Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(5): 2137-2143
Received: 20-07-2017
Accepted: 21-08-2017

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Combining Ability and Gene Action Studies in Brinjal (*Solanum melongena* L.)

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Abstract
The combining ability analysis of a 10 x 10 half diallel set of crosses in brinjal was undertaken for fruit yield and its attributing characters. Ten parents, 45 F_1's and one standard check were evaluated at Main Vegetable Research Station, Anand Agricultural University during 2016-17. The analysis of variance revealed presence of considerable variability among genotypes for all the characters under study. Combining ability analysis revealed importance of both additive and non additive variances in expression of various traits. The magnitude of variance due to specific combining ability was higher in comparison to variance due to general combining ability for plant height, number of fruits per plant, fruit yield per plant, dry matter, ascorbic acid, total soluble sugars and acidity suggesting greater role of non-additive genetic variance. Whereas, for rest of the characters predominance of additive gene action involved. Among the parental genotypes, GAOB 2 was good general combiner and GBL1, Doli 5, GP-BRJ-215 and GP-BRJ-216 were average general combiners for fruit yield per plant and were also good/ average general combiners for most of the yield contributing component characters and quality characters. In respect to estimates of specific combining ability effects, for fruit yield per plant, the hybrids GBL 1 × Doli 5, JBL 10-08-07 × GP-BRJ-216, and GAOB 2 x JBL 10-08-01 registered high *per se* performance and significant high values of sca effects in desired direction for the important yield contributing characters and nutritional quality parameters. Therefore, the above hybrids may be favoured for commercial cultivation as hybrids after critical evaluation over locations. All the parents involved in these crosses had good or average gca effects. Hence, their hybrids are also expected to throw-off transgressive recombinants in segregating generations, combining favourable traits into one genotype for development as improved varieties.

Keywords: Diallel cross, brinjal, combining ability, fruit yield

Introduction
Brinjal or eggplant (*Solanum melongena* L.) is widely cultivated as one of the most important vegetables in both sub-tropical and tropical areas of India as well as abroad. It is autogamous diploid with chromosome number 2n = 24 and belongs to the family *solanaceae*. India is considered as the primary centre of origin of brinjal (Vavilov, 1931) [16]. It is the most consumed crop in India, where it accounts for about 13.558 million tonnes production of brinjal from an area of 0.711 million hectares under cultivation with a productivity of 19.06 MT/ha (Anon., 2014) [1]. Brinjal producing major states are West Bengal, Orissa, Bihar and Gujarat. Although it is a self- compatible and highly self -pollinating crop, yet cross pollination to the extent of 30 to 40 % has also been reported in Bulgaria. Combining ability analysis is main tool for choice of parents as well as understanding of the nature of gene action. So, information on importance of general and specific combining ability is of immense use in the development of efficient breeding programme. Keeping this in view, the present study was therefore conducted to estimate the general combining ability effect of parents, specific combining ability effect of hybrids and to elucidate nature of gene action for fruit yield and its component characters.

Material and Methods
The experimental material was developed at the Main Vegetable Research Station, AAU, Anand during *Kharif* - *Rabi* 2015-16, by using ten genotypes which were crossed following half diallel mating design. Thus, the experimental material consisted of 56 genotypes comprising of ten parents *viz*., GAOB 2, GBL 1, Doli 5, Punjab Sadabahar, JBL 10-08-07, JBL 10-08-01, AB 13-03, Kashi Taru, GP-BRJ-215 and GP-BRJ-216, their 45 hybrids and one standard check GABH 3. The experimental material was sown in a randomized complete block design (RCBD) with two replications at Main Vegetable Research Station, AAU, Anand during *Kharif* – *Rabi* 2016-17. Each entry was grown in a single row of 4.80 m length keeping row to row 90 cm and plant to plant 60 cm distance.

The recommended agronomic practices were followed to raise the healthy crop. The observations were recorded on five randomly selected plants for each treatment in each replication for fruit yield (kg) and its six component characters *viz*., plant height (cm), number of branches per plant, number of fruits per plant, fruit length (cm), fruit girth (cm) and fruit weight (g), seven quality characters *viz*., dry matter (mg/100mg), total phenol (mg/100g), ascorbic acid (mg/100g), total soluble sugars (%), total anthocyanin (mg/100g), acidity (%) and total soluble solids (^{0}Brix) and for days to 50 per cent flowering, observation recorded on flowers appears in about 50 per cent of plants in a plot. Analysis of data for general and specific combining ability was carried out following Griffing's (1956) [7] Method II, Model I (Fixed model).

Result and Discussion

The analysis of variance for combining ability for fruit yield and it attributing traits are presented in Table 1. The ANOVA revealed that mean squares due to parents and hybrids were significant for all the characters except days to 50 per cent flowering and total phenol which was indication of parents and hybrids differed significantly in their combining ability effects and importance of both additive as well as non-additive effects for their inheritance. Whereas, mean squares due to only parents was found significant for days to 50 per cent flowering and total phenol suggesting importance of additive genetic effects only.

