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Combining ability for yield and yield-related traits in Manjarigota type brinjal (*Solanum melongena* L.)

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ABSTRACT

Twenty one F_1 crosses of Manjarigota type of brinjal in a line X tester (mating design) involving seven lines and three testers were evaluated for general combining ability (GCA) of the parents and specific combining ability (SCA) of the crosses for various quantitative characters. Combining ability analysis revealed that two lines viz, IIHR-574 (L3) and IIHR-575 (L4), and two testers, IIHR-438-2 (T1) and IIHR-500A (T2) were good general combiner for most of the characters studied and, hence, can be used for further improvement of quantitative traits in Manjarigota type of brinjal. Among the 21 F_1 crosses evaluated, two crosses, L4xT2 and L3xT3, were found to be good specific combiners for most of the yield contributing traits, viz, fruit length, fruit diameter, number of fruits per plant, fruit yield per plant and plant height. Therefore, these cross-combinations can be commercially exploited for heterosis breeding to isolate desirable genotypes of manjarigota type brinjal.

Key words: Manjarigota, brinjal (egg plant) heterosis, combining ability, GCA, SCA

INTRODUCTION

Brinjal (*Solanum melongena* L.) is an important solanaceous vegetable crop of Indian origin showing a wide variability for colour, size and shape of fruits. It is often referred to as a poor man's crop (Sharma *et al*, 2004). It is one of the cosmopolitan and most popular vegetables, grown in almost all parts of the country. It is cultivated in an area of about 6.8 lakh hectares, with production of 118.96 lakh tones and productivity of 17.5t per ha. Among Brinjal growing states in India, West Bengal ranks first in area (1.58 lakh ha) and, also, in production (28.70 lakh t) and productivity (18.1 t/ha) (Anon., 2011).

Manjarigota type of brinjal is purple in colour, with white stripes and is in great demand in Karnataka, Maharashtra, Tamil Nadu and parts of Andhra Pradesh. Information on genetic make-up of Manjarigota type brinjal is limited. Hence, considering its demand, an attempt was made to estimate its combining ability for yield and yield components. Selection of best parents for hybridization needs to be based on complete genetic information and estimated pre-potency of potential parents. With these points in view, combining ability studies were undertaken which are a prerequisite for any heterosis breeding programme. These provide the desired information on exploitation of heterosis to enhance productivity in any crop improvement programme for commercial purposes.

MATERIAL AND METHODS

The present study was undertaken at Division of Vegetable Crops, Indian Institute of Horticultural Research (IIHR), Hessaraghatta, Bangalore, during July 2010 – May 2011. The experimental field is located at an altitude of 890 meters above MSL, 13°58' N latitude and 78°E longitude. The experimental material consisted of seven parental lines, viz, IIHR-228 (L_1), IIHR-569 (L_2), IIHR-574 (L_3), IIHR-575 (L_4), IIHR-587 (L_5), IIHR-592 (L_6), IIHR-570 (L_7), and three testers, IIHR-438-2 (T_1), IIHR-500A (T_2) and IIHR-571 (T_3). Detailed information on lines and testers used is presented in Annexure 1. Crossing was done as per L X T mating design, and a total of 21 F_1 crosses were obtained. Twenty one F_1 hybrids and ten parents were evaluated in Randomized Block Design, with three replications. Package of practices for successful cultivation of the crop was followed. Observations on five randomly-selected plants were recorded for various traits. Combining ability analysis was computed as per Kempthrone (1957).

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Annexure 1. Salient features of parents and checks used in the present study

S. No.	Parents	Source	Description
Line			
1	**(L1)** IIHR-228	IIHR, Bangalore	Plants are dwarf, spiny and highly branched; Fruits are round in shape; light purple and, calyx, highly spiny
2	**(L2)** IIHR-569	IIHR, Bangalore	Plants are tall; Fruits are round to oval in shape, medium purple in colour, with white stripes
3	**(L3)** IIHR-574	IIHR, Bangalore	Plants are medium-tall and bushy. Fruits are oval in shape and light purple in colour
4	**(L4)** IIHR-575	IIHR, Bangalore	Plants are tall and bushy. Fruits are oval, with a flat base, dark purple in colour with white strips.
5	**(L5)** IIHR-587	IIHR, Bangalore	Plants are tall and bushy. Fruits are oval in shape, purple in colour, with white stripes
6	**(L6)** IIHR-592	IIHR, Bangalore	Plants are medium-tall and bushy; Fruits are round in shape, and light purple in colour
7	**(L7)** IIHR-570	IIHR, Bangalore	Plants are tall; Fruits are oval in shape, dark purple in colour, with white stripes
Tester			
1	**(T1)** IIHR-438-2	IIHR, Bangalore	Plants are tall; Fruits are oval to oblong in shape, dark purple in colour, with white stripes
2	**(T2)** IIHR-500A	IIHR, Bangalore	Plants are tall. Fruits are oblong in shape, light purple in colour, with white stripes
3	**(T3)** IIHR-571	IIHR, Bangalore	Plants are medium-tall. Fruits are round in shape, medium-purple in colour, with white stripes
Check			
1	**Kalpataru**	Mahyco, Jalna	Plants are tall; Fruits are round in shape, medium purple in colour, with white stripes
2	**SuperMohini**	Mahyco, Jalna	Plants are medium-tall. Fruits are round in shape, dark purple in colour, with white stripes

