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Combining ability for yield and other quantitative traits in eggplant (*Solanum melongena* L.)

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Abstract: Combining ability for yield and its components were analyzed in a diallel crosses, involving 7 genotypes of eggplant. The GCA and SCA were significant for all characters, indicating the importance of both additive and non-additive genetic components. The genotypes, R-1proved as best general combiner for days to 50 % flowering and earliness, P-3 for plant height (tall stature), C-2 proved as best general combiner for average fruit weight, fruit diameter, fruits size and yield per plant, whereas I-9 for proved good general combiners fruit length. Among the crosses, C-2 x P-3, P-1 x P-2,P-2 x I-9and P-3 x R-1 were good specific combiners for yield per plant.

Keywords: Combining ability, eggplant, diallel, GCA, SCA

Introduction

Eggplant (*Solanum melongena* L.), also known as brinjal, is a commercially and nutritionality important solanaceous vegetable crop of India grown extensively throughout the year in all parts of India except at higher altitude. It is widely cultivated in both subtropical and tropical regions of the globe mainly for its immature fruits as vegetables. It is popular among people of all social strata and hence, it is apply referred as "vegetable of masses" (Patel and Sarnaik, 2003). With increasing popularity of F_1 hybrids in eggplant, it is imperative to obtain hybrids having excellent and marketable fruitquality 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 governing the inheritance of economically important quantitative characters can help breeders to select suitable parents and devise an appropriate breeding strategy (Kumar *et al.*, 2003).

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The common approach for 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 under taken to elucidate information on the 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.

Materials and Methods

The experiment was conducted during *Kharif* 2010-11 and 2011-12 at Experimental Research Farm of Indian Institute of Vegetable Research, Varanasi. Seven diverse genotypes of Eggplant *viz.* P-1, P-2, C-2, B-14, P-3, I-9 and R-1were crossed using in half diallel mating design to derive 21 F_1 hybrids. All the 21 F_1hybrid and 7 parents were evaluated in a Randomized Block Design at 60 x 45 cm spacing in three replications during 2011-12. Standard cultural practices were followed to raise the normal crop.

Data were recorded on five randomly selected plants in each treatment over replication for various quantative traits *viz.*, days to 50 % flowering, days to 50 % harvesting (earliness), average fruit weight, plant height, number of branches/plant, fruit length, fruit diameter, fruit size, number of fruit per plant and yield per plant. The combining ability was calculated according to the Model - I and Method - II of Griffing (1956).

Results and Disussion

The analysis of variance showed significant differences among the genotypes for different traits.Variance due to treatment was highly significant for all the traits, Variance due to parent was highly significant for all traits except plant height number of branches, whereas variance due to hybrids was highly significant for all the traits. Variance due to parent's hybrids showed significant difference for all the traits except days to 50 % flowering, plant height, number of branches/ plant, fruit size and number of fruit per plant.The above resultindicates the involvement of both additive and non-additive type of gene actions in expression of the characters.

A wide range of variation was observed in estimating the components of genetic variance (0.2g) (Table 1). The estimates of component of genetic variance due to SCA were comparable to GCA for all the traits. Value for the average degree of dominance showed presence of epistasis, dominance to over dominance each of the traits.

The variances due to GCA were highly significant for all the traits indicating highly significant difference for the parents for all the traits except number of branches/ plant. The mean squares due to SCA were also highly significant for all the traits indicating the importance of both additive and non additive type of generation for the traits. Similar finding have also been reported by Chaudhary and Malhotra (2000) and Suneeta *et al.* (2006) where the estimates of variance GCA (male) were found positive for all the characters except single fruit weight, whereas the variance GCA (female) estimates were positive for all characters.

The positive and significant combining ability effects are desirable for average fruit weight, plant height, number of branches/ plant, fruit length, fruit diameter, fruit size, number of fruit/ plant and yield/plant, whereas negative values for days to 50 % flowering and days to 50 % harvesting. On the basis of *per se* performance and GCA effects C-2 and I-9 were the best parent**s** for all desired traits except for number of fruit per plant and number of branches/ plant. R-1was the best combiner for early flowering (-1.82), while P-1 for late flowering (2.13), whereas R-1 showed highly significant and negative GCA effects for early harvesting (-3.37) and P-1 showed highly significant positive GCA effects for late harvesting (1.78). Based on *per se* performance and GCA effects, R-1 was found as best combiners for early flowering and harvesting, whereas P-1 was found suitable for late flowering and harvesting.