Both the variances, due to general combining ability and specific combining ability were significant for all the characters except days to 50 per cent flowering and total phenol, revealing importance of both general combining ability (σ^2 gca) and specific combining ability (σ^2 sca) variances for their inheritance, whereas, for the said characters variance due to only general combining ability was significant suggesting importance of additive genetic variance only. The magnitude of variance due to general combining ability was higher in comparison to variance due to specific combining ability for days to 50 per cent flowering, number of branches per plant, fruit length, fruit girth, fruit weight, total phenol, total anthocyanin and total soluble solids indicating larger influence of additive genetic variance in comparison to its counterpart non-additive genetic variance. Whereas, the magnitude of variance due to specific combining ability was higher in comparison to variance due to general combining ability for plant height, number of fruits per plant, fruit yield per plant, dry matter, ascorbic acid, acidity and total soluble sugars suggesting greater role of non-additive genetic variance.

The estimates of general GCA effects are presented in Table 2.

For days to 50 per cent flowering the values of gca effect ranged from -2.96 (Punjab Sadabahar) to 1.12 (GP-BRJ-215). The parent Punjab Sadabahar depicted significant negative estimates of gca effect, hence, parent Only one parent Punjab Sadabahar was identified as good general combiner. While one hybrid exhibited significant sca effect with negative values favoured for earliness *viz*., hybrid Punjab Sadabahar × AB 13-03 and it was designated as good specific combiner for imparting earliness. Higher estimate of σ^2 gca in comparison to σ^2 sca revealed preponderance of additive genetic variance. The present findings are in congruent with the reports of Thangavel (2011) [15], Choudhary and Didel (2014) [4] and Reddy and Patel (2014) [11].

The minimum and maximum values of gca effect for plant height were -10.66 (Punjab Sadabahar) and 8.86 (GP-BRJ-216) respectively. Four parents GP-BRJ-216 (8.86) followed by JBL 10-08-01 (6.64), JBL 10-08-07 (6.00) and GP-BRJ-215 (4.00) had significant positive gca effect, hence they were identified as the good general combiners. The values of sca effect ranged from -15.30 (AB 13-03 × GP-BRJ-216) to 21.69 (JBL 10-08-01 × AB 13-03). The cross JBL 10-08-01 × AB 13-03 (21.69) exhibited the highest value of sca effect followed by JBL 10-08-07 × AB 13-03 (19.46) and GAOB 2 × Doli 5 (16.41), therefore these were designated as good specific combiners for producing good plant height. The larger estimate of σ^2 sca suggested preponderance of non-additive genetic variance and the findings are in agreement with the observations of Thangavel (2011) [15], Reddy and Patel (2014) [11], Gadhiya *et al.* (2015) [6] and Kumar and Arumugam (2016) [8].

The estimates of gca effect for number of branches per plant varied from -2.56 (AB 13-03) to 4.04 (Doli 5). Three parents *viz*., Doli 5 (4.04), GP-BRJ-215 (2.94) and GBL 1(1.08) had significant positive value of gca effect and they were identified as good general combiners. The values of sca effect ranged from -4.93 (Doli 5 × AB 13-03) to 4.08 (GBL 1 × Doli 5). The hybrid GBL 1 × Doli 5 (4.08), Punjab Sadabahar × AB 13-03 (3.67) and GBL 1 × AB 13-03 (3.22) were considered as good specific combiners as estimates of sca effect were positive. The larger estimate of σ^2 gca depicted additive gene effect. The findings are in concordant to the reports of Bisht *et. al.* (2006) [3] and Deshmukh *et al*. (2014) [5].

For number of fruits per plant, the estimates of gca effect ranged from -9.50 (JBL 10-08-01) to 10.03 (Doli 5). Three parents Doli 5(10.03), Punjab Sadabahar (4.44) and GBL 1 (3.62) exerted significant positive gca value and were designated as good general combiners. The values of sca effect varied from -17.18 (Doli 5 × Punjab Sadabahar) to 38.63 (GBL 1 × Doli 5). The cross GBL 1 × Doli 5 (38.63) depicted the highest sca effect followed by JBL 10-08-07 × GP-BRJ-216 (36.47) and Doli 5 × GP-BRJ-215 (24.46) and were classified as good specific combiners. The larger estimate of σ^2 sca indicated that non-additive genetic variance. The findings are in akin with the reports of Reddy and Patel (2014) [11], Gadhiya *et al.* (2015) [6], Prasad *et al.* (2015) [10] and Kumar and Arumugam (2016) [8].

