Pak. J. Sci. Ind. Res. 2006 **49** (2) 134-139

Genetic Architecture of Yield in Eggplant (*Solanum melongena*)

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(received September 13, 2005; revised February 16, 2006; accepted March 31, 2006)

Abstract. The genetic architecture of yield in eggplant was studied in a nine parent half diallel cross. The values of mean square for GCA (general combining ability) and SCA (specific combining ability) were highly significant which suggested the presence of both additive and non-additive genetic variance in the population. The higher magnitude of GCA, as compared with SCA, indicated predominance of additive genetic variance. In most of the cases, the cross between poor and poor parents showed positive SCA effect for yield per plant, which indicated the higher yield. The estimates of better parent heterosis ranged from 3 to 90 percent and the mid-parent heterosis ranged from 30 to 105 percent. Analysis for genetic components of variation suggested that additive components were more important in the inheritance of yield per plant. This character was observed being controlled by two to three pairs of genes or groups of genes. Narrow sense heritability was 21 percent indicating probability of selection in generations. The graphical analysis also indicated wide genetic diversity among the parents.

Keywords: eggplant, combining ability, heterosis, genetic architecture, *Solanum melongena*, additive genetic variance

Introduction

Eggplant (*Solanum melongena*) is an important, widely and round the year cultivated vegetable in Bangladesh, both with respect to its production and the area of cultivation. However, its production statistics have become almost stagnant, as the yield per hectare is not increasing to meet the food requirements of the increasing human population. The vegetable is cultivated on an area of about 64,234 hectares, with a total production of 381,420 tons; the average yield being only 5.93 tons per hectare (BBS, 2004). This is a very low vegetable yield, as compared with that obtained in other tropical countries. A large number of farmers are using their local varieties having different genotypes, most of which have lost their potentiality due to low percentage of cross-pollination (up to only 40%). Besides, only a limited number of progressive farmers are sowing the commercial hybrid varieties, namely, Tarapuri, Challenger, etc. These hybrid varieties, however, are not available to a large majority of the farmers due to high price of seeds. A well-planned and dynamic eggplant breeding research programme is therefore needed to meet the demand of eggplant vegetable production. Furthermore, hybrid varieties may play a vital role in satisfying the interests of both producers and consumers.

The understanding of the nature and magnitude of gene interaction is an important factor in the development of an effective breeding programme. The diallel analysis provides an efficient means of rapidly obtaining an overall picture of the genetic control of a character in a set of parents in the early generations. In the Bangladesh context, the information on this aspect of eggplant is insufficient. Therefore, the present study was undertaken to investigate the genetic architecture of yield in eggplant.

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Materials and Methods

The eggplant breeding studies were carried out at the experimental fields of Olericulture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute at Gazipur (HRC, BARI), during the winter season of 2002-2003. Seeds of the nine parents used in the study were: P1= BL081 (the fruit size slightly longer than broad and the colour green mottle); P2 = BL083 (the fruit size several times as long as broad and the colour deep purple); P3 = B009 (the fruit size several times as long as broad and the colour purple); P4 = Kazla (the fruit size three times as long as broad and the colour deep purple); P5 = BL113 (the fruit size three times as long as broad and the colour purple-mottle); P6 = BL099 (the fruit size several times as long as broad and the colour purple green); P7 = Uttara (the fruit size three times as long as broad and the colour light purple); P8 = BL114 (the fruit size slightly longer than broad and the colour deep purple); and P9 = Islampuri (the fruit size as long as broad and the colour deep purple).

The parents and their thirty-six hybrids (excluding reciprocals), were sown on the seedbeds on 16th September 2002. Seedlings (45-day old), were transplanted in the main field on 30th October 2002. The experiment was laid out in a RCB design with three replications. The unit plot size was 7.5 m × 0.70 m and 10 plants per entry were transplanted in a plot, with the plant spacing of 75 cm in a single row, maintaining a row to row distance of 70 cm. Data on yield per plant were recorded from five randomly selected plants from each parental and hybrid lines per replication. The data were statistically analysed following the procedures of Jinks (1971), Griffing (1956) and Hayman (1954).

