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Research Note

Combining ability for yield and different characters in brinjal (*Solanum melongena L.*)

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Abstract
A field experiment was carried out with a view to estimate, combining ability and gene effects in brinjal (*Solanum melongena* L.). The experimental material comprised of 37 genotypes including 8 parents, 28 hybrids and one standard check (Surati Ravaiya) was laid out in Randomized Block Design with three replications at Regional Horticultural Research Station (R.H.R.S.), Navsari Agricultural University, Navsari, Gujarat during *Rabi* 2015-16. Combining ability analysis revealed that both additive as well as non-additive gene effects were important in the inheritance of all the traits studied. However, magnitude of variances due to *sca* was comparatively larger than those of *gca* for most of the economic traits indicated preponderance of non-additive gene action. Among the parents, JBGR-1, NSR-1 and JBL-08-8 were good general combiners for majority of the traits. The crosses *viz.,* AB-09-1 × AB-12-10, AB-09-1 × AB-08-5, AB-08-5 × JBL-08-8 and GJB-3 × AB-12-10 showed higher order *sca* effects in addition to performance for fruit yield and its component characters.

Key words
Combining ability, brinjal, *sca,* additive, non-additive

Brinjal or eggplant (*Solanum melongena* L.) belongs to the family Solanaceae is one of the important and popular vegetable crops grown in India and other parts of the world and is probably a native of India and has been cultivated since prehistoric times. It is widely cultivated in both subtropical and tropical regions of the globe mainly for its immature fruits as vegetable. It is popular among people of all social starta and hence, it is referred as "vegetable of masses" (Patel and Sarnaik, 2003). With increasing popularity of F_1 hybrids in egg plant, it is imperative to obtain hybrids having excellent and marketable fruit quality coupled with high yields. A knowledge of general combining ability (GCA) and specific combining ability (SCA) helps in choice of parents or hybrids and the nature of gene action provides a basis for choosing an effective breeding methodology. Information on combining ability and the types of gene action that governs the inheritance of economically important quantitative characters can help breeders to select suitable parents and devise efficient breeding strategy. While selecting parents on the basis of *per se* performance does not necessarily fetch good combinations. It provides the breeders an insight in to nature and relative magnitude of fixable and non-fixable genetic variances. In this context, the present investigation was undertaken to elucidate information on the basis of nature of gene action and combining ability of eggplant genotypes for superior hybrids of excellent qualities coupled with high yields in addition to identification of hybrid for commercial exploitation.

The experiment was conducted at Regional Horticultural Research Station (R.H.R.S.), ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat during *Rabi* 2015-16. Eight diverse genotypes *viz*., AB-09-1, AB-08-5, NSRP-1, JBGR-1, NSR-1, GJB-3, JBL-08-8 and AB-12-10 were obtained from various SAUs of Gujarat and crossed in all possible combinations excluding reciprocals to get 28 F_1s. The experimental material comprised of 37 genotypes including 28 F_1s, 8 parents and a commercial check (Surati Ravaiya) were evaluated in Randomized Block Design (RBD) with three replications at 90 × 75 cm spacing. The recommended agronomic practices and plant protection measures were adopted for raising a good crop. Data were recorded from five competitive plants that are randomly selected from the middle of each row in each replication to record the observations on ten plant characters *viz.,* days to fifty per cent flowering, plant height at harvest (cm), number of branches per plant at harvest, fruit length (cm), fruit diameter (cm), average fruit weight (g), number of fruits per plant, fruit yield per plant (kg), total phenol content (mg/100g) and total soluble solids (%). The combining ability was calculated according to the Model-I and Method-II of Griffing (1956).

The analysis of variance for combining ability of various traits is presented in table 1. It was observed that *gca* and *sca* variances were significant for all the traits, except *gca* effect for days to 50% flowering, plant height at harvest and number of fruits per plant. The significance of both *gca* and *sca* variances for most of the traits indicated that both additive as well as non-additive type of gene actions were involved in the inheritance of these traits which were also reported by Rai and Asati (2011), Patel *et al*. (2013),

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Choudhary and Didel (2014) and Reddy and Patel (2014).

However, the *gca*/*sca* variance ratio was less than unity for most of the traits under study indicating the greater role of non-additive genetic variance in the inheritance of these traits. Thus, these traits might be governed by dominance, additive x dominance and/or dominance x dominance type of gene action. The result have been reported by Sao and Mehta (2010), Ramireddy *et al.* (2011), Shinde *et al.* (2011), Bhusan *et al.* (2012), Singh *et al.* (2013), Tiwari *et al.* (2013), Reddy and Patel (2014) and Venkata Naresh *et al.* (2014).

