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Hybrid vigour and combining ability studies for fruit quality characters in egg plant *(Solanum melongena* l.)

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Hybrid vigour and combining ability of 45 egg plant hybrids obtained from the diallel mating (excluding reciprocals) of ten elite homozygous lines obtained from the Main Vegetable Research Station, Anand, Gujarat, India, were studied for different fruit quality characters. Maximum hybrid vigour was observed for total soluble sugars, while high heterosis was noticed for number of seeds per fruit and its ratio with fresh marketable fruit weight and mature fruit weight. Fresh marketable fruit weight had recorded moderate mid-parent heterosis to an extent of 81.17 per cent, and low heterobeltiosis and standard heterosis, to an extent of 39.05 and 27.50 per cent, respectively. High heterosis was observed in crosses involving at least one good parent, identified on the basis of mean performance for the trait. The combining ability analysis also revealed pre-ponderant non-additive gene action for majority of the fruit quality traits studied, indicating the importance of heterosis breeding for improvement of these traits. A perusal of the general combining ability effects of the parents studied revealed Bombay Gulabi and Surati Ravaiya to be good general combiners for fresh marketable fruit weight. These parents were also noticed to be good combiners for mature fruit weight, seed number/mature fruit weight and total soluble sugars. Desirable specific combining ability effects were noticed in several hybrids for the various fruit quality traits studied. Among these, AB 98-13 x Bombay Gulabi and Surati Ravaiya x JBPR 1 hybrids had recorded high mean, heterosis and specific combining ability effects for fresh marketable fruit weight in addition to desirable levels of total phenols and fruit drymatter. The hybrid, Surati Ravaiya x JBPR 1 had also recorded desirable heterosis and specific combining ability effects for total soluble sugars. Hence, these hybrids are identified as potential high yielding, heterotic and quality egg plant hybrids for commercial exploitation.

Key words *:* Egg plant, Hybrid vigour, Combining ability, Fruit quality

INTRODUCTION

EGG plant is one of the most common, highly productive and popular vegetable crops. It is quite popular as the poor man's crop and is mostly cultivated in the rainy season. Average productivity of the crop is however, reported to be low, mainly due to non-availability of suitable high yielding varieties/hybrids (Varghese and Vahab, 1994). Improvement in the productivity levels of the crop are being attempted through the exploitation of hybrid vigour. Fruit quality is also an important consideration in egg plant breeding programs, as hybrids and varieties with high fruit drymatter and total soluble sugars in addition to low seed content and total phenols are highly desired by the consumers and fetch premium market price, while fresh marketable fruit weight is important from the producer's view point. For development of superior hybrids, information on heterosis and combining ability is a pre- requisite, as they help in the identification of superior parents with better general combining ability and heterotic crosses with high specific combining ability effects (Singh *et al*., 1991). Knowledge regarding the nature of gene action governing quantitative traits is also essential for systematic crop improvement programmes (Chaudhary and Malhotra, 2000). However, little information is available on the extent of heterosis, nature of gene action and combining ability for fruit quality characters in egg plant. The present investigation was undertaken in this context to elucidate information on the extent of heterosis, nature of gene action and combining ability of egg plant genotypes for fruit quality characters, in addition to identification of suitable high yielding, heterotic and quality hybrids for commercial exploitation.

MATERIALS AND METHODS

The experimental material comprised of ten elite homozygous lines of egg plant, namely, KS 224, JB 64-1-2, AB 98-10, AB 98-13, PLR 1, Gandhinagar Local, Bombay Gulabi, Morvi 4-2, Surati Ravaiya and JBPR 1 obtained from the germplasm collections maintained at the Main Vegetable Research Station, Gujarat Agricultural University, Anand, Gujarat. These lines were involved in a 10 x 10 diallel mating (excluding reciprocals) to produce 45 hybrids. These 45 hybrids and their ten parents were evaluated in a complete randomized block design with three replications for fruit quality characters, namely, fresh marketable fruit weight (g), mature fruit weight (g), fruit drymatter (mg/100mg), 1000-seed weight (g), total soluble sugars (mg/100mg) and total phenols (mg/100mg). The experiment was undertaken at the Main Vegetable Research Farm, Anand, Gujarat.