The GCA effects were significant and positive for P-2 and C-2 for average fruit weight, whereas significant and positive GCA effects for tall plant type were exhibited by P-3 and R-1. Evidenced by the significant positive GCA effects, none of lines showed significant good

Table 1: Estimates of components of genetic variance and degree of dominance for ten characters of eggplant

Components	Characters									
	DF	DH	AFW	PH	NB	FL	FD	FS	NFPP	YPP
σ^2 gca	1.79	4.31	20755.35	13.21	0.04	2.91	0.74	17.30	0.66	0.04
σ^2 sca	10.89	15.32	158789.14	124.54	0.50	7.06	1.27	208.25	9.90	0.49
σ^2 e	0.94	0.25	6210.41	31.28	0.34	0.55	0.19	34.66	2.00	0.08
σ^2 A	3.58	8.62	41510.70	26.41	0.09	5.81	1.48	34.60	1.32	0.07
σ^2 D	10.89	15.32	158789.14	124.54	0.50	7.06	1.27	208.25	9.90	0.49
$\sqrt{\frac{\sigma^2}{\sigma^2}}$	0.57	0.75	0.51	0.46	0.42	0.91	1.08	0.41	0.37	0.38

DF=Days to 50% flowering, DH= Days to 50% harvesting, AFW= Average fruit weight (g), PH= Plant height (cm), NB= Number of branches, FL= Fruit length (cm), FD= Fruit diameter (cm), FS= Fruit size (cm^2), NFPP= Number of fruit per plant, YPP= Yield per plant (kg.)

Table 2: Estimates of general combining ability (gca) effects of parent for ten characters of eggplant

S. No.	Parent	DF	DH	AFW	PH	NB	FL	FD	FS	NFPP	YPP
1	P-1	2.13**	1.78**	-8.14	-4.82*	-0.19	-1.18**	-0.7**	0.08	-1.79**	-0.20
2	P-2	0.61	0.44*	122.41**	-2.09	-0.03	-0.84**	0.62**	-0.65	1.32*	-0.03
3	C-2	-0.43	0.80**	255.74**	0.67	0.16	-1.10**	1.11**	7.07**	-0.31	0.22*
4	B-14	0.71*	1.14**	-106.48**	-3.91	-0.48*	-1.78**	0.44**	-1.17	0.13	-0.20
5	P-3	0.32	1.74**	-39.1	5.02*	0.38	0.14	0.33*	-3.97	0.02	0.25*
6	I-9	-1.54**	-2.53**	-40.93	-0.47	0.23	2.28**	-0.39*	4.72*	0.43	0.17
7	R-1	-1.82**	-3.37**	-183.52**	5.60**	-0.07	2.48**	-1.41**	-6.09**	0.21	-0.22*
S.E(g_j) ±		0.3	0.16	24.32	1.73	0.18	0.23	0.13	1.81	0.44	0.09

*, ** Significant at 0.05 and 0.01 levels, respectively

DF=Days to 50% flowering, DH= Days to 50% harvesting, AFW= Average fruit weight (g), PH= Plant height (cm), NB= Number of branches, FL= Fruit length (cm), FD= Fruit diameter (cm), FS= Fruit size (cm^2), NFPP= Number of fruit per plant, YPP= Yield per plant (kg.)

general combiners, whereas two lines showed significant GCA effects. The lines R-1 (2.48) and I-9 (2.28) exhibited positive and significant GCA effects and thus were found to be good general combiners. The lines C-2 (1.11) and P-2 (0.62) showed significantly positive GCA effect and proved to be good general combiners for fruits diameter, whereas C-2 and I-9were showed significant and positive GCA effects for fruit size. Only one line, P-2 (1.23) showed significantly high and positive GCA effects.For yield per plant, the lines that proved to be good general combiners with significantly positiveGCA effect were P-3 (0.25) and C-2 (0.22). Rest of the lines had poor GCAeffects.