For exploitation of heterosis, the information on *gca* should be supplemented with *sca* and hybrid performance. The estimates of *sca* effects revealed that none of the crosses was constantly superior for all the traits. These results are strengthened by the findings of Aswani and Kandelwal (2005) and Sao and Mehta (2010).

The character-wise estimates of general combining ability effects for each parent are presented in Table 2. Among eight parents, none of parent was good general combiner for all the traits studied. Parents AB-08-5, NSRP-1 and JBL-08-8 had positive *gca* effects in desirable direction for days to fifty per cent flowering, total phenol content and total soluble solids which consider it as average general combiner for this traits.

Parent JBL-08-8 had significant positive *gca* effects in desirable direction for plant height at harvest and fruit diameter which consider as a good general combiner for these traits. Parents NSR-1 had significant positive *gca* effects in desirable direction for number of branches per plant at harvest and fruit yield per plant which consider as a good general combiner. Parent JBGR-1 had also significant positive *gca* effects in desirable direction for number of branches per plant at harvest and average fruit weight which consider it as a good general combiner. Parent AB-09-1 have showed good general combiner for only total phenol content while, parents GJB-3 showed good general combiner for only fruit length. None of the parents showed desirable direction for number of fruits per plant as a good general combiner.

In the present study, both *gca* and *sca* variances were highly significant for days to fifty per cent flowering, number of branches per plant, fruit length, fruit diameter, average fruit weight, number of fruits per plant, fruit yield per plant, total phenol content and TSS content. This suggested that both additive and non-additive variances were important in the expression of these traits. It was observed that none of the parent was showing significant favourable *gca* effects for all the characters. These findings are supported by Sao and Mehta (2010). The specific combining ability (*sca*) effects of all 28 crosses for different traits are presented in table 3.

Average fruit weight, number of fruits per plant , fruit length and fruit yield per plant are important growth parameters which act as a source traits to support yield. Among 28, six hybrids AB-09-1 × NSRP-1, AB-09-1 × AB-12-10, AB-08-5 × GJB3, AB-08-5 × JBL-08-8, JBGR-1 × NSR-1 and GJB-3 × AB-12-10 have significant *sca* effect in desired direction for average fruit weight. Crosses *viz.*, AB-09-1 × AB-08-5, AB-09-1 × NSRP-1, AB-09-1 × AB-12-10, AB-08-5 × JBL-08-8 and GJB-3 × AB-12-10 exposed significant *sca* effect in desired direction for number of fruits per plant. Eight hybrids showed significant *sca* effect in desired direction for fruit length and 10 hybrids *viz.*, AB-09-1 × AB-08-5, AB-09-1 × NSRP-1, AB-09-1 × JBGR-1, AB-09-1 × AB-12-10, AB-08-5 × JBGR-1, AB-08-5 × JBL-08-8, NSRP-1 × GJB3, NSRP-1 × AB-12-10, JBGR-1 × NSR-1, NSR-1 × AB-12-10 and GJB-3 × AB-12-10 recorded significant *sca* effect in desired direction for fruit yield per plant. Similar results have been reported by Rai and Asati (2011), Ramireddy *et al.* (2011), Shinde *et al.* (2011), Bhusan *et al.* (2012), Patel *et al.* (2013), Singh *et al.* (2013), Tiwari *et al.* (2013), Choudhary and Didel (2014) and Reddy and Patel (2014) and Venkata Naresh *et al.* (2014).

AB-09-1 × AB-12-10 showed high heterosis for fruit yield per plant, but involve average combiner parents. From present investigation, it was revealed that the best performing parents may not be a best general combiner. The crosses exhibiting high *per se* performance may results from either good x good, good x average, average x average and poor x poor general combining parents. The good general combining parents when crossed do not always produce high *sca* effects while poor general combining parents not always produce low *sca* effects. These results are strengthened by the findings of Aswani and Kandelwal (2005) and Sao and Mehta (2010).

Among the parents, *viz.*, JBGR-1, NSR-1 and JBL-08-8 were found to be good general combiners for majority of the characters. Hybrids *viz.*, AB-09-1 × AB-12-10, AB-09-1 × AB-08-5, AB-08-5 × GJB-3, AB-08-5 × JBL-08-8, GJB-3 × JBL-08-8, GJB-3 × AB-12-10, JBGR-1 × NSR-1, NSR-1 × AB-12-10 and AB-09-1 × NSRP-1 identified have high *sca* effects for at least one major yield components like number of fruits per plant and average fruit weight. The crosses showing high *sca* effects were not always the results of good × good *gca* combiners.