Results and Discussion

Combining ability. The values of mean sum of square for both GCA (general combining ability) and SCA (specific combining ability) were highly significant for yield per plant, which suggests the presence of both additive and non-additive genetic variance in the eggplant population (Table 1). However, the higher magnitude of GCA compared to SCA indicated predominance of additive genetic variance. The GCA component is primarily a function of the additive genetic variance. The general combining ability of parents plays a significant role in the selection of parents for breeding trials. A parent with the higher positive significant GCA effects is considered as a good general combiner for yield improvement. The magnitude and direction of the significant effects for the nine parents was expected to provide meaningful comparisons and were likely to yield indicators for future breeding programmes.

Additive genetic variance for yield in eggplant has been also reported by several authors (Kumar *et al.,* 1996; Padmanabham and Jagdish, 1996; Chadha and Hegde, 1989; Rashid *et al.,* 1988; Kumar and Ram, 1987). Whereas the SCA effects signify the role of non-additive gene action in the expression of the characters, it also indicates the highly specific combining ability leading to highest performance of some specific cross combinations. This explains the basis for its relationship to a particular cross. Verma (1986) has reported non-additive genetic variance, while Dahiya *et al.* (1985) observed both additive and non-additive effects for this character in eggplant.

Table 1. Analysis of variance of general and specific combining abilities (GCA and SCA, respectively) and heterosis for yield per plant

Combining ability type	Mean sum of square for combining ability	Source of variation	Mean sum of square for heterosis
GCA	231628**	Genotype	605797**
SCA	195335**	Replication	41840**
Error	9870	Error	29610

** significant at 1% level

The higher GCA variance, as compared to SCA variance, suggested the predominance of additive genetic variance. Peter and Singh (1976) have also reported that fruit yield per plant was controlled by both additive and non-additive gene action. Similar results were also observed by Dahiya *et al.* (1985). Additive genetic variance for yield has been reported by Chadha and Sharma (1989), Saha (1989), and Verma (1986). On the contrary, Singh *et al.* (1978) observed that the yield per plant was controlled by non-additive gene action in the F_1 and F_2 generations. Chadha and Hegde (1989), and Kumar and Ram (1987) have also reported on the importance of non-additive genetic variances.

The parent P4 showed the highest positive significant GCA effects followed by the parent P1 (Table 2). On the contrary to these two parents, P9, P2, P6 and P7 showed significant negative GCA effects for yield per plant. Therefore, the parent P4 and P1 were the best general combiners to be used in crosses for the improvement of yield per plant. Chaudhary and Malhotra (2000) reported significant GCA for yield in eggplant. Several other workers have also reported some good general combiners for yield elsewhere (Kumar *et al.*, 1996; Patel *et al.*, 1994; Singh *et al.*, 1991).

Out of the 36 cross combinations, 24 crosses showed positive SCA effect for yield, while among these, 22 crosses exhibited positive significant SCA effects (Table 2). The highest significant positive SCA effects were shown by the hybrid P4 × P5 (858**), followed by P2 × P8 (688**), P4 × P8 (614**) and P2 × P5 (605**). Thus, P4 × P5 was the best combination (good × poor combiner), followed by the other three hybrids for yield per plant in eggplant. Good specific combining abilities for fruit yield in eggplant have been reported (Chaudhary and Malhotra, 2000; Kumar *et al.*, 1996; Padmanabham and Jagadish, 1996; Patel *et al.*, 1994).