The minimum and maximum values of gca effect for fruit yield per plant were -0.42 (AB 13-03) and 0.42 (GAOB 2), respectively. The highest positive gca effect was observed with the parent GAOB 2 (0.42) followed by GBL 1 and GP-BRJ-216 (0.25). The former parent was significantly superior to the rest of the parents. Hence, it was identified as better general combiner. The larger estimate of σ^2 sca indicated that non-additive genetic variance was pronounced. The results are in conformity with the reports of Sao and Mehta (2010) [12], Thangavel (2011) [15], Mishra *et al.* (2013) [9], Reddy and Patel (2014) [11], Prasad *et al*. (2015) [10], Gadhiya *et al.* (2015) [6] and Kumar and Arumugam (2016) [8].

For fruit length, the minimum and maximum values of gca effect were -2.44 (JBL 10-08-07) and 2.45 (GP-BRJ-216), respectively. The parents GP-BRJ-216 (2.45), GP-BRJ-215 (1.99) and Punjab Sadabahar(1.91) registered positive significant gca effect, hence they were identified as the good general combiners. The estimates of sca effect varied from -2.79 (Doli 5 × GP-BRJ-216) to 2.44 (GAOB 2 × AB 13-03). Total six hybrids exerted significant positive estimates.

Among them, the hybrid GAOB 2 × AB 13-03 (2.44) registered the highest sca effect followed by GBL 1 × Doli 5 (2.23) and KashiTaru × GP-BRJ-216 (2.16) and were designated as better specific combiners. The higher estimate of σ^2 gca depicted additive genetic variance was pronounced for this trait. The findings are in conformity with the reports of Bisht *et. al.* (2006) [3], Reddy and Patel (2014) [11] and Prasad *et al*. (2015) [10].

The estimates of gca effect for fruit girth varied from -1.46 (GP-BRJ-216) to 2.67 (GAOB 2). Three parents GAOB 2 (2.67), JBL 10-08-07 (2.00) and JBL 10-08-01 (1.94) had significant positive estimate and were designated as good general combiners. While, the parents GP-BRJ-216 (-1.46), Doli 5 (-1.42) and Punjab Sadabahar (-1.35) depicted significant negative gca effects, these parents could be good general combiners when thin fruits are favoured as a quality parameter. The estimates of sca effect varied from -1.27 (JBL 10-08-01 × AB 13-03) to 3.40 (GAOB 2 × JBL 10-08-07). The hybrid GAOB 2 × JBL 10-08-07 (3.40) manifested the highest sca effect followed by AB 13-03 × GP-BRJ-216 (1.90) and JBL 10-08-07 × Kashi Taru (1.78), hence they were designated as good specific combiners for increasing fruit girth. Whereas, the F_1 JBL 10-08-01 × AB 13-03 (-1.27) had the least estimate of sca effect followed by Punjab Sadabahar × JBL 10-08-07 (-1.25) and Doli 5 × JBL 10-08-07(-1.07), hence these were designated as good specific combiners, when thin fruit girth is desired in respect to quality parameter. The larger estimate of σ^2 gca indicated that additive genetic variance was pronounced for the inheritance of the character. The findings are in agreement with the reports of Bisht *et. al.* (2006) [3], Choudhary and Didel (2014) [4] and Prasad *et al*. (2015) [10].

The minimum and maximum values of gca effect for fruit weight were -9.55 (Doli 5) to 10.81 (GAOB 2), respectively. The highest gca effect was observed with the parent GAOB 2(10.81) followed by JBL 10-08-01 (9.82) andJBL 10-08-07 (3.70) and were identified as good general combiners. The estimates of sca effect for fruit weight ranged from -11.01 (JBL 10-08-07 × GP-BRJ-216) to 11.47 (GAOB 2 × Punjab Sadabahar). Total five crosses exerted significant sca effect, of which, the highest sca effect was depicted by cross GAOB 2 × Punjab Sadabahar (11.47) followed by GAOB 2 × JBL 10-08-01 (11.16), JBL 10-08-07 × KashiTaru (10.13), GBL 1 × JBL 10-08-01 (9.53) and AB 13-03× GP-BRJ-216 (8.32) and they were designated as good specific combiners. The higher estimate of σ^2 gca indicated that importance additive genetic variance. The present results are in accordance with those obtained by Bisht *et. al.* (2006) [3] and Reddy and Patel (2014) [11].

For dry matter, the estimates of gca effect ranged from -0.60 (GBL 1) to 0.83 (GP-BRJ-216). In brinjal, less moisture content and more of dry matter content is desirable for long shelf-life, hence, parents with significant positive gca effect were considered as good general combiners. Three parents GP-BRJ-216 (0.83), AB 13-03 (0.57) and JBL 10-08-07 (0.36) exhibited significant positive gca value and were designated as good general combiners for increasing dry matter. The values of sca effect varied from -1.72 (GBL 1 × JBL 10-08-07) to 2.10 (GAOB 2 × Punjab Sadabahar). Total 15 crosses registered significant values of sca effect, of which, the cross GAOB 2 × Punjab Sadabahar (2.10) depicted the highest sca effect followed by JBL 10-08-01 × GP-BRJ-216 (1.56) and JBL 10-08-07 × AB 13-03 (1.40) and were designated as good specific combiners. The larger estimate of σ^2 sca suggested pronounced effect of non-additive genetic variance. The findings are in conformity with the reports of Suneetha *et al.* (2008) [13] and Bhushan *et al*. (2012) [2].