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The superior crosses (Hybrids *viz.*, AB-09-1 × AB-12-10, AB-09-1 × AB-08-5, AB-08-5 × GJB-3, AB-08-5 × JBL-08-8, GJB-3 × JBL-08-8, GJB-3 × AB-12-10, JBGR-1 × NSR-1, NSR-1 × AB-12-10 and AB-09-1 × NSRP-1) attempted through Diallel mating design by utilization of local germplasm of brinjal on the basis of *gca* and *sca* effects can be further exploited for commercial cultivation after multilocation testing. It is also necessary to assess genetic potentialities of the parent in hybrid combination through systematic studies in relation to general and specific combining abilities.

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Table 1. Analysis of variance for combining ability effects for different characters in brinjal

Source of variation	df	Days to 50 per cent flowering	Plant height at harvest (cm)	No. of branches per plant at harvest	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Number of fruits per plant	Total phenol content (mg/100g)	TSS (%)	Fruit yield per plant (kg)
Gca	7	14.43	17.82	0.56**	1.09**	1.03**	79.18*	2.72	0.006**	0.39**	0.32**
Sca	28	34.26**	32.73*	1.23**	1.46**	0.43**	168.85**	4.55**	0.005**	0.63**	0.19**
Error	70	15.15	18.74	0.11	0.22	0.19	27.23	1.32	0.0002	0.00	0.01
σ2 *gca*		-0.07	-0.12	0.05	0.08	0.10	5.19	0.14	0.0006	0.03	0.02
σ2 *sca*		19.11	13.99	1.12	1.25	0.31	141.61	3.23	0.005	0.62	0.11
σ2 *gca* / σ2 *sca*		-0.003	-0.01	0.04	0.06	0.32	0.04	0.04	0.12	0.05	0.18

*, ** significant at 5 and 1 per cent level, respectively

Table 2. Estimation of general combining ability effects of parents for different characters in brinjal

Sr. No	Parents	Days to 50 per cent flowering	Plant height at harvest (cm)	No. of branches per plant at harvest	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Number of fruits per plant	Total phenol content (mg/100g)	TSS (%)	Fruit yield per plant (kg)
1	AB-09-1	-0.79	-0.46	0.11	-0.15	-0.07	1.26	0.28	0.044 **	0.02	0.07
2	AB-08-5	0.87	-0.31	0.10	-0.23	-0.55 **	-2.39	-0.33	0.020 **	-0.121 **	-0.07
3	NSRP-1	2.21	0.64	-0.35 **	-0.19	-0.09	-4.15 **	-0.70 *	0.018 **	-0.302 **	-0.16 *
4	JBGR-1	-0.42	-0.31	0.15	0.19	0.29 **	3.42 *	0.63	-0.006	0.231 **	0.11 **
5	NSR-1	-1.37	-1.62	0.21 *	0.25	0.29 **	2.49	0.47	-0.012 **	0.191 **	0.09*
6	GJB-3	-0.18	0.34	-0.02	-0.35 *	-0.35 **	-0.21	-0.08	-0.032 **	0.035 **	0.01
7	JBL-08-8	0.75	2.79 *	-0.40 **	-0.11	0.21 *	-2.73	-0.66	-0.022 **	-0.119 **	-0.08 *
8	AB-12-10	-1.08	1.06	0.19	0.59 **	0.27 **	2.33	0.39	-0.009	0.066 **	0.08
	S.Em (±) (gi)	1.51	1.29	0.10	0.14	0.10	1.54	0.34	0.00	0.01	0.32

*, ** significant at 5 and 1 per cent level, respectively

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Table 3. **Magnitude of specific combining ability (*sca*) effects of hybrids for different characters in brinjal**