Sowings were undertaken in the nursery during the last week of July and transplanting of the seedlings was effected 35-40 days after sowing, depending on the growth of seedlings. The normal, healthy and vigorous seedlings of each genotype were transplanted in a single row plot of 6 m length, with a spacing of 90 x 60 cm and the crop was raised following recommended package of practices. Observations were recorded on five random, competitive plants tagged for each entry, in each replication and the average values were computed. Data on fresh marketable fruit weight was obtained for each picking and the average was computed, while the observations on fruit drymatter, total soluble sugars and total phenols were recorded as the mean values of five random fresh fruits, taken from each genotype in each replication. For mature fruit weight, five random mature fruits were taken and the average was computed, while for 1000-seed weight and number of seeds per fruit, five random mature fruits were taken for seed extraction and weighment of the seeds obtained after extraction, washing and drying. The estimates of total soluble sugars and total phenols were obtained following the procedures outlined by Dubois *et*

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al.(1956) and Malik and Singh (1980), respectively; and the values were computed utilizing the formulas provided by Sadasivam and Manickam (1992). Heterosis over mid-parent, better parent and the standard check, Bombay Gulabi were obtained as per the procedures outlined by Fonesca and Patterson (1968) and their significance was tested using t-test as suggested by Snedecor and Cochran (1967). Further, the least parent was considered as the better parent for the negative traits, namely, 1000-seed weight, number of seeds per fruit, seed number/ fresh marketable fruit weight, seed number/mature fruit weight and total phenols. The estimates of combining ability variances and effects were obtained using Diallel analysis, Method 2 of Model I, suggested by Griffing (1956).

RESULTS AND DISCUSSION

The analysis of variance revealed significant mean squares for the genotypes, parents and hybrids for fruit quality characters studied, indicating the existence of sufficient variation in the material under investigation. Further, the parent vs. hybrids component of variation was also significant for majority of the traits studied, indicating the existence of significant levels of heterosis in the material studied.

An analysis of hybrid vigour for the fruit quality traits (Table 1) revealed maximum expression of heterosis for total soluble sugars. High hybrid vigour to an extent of 766.67 per cent over mid-parent, 505.34 per cent over better parent and 319.92 per cent over the standard check was observed for the trait. In contrast, Dahiya *et al.*(1984) had reported low better parent heterosis and standard heterosis for the trait to an extent of 3.64 and 8.56 per cent, respectively. Further, number of seeds per fruit and its ratio with fresh marketable fruit weight and mature fruit weight had recorded high levels of maximum heterosis (>100 per cent) in the present investigation, while the maximum heterosis observed for 1000-seed weight and fruit drymatter was low (<50 per cent). Dahiya *et al.* (1984) had also reported similar low better parent heterosis and standard heterosis for fruit drymatter.

Significant and desirable levels of hybrid vigour over mid-

Table 1 : Mid-parent, better parent and standard heterosis (Over Bombay Gulabi) for fruit weight and seed characters in egg plant

Character	Mid-parent Heterosis			Better parent Heterosis			Standard heterosis		
	Range	No. of desirable heterotic hybrids	Best hybrid combination	Range	No. of desirable heterotic hybrids	Best hybrid combination	Range	No. of desirable heterotic hybrids	Best hybrid combination
Fresh marketable fruit weight	-32.90** to 81.17**	6	Surati Ravaiya x JBPR 1	-45.75** to 39.05*	4	PLR 1 x Gandhinagar Local	-65.00** to 27.50**	2	Surati Ravaiya x JBPR 1
Mature fruit weight	-71.05** to 73.14**	7	KS 224 x AB 98-13	-82.80** to 62.35**	1	KS 224 x AB 98-13	-88.97** to -21.63**	-	-
Fruit dry matter	-22.89** to 16.13**	4	Bombay Gulabi x Morvi 4-2	-28.62** to 8.69**	3	JB 64-1-2 x AB 98-10	-7.14** to 42.86**	35	JB 64-1-2 x AB 98-10
1000-seed weight	-26.77 to 21.76	3	AB 98-10 x Bombay Gulabi	-35.97** to 17.60**	12	JB 64-1-2 x PLR 1	-25.43 to 33.07	-	-
Number of seeds per fruit	-61.91** to 108.43**	6	AB 98-13 x Surati Ravaiya	-45.42* to 206.62**	2	AB 98-13 x Morvi 4-2	-23.90 to 286.66**	-	-
Seed number/ fresh marketable fruit weight	-61.30** to 157.15**	5	AB 98-13 x Surati Ravaiya	-58.99** to 269.77**	2	AB 98-13 x Surati Ravaiya	-26.12 to 269.77**	-	-
Seed number /mature fruit weight	-71.29** to 115.62**	5	AB 98-13 x Morvi 4-2	-45.44 to 446.19**	1	AB 98-13 x Morvi 4-2	-35.38 to 446.19**	-	-
Total soluble sugars	-95.13** to 766.67**	21	KS 224 x JB 64-1-2	-96.37** to 505.34**	18	KS 224 x JB 64-1-2	-92.34** to 319.92**	21	KS 224 x JB 64-1-2
Total phenols	-69.41** to 109.84**	24	AB 98-13 x Bombay Gulabi	-70.37** to 105.37**	32	AB 98-13 x Bombay Gulabi	-71.11** to 42.22**	36	AB 98-13 x Bombay Gulabi