The estimates of gca effect for total phenol varied from -3.71 (JBL 10-08-01) to 3.16 (Kashi Taru). In brinjal, less phenol content is desirable, hence, parents with significant negative gca effect were considered as good general combiners. The parents JBL 10-08-01 (-3.71), JBL 10-08-07 (-2.89) and GAOB 2 (-2.38) with significant and negative estimates were designated as good general combiners for decreasing phenol content. The estimates of sca effect varied from -2.58 (AB 13-03 × Kashi Taru) to 3.59 (Doli 5 × JBL 10-08-07). The cross AB 13-03 × Kashi Taru (-2.58) had the least value of sca effect followed by GAOB 2 × Kashi Taru (-2.24) and GAOB 2 × GBL 1 (-2.06), hence they were designated as good specific combiners for decreasing phenol content. The higher estimate of σ^2 gca indicated preponderance of additive genetic variance. The results are in conformity with the findings of Bhushan *et al.* (2012) [2].

The minimum and maximum values of gca effect for ascorbic acid content were -1.34 (Kashi Taru) and 1.96 (GBL 1), respectively. The parent GBL 1 (1.96) exhibited the highest estimate of gca effect followed by Doli 5 (1.37) and GP-BRJ-215 (0.26), all these parents were significantly positive, hence these were identified as good general combiners. The value of sca effects for ascorbic acid content ranged from -2.68 (JBL 10-08-07 × GP-BRJ-215) to 2.73 (GAOB 2 × GBL 1). The hybrid GAOB 2 × GBL 1 (2.73) exhibited the highest value of sca effect followed by Doli 5 × JBL 10-08-07 (2.72) and JBL 10-08-07 × GP-BRJ-216 (2.71), hence they were classified as good specific combiners. The higher estimate of σ^2 sca revealed preponderance of non-additive gene action. The findings are in congruent with the results of Kumar and Arumugam (2016) [8].

For total soluble sugars, the estimates of gca effect ranged from -0.19 (GP-BRJ-216) to 0.29 (JBL 10-08-01). The cross JBL 10-08-01 (0.29) depicted the highest gca effect followed by JBL 10-08-07 (0.20), GAOB 2 (0.09) and GP-BRJ-215 (0.04) hence, they were designated as good general combiners. The estimates of sca effect ranged from -0.43 (GAOB 2 × GP-BRJ-216) to 0.64 (JBL 10-08-01 × GP-BRJ-216). A total 16 hybrids exerted significant sca effect, of which, the hybrid JBL 10-08-01 ×GP-BRJ-216 (0.64) manifested the highest sca effect followed by Kashi Taru ×GP-BRJ-215 (0.58) and GAOB 2 × JBL 10-08-01 (0.54). These hybrids were identified as good specific combiners. The higher estimate of σ^2 sca indicated preponderance of non-additive genetic variance. The findings corroborate with reports of Tha *et al*. (2006) [14] and Suneetha *et al.* (2008) [13].

The estimates of gca effect for total anthocyanin varied from -20.55 (GP-BRJ-216) to 21.98 (Doli 5). The parent Doli 5 (21.98) had highest gca effect followed by, Punjab Sadabahar (20.13) and GBL 1 (15.80) hence, they were designated as good general combiners. The estimates of sca effect varied from -35.49 (GBL 1 × Punjab Sadabahar) to 38.42 (Punjab Sadabahar × GP-BRJ-215). The cross Punjab Sadabahar × GP-BRJ-215 (38.42) depicted the highest sca effect followed by GBL 1 × GP-BRJ-215 (25.83) and GBL 1 × GP-BRJ-216 (25.18) hence they were designated as good specific combiners. The larger estimate of σ^2 gca indicated greater contribution of additive genetic variance. The results are in conformity with the findings of Bhusan *et al.* (2012) [2].

The minimum and maximum values of gca effect for acidity

content were -0.02 (GAOB 2) and 0.04 (AB 13-03), respectively. In brinjal, less acidity content is desirable, hence, parents with significant negative gca effect were considered as good general combiners. The parent GAOB 2 (-0.02) exhibited the least estimate of gca effect followed by GBL 1 and Doli 5 (-0.01), hence, these were identified as good general combiners. The sca effects for acidity content ranged from -0.10 (Punjab Sadabahar × GP-BRJ-216) to 0.17 (Punjab Sadabahar × GP-BRJ-215). The hybrid Punjab Sadabahar × GP-BRJ-216 (-0.10) manifested the least sca effect followed by Punjab Sadabahar × AB 13-03 (-0.09) and GBL 1 × AB 13-03 (-0.08), hence these were identified as good specific combiners. The higher estimate of σ^2 sca revealed non-additive gene action pronounced for inheritance of this trait.

