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Combining Ability Estimates in Nine Eggplant Varieties

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Abstract. Combining ability effects were estimated for yield, yield components and plant height in a 9 x 9 diallel analysis excluding reciprocals. The variances for general combining ability (GCA) and specific combining ability (SCA) were highly significant indicating the presence of additive as well as non-additive gene effects in the traits studied. The relative magnitude of these variances indicated that additive gene effects were more prominent for all the character under study. The eggplant genotype P4 proved to be the best general combiner for yield followed by P1 and P5. In general the cross P4 x P5 proved better for yield and also number of fruits per plant, whereas the cross P7 x P9 for fruit diameter and individual fruit weight.

Keywords: eggplant (*Solanum melongena* L.), combining ability, general combining ability (GCA), specific combining ability (SCA)

Introduction

Eggplant (*Solanum melongena* L.) is the most important vegetable grown in Bangladesh with respect to production and area. At the present time production has become almost stagnant and yield/hectare is not increasing desirably to meet the food requirements of the increasing human population. Thus, a well-planned and dynamic eggplant breeding research programme is needed to be intensified to meet the required demand of eggplant production. Before undertaking a crop improvement programme, information on genetic mechanism like combining ability is of utmost importance in deriving superior genotypes for yield. Sprague and Tatum (1942) gave the definition of combining ability and partitioned it into general combining ability (GCA) and specific combining ability (SCA). The diallel technique was developed by Griffing (1956) emphasized the domain for self fertilized crops like eggplant when the technique is used to obtain the relative contribution of general and specific combining abilities. Malik *et al.* (1988) and Singh *et al.* (1980) reported that both, general and specific variances were significant for most of the characters studied indicating the involvement of additive and non-additive gene effects. While Khan *et al.* (1985) reported significant GCA variances for most of the characters studied. The present study was therefore, undertaken to evaluate the general and specific combining ability estimates for plant height, yield and yield components in nine eggplants varieties. The estimates thus obtained would be helpful, for deriving superior eggplant genotypes from the desirable cross combinations.

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Materials and Methods

The experiment was conducted at the experimental field of Olericulture Division of HRC, Bangladesh Agricultural Research Institute (BARI) Gazipur, Bangladesh, during the winter season of 2002-2003. The seeds of nine parents (P_1 = BL081; P_2 = BL083; P_3 = B009; P_4 = Kazla; P_5 = BL113; P_6 = BL099; P_7 = Uttara; P_8 = BL114 and P9 = Islampuri) and their thirty-six hybrids (excluding reciprocals) were sown on the seedbed on 16th September 2002. Forty-five days old seedlings were transplanted in the main field on 30th October 2002. The experiment was laid out in a randomized complete block design (RCBD) design with three replications. The unit plot size was 7.5 x 0.70 m and 10 plants were accommodated in a plot with a plant spacing of 75 cm apart in single row maintaining a row to row distance of 70 cm. Data was recorded from five randomly selected plants from each plot for days to 50% plant flowering, days to 1st harvest, plant height at first harvest, number of primary and secondary branches at last harvest, fruit length, fruit diameter, number of fruits/plant, individual fruits weight and yield per plant. Data was analyzed by MSTATC programme, where as general and specific combining ability effects were estimated following the method 2 model, 1-approach suggested by Griffing (1956).

Results and Discussion

The analysis of variance for combining ability (general and specific combining ability) were found highly significant for most of the characters studied (Table 1) except number of branches, fruit diameter indicating both additive and non-additive gene actions for the expression of these characters.

Table 1. Analysis of variance for combining ability in eggplant

Source of variation	df	Mean sum of square: Days to 50% flowering	Days to first harvest	Plant height at first harvest (cm)	No. of primary and secondary branches	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)	No. of fruits per plant	Yield/ plant (gm)
GCA	8	273.15**	79.89**	98.55**	1.19	53.35**	14.36**	5922.35**	348.03**	231627.64**
SCA	36	83.34**	25.78**	39.65**	3.88**	7.11**	1.34	601.87**	37.11**	195335.33**
Error	88	11.35	9.08	2.01	0.53	0.10	0.01	16.04	3.11	9870.18

* = significant at 5% level; ** = significant at 1% level

The general combining ability (GCA) variances were higher in magnitude, than the specific combining ability (SCA) variances for all the characters studied, indicating the predominance of the additive gene effects for the characters. Additive gene effects appeared more important than non-additive gene effects for fruit set, early yield, average fruit weight and total yield.