Heterosis. All the corss combinations showed positive mid-parent heterosis (Table 3). Among them, 28 hybirds showed significant positive mid-parent heterosis for yield. The estimates of mid-parent heterosis ranged from 30 to 105%. The highest heterotic response for yield was observed in hybird P4 x P5, followed by P2 x P5 (100%) and P2 x P8 (94%). Out of the 36 corsses, 35 hybirds showed positive-better parent heterosis. Among these, 23 hybirds had significant positive better-parent heterosis. The estimates of better-parent heterosis ranged from 3 to 90%. The highest significant positive heterotic effect was observed in the hybird P4 x P5 (90%), followed by P2 x P5 (76%). Dharmegowda (1977) concluded that the increase in yields of eggplant hybirds was mainly due to fruit number and weight, while Balamohan *et al.* (1983) and Singh and Swarup (1971) reported that heterosis in yield was attributed to increase in the number of branches, fruit number and length.

Genetic components of variation. The estimate of genetic components of variation and their ratios are presented in Table 4. The estimate of additive genetic variance (D) was significant for the vegetable yield per plant. The results indicated that the additive component was important in the inheritance of the trait. The h_2 (the dominance component) value was also highly significant. The ratio $(H_1/D)^{1/2}$, which measures the degree of dominance over all loci, indicated that the additive component predominates for the character. The component F determines the relative frequencies of dominance to recessive alleles in the parents. The negative value of F indicated that the proportion of recessive alleles was more than that of dominant alleles for yield per plant. The ratio $H_2/4H_1$ measures the proportion of positive and negative alleles at all loci. The value was 0.24 indicating the symmetric distribution of positive and negative alleles at all loci. The ratio of the number of dominant and recessive alleles, determined from $(4DH_1)^{1/2} + F/(4DH_1)^{1/2} - F$ was less than 1.0, which confirmed the results obtained from $H_2/4H_1$.

The ratio h_2/H_2 estimates the number of genes or groups of genes. It was found that two to three pairs of genes or groups of genes were involved in controlling the character. Heritability in the narrow sense was 21% for yield, indicating probability of selection in the generations.

Graphical analysis. Graphical analysis of parent-offspring covariances (Wr) on array variances (Vr) is shown in Fig. 1. It was observed from the Wr/Vr graph that the slope of the regression line for fruit yield was significantly below 1.0 (0.13±0.05), suggesting significant non-allelic interaction for this character. The regression line intersected the Wr axis above the origin, suggesting incomplete to partial dominance in addition to the interaction. The relative values of Vr and Wr showed that the parent P3 had the most dominant alleles, while the parent P5 had the most recessive alleles (Fig. 1). The other parents fell in between suggesting the equal frequency of dominant and recessive alleles.

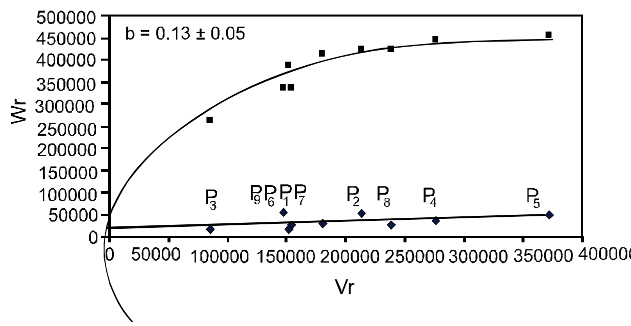

Fig. 1. Array variances (Vr) and parent-offspring covariances (Wr) regression and limiting parabola for yield per plant.

Table 2. Specific and general combining ability effects (SCA and GCA, respectively) for yield per plant

Female parents/ statistical analysis	Specific combining ability									General combining ability
	Male parents									
	P1	P2	P3	P4	P5	P6	P7	P8	P9	
P1		-252**	25	266**	432**	174*	515**	-271**	127	107**
P2			165*	-307**	605**	236**	51	688**	30	-97**
P3				-324**	241**	111	-159	320**	456**	-05
P4					858**	374**	233**	614**	-97	287**
P5						99	-369**	-391**	-195*	86**
P6							-210*	-318**	478**	-84**
P7								228**	316**	-85**
P8									-74	00
P9										-209**
SE	(Sij)				80					
SE	(Gi)									28
5%					16					56
1%					212					74

