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Combining ability for shoot and fruit borer resistance and other quantitative traits in brinjal (*Solanum melongena* L.)

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SUMMARY

Brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) is a serious pest which causes up to 70% yield loss and fruit infestation to the tune of 23% by either boring into the young tender shoots or fruits. Breeding for resistance to this pest is difficult. In the present study, combining ability of tolerance to brinjal shoot and fruit borer infestation was done along with other yield attributes to identify the nature of gene action operative for these traits. Three female and five male parents for hybridization were selected on the basis of susceptibility towards the infestation of shoot and fruit borer from fourty genotypes of brinjal mated in line x tester design. Observation was recorded for plant height, number of primary branches per plant, days to 50% flowering, fruits per plant, fruit length, fruit girth, fruit weight, fruit yield per plant and percentage fruit and shoot infested. Prevalence of additive variance was found for most of the traits. In all the crosses the ó^{2}gca was much higher than ó^{2}sca. Predictability ratio was more than 0.5 for all the traits indicating predominance of additive genetic effects for those traits. So, conventional breeding approaches like pedigree, single seed descent and recurrent selection methods can be used to improve these characters. In case of shoot and fruit infestation percentage by the borer, negative gca effect was shown by the parents like BCB 38, BCB 23 and BCB 14 but, no cross showed significant negative sca effect. So, this trait was predominantly governed by additive gene action. It also suggests that heterosis breeding approach would not be possible for this trait as no cross found to have significant negative sca effect.

Key words : Combining ability, Brinjal, Fruit and shoot borer resistance

Brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) is a serious pest which causes up to 70% yield loss and fruit infestation to the tune of 23% (Nair and Abraham, 1988) by either boring into the young tender shoots or fruits. Breeding for resistance to this pest is difficult because of various limitations such as non availability of resistance source, meagre information on the morphological, biochemical and molecular factors responsible for resistance or tolerance and complex genetic control for the host tolerance. Though, many investigations were done on combining ability and tolerance to shoot and fruit borer infestation on brinjal separately, very few workers had actually tried to combine these experiments in a single experiment. So, in the present study combining ability of tolerance to brinjal shoot and fruit borer infestation was done along with other yield attributes to identify the nature of gene action operative for these traits.

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MATERIALS AND METHODS

Three female (line) and five male parents (tester) for hybridization were selected on the basis of susceptibility towards the infestation of shoot and fruit borer from forty genotypes of brinjal. The three selected female parents were HE 12 (BCB 38), Uttara (BCB 75) and Pusa Purple Cluster (BCB 43) which were relatively tolerant towards infestation and the five male parents *viz*., Muktakeshi (BCB 14), Bhangar (BCB 15), Nadia Local (BCB 23), Duli (BCB 24) and Makra (BCB 87) were all susceptible one. Crossing was made in line ´ tester mating design and the hybrids were evaluated for two successive seasons for different yield attributes as well as resistance towards infestation of brinjal fruit and shoot borer and pooled data was taken for combining ability analysis. Field experiment was conducted at Central Research Farm, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya, lying at 23^{0}N latitude, 89^{0}E longitude and 9.75 m above mean sea level. The layout of the experiment was Randomized Block Design with three replications. Observation on five plants from each replication were recorded on plant height, number of primary branches per plant, days to 50% flowering, fruits per plant, fruit length, fruit girth, fruit weight, fruit yield per plant and percentage fruit and shoot infested.

RESULTS AND DISCUSSION

In combining ability analysis (Table1) the hybrid mean squares were partitioned into lines, testers and line x tester interaction components. The variance due to lines and testers were significant for most of the characters except number of primary branches per plant for which the testers did not vary significantly. This indicated prevalence of additive variance for these characters. The mean squares due to line x tester interaction component also emerged significant for most of the traits except primary branches per plant, fruit girth, fruit yield per plant and shoot and fruit infestation percentage indicating that combining ability did not contribute remarkably in the expression of these traits. Therefore, total variation among hybrids in these traits might be attributed to gca differences existing among parents.