RESULTS AND DISCUSSION

Analysis of Variance (Table 1) indicated the mean sum of squares due to the parents was significant for most of the characters, except days to first flower opening and number of primary branches (Table 1). Contribution of parents and crosses to combining ability variance, variance due to GCA of parents, SCA of crosses and the ratio of GCA to SCA for all traits, is presented in Table 2. Results revealed that SCA variance was higher compared to GCA variance for all the characters studied, indicating an involvement of non-additive genes in the inheritance of these traits. Involvement of non-additive gene action for various traits in the present investigation too is in consonance with findings of Singh *et al* (2002). Contribution of lines, as compared to testers, was found to be higher for all the characters studied, except for days to first fruit harvest, fruit length and number of primary branches. Line x Tester contribution was found to be greater for all the characters, except days to 50% flowering.

General combining ability

General combining ability (GCA) effects of lines and testers for various characters are presented in Table 3. GCA effects for days to first flower among lines and testers was negatively significant only in the line, L_3 (-1.19) and tester, T_1 (-0.79), in accordance with findings of Indiresh *et al* (2005). For days to 50% flowering, the only line, L_3 (-1.09) and testers, T_1 (-0.49) and T_3 (-0.82), showed negatively significant GCA effects. This indicates that L_3, T_3 and T_1 were good general combiners. GCA effect for per cent fruit set was highest in L_4 (4.66), followed by L_6 (1.62); among the three testers, only tester T_2 (2.63) showed a positively significant GCA effect. For days to first fruit harvest, line L_3 (-3.76) and tester T_3 (-2.47) showed negatively significant GCA effects. For fruit length, GCA effect observed in L_3 (0.54) and among testers T_2 (0.51) showed a positive significance. As for GCA effect for fruit diameter, two lines, L_3 (0.37), followed by L_6 (0.36); and, among testers, none was significant. These results confirm the findings of Rai and Asati (2011) and Padmanabham and Jagadish (1996).

A positive and significant GCA for average fruit weight was recorded in two lines, L_3 (9.63), followed by L_4 (5.52), while, none of the testers was a good general combiner. For number of fruits per plant, two lines, namely L_4 (3.49) and L_3 (1.60), recorded significant and positive GCA effect; among the three testers, only tester T_2 (0.84) showed positively significant GCA effect. Highest positive GCA effect was observed in L_4 (0.32) and L_3 (0.32), while,

only one tester, T_2 (0.18) showed positively significant GCA effect for yield per plant. GCA effect for number of seeds per fruit was negatively significant in L_5 (-1.57) and L_1 (-1.27) among the lines, while, in the testers, none was significant. This indicates that number of seeds showed be low in the fruit during its horticultural maturity (tender stage). Highest positive GCA effect was observed in the lines L_4 (5.38), followed by L_6 (4.54) and L_2 (1.84) for plant height, while, none of the testers showed a positive significance for this trait. For number of primary branches, line L_6 (0.66), followed by L_3 (0.43) and L_5 (0.40), and the tester, T_1 (1.01), showed positively significant GCA effect. Similar results were also reported by Baig and Patil (2002).

Specific combing ability (SCA)

Specific combining ability effects of crosses for various characters are presented in Table 4. Specific combining ability of the crosses studied for days to first flower opening revealed that none of the crosses were negatively significant. For days to 50% flowering, the highest negative SCA effect was found in the cross L_7 x T_1 (-1.39), followed by L_5 x T_2 (-1.31). These crosses may be considered suitable for exploitation of heterosis for earliness. SCA effect for per cent fruit set was highest in the cross L_3 x T_3 (9.61), followed by L_6 x T_1 (5.79). Negatively significant SCA effect in the cross L_1 x T_3 (-6.96), followed by L_3 x T_3 (-4.85), was seen for days to first fruit harvest. For fruit length, the cross L_4 x T_2 (1.90) recorded high SCA effect, followed by L_6 x T_2 (1.65); and, for fruit diameter, the cross L_6 x T_2 (1.73), followed by L_4 x T_2 (1.50). These results are in accordance with Das and Barua (2001).