For total soluble solids, the estimates of gca effect ranged from -0.21 (Kashi Taru) to 0.24 (GP-BRJ-216). The parent GP-BRJ-216 (0.24) depicted the highest gca effect followed by GP-BRJ-215 (0.10) and JBL 10-08-01 (0.08) hence, they were identified as good general combiners. The estimates of sca effect ranged from -0.26 (GAOB 2 × AB 13-03) to 0.39 (GAOB 2 × JBL 10-08-01). The hybrid GAOB 2 × JBL 10-08-01 (0.39) manifested the highest sca effect followed by Doli 5 × GP-BRJ-216 (0.36) and GAOB 2 × JBL 10-08-07 (0.35) and these hybrids were identified as good specific combiners. The higher estimate of σ^2 gca indicated that additive genetic variance was pronounced for the inheritance of the character. The results are in agreement with the findings of Bhushan *et al.* (2012) [2].

Table 1: Analysis of variance for combining ability in brinjal

Characters	DAF	PH	NOB	NOF	FY	FL	FG	FW	DM	TP	AA	TSSu	TA	A	TSS
Parents (GCA)	16.43**	470.85**	56.99**	405.30**	0.8429**	39.06**	30.79**	514.11**	2.69**	67.78**	12.51**	0.29**	3014.93**	0.00347**	0.25**
Hybrids (SCA)	2.04	56.69**	5.63**	233.53**	0.8126**	1.60**	0.95*	40.39**	0.80**	1.78	2.21**	0.09**	217.23**	0.00321**	0.03**
Error	1.94	11.94	1.92	46.23	0.2059	0.69	0.57	17.38	0.04	1.94	0.09	0.01	0.55	0.00004	0.02
σ^2gca	1.19**	34.51**	4.28**	14.31**	0.0024**	3.12**	2.49**	39.47**	0.16**	5.50**	0.86**	0.02**	233.14**	0.00002**	0.02**
σ^2sca	0.09	44.74**	3.72**	187.6**	0.6075**	0.91**	0.38**	23.01**	0.76**	-	2.12**	0.08**	216.68**	0.00317**	0.02**
σ^2gca / σ^2sca	12.37	0.77	1.15	0.07	0.004	3.44	6.57	1.71	0.204	-	0.40	0.21	1.07	0.007	1.071

*and **, significant at 5 % and 1 % levels of probability, respectively.
"-" indicate negative estimates.

DF	=	Days to 50 per cent flowering	PH	=	Plant height (cm)
NOB	=	Number of branches per plant	NOF	=	Number of fruits per plant
FY	=	Fruit yield per plant	FL	=	Fruit length (cm)
FG	=	Fruit girth (cm)	FW	=	Fruit weight (g)
DM	=	Dry matter (mg/100mg)	TP	=	Total phenol
AA	=	Ascorbic acid (mg/100mg)	TSSu	=	Total soluble sugars (%)
TA	=	Total anthocyanin (mg/100mg)	A	=	Acidity (%)
TSS	=	Total soluble solids (^{0}Brix)			

Conclusion

The result of this investigation revealed that none of the parents was found to be good general combiner for all the characters under study (Table 2). However, parents GAOB 2 was good general combiner and GBL 1, Doli 5, GP-BRJ-215 and GP-BRJ-216 were average general combiners fruit yield per plant and were also good or average general combiners for rest of the characters. These parents may be extensively used in crossing programme to accumulate desirable genes of quantitative and/or qualitative characters in limited genotypes leading to gene pyramiding, which may have immense value as pre-breeding material and for heterosis breeding. For fruit yield per plant, hybrids GBL 1 × Doli 5, JBL 10-08-07 × GP-BRJ-216, GBL 1 × AB 13-03, JBL 10-08-07 × AB 13-03, Doli 5 × Kashi Taru, GAOB 2 × JBL 10-08-01, Punjab Sadabahar × AB 13-03, GBL 1 × GP-BRJ-216, Punjab Sadabahar × GP-BRJ-215 and JBL 10-08-07 × Kashi Taru exhibited high sca effects and *per se* performance as well as these hybrids also registered high sca effects for its several component characters (Table 3 and 4). Therefore, these cross combinations may be favoured for commercial cultivation as hybrids after critical evaluation in varied environments or over locations. All the parents involved in these crosses had good or average gca effects. Hence, their hybrids are also expected to throw-off transgressive recombinants in segregating generations, combining favourable traits into one genotype for development as improved varieties with enhanced nutritional quality.