The GCA component is primarily a function of the additive genetic variance. GCA variances with each parent play significant role in the choice of parents. A parent with higher positive significant GCA effects is considered as a good general combiner. The magnitude and direction of the significant effects for the nine parents provide meaningful comparisons and would give indications to the future-breeding programme. The results of GCA effects for nine varieties and the SCA effects of 36 F_1 crosses for the different characters were estimated and presented in Table 2 and 3. The SCA effects signify the role of non-additive gene action in the expression of the characters. It indicates the highly specific combining ability leading to highest performance of some specific cross combinations. That is why, it is related to a particular cross. High SCA effects may arise not only in crosses involving high combiners but also in those involving low combiners. Thus in practice, some of the low combiners should also be accommodated in hybridization programme.

GCA effects. In Table 2 it is mentioned that the parent P_5 (-5.83**) appeared as the best general combiner followed by P_1 (-4.67**) and P_4 (-3.52**) for days to 50% flowing. While parent P_1 (-2.04) appeared as the best general combiner for early harvest followed by P_5 (-1.68). The parent P_3 (3.04**) exhibited the highest GCA effect for fruit length followed by P_2 (2.80**), and P_5 (1.41**). Parent P_9 showed the highest GCA for fruit diameter (2.59**) and individual fruit weight (52.64**) closely followed by P_1. The parent P_4 (7.03**) followed by P_5 (4.28**) and P_6 (3.87**) exhibited the highest positive significant GCA effect for number of

Table 2. Estimate of general combining ability effect for eight characters of nine eggplant varieties

Parent	Days to 50% flowering	Days to first harvest	Plant height at first harvest (cm)	No. of primary and secondary branches	Fruit length (cm)	Fruit diameter (cm)	Individual fruit wt. (g)	No. of fruits/ plant	Yield/ plant (g)
P_1	-4. 67**	-2.04*	3.08**	0.26	-3.26**	0.92**	24.27**	-4.52**	106.97**
P_2	2.42	-0.25	-1.46**	0.25	2.80**	-0.30**	-5.97**	-2.49**	-97.18**
P_3	-0.73	-0.95	4.97**	0.23	3.09**	-0.66**	-8.82**	1.47**	-5.12
P_4	-3.52**	-1.47	1.26**	0.35	-1.27**	-0.40**	-13.50**	7.03**	286.85**
P_5	-5.83**	-1.68	-2.22**	-0.24	1.41**	-0.71**	-13.27**	4.28**	85.67**
P_6	4.15**	3.02**	1.15**	-0.13	1.21**	-0.98**	-15.36**	3.87**	-84.33**
P_7	-1.13	-1.38	3.77**	-0.23	-0.78**	-0.78**	-14.46**	1.38**	-83.66**
P_8	-0.92	-1.22	-3.61**	0.18	-1.69**	0.33**	-5.53**	0.76	0.09
P_9	10.24**	5.96**	0.59	-0.61**	-1.52**	2.59**	52.64**	-11.8**	-209.30**
S.E(Gi)	0.96	0.86	0.40	0.21	0.09	0.03	1.14	0.50	28.24
LSD (5%)	1.91	1.71	0.80	0.41	0.18	0.06	2.27	1.00	56.20
LSD (1%)	2.53	2.26	1.06	0.55	0.24	0.08	3.01	1.32	74.53

* = significant at 5% level; ** = significant at 1% level; (P_1 = BL081; P_2 = BL083; P_3 = B009; P_4 = Kazla; P_5 = BL113; P_6 = BL099; P_7 = Uttara; P_8 = BL114 and P_9 = Islampuri)

fruit per plant. P_4 proved to have the greatest relative GCA effect (286.85**) followed by P_1 (106.47**) for yield per plant. The variety P_9 (-209.30**) was, however, poor combiner for yield per plant. Almost similar trends of additive and non-additive gene actions have been reported by different earlier research workers like Shamanin *et al.* (1985) and Gill *et al.* (1984).