SCA effect for average fruit weight was highest in the cross L_2 x T_3 (23.15), followed by L_7 x T_1 (18.50). For number of fruits per plant, the cross L_6 x T_3 (5.38) recorded highest SCA effect, followed by L_2 x T_1 (3.79). Good specific

Table 1. Analysis of Variance (Mean sum of Squares) of parents and hybrids for various traits in brinjal

Source of variation	Treatment	Parent	Cross	Parents Vs Crosses	Lines x Testers	Error
Degrees of Freedom	30	9	20	1	12	60
Days to first flower opening	8.01	5.41	9.27*	6.19	6.93	2.71
Days to 50% flowering	7.65**	5.04*	9.01**	3.92*	3.86*	0.84
% Fruit set	94.45**	26.93**	99.97**	591.59**	113.79**	3.81
Days to first fruit harvest	58.50**	53.70**	62.03**	31.15*	56.37**	7.16
Fruit length (cm)	4.36**	4.46**	4.27**	5.42**	5.69**	0.34
Fruit diameter (cm)	2.34**	1.83**	2.65**	0.68	3.83**	0.25
Average fruit weight (g)	693.80**	525.80**	692.68**	2230.41**	947.02**	46.00
Number of fruits per plant	40.32**	28.53**	39.12**	170.53**	42.05**	2.67
Yield per plant (kg)	0.41**	0.08*	0.45**	2.70**	0.38**	0.01
Average seed weight / fruit (g)	12.58*	8.70*	14.23*	14.65*	9.14*	2.07
Plant height (cm)	147.56**	210.56**	123.64**	59.15**	114.50**	2.29
Number of primary branches	3.97**	0.93	4.10**	28.59	2.77**	0.32

* Significant @ 5% level; ** Significant @ 1% level

Table 2. Variance of combining ability, their ratio and contribution of lines and testers in brinjal

Character	Estimated variance components			Contribution of lines (%)	Contribution of testers (%)	Contribution of lines × testers (%)
	GCA	SCA	GCA/SCA			
Days to first flower opening	0.06	3.51	0.017	26.69	28.44	44.85
Days to 50% flowering	0.13	4.25	0.031	43.30	30.96	25.72
% Fruit set	-0.35	32.69	-0.01	20.39	11.31	61.31
Days to first fruit harvest	0.14	26.63	0.005	17.63	27.84	54.52
Fruit length (cm)	-0.03	1.29	-0.028	9.25	10.77	79.96
Fruit diameter (cm)	-0.03	0.64	-0.046	9.80	3.57	86.62
Average fruit weight (g)	-6.62	17.37	-0.262	14.90	3.06	82.03
Number of fruits per plant	-0.07	10.01	-0.007	32.63	2.87	64.49
Yield per plant (kg)	0.001	0.15	0.006	37.96	11.42	50.60
Average seed weight / fruit (g)	0.13	3.30	0.039	59.71	1.71	38.56
Plant height (cm)	0.23	32.08	0.007	43.81	0.62	55.56
Number of primary branches	0.03	2.27	0.014	17.17	42.24	40.58

GCA: General Combining Ability; SCA: Specific Combining Ability

Table 3. Estimates of general combining ability (GCA) effect of parents (Lines and Testers) for different traits in brinjal