*,** Significant at 5 and 1 per cent levels, respectively

parent, better parent and the standard check, Bombay Gulabi were also noticed in several hybrids for the different fruit quality traits studied (Table 1), indicating the potential of egg plant hybrids for commercial exploitation. Significant and desirable levels of mid-parent heterosis were noticed for fresh marketable fruit weight in six hybrids, while four hybrids had recorded significant and desirable better parent heterosis for the trait. Further, the hybrids, AB 98-13 x Bombay Gulabi and Surati Ravaiya x JBPR 1 had recorded significant and desirable levels of mid, better and standard heterosis for the trait, in addition to significant and desirable heterosis over mid, better and standard parents for total phenols and over standard parent for fruit drymatter. The hybrid, Surati Ravaiya x JBPR 1 had also exhibited significant and desirable levels of heterosis over mid, better and standard parents for total soluble sugars. Hence, these hybrids are identified as promising high yielding and heterotic hybrids with good fruit quality. The analysis of such elite crosses exhibiting significant and desirable heterosis for the various traits revealed the involvement of at least one good parent, identified on the basis of mean performance. Similar findings were reported earlier by Dixit and Gautam(1987).

The analysis of variance for combining ability (Table 2) revealed significant mean squares due to both *gca* (general combining ability) and *sca* (specific combining ability) for all the fruit quality characters, except 1000-seed weight, indicating the importance of both additive and non-additive gene actions for these traits. However, non-additive gene action was preponderant for all the fruit quality characters studied, with the exception of mature fruit weight, indicating the need for heterosis breeding for improvement of these traits. The predominant role played by non-additive gene action in brinjal has also been reported by Patil and Shinde(1989). Predominance of non-additive gene action for fruit dry matter (Kapadia, 1995), total soluble sugars and total phenols (Patel, 2003) has also been reported earlier.

A perusal of the general combining ability effects for

Table 2 : Combining ability analysis of variance for fruit weight and seed characters in egg plant

Source	Degrees of freedom	Fresh marketable fruit weight	Mature fruit weight	Fruit dry matter	1000-seed weight	Number of seeds per fruit	Seed number/ marketable fruit weight	Seed number/ mature fruit weight	Total soluble sugars	Total phenols
gca	9	2095.63**	162691.65**	1.05**	0.76**	14773306.56**	61.26**	22.06**	6.92**	0.007**
sca	45	447.95**	7683.79**	0.43**	0.16	278668.99**	91.68**	1.22**	6.90**	0.016**
Error	108	58.51	1673.63	0.01	0.11	45506.99	18.32	1.15	0.001	0.000
σ^2gca		169.76	13418.17	0.09	0.05	118983.29	3.58	1.74	0.58	0.00
σ^2sca		389.44	6010.16	0.42	0.05	233162.00	73.36	3.07	6.90	0.01
σ^2gca/ó^{2}sca		0.44	2.23	0.21	1.00	0.51	0.05	0.57	0.08	0.00

*,** Significant at 5 and 1 per cent levels, respectively

Table 3 : Ranking of parents with respect to general combining ability effects and number of hybrids exhibiting significant and desirable specific combining ability (*sca*) effects for fruit weight and seed characters in egg plant