SCA effects. Out of 36 crosses, nine crosses exhibited highly significant negative SCA values with the largest negative values in crosses $P_3 \times P_6$ (-14.82**), $P_1 \times P_4$ (-13.22**), $P_2 \times P_8$ (-12.58**) and $P_3 \times P_8$ (-11.76**) for days to 50% flowering (Table 3). Pan *et al.* (1996) reported earliness in eggplant hybrids.

For days to first harvest 22 F_1s showed negative SCA values out of which five hybrids viz. $P_6 \times P_9$ (-8.16**); $P_2 \times P_8$ (-8.04**); $P_3 \times P_5$ (-7.22**); $P_3 \times P_8$ (-7.01**) and $P_1 \times P_7$ (-6.43**) exhibited highly significant values. Therefore these five crosses with highly significant negative SCA values were the best specific combiners for early harvest. Tan *et al.* (1997) and Pan *et al.* (1996) also reported early harvest in hybrids of eggplant.

Table 3. Specific combining ability (SCA) effect of 36 crosses for nine characters in eggplant

Hybrids	Days to 50% flowering	Days to first harvest	Plant height at first harvest (cm)	No. of primary branches at last harvest	Fruit length (cm)	Fruit diameter (cm)	Individual fruit wt. (g)	No. of fruits/ plant	Yield/plant (g)
$P_1 \times P_2$	-8.49	-0.22	2.83*	1.36*	1.66**	-0.37**	-14.88**	-0.40	-252.29**
$P_1 \times P_3$	-4.00	-1.52	-1.93	1.31*	-1.40**	-0.80**	-20.77**	3.55*	24.98
$P_1 \times P_4$	-13.21**	-3.67	9.74**	0.15	3.16**	-0.30**	-0.75	-1.42	265.68**
$P_1 \times P_5$	4.09	-0.46	1.26	-0.53	3.18**	0.11	-0.41	0.73	432.19**
$P_1 \times P_6$	-4.88	-0.49	3.86**	0.56	-4.66**	1.52**	-18.30**	3.21*	173.53*
$P_1 \times P_7$	-10.61**	-6.43**	12.61**	2.87**	-1.67**	-0.52**	-13.70**	8.10**	515.19**
$P_1 \times P_8$	-2.49	3.42	-5.59**	0.23	2.25**	-0.77**	-33.90**	3.42*	-271.23**
$P_1 \times P_9$	15.03**	4.24	-3.71**	-2.95**	0.78**	2.64**	90.34**	-3.63*	127.50
$P_2 \times P_3$	4.24	2.69	3.27**	0.73	2.98**	-0. 95 **	9.40**	-0.88	164.80*
$P_2 \times P_4$	9.70**	2.87	10.51**	0.90	-0.23	-0.18*	-4.48	0.95	-306.84**
$P_2 \times P_5$	4.33	6.09*	0.62	2.02**	-0.88**	1.03**	20.93**	1.40	605.01**
$P_2 \times P_6$	3.30	1.72	1.89	-3.09**	0.99**	-0.33**	4.98	2.31	236.35**
$P_2 \times P_7$	6.30*	6.45**	-0.86	-2.15**	2.18**	0.24**	19.51**	-3.87**	51.35
$P_2 \times P_8$	-12.58**	-8.04**	3.55**	0.91	0.15**	0.09	7.31*	7.29**	688.26**
$P_2 \times P_9$	2.27	-4.22	7.72**	-0.70	-1.05**	2.93**	-39.62**	5.34**	29.65
$P_3 \times P_4$	11.85**	3.90	-4.58**	0.25	3.22**	0.12	-1.63	-2.17	-324.23**