In all the crosses the variance due to gca (ó^2 gca) was much higher than variance due to sca (ó^2 sca) (Table 2). Additive component of variance showed higher value in magnitude than dominance component of variance in this case. Predictability ratio *i.e.* additive genetic variance expressed as proportion of total genetic variance [2 ó^{2}gca/ (2 ó^{2}gca + ó^{2}sca)] was more than 0.5 for all the traits indicating predominance of additive genetic effects for those traits. The results were in conformity with the findings of earlier workers (Mandal and Dana, 1993; Rai *et al.*, 1998; Tomar *et al.*, 1997 and Chezhian *et al.*, 2000). So, conventional breeding approaches like pedigree, single seed descent and recurrent selection methods can be used to improve these characters.

The estimates of GCA effects (Table 3) revealed that BCB 14 was good general combiner followed by BCB 43 for plant height while BCB 75 was the best general combiner for number of primary branches/plant. The traits like days to 50% flowering where negative gca effects was desirable, BCB 38 followed by BCB 14 showed highest gca effects. In case of trait like number of fruit per plant which is a good indicator of high yield potential, the parents like BCB 38, BCB 75, BCB 15, and BCB 23 showed significant positive gca effects. The characters like fruit length and fruit girth which are indicator of fruit appearance, few parents showed positive significant gca effects (two parents in each case). In case of fruit weight, BCB 24 was the best general combiner followed by BCB 87. Fruit yield/plant, which is a complex character and controlled by many other yield components, was found to have mostly positive gca effects among the parents. The best general combiner for fruit yield was BCB 15 followed by BCB 38, BCB 24 and BCB 14. In

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

Sources of variation	df	Plant height (cm)	Primary branches	Days to 50% flowering	Fruits/ plant	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Fruit yield/ plant (kg)	% shoot infestation	% fruit infestation
Replication	2	8.01	2.36	2.15	11.75	0.26	0.07	16.08	0.12	1.59	2.99
Parents (P)	7	189.33**	8.47**	523.23**	1602.74**	24.27**	33.92**	6139.57**	2.62**	52.43**	226.89**
Lines (L)	2	102.8**	10.77*	217.00**	907.00**	18.65**	0.33	563.44**	1.05**	22.29**	47.82**
Tester (T)	4	269.2**	3.167	179.01**	801.27**	33.03**	14.4**	4585.94**	0.56**	28.59**	66.64**
L vs T	1	42.85*	25.07**	2512.23**	6200.1**	0.48	179.21**	23506.33**	13.98**	208.06**	1226.03**
Hybrids (H)	14	391.27**	9.97**	211.83**	373.23**	5.25**	6.23**	862.23**	2.03**	24.4**	45.41**
P vs H	1	1751.5**	131.38**	3630.82**	1068.2**	82.74**	28.99**	799.08**	9.69**	0.51	260.78**
Error	44	6.64	2.27	5.46	13.04	0.83	0.52	15.14	0.08	2.345	1.52

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 2 : Variance of combining ability for different characters in brinjal

Parameter	Plant height (cm)	Primary branches	Days to 50% flowering	Fruits/ plant	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Fruit yield/ plant (kg)	% shoot infestation	% fruit infestation
σ^2_{gca}	61.04	2.14	48.6	43.28	0.706	0.88	111.14	0.26	5.61	10.586
σ^2_{sca}	27.00	0.31	10.325	36.13	0.48	-0.01	28.00	0.206	0.13	-0.17
σ^2_A (at F=1)	122.08	4.28	97.2	86.56	1.41	1.76	222.27	0.52	11.22	21.17
σ^2_D (at F=1)	27.00	0.31	10.325	36.13	0.48	-0.01	28.00	0.206	0.13	-0.17
Predictability ratio	0.82	0.93	0.9	0.71	0.75	1.01	0.89	0.72	0.99	1.01

Table 3: Estimates of gca effects of the parental lines for different characters in brinjal