Characters	Ranking of Parents for general combining ability effects										Number of hybrids with significant and desirable *sca* effects
	KS 224	JB 64-1-2	AB 98-10	AB 98-13	PLR 1	Gandhi-nagar Local	Bombay Gulabi	Morvi 4-2	Surati Ravaiya	JBPR 1	
Fresh marketable fruit weight	Low	Low	Low	Low	Low	Low	High	Low	High	Low	7
Mature fruit weight	Low	Low	Low	Low	Low	Low	High	High	High	Low	5
Fruit dry matter	Low	High	High	Low	Low	High	Low	Low	Low	High	19
1000-seed weight	Low	Low	Low	Low	High	High	Low	Low	Low	Low	9
Number of seeds per fruit	Low	High	High	Low	High	Low	Low	Low	Low	High	7
Seed number/fresh marketable fruit weight	Low	Low	Low	Low	Low	Low	Low	Low	Low	High	10
Seed number /mature fruit weight	High	Low	Low	Low	Low	Low	High	High	High	Low	6
Total soluble sugars	High	High	Low	Low	High	Low	High	High	High	High	20
Total phenols	Low	Low	Low	Low	High	Low	Low	Low	Low	Low	14

parents (Table 3) revealed Bombay Gulabi and Surati Ravaiya to be good combiners for fresh marketable fruit weight. PLR 1 was noticed to be a good combiner for low seed weight, seed number and total phenols, in addition to high total soluble sugars, while JBPR 1 was observed to be a good combiner for fruit dry matter, seed content, seed number/fresh marketable fruit weight and total soluble sugars. Further, Morvi 4-2 for mature fruit weight; JB 64-1-2, AB 98-10 and Gandhinagar Local for fruit drymatter; Gandhinagar Local for 1000-seed weight; JB 64-1-2 and AB 98-10 for number of seeds per fruit; KS 224 and Morvi 4-2 for seed number/mature fruit weight; and KS 224, JB 64-1-2 and Morvi 4-2 for total soluble sugars were also observed to be good combiners. Hence, these parents may be used in crop breeding programs aimed at improvement of the respective traits.

Table 4 : Details of the promising hybrids identified for fresh marketable fruit weight in egg plant

Promising hybrids	Mean performance	Heterosis			Specific combining ability effect	Characterization of parents with regards to general combining ability effects	Significant and desrible performance noticed for other characters w.r.t mean performance, standard heterosis and *sca* effects
		Over mid-parent	Over better parent	Over best parent			
AB 98-13 x Bombay Gulabi	158.33	60.47**	18.75*	18.75*	57.38**	Low x High	Fruit drymatter and total phenols
Surati Ravaiya x JBPR 1	170.00	81.17**	27.50**	27.50**	71.55**	High x Low	Fruit drymatter, total phenols and total sugars

*,**Significant at 5 and 1 per cent levels, respectively

The study of specific combining ability effects (Table 3) revealed significant and desirable effects for several hybrids with regards to the fruit quality characters studied. Seven hybrids had exhibited significant and desirable specific combining ability effects for fresh marketable fruit weight. Among these, only two hybrids (AB 98-13 x Bombay Gulabi and Surati Ravaiya x JBPR 1) had recorded significant and desirable specific combining ability effects, coupled with high mean performance and heterosis for fresh marketable fruit weight (Table 4). An analysis of the general combining ability effects of the parents for these elite crosses revealed the involvement of one high and one low parent. The production of such superior hybrids with the combination of high and low general combining ability parents has also been reported earlier (Chaudhary and Malhotra, 2000). Das and Barua (2001) inferred that such crosses would throw up desirable transgressive segregants, if the additive genes present in the good combiner and complementary epistatic effects, present in the cross, act in the same direction so as to maximize the desirable plant attributes. Hence, advance generation progenies of these crosses should be studied for isolation of desirable transgressive segregants. Further, the two hybrids had recorded desirable specific combining ability effects in addition to desirable mean performance and standard heterosis for total phenols and fruit drymatter. In addition, Surati Ravaiya x JBPR 1 hybrid had recorded desirable specific combining ability effects, mean performance and heterosis for total soluble sugars. Hence, these hybrids are identified as potential quality hybrids for commercial exploitation after evaluation in multi-location and on-farm trials.

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