$P_3 \times P_5$	-9.18**	-7.22**	-2.94*	0.77	2.11**	-0.14	-1.53	7.08**	240.61**
$P_3 \times P_6$	-14.8**	-3.58	2.67*	1.20*	0.77**	0.24**	3.29	0.43	110.95
$P_3 \times P_7$	-5.21	-4.52	-2.49*	-0.53	2.16**	0.17	3.92	-2.82	-159.05
$P_3 \times P_8$	-11.76**	-7.01**	2.96*	2.86**	-2.13**	-0.51**	-6.17	8.53**	319.86**
$P_3 \times P_9$	-9.24**	-2.86	-0.57	-0.65	0.17	0.10	17.79**	-2.24	455.92**
$P_4 \times P_5$	5.27	4.63	-4.30**	0.91	-4.34**	0.13	16.19**	7.18**	858.34**
$P_4 \times P_6$	-6.03*	1.93	0.37	2.91**	1.32**	-0.89**	3.28	8.49**	373.65**
$P_4 \times P_7$	-0.76	2.33	-1.18	-2.18**	-1.36**	1.81**	26.95**	-6.05**	232.65**
$P_4 \times P_8$	1.70	2.18	2.26	-0.23	-0.48	0.63**	-0.86	11.77**	613.89**
$P_4 \times P_9$	-7.79**	-4.34	-11.67**	0.69	4.36**	-2.03**	-41.22**	1.79	-96.72
$P_5 \times P_6$	-5.06	-4.52	9.58**	0.32	4.38**	0.25**	-0.95	6.28**	98.83
$P_5 \times P_7$	-6.79	-1.13	1.41	2.20**	-4.33**	-0.39**	4.25	-5.60**	-369.17**
$P_5 \times P_8$	-5.33	-0.95	-11.86**	-4.32*	2.21**	-0.40**	24.88**	-14.08**	-391.26**
$P_5 \times P_9$	0.85	-0.13	-0.92	-1.43*	0.18	-1.66**	-43.75**	1.28	-194.87*
$P_6 \times P_7$	4.24	-1.49	-4.07	-0.88	-3.34**	0.29**	-3.70	0.74	-210.50
$P_6 \times P_8$	13.70**	5.69*	1.60	-0.55	-1.09**	-0.33**	-3.67	4.41**	-317.59**
$P_6 \times P_9$	0.88	-8.16**	0.08	-1.97**	-5.25**	-1.38**	26.14**	-5.22**	478.47**
$P_7 \times P_8$	4.30	8.09**	-0.01	-3.11**	3.70**	-0.39**	9.17**	0.22	228.07**
$P_7 \times P_9$	9.49	-1.76	-0.47	1.71**	0.43	-2.58**	-36.93**	6.64**	316.47**
$P_8 \times P_9$	-5.73	-1.25	5.97*	3.53**	0.04	0.23*	22.70**	-5.87**	-73.96
S.E. (Sij)	2.73	2.44	1.15	0.59	0.25	0.09	3.24	1.43	80.38
LSD (5%)	5.42	4.85	2.29	1.17	0.50	0.18	6.45	2.84	159.95
LSD (1%)	7.19	6.43	3.03	1.56	0.67	0.24	8.55	3.76	212.15

* = significant at 5% level; ** = significant at 1% level; (P_1 = BL081; P_2 = BL083; P_3 = B009; P_4 = Kazla; P_5 = BL113; P_6 = BL099; P_7 = Uttara; P_8 = BL114 and P_9 = Islampuri)

The highest significant and positive SCA effect for plant height was obtained by the cross $P_1 \times P_7$ (12.61**) followed by $P_2 \times P_4$ (10.51**) and $P_1 \times P_4$ (9.74**). The highest significant negative SCA effect was obtained by $P_5 \times P_8$ (-11.86**) followed by $P_4 \times P_9$ (-11.67**). Prasath *et al.* (2000), Ingale and Patil (1997) and Saha *et al.* (1991) selected some hybrids in case of plant height.