Hybrids	Plant height (cm)	Primary branches	Days to 50% flowering	Fruits/ plant	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Fruit yield/ plant (kg)	% shoot infestation	% fruit infestation
38 x 14	23.99**	15.66**	-34.02**	4.98	14.03**	12.78**	3.78	27.24**	-9.42**	-13.44**
38 x 15	-3.94**	36.00**	-47.27**	8.40**	5.42**	29.26**	2.01	37.35**	-5.1**	-5.39**
38 x 23	9.49**	20.00**	-19.1**	-11.24**	15.86**	33.33**	22.18**	-3.66**	-3.74**	-9.18**
38 x 24	15.39**	5.00**	-39.81**	-6.45*	37.98**	31.20**	7.15*	29.28**	3.04**	-7.99**
38 x 87	-1.35	17.07**	-26.67**	-15.65**	-1.20	32.86**	16.08**	8.92**	2.65*	-10.10**
75 x 14	20.1**	25.58**	-21.05**	67.90**	10.69**	20.63**	-13.41**	38.73**	3.24**	-3.41**
75 x 15	5.96**	30.77**	-14.96**	115.95**	17.67**	27.79**	-22.35**	70.62**	10.63**	-1.05
75 x 23	7.79**	18.07**	-9.43**	17.51**	7.86**	30.19**	8.37**	15.83**	5.2**	0.41
75 x 24	19.45**	30.12**	-16.67**	35.57**	38.32**	29.77**	1.18	37.89**	7.92**	-0.10
75 x 87	9.27**	29.41**	-5.98**	-6.87*	10.76**	47.95**	-7.16*	-26.00**	15.63**	-0.24
43 x 14	23.42**	20.00**	-28.3**	-0.55	21.25**	29.28**	3.96	6.82**	4.34**	-9.21**
43 x 15	31.2**	25.37**	-39.5**	9.78**	22.38**	28.3**	-5.55	14.15**	8.71**	-2.57**
43 x 23	13.87**	8.33**	-18.37**	5.04	21.31**	45.03**	8.37**	2.05**	1.01	-5.24**
43 x 24	19.51**	13.89**	-19.64**	3.53	39.65**	36.87**	6.42*	21.84**	5.76**	-6.59**
43 x 87	15.12**	5.41**	-10.09**	1.32	12.50**	39.34**	2.58	-1.17**	4.93**	-8.28**
SE(±)	1.82	1.065	1.65	2.55	0.64	0.51	2.75	0.196	1.08	0.87

* and ** indicate significance of values at P=0.05 and 0.01, respectively

case of shoot and fruit infestation percentage by the borer, negative gca effects, which is desirable, was shown by parents like BCB 38, BCB 23 and BCB 14.

Among the fifteen cross combinations, only few showed significant sca effects (Table 4) which indicates lower potentiality for exploitation of heterosis in Brinjal for these traits. Highest magnitude of sca effects for fruits number per plant was shown by the cross BCB 75 x BCB 15. The only one combination (BCB 43 x BCB 15) showed negative sca effect which is desirable for days to 50% flowering. In case of fruit weight, two cross combinations *viz*., BCB 75 x BCB 23 and BCB 75 x BCB 24 showed positive and significant sca effect. Crosses like BCB 75 x BCB 15, BCB 43 x BCB 24 and BCB 38 x BCB 87 showed positive and significant sca effect for fruit yield per plant. In case of shoot and fruit infestation percentage, no cross showed significant negative sca effect. So, this trait was predominantly governed by additive gene action as opposed to earlier findings (Baig and Patil, 2002). It also suggests that heterosis breeding approach would not be possible for this trait as no cross found to have significant negative sca effect.