The data fairly showed that none of the parental line was good general combiner for all the traits. However, R-1proved as best general combiner for days to 50 % flowering and days to 50 % harvesting (earliness), P-3 for plant height (tall stature), C-2 proved as best general combiner for average fruit weight, fruit diameter, fruits size and yield per plant, whereas I-9 for fruit length. It is therefore, suggested that these genotypes/cultivars may be used in improvement programme. The lines R-1 and I-9 proved to be good combiners for earliness and can be utilized further for the same trait in breeding programme.

The GCA effect together with relative *per se* performance is useful for selecting desirable parent with favorable genes for different components traits of yield. The *per se* performance of the parent and their GCA effects for all the traits were in close agreement indicating that the performance of the parent for these traits could possibly be taken as a criteria for select of parents. GCA effects represent additive x additive interaction effects. In eggplant, the importance of this type interaction had been reported by many worker like Chaudhary (1999), Chaudhary and Malhotra (2000), Das and Barua (2001), Singh *et al.* (2002), Suneeta *et al.* (2006) and Sao and Mehta (2010).

In general, SCA is associated with interaction effect which may be due to dominance and epistatic component of variation that is non-fixable in nature. Hence, it can

Table 3: Estimates of specific combining ability (sca) effects of crosses for ten characters of eggplant

S. No.	Crosses	DF	DH	AFW	PH	NB	FL	FD	FS	NFPP	YPP
1	P-1 X P-2	1.31	-1.84**	28.24	8.18*	-0.58	-0.19	0.42	10.20**	-3.08**	-0.40*
2	P-1 X C-2	2.96**	0.56	434.91**	-4.78	-0.76	0.34	-0.93**	-0.04	-0.79	-0.42*
3	P-1 X B-14	5.01**	6.33**	82.13	-9.50*	0.20	1.08*	1.40**	13.64**	1.10	0.68**
4	P-1 X P-3	-0.58	-0.24	-485.28**	-10.43**	-0.98*	-0.17	-2.52**	-20.69**	1.88	0.74**
5	P-1 X I-9	-0.03	2.00**	-470.09**	-0.81	1.16**	-0.67	-0.90**	-8.11*	0.14	-0.60**
6	P-1 X R-1	0.57	1.45**	-307.50**	18.19**	-0.21	-0.41	-0.68*	-4.60	1.36	-0.15
7	P-2 X C-2	-1.64*	0.59	-272.32**	-6.07	-0.29	-1.77**	-1.09**	-22.04**	1.10	0.25
8	P-2 X B-14	1.71**	0.65	-725.09**	-6.16	-0.33	-0.42	-0.25	-8.98*	2.32*	-0.18
9	P-2 X P-3	-7.72**	-2.90**	-20.83	17.61**	1.82**	2.29**	-1.57**	6.74	2.10*	-0.11
10	P-2 X I-9	1.08	-3.23**	-215.65**	-4.74	-0.36	1.72**	-0.22	-15.12**	-1.31	-1.02**
11	P-2 X R-1	4.08**	10.29**	150.28**	-10.34**	1.27**	-0.38	-0.70*	-3.98	7.92**	-0.38*
12	C-2 X B-14	2.00**	-5.37**	123.24*	3.59	0.16	2.34**	-0.47	22.15**	-0.71	-0.80**
13	C-2 X P-3	-3.24**	-0.18	-669.17**	-14.81**	-0.36	4.55**	1.68**	29.22**	6.73**	0.86**
14	C-2 X I-9	-0.82	4.01**	-258.98**	23.31**	1.45**	-5.21**	0.46	-26.64**	-3.68**	-0.14
15	C-2 X R-1	-0.87	-2.77**	133.61*	5.81	0.08	-1.32**	0.69*	4.34	-0.79	0.49**
16	B-14 X P-3	-3.01**	0.35	-373.61**	-11.20**	-1.40**	-1.57**	-0.22	-8.43*	-0.05	-0.12
17	B-14 X I-9	3.38**	1.35**	346.57**	-10.28**	0.08	-0.97	0.63*	20.01**	-3.12**	-0.74**
18	B-14 X R-1	-3.27**	45.83**	22.08	-0.29	0.92	-0.84	-5.99**	-3.23	-1.26	-2.02**
19	P-3 X I-9	0.10	6.16**	569.17**	10.39**	0.56	-4.69**	1.44**	-1.08	-2.68**	-0.33
20	P-3 X R-1	0.41	-0.77*	478.43**	7.15	0.86**	-5.69**	1.67**	-2.87	-3.45**	0.45*
21	I-9 X R-1	-0.10	-1.85**	-229.72**	-6.63	-0.99*	2.81**	-0.48	0.33	2.81**	1.06**
S.E(si) ±		0.74	0.39	60.19	4.27	0.44	0.57	0.33	4.50	1.08	0.21