Table 2: Estimation of general combining ability (gca) effects of parents for various characters in brinjal

Characters / Parents		DAF	PH	NOB	NOF	FY	FL	FG	FW	DM	TP	AA	TSSu	TA	A	TSS
GAOB 2		0.46	0.94	-1.39**	-4.22*	0.42**	-2.39**	2.67**	10.81**	-0.24**	-2.38**	-0.86**	0.09**	3.02**	-0.02**	0.07
GBL 1		0.25	-3.81**	1.08**	3.62	0.25	0.38	0.02	0.39	-0.60**	-0.56	1.96**	-0.11**	15.8**	-0.01**	-0.06
Doli 5		0.01	-3.45**	4.04**	10.03**	0.01	-1.02**	-1.42**	-9.55**	0.09	1.67**	1.37**	-0.02	21.98**	-0.01**	0.03
Punjab Sadabahar		-2.96**	-10.66**	-2.47**	4.44*	-0.02	1.91**	-1.35**	-5.52**	-0.48**	1.96**	-0.07	-0.09**	20.13**	0.01	-0.15**
JBL 10-08-07		0.71	6.00**	-0.95*	-3.19	-0.05	-2.44**	2.00**	3.70**	0.36**	-2.89**	-0.86**	0.20**	-16.76**	0.01**	0.06
JBL 10-08-01		0.17	6.64**	-1.04*	-9.50**	-0.04	-1.38**	1.94**	9.82**	0.08	-3.71**	0.21*	0.29**	-1.98**	0.01**	0.08*
AB 13-03		-0.17	-5.12**	-2.56**	-2.73	-0.42**	-0.38	-0.56*	-4.80**	0.57**	-0.49	-0.47**	-0.05**	-5.00**	0.04**	-0.17**
KashiTaru		-0.63	-3.39**	0.13	-4.89*	-0.39**	0.89**	-0.58**	-1.85	-0.38**	3.16**	-1.34**	-0.15**	2.71**	-0.01**	-0.21**
GP-BRJ-215		1.12**	4.00**	2.94**	2.87	0.01	1.99**	-1.25**	-3.22**	-0.24**	2.23**	0.26**	0.04*	-19.35**	-0.01**	0.10**
GP-BRJ-216		1.04*	8.86**	0.21	3.58	0.25	2.45**	-1.46**	0.21	0.83**	1.00*	-0.22*	-0.19**	-20.55**	0.01	0.24**
Range	Min.	-2.96	-10.66	-2.56	-9.50	-0.42	-2.44	-1.46	-0.60	-3.71	-1.34	-0.19	-20.55	-0.02	-0.21	-0.21
	Max.	1.13	8.86	4.04	10.03	0.42	2.45	2.67	0.83	3.16	1.96	0.29	21.98	0.04	0.24	0.24
Signi-ficant	Total	3	9	8	5	3	7	9	8	8	8	9	10	8	6	6
	Positive	2	4	3	2	1	3	3	3	5	3	4	5	3	3	3
	Negative	1	5	5	3	2	4	6	5	3	5	5	5	5	3	3
S.E.		0.38	0.94	0.37	1.86	0.12	0.22	0.20	1.14	0.05	0.38	0.08	0.01	0.20	0.0017	0.03
C.D. at 5%		0.74	1.85	0.74	3.64	0.24	0.44	0.40	2.23	0.11	0.74	0.16	0.03	0.39	0.0034	0.06

*and **, significant at 5 % and 1 % levels of probability, respectively.

Table 3: Top ten good specific combining crosses for fruit yield, their *per se* performance, gca effect of parents and significant sca effect for other traits in desired direction

Crosses	sca effect	Fruit yield per plant (kg)	gca effect		Significant sca effect for other traits in desired direction
			♀	♂	
GBL 1 × Doli 5	1.95**	6.73	A	A	NOB, NOF, FL, TSSu, TA
JBL 10-08-07 × GP-BRJ-216	1.71**	6.44	A	A	NOF, AA, TSSu, Ac
GBL 1 × AB 13-03	1.51**	5.87	A	P	NOB, NOF, TSSu, Ac
JBL 10-08-07 × AB 13-03	1.44**	5.50	A	P	PH, NOF, DM, TA, TSSu, TSS
Doli 5 × Kashi Taru	1.33**	5.47	A	P	NOF, DM, TA
GAOB 2 × JBL 10-08-01	1.15**	6.06	G	A	FL, FW, DM, TSSu, TSS
Punjab Sadabahar × AB 13-03	1.06**	5.14	A	P	DF, NOB, NOF, Ac
GBL 1 × GP-BRJ-216	0.89**	5.92	A	A	NOF, DM, TA
Punjab Sadabahar × GP-BRJ-215	0.87**	5.38	A	A	FL, TSSu, TA, TSS
JBL 10-08-07 × Kashi Taru	0.85**	4.94	A	P	FW, FG, DM, TSSu, TA, Ac