Joint study of gca and sca effect (Table5) revealed that in case of only one combination (BCB 75 x BCB 15) the both parents had high gca effect for fruits number per plant. So, the hybrid advantage was due to additive x additive gene interaction and it could be fixable in subsequent generation. The hybrid also sowed additive x dominance interaction for fruit yield per plant and in terms of *per se* performance the hybrid also out yielded other hybrids(5.03 kg fruit yield per plant). In terms of earliness,

Table 4: Estimates of sca effects of hybrids for different characters in brinjal

Hybrids	Plant height (cm)	Primary branches	Days to 50% flowering	Fruits/ plant	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Fruit yield/ plant (kg)	% shoot infestation	% fruit infestation
38 x 14	4.58**	-0.44	2.38	1.4	0.39	-0.24	-1.28	0.09	-0.64	-0.38
38 x 15	-6.88**	0.89	-1.96	-3.04	-0.98	0.3	4.33	-0.06	-1.06	0.43
38 x 23	3.08*	0.78	3.38**	-1.71	0.69	0.09	-2.48	-0.37*	0.51	-0.19
38 x 24	1.71	-1.33	-2.29	0.96	0.82	0.14	-4.86*	0.01	0.9	0.25
38 x 87	-2.48	0.11	-1.51	2.4	-0.91	-0.29	4.29	0.34*	0.29	-0.1
75 x 14	-0.81	-0.18	-2.09	2.73	-0.47	-0.04	-3.23	0.14	-0.27	0.25
75 x 15	-2.73	-0.84	5.58**	9.96**	0.56	-0.06	-6.44**	0.58**	0.37	-1.01
75 x 23	-0.61	-0.62	-2.09	-2.38	-0.77	-0.3	6.81**	0.12	-0.2	0.05
75 x 24	1.99	0.93	-0.76	-2.38	-0.04	-0.18	4.75*	-0.04	-0.62	0.08
75 x 87	2.17	0.71	-0.64	-7.93**	0.73	0.58**	-1.89	-0.8	0.73	0.63
43 x 14	-3.76*	0.62	-0.29	-4.13	0.09	0.28	4.51	-0.23	0.92	0.13
43 x 15	9.61**	-0.04	-3.62*	-6.91**	0.42	-0.24	2.11	-0.51**	0.69	0.59
43 x 23	-2.46	-0.16	-1.29	4.09	0.09	0.22	-4.33	0.25	-0.32	0.14
43 x 24	-3.7*	0.4	3.04*	1.42	-0.78	0.04	0.12	0.04	-0.28	-0.33
43 x 87	0.31	-0.82	2.16	5.53*	0.19	-0.3	-2.4	0.45**	-1.01	-0.53
SE(±)	1.488	0.87	1.35	2.085	0.525	0.172	2.246	0.16	0.884	0.71

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 5 : Joint study of gca and sca effect

Characters	Best general combiner				Best specific combiner			
		Genotype	gca effect	*Per se* performance	Hybrid	sca effect	Per se performance	gca status of parents
Plant height(cm)	Line	BCB 43	8.52**	79.30	BCB 43 x BCB 15	9.61**	96.87	H x L
	Tester	BCB 14	15.96**	86.53	BCB 38 x BCB 14	4.58**	95.80	L x H
					BCB 38 x BCB 23	3.08*	72.33	L x L
Days to 50% flowering	Line	BCB 38	-8.71**	35	BCB 43 x BCB 15	-3.62*	36	M x M
	Tester	BCB 14	-3.31**	62				
No. of fruits/plant	Line	BCB 38	3.82**	71.67	BCB 75 x BCB 15	9.96**	58.67	H x H
	Tester	BCB 23	11.04**	47.00	BCB 43 x BCB 87	5.53*	25.67	L x L
Fruit weight(g)	Line	BCB 43	0.79	61.10	BCB 75 x BCB 23	6.81**	75.33	L x L
	Tester	BCB 24	23.45**	165.30	BCB 75 x BCB 24	4.75*	122.82	L x H
Fruit yield/plant(kg)	Line	BCB 38	0.42**	4.56	BCB 75 x BCB 15	0.58**	5.03	M x H
	Tester	BCB 15	0.63**	2.25	BCB 43 x BCB 87	0.45**	3.41	L x L
					BCB 38 x BCB 87	0.34*	3.40	H x L

* and ** indicate significance of values at P=0.05 and 0.01, respectively; H= High gca effect, M= Medium gca effect and L= Low gca effect

the best hybrid was BCB 38 x BCB 15 which involved the parents having both medium gca effect. It might be due to constellation of favourable genes contributed by the parents (Patel *et al.*, 1994).

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