*, ** Significant at 0.05 and 0.01 levels, respectively

DF=Days to 50% flowering, DH= Days to 50% harvesting, AFW= Average fruit weight (g), PH= Plant height (cm), NB= Number of branches, FL= Fruit length (cm), FD= Fruit diameter (cm), FS= Fruit size (cm^2), NFPP= Number of fruit per plant, YPP= Yield per plant (kg.)

be utilization in F_1 generation only for development of hybrid varieties. Out of 21 crosses, 5 crosses showed negative estimates and the best crosses for early flowering were P-2 X P-3 (-7.72), B-14 x R-1 (-3.27)andC-2 x P-3(-3.24), respectivelywhereas,out of 15 crosses, 7 crosses showed negative significant estimate. The best crosses C-2 x B-14 (-5.37), P-2 x I-9 (-3.23) and C-2 x R-1 (-2.77) was found to the best combination for days to 50 % harvesting (Table 3). Seven crosses exhibited significantly positive estimates, which is considered desirable and the best three crossesfor average fruits weightwere P-1 x C-2 (434.91), P-3 x I-9 (569.17) and P-3 x R-1 (478.43).P-1 x P-2 (8.18), P-1 x R -1 (18.19), P-2 x P-3 (917.16), C-2 x I-9 (23.31) and P-3 x I-9 (10.39) exhibited highest SCA effects for plant height, whereas the significant and positive SCA effects were obtained in five crosses of eight crosses exhibiting positive estimates and the cross combinations as good specific combiners for number of branches/ plant were P-2 x P-3(1.82), C-2 x I-9 (1.45) and P-2 x R-1 (1.27).

Six out of 12 significant crosses showed positive estimates and the best crosses for long fruit/ plant were C-2 x P-3(4.55), I-9 x R-1 (2.81) and C-2 X B-14(2.34), whereas out of fourteen crosses, six crosses exhibited significantly positive and the best crosses combination were P-3 x R-1 (1.67), P-3 x I-9 (1.44) and B-14 x I-9(0.63) for fruit diameter.The best crosses for fruit size were C-2 x P-3 (29.22), C-2 x B-14 (22.15) and B-14 x I-9 (20.01).Five crosses proved to be superior combination for the trait exhibiting highly significant positive SCA effects and the best crosses combination were P-2 x R-1(7.92), C-2 x P-3 (6.73) and P-2 x B-14 (2.32) for number of branches/ plant, whereas the best three crosses for yield per plantI-9 x R-1(1.06), C-2 x P-1 (0.86), and P-1 x P-3 (0.74). The crosses that were good specific combiners for earliness i.e. Days to 50 % flowering and days to 50 % harvesting were C-2 x P-3, I-9 x R-1 and P-3 x I-9. The combinations for plant height was P-1 x P-2, whereas P-3 x R-1was best for average fruit weight. P-1 x I-9, P-3 x R-1 and P-2 x R-1 were superior, respectively for fruit length, fruit diameter, fruit size, number of fruit per plant and yield per plant the superior fruit size number of plant and yield combination SCA effects.

The good general combiners generally possess high additive gene effects compared to poor general combiners. Therefore, it may be concluded that high SCA effects of crosses involving good x poor combiners might have resulted due to the interaction of additive vs. non-additive (dominance) components, whereas desirable SCA effects crosses involving poor x poor combiners may be due to dominance x dominance type of gene action. In present investigation, crosses showing significant SCA effects involving good x poor, poor x poor, good x good, average x poor, good x average x average general combiners as parents were observed. This indicated the importance of genetic divergence of the lines involved in the crosses for different characters, which might be due to the presence of unfavorable gene in the parent for these characters.

Desirable positive and significant SCA effects were observed in a number of cross combinations for different traits. Similar pattern of association between SCA effects for yield/ plant with other yield attributing traits have been reported by Das and Barua (2001), Singh *et al.* (2002) and Sao and Mehta (2010).

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