenotypic expression of a character. The genotypes × environments (G × E) interaction is particularly important in the expression of quantitative characters which are controlled by polygenic systems and are greatly modified by the environmental influences. The mean squares due to genotypes were highly significant for all the traits when tested against pooled error and pooled deviation which indicated the presence of considerable genetic variability in the material tested. The genotypes x environment interaction was highly significant for all the characters when tested against pooled error and pooled deviation, but stomatal conductance, total soluble solids, fruit diameter, fruit per plant and fruit dry matter when tested against pooled deviated.The non-linear component (pooled deviation) was also found highly significant for days to 50% flowering, plant height primary branches per plant, secondary branches chlorophyll content, total soluble solids, total phenol, fruit weight and fruit dry matter indicating lack of possibility to predict the performance of genotypes across the environments for these characters. These results are in accordance with those of Srivastava *et al.*, (1997) and Chowdhury and Talukdar (1997).

Among all the hybrids, the crosses *viz*., JBL 12-6-4-1 × PLR-1, JBL 12-6-4-1 × GJB-2, JB-12-6 × PLR-1, JB-12-6 × Pant Rituraj, JB-12-6 × GJB-2, JBCL-1 × PLR-1, JBCL-1 × Pant Rituraj, JBG-10-208 × Pant Rituraj, JBL-12-8-1-1 × PLR-1, JBL-12-8-1-1 × Pant Rituraj, AB-8-6 × PLR-1, AB-8-6 × Pant Rituraj, AB-7-2 × PLR-1, AB-7-2 × Pant Rituraj and AB-8-14 × GJB-2 were high yielders with average responsiveness and stable performance as they had regression coefficient around unity and non-significant deviation from regression. This indicated that these hybrids were stable and performed well under different environmental conditions. Singh (1983) had suggested the utilization of stable and potential genotypes in breeding programmes for incorporation of stability. Hence, stability of the identified genotypes (hybrids) for fruit yield per plant has been characterized with respect to the yield attributes and the information is presented in Table 3.

The preponderance of non-additive genetic variance was observed in the inheritance of secondary branches per plant, fruit yield per plant, photosynthesis rate, stomatal conductance and total soluble solids whereas, both additive and non-additive gene action were governing the character fruit diameter. This suggested that heterosis breeding or biparental mating would be more suitable for the improvement of these traits in brinjal. Considerable amount of standard heterosis was observed for most of the characters studied. The crosses JB-12-6 × PLR-1, AB-7-2 × PLR-1 and JBL-12-8-1-1 × Pant Rituraj displayed high magnitude of standard heterosis over both checks along with high *per se* performance for fruit yield per plant. These crosses may be rigourasely evaluated over multi locational trials to identify high yielding and stable hybrids of brinjal.

The lines JB-12-6, JBCL-1, JBL-12-8-1-1, AB-8-6, AB-7-2 and testers PLR-1 and Pant Rituraj displayed high gca effect, good *per se* performance along with stability for fruit yield per plant. While the top five crosses JBL-12-6-1-2 × Pant Rituraj, AB-8-14 × GJB-2, AB-7-2 × PLR-1, JBL-12-8-1-1 × Pant Rituraj and JBG-10/208 × JBGR-1 displayed high sca effect for fruit yield per plant.

The prevalence of both additive and non-additive genetic effects suggested the simultaneous exploitation of these gene actions by adopting selective intermating and recurrent selection, which would accumulate more of additive genetic variability. The non-additive gene effect can be well exploited by the breeding procedures involving heterosis breeding in brinjal. The crosses exhibited average stability and wider adaptability for fruit yield per plant were JB-12-6 × PLR-1, AB-7-2 × PLR-1, JBL-12-8-1-1 × Pant Rituraj, JBCL-1 × PLR-1 and AB-7-2 × Pant Rituraj were identified as the stable genotypes for fruit yield and its components and hence, may be utilized in breeding programmes for incorporation of stability in brinjal in present situation.

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