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

Table 3. Mean performance and percent heterosis over mid-parent and better-parent for yield per plant in eggplant

Crosses/ parents/ statistical analysis	Mean performance (g/plant)	Yeild per plant (% improvement)		Crosses/ statistical analysis	Mean performence (g/plant)	Yield per plant (% improvement)	
		mid-parent	better-parent			mid-parent	better-parent
P1 × P2	1614	23	3	P4 × P5	3087	105**	90**
P1 × P3	1983	32**	27*	P4 × P6	2433	71**	50**
P1 × P4	2516	58**	55**	P4 × P7	2292	52**	41**
P1 × P5	2481	68**	59**	P4 × P8	2757	79**	70**
P1 × P6	2053	48**	31*	P4 × P9	1837	45**	13
P1 × P7	2395	62**	53**	P5 × P6	1957	50**	41**
P1 × P8	1692	12	8	P5 × P7	1489	7	7
P1 × P9	1882	52**	20	P5 × P8	1551	9	6
P2 × P3	1919	54**	34**	P5 × P9	1538	33**	11
P2 × P4	1740	30**	7	P6 × P7	1478	13	6
P2 × P5	2450	101**	76**	P6 × P8	1454	9	- 0
P2 × P6	1911	68**	57**	P6 × P9	2041	91**	68**
P2 × P7	1727	41**	24*	P7 × P8	2001	41**	37**
P2 × P8	2448	95**	68**	P7 × P9	1880	63**	35**
P2 × P9	1580	60**	50**	P8 × P9	1573	32*	8
P3 × P4	1814	19	12				
P3 × P5	2178	56**	52**				
P3 × P6	1878	42**	31**				
P3 × P7	1609	14	13				
P3 × P8	2171	50**	49**				
P3 × P9	2078	77**	47**				
P1	1563						
P2	1054						
P3	1429						
P4	1622						
P5	1388						
P6	1216						
P7	1387						
P8	1459						
P9	917						
SE	51	14	12	SE	51	14	12
LSD (0.05)		28	24	LSD (0.05)		27	24
LSD (0.01)		37	32	LSD (0.01)		37	32

*significant at 5% level; **significant at 1% level; LSD = least significant difference; SE = standard error

Table 4. Estimates of genetic components of variation and their ratio

Component of variation	Yeild per plant	Component of variation	Yeld per plant
D	31994 ±32215	$(H_1/D)^{1/2}$	4.53
H_1	655961 ** ±71105	$H_2/4H_1$	0.24
H_2	633009 ** ±61125	$\frac{(4DH_1)^{1/2} + F}{(4DH_1)^{1/2} - F}$	0.34
F	-44850 ±75152	h_2/H_2	2.11
h_2	1333849 ** ±40948	h_2 (narrow-sense)	0.21
E	29610 ** ±10187		

**significant at 1% level; D = additive genetic variance; H_2 = dominance component

All the Wr, Vr points fell within the boundary of the limiting parabola and the parents also clustered into four distinct groups on the regression line showing diversity in the parents. Singh *et al.* (1982) reported that the top five high yielding crosses in eggplant showed overdominance for fruit yield per plant. Gopinath and Madalageri (1986) and Dahiya *et al.* (1984) also recorded overdominance for fruit yield in eggplant, while Singh (1984) reported partial dominance.

Conclusions

In the present study, the parents, P4, P1 and P5 were found to be good general combiners for yield per plant and may be used in breeding programmes for the development of high yielding varieties. The crosses, P4 × P5, P2 × P8, P4 × P8, and P2 × P8 were found to be promising for high yielding. The additive components of variation were important for the yield per plant. The genetic components of variation analysis suggested that the proportion of recessive alleles was more than that of dominant alleles in the parents. The yield was observed being controlled by two to three pairs of genes or groups of genes. The graphical analysis indicated wide genetic diversity among the parents.

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