DF	=	Days to 50 per cent flowering	PH	=	Plant height (cm)
NOB	=	Number of branches per plant	NOF	=	Number of fruits per plant
FY	=	Fruit yield per plant	FL	=	Fruit length (cm)
FG	=	Fruit girth (cm)	FW	=	Fruit weight (g)
DM	=	Dry matter (mg/100mg)	TP	=	Total phenol
AA	=	Ascorbic acid (mg/100mg)	TSSu	=	Total soluble sugars (%)
TA	=	Total anthocyanin (mg/100mg)	Ac	=	Acidity (%)
TSS	=	Total soluble solids (^{0}Brix)			

Table 4: Top three better performing parents (*per se* and gca) and hybrids (*per se* and sca) for for various characters in brinjal

Characters	Parental performance		Top ranking hybrids	
	Per se	**gca**	***Per se***	**sca**
Days to 50 per cent flowering	Punjab Sadabahar (47.50)	Punjab Sadabahar (-2.96)	Punjab Sadabahar × AB 13-03 (44.5)	Punjab Sadabahar × AB 13-03 (-3.69)
	Doli 5 (50.00)	Kashi Taru (-0.62)	GBL 1 × Punjab Sadabahar (47)	GAOB 2 × AB 13-03 (-2.11)
	Kashi Taru (50.00)	AB 13-03 (-0.17)	GAOB 2 × Punjab Sadabahar(47.5)	GP-BRJ-215× GP-BRJ-216 (-1.98)
Plant height (cm)	GP-BRJ-216 (87.51)	GP-BRJ-216 (8.86)	JBL 10-08-01 × AB 13-03 (89.46)	JBL 10-08-01 × AB 13-03 (21.69)
	JBL 10-08-01 (76.47)	JBL 10-08-01 (6.64)	GP-BRJ-215× GP-BRJ-216 (88.32)	JBL 10-08-07 × AB 13-03 (19.46)
	JBL 10-08-07 (73.37	JBL 10-08-07 (6.00)	JBL 10-08-07 × AB 13-03 (86.58)	GAOB 2 × Doli 5 (16.41)
Number of branches per plant	Doli 5 (31.39)	Doli 5 (4.04)	GBL 1 × Doli 5 (33.85)	GBL 1 × Doli 5 (4.08)
	GP-BRJ-215 (26.30)	GP-BRJ-215 (2.94)	Doli 5 × GP-BRJ-215 (32.11)	Punjab Sadabahar × AB 13-03 (3.67)
	Kashi Taru (25.30)	GBL 1 (1.08)	Doli 5 × GP-BRJ-216 (31.72)	GBL 1 × AB 13-03 (3.22)
Number of fruits per plant	Punjab Sadabahar (71.81)	Doli 5 (10.03)	GBL 1 × Doli 5 (118.74)	GBL 1 × Doli 5 (38.63)
	GAOB 2 (63.95)	Punjab Sadabahar (4.44)	Doli 5 × GP-BRJ-215 (103.82)	JBL 10-08-07 × GP-BRJ-216 (36.47)
	GBL 1 (58.23)	GBL 1 (3.62)	JBL 10-08-07 × GP-BRJ-216 (103.32)	Doli 5 × GP-BRJ-215 (24.46)
Fruit yield per plant (kg)	GAOB 2 (5.13)	GAOB 2 (0.42)	GBL 1 × Doli 5 (6.73)	GBL 1 × Doli 5 (1.95)
	JBL 10-08-01 (4.89)	GBL 1 (0.25)	JBL 10-08-07 × GP-BRJ-216 (6.44)	JBL 10-08-07 × GP-BRJ-216 (1.71)
	Punjab Sadabahar (4.33)	GP-BRJ-216 (0.25)	GAOB 2 × JBL 10-08-01 (6.06)	GBL 1 × AB 13-03 (1.51)
Fruit length (cm)	GP-BRJ-216 (19.03)	GP-BRJ-216 (2.45)	Punjab Sadabahar × GP-BRJ-215 (20.64)	GAOB 2 × AB 13-03 (2.44)
	Punjab Sadabahar (18.09)	GP-BRJ-215 (1.19)	GP-BRJ-215× GP-BRJ-216 (20.51)	GBL 1 × Doli 5 (2.23)
	GP-BRJ-215 (17.46)	Punjab Sadabahar (1.91)	Kashi Taru × GP-BRJ-216 (20.24)	Kashi Taru × GP-BRJ-216 (2.16)
Fruit girth (cm)	JBL 10-08-01 (16.60)	GAOB 2 (2.67)	GAOB 2 × JBL 10-08-07 (19.90)	GAOB 2 × JBL 10-08-07 (3.40)
	GAOB 2 (15.64)	JBL 10-08-07 (2.00)	GAOB 2 × JBL 10-08-01 (17.70)	AB 13-03× GP-BRJ-216 (1.90)