Seven cross combinations showed higher positive significant SCA effect with the largest value in cross $P_8 \times P_9$ (3.53**) for number of primary and secondary branches. Several workers like Babu and Thirumurugan (2001), Prasath *et al.* (2000), Ingale and Patil (1997) and Saha *et al.* (1991) reported some hybrid superior for these characters.

The crosses of $P_5 \times P_6$ and $P_4 \times P_9$ gave the best SCA effects for fruit length with a value of 4.38** and 4.36**, respectively followed by $P_7 \times P_8$ (3.70**). Several workers reported about some superior hybrids for fruit length. Fruit length of hybrids in eggplant was also reported by Babu and Thirumurugan (2001), Prasath *et al.* (2000), Ingale and Patil (1997) and Prakash *et al.* (1994).

Among 36 cross combinations, 17 crosses showed positive SCA effect for fruit diameter, highest SCA effect for cross $P_2 \times P_9$ (2.93**) closely followed by the cross $P_1 \times P_9$ (2.64). Prasath *et al.* (2000) and Prakash *et al.* (1994) reported good specific combinations for fruit diameter in eggplant. Ingale and Patil (1997) reported a superior hybrid for fruit diameter.

Eleven cross combinations exhibited higher positive significant SCA effect with the largest value in cross $P_1 \times P_9$ (90.34**) for individual fruit weight. The crosses with highest significant positive SCA values are considered as the best for individual fruit weight. Prasath *et al.* (2000), Ingale and Patil (1997) and Dixit *et al.* (1982) reported some best hybrids for individual fruit weight.

The highest positive significant SCA effect for number of fruits per plant was obtained by the cross $P_4 \times P_8$ (11.77**) followed by $P_3 \times P_8$ (8.53**) and $P_4 \times P_6$ (8.49**). These positive significant SCA values indicated that these F_1s produced more number of fruits per plant than the means of their parents. Dixit *et al.* (1982) selected two superior hybrids for number of fruits per plant. Same study for superior hybrids was also reported by Balamohan *et al.* (1983).

Out of 36 cross combination 24, crosses showed positive SCA effect for yield per plant, among them 18 crosses exhibited positive significant SCA effect (Table 3). The highest positive significant SCA effects were shown by the hybrid $P_4 \times P_5$ (858.34**) followed by $P_2 \times P_8$ (688.26**), $P_4 \times P_8$ (613.89**) and $P_2 \times P_5$ (605.01**). Thus $P_4 \times P_5$ was the best combination (good x poor combiner) followed by other three hybrids for yield per plant in eggplant. The other higher values of positive SCA effect may be considered as good specific combiner (poor x poor combiner or good x poor combiner) for fruit yield per plant. Chaudhary and Malhotra (2000), Ingale and Patil (1997), Kumar *et al.* (1996) and Patel *et al.* (1994) reported good SCA for fruit yield. Khan *et al.* (1985) reported that the parents having poor GCA for certain traits when crossed with parents having high GCA for the same traits usually generated high positive SCA effect. Similar trends were found in this study. The parents like P_2 having poor GCA for yield, when crossed with P_8 and P_5 having poor and good GCA, respectively for this character gave high positive SCA effects. Since a relationship seems to exist between general and specific combining ability effects, it would safely be assumed that P_2 would be outstanding parent contributing to yield through additive gene action.

From the results of this study, it is concluded that the crosses showing high SCA for yield also manifested high or average SCA for yield components. Varieties P_4, P_1, P_5 and P_8 showed relatively high GCA effects for yield and yield components. It can thus be concluded that these four eggplant varieties P_4, P_1, P_5 and P_8 can be used extensively in cross breeding programme for deriving desirable genotypes in the segregating generations.

These findings along with other information on combining ability in eggplant are expected to help a plant breeder to plan an effective hybrid variety development programme of eggplant in under environmental condition of Bangladesh. The information may also help a plant breeder of the similar tropical environment in the other parts of the world.

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