Sr. No.	Crosses	Days to 50 per cent flowering	Plant height at harvest (cm)	No. of branches per plant at harvest	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Number of fruits per plant	Total phenol content (mg/100g)	TSS (%)	Fruit yield per plant (kg)
1	AB-09-1 × AB-08-5	6.75*	8.18**	-1.34**	-0.90**	0.69**	-12.13**	2.81**	0.10**	-0.86**	0.57**
2	AB-09-1 × NSRP-1	-4.27	-3.87	1.01**	0.96**	-0.05	11.78**	1.96**	-0.04**	0.46**	0.36*
3	AB-09-1 × JBGR-1	-4.29	-2.92	0.50	0.83*	0.25	4.21	0.64	0.00	0.43**	0.11*
4	AB-09-1 × NSR-1	5.92	-7.44*	1.48**	1.92**	1.23**	-19.35**	-1.97**	0.03**	0.75**	-0.36**
5	AB-09-1 × GJB3	3.87	4.14	-1.00**	-0.50	-0.43	-11.74**	-1.92**	-0.04**	-0.74**	-0.40*
6	AB-09-1 × JBL-08-8	6.47*	4.99	-1.33**	-1.53**	0.33	-17.47**	-2.71**	0.05**	-0.92**	-0.52**
7	AB-09-1 × AB-12-10	10.62**	-11.17**	2.25**	2.43**	0.78**	26.25**	4.36**	0.14**	1.44**	0.90**
8	AB-08-5 × NSRP-1	-1.51	2.15	-0.22	-0.09	-0.60*	1.00	0.18	-0.02*	0.05	0.04
9	AB-08-5 × JBGR-1	-4.18	1.11	0.32	0.71	0.00	5.70	0.89	-0.03**	0.37**	0.15*
10	AB-08-5 × NSR-1	-2.25	-4.82	0.06	0.42	0.37	4.37	0.67	-0.05**	0.24**	0.10
11	AB-08-5 × GJB3	-8.54**	9.64**	-1.96**	-1.56**	-0.90**	17.26**	-3.30**	0.05**	-1.11**	-0.57**
12	AB-08-5 × JBL-08-8	-8.49**	-9.86**	1.70**	1.70**	1.37**	21.23**	3.80**	-0.09**	1.47**	0.68**
13	AB-08-5 × AB-12-10	4.18	6.60	-1.04**	-1.16**	-0.23	-8.54*	-1.43	0.04*	-0.49**	-0.27*
14	NSRP-1 × JBGR-1	8.36**	5.65	-0.97**	-1.29**	-0.14	-13.00**	-2.15**	-0.30**	-0.63**	-0.37*
15	NSRP-1 × NSR-1	1.57	2.24	-0.29	-0.53	0.20	-3.38	-0.55	-0.04**	-0.39**	-0.36*
16	NSRP-1 × GJB3	-4.26	-2.47	0.69**	0.91**	0.30	8.10	1.47	0.13**	0.51**	0.25*
17	NSRP-1 × JBL-08-8	-0.33	-0.07	0.11	-0.41	-0.60*	-0.72	0.16	0.09**	-0.07**	-0.00
18	NSRP-1 × AB-12-10	-3.49	-2.16	0.70**	0.23	-0.03	8.07	1.43	-0.06**	0.68**	0.25*
19	JBGR-1 × NSR-1	-3.66	-4.10	0.86**	0.95**	-0.84**	8.47*	1.36	0.03**	0.74**	0.27*
20	JBGR-1 × GJB-3	2.88	0.51	-0.16	0.16	-0.33	-3.43	-0.52	-0.13**	-0.28**	-0.13*
21	JBGR-1 × JBL-08-8	4.82	0.61	-0.35	-0.73	0.33	-7.64	-1.05	-0.14**	-0.54**	-0.25*
22	JBGR-1 × AB-12-10	7.54**	5.23	-1.11	-1.60**	0.36	-14.51**	-2.41**	-0.07**	-0.87**	-0.48**
23	NSR-1 × GJB-3	0.03	-0.13	0.11	0.45	0.20	1.28	0.27	-0.01	0.03	0.01
24	NSR-1 × JBL-08-8	3.52	1.71	-0.36	-0.74*	-0.44	-6.21	-0.82	0.03**	-0.48**	-0.21*
25	NSR-1 × AB-12-10	-4.59	-2.12	0.58*	0.27	-0.42	6.70	1.12	-0.01	0.44**	0.19*
26	GJB-3 × JBL-08-8	-6.18*	4.35	-1.05**	-1.17**	0.03	-14.27**	-2.54**	0.12**	-1.00**	-0.42*
27	GJB-3 × AB-12-10	-6.22*	-6.15	1.22**	1.35**	-0.07	14.24**	1.90*	0.01	1.11**	0.44*
28	JBL-08-8 × AB-12-10	-0.22	-2.98	-0.15	-0.84*	0.07	-3.58	-0.32	0.00	-0.30**	-0.14*
	CD (5%)	**6.12**	**6.81**	**0.53**	**0.74**	**0.54**	**8.21**	**1.80**	**0.02**	**0.06**	**0.11**
	CD (1%)	**7.03**	**7.83**	**0.61**	**0.85**	**0.62**	**9.44**	**2.07**	**0.03**	**0.07**	**0.43**

*, ** significant at 5 and 1 per cent level, respectively