	JBL 10-08-07 (15.46)	JBL 10-08-01 (1.94)	JBL 10-08-07 × JBL 10-08-01 (15.52)	JBL 10-08-07 × Kashi Taru (1.78)
Fruit weight (g)	JBL 10-08-01 (92.38)	GAOB 2 (10.81)	GAOB 2 × JBL 10-08-01 (101.24)	GAOB 2 × Punjab Sadabahar (11.47)
	JBL 10-08-07 (85.55)	JBL 10-08-01 (9.82)	GBL 1 × JBL 10-08-01 (89.20)	GAOB 2 × JBL 10-08-01 (11.16)
	GAOB 2 (80.17)	JBL 10-08-07 (3.70)	GAOB 2 × GP-BRJ-216 (87.26)	JBL 10-08-07 × Kashi Taru (10.13)
Dry matter (mg/100mg)	AB 13-03 (11.39)	GP-BRJ-216 (0.83)	JBL 10-08-01 × GP-BRJ-216 (11.59)	GAOB 2 × Punjab Sadabahar (2.10)
	GP-BRJ-216 (10.51)	AB 13-03 (0.57)	JBL 10-08-07 × AB 13-03 (11.45)	JBL 10-08-01 × GP-BRJ-216 (1.56)
	Kashi Taru (9.67)	JBL 10-08-07 (0.36)	AB 13-03× GP-BRJ-216 (10.64)	JBL 10-08-07 × AB 13-03 (1.40)
Total phenol (mg/100g)	JBL 10-08-01 (90.53)	JBL 10-08-01 (-3.71)	GAOB 2 × JBL 10-08-07 (91.17)	AB 13-03 × Kashi Taru (-2.58)
	JBL 10-08-07 (92.19)	JBL 10-08-07 (-2.89)	JBL 10-08-07 × JBL 10-08-01 (91.39)	GAOB 2 × Kashi Taru (-2.24)
	GAOB 2 (93.68)	GAOB 2 (-2.38)	GAOB 2 × JBL 10-08-01 (91.65)	GAOB 2 × GBL 1 (-2.06)
Ascorbic acid (mg/100 g)	GBL 1 (13.41)	GBL 1 (1.96)	GAOB 2 × GBL 1 (13.43)	GAOB 2 × GBL 1 (2.73)
	Doli 5 (12.31)	Doli 5 (1.37)	GBL 1 × Doli 5 (13.26)	Doli 5 × JBL 10-08-07 (2.72)
	JBL 10-08-01 (11.84)	GP-BRJ-215 (0.26)	Doli 5 × JBL 10-08-07 (12.84)	JBL 10-08-07 × GP-BRJ-216 (2.71)
Total soluble sugars (%)	GAOB 2 (3.21)	JBL 10-08-01 (0.29)	GAOB 2 × JBL 10-08-01 (3.68)	JBL 10-08-01 × GP-BRJ-216 (0.64)
	JBL 10-08-01 (3.02)	JBL 10-08-07 (0.20)	JBL 10-08-01 × GP-BRJ-216 (3.50)	Kashi Taru × GP-BRJ-215 (0.58)
	JBL 10-08-07 (2.78)	GAOB 2 (0.09)	JBL 10-08-07 × JBL 10-08-01 (3.28)	GAOB 2 × JBL 10-08-01 (0.54)
Total anthocyanin (mg/100 g)	Doli 5 (103.43)	Doli 5 (21.98)	Doli 5 × Punjab Sadabahar (89.44)	Punjab Sadabahar × GP-BRJ-215 (38.42)
	GBL 1 (78.98)	Punjab Sadabahar (20.13)	GBL 1 × Doli 5 (85.99)	GBL 1 × GP-BRJ-215 (25.83)
	Punjab Sadabahar (75.81)	GBL 1 (15.80)	Punjab Sadabahar × GP-BRJ-215 (82.30)	GBL 1 × GP-BRJ-216 (25.18)
Acidity (%)	GAOB 2 (0.11)	GAOB 2 (-0.02)	Punjab Sadabahar × GP-BRJ-216 (0.12)	Punjab Sadabahar × GP-BRJ-216 (-0.10)
	Kashi Taru (0.18)	GBL 1 (-0.01)	GP-BRJ-215× GP-BRJ-216 (0.14)	Punjab Sadabahar × AB 13-03 (-0.09)
	Doli 5 (0.19)	Doli 5 (-0.01)	GAOB 2 × GBL 1 (0.15)	GBL 1 × AB 13-03 (-0.08)
Total soluble solids (^{0}Brix)	GP-BRJ-216 (3.70)	GP-BRJ-216 (0.24)	Doli 5 × GP-BRJ-216 (4.11)	GAOB 2 × JBL 10-08-01 (0.39)
	GP-BRJ-215 (3.55)	GP-BRJ-215 (0.10)	GAOB 2 × JBL 10-08-01 (4.01)	Doli 5 × GP-BRJ-216 (0.36)
	JBL 10-08-01 (3.45)	JBL 10-08-01 (0.08)	GAOB 2 × JBL 10-08-07 (3.95)	GAOB 2 × JBL 10-08-07 (0.35)

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