Parent	Days to first flower opening	Days to 50% flowering	% Fruit set	Days to first fruit harvest	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	Number of seeds per fruit (g)	Plant height (cm)	No. of primary branches
Lines												
L_1	0.55	0.79*	-3.57**	-0.31	-0.66**	-0.10	-3.03	-2.95**	-0.26**	-1.27*	-5.02**	-0.37
L_2	-0.50	-0.98**	-1.18	1.68	0.07	-0.10	-6.92**	-2.17**	-0.28**	1.98**	1.84**	-0.63**
L_3	-1.19*	-1.09**	-2.37**	-3.76**	0.54**	0.37*	9.63**	1.60**	0.32**	2.33**	-1.38**	0.43*
L_4	1.60**	1.79**	4.66**	2.12*	-0.00	-0.12	5.52*	3.49**	0.32**	-0.51	5.38**	-0.48*
L_5	0.58	1.12**	1.02	1.01	-0.13	0.09	-0.03	0.26	0.05	-1.57**	-6.26**	0.40*
L_6	-0.68	-0.98**	1.62*	0.46	0.01	0.36*	-6.80**	0.04	-0.11**	2.04*	4.54**	0.66**
L_7	-0.35	-0.65*	-0.18	-1.20	0.33	-0.50**	1.63	-0.28	-0.03	0.96	0.91	-0.00
SEm±	0.54	0.30	0.65	0.89	0.19	0.16	2.26	0.54	0.03	0.48	0.50	0.18
Testers												
T_1	-0.79*	-0.49*	-0.88*	-0.66	-0.10	-0.23*	-3.61*	-0.34	-0.09**	0.24	0.24	1.01**
T_2	1.28**	1.31**	2.63**	3.14**	0.51**	0.17	2.33	0.84**	0.18**	0.13	0.44	-0.29*
T_3	-0.48	-0.82**	-1.74	-2.47**	-0.40**	0.06	1.28	-0.49	-0.09**	-0.38	-0.68**	-0.72**
SEm±	0.35	0.20	0.42	0.58	0.12	0.10	1.48	0.35	0.02	0.31	0.33	0.12

* Significant @ 5% level; ** Significant @ 1% level

Table 4. Estimates of specific combining ability (SCA) effect of crosses for various traits in brinjal

Cross	Days to first flower opening	Days to 50% flowering	% Fruit set	Days to first fruit harvest	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	Number of seeds per fruit (g)	Plant height (cm)	No. of primary branches
$L_1 \times T_1$	2.26*	0.49	-3.02**	5.88**	0.08	-0.34	0.50	-0.09	0.02	-0.19	-3.79**	-1.24**
$L_1 \times T_2$	-1.54	0.01	5.69	1.07	-0.80	-0.70*	8.88*	-2.61**	-0.10	-1.91*	0.16	0.85*
$L_1 \times T_3$	-0.71	-0.50	-2.67*	-6.96**	0.71	1.04**	-9.39*	2.71**	0.07	2.11*	3.63**	0.38
$L_2 \times T_1$	0.12	-0.73	-2.10	-3.11*	1.15**	0.75*	-13.26**	3.79**	0.09	1.18	-4.72**	1.57**
$L_2 \times T_2$	0.78	1.46**	-2.77*	1.07	-1.06**	-0.27	-9.88*	0.26	-0.17*	-0.37	0.95	-1.11**
$L_2 \times T_3$	-0.91	-0.73	4.87**	2.03	-0.09	-0.47	23.15**	-4.06**	0.08	-0.81	3.76**	-0.46
$L_3 \times T_1$	-1.11	-0.28	-1.70	-0.66	-0.51	-0.50	-11.49**	-0.31	-0.19	1.29	0.05	-0.95**
$L_3 \times T_2$	2.00*	1.23*	-7.91**	5.52**	-0.90**	-0.72*	7.88*	3.15**	0.35**	1.27	-5.48**	1.37**
$L_3 \times T_3$	-0.88	-0.95	9.61**	-4.85**	1.41**	1.23**	3.60**	-2.84**	-0.16*	-2.56**	5.43**	-0.41
$L_4 \times T_1$	0.88	0.49	3.68*	-0.88	-0.12	-0.26	-27.38**	0.79	-0.41**	0.58	-4.15**	0.20
$L_4 \times T_2$	-0.39	-0.31	-0.05	-3.69*	1.90**	1.50**	13.00**	3.26**	0.66**	-1.07	11.59**	-0.03
$L_4 \times T_3$	-0.48	-0.17	-3.62**	4.58**	-1.77**	-1.24**	14.38**	-4.06**	-0.25**	0.48	-7.44**	-0.16
$L_5 \times T_1$	0.10	1.15*	-6.63**	-1.44	0.006	0.37	20.17**	-0.98	0.23**	-0.62	1.39	0.20
$L_5 \times T_2$	0.02	-1.31*	3.44**	0.41	0.68*	-0.71*	-3.77	-2.17*	-0.25**	0.21	0.62	-0.70*
$L_5 \times T_3$	-0.13	0.15	3.18**	1.03	-0.69	0.34	-16.39**	3.15**	0.02	0.41	-2.01*	0.50
$L_6 \times T_1$	-0.42	0.26	5.79**	1.44	-0.69*	-0.53	12.95**	-5.09**	-0.18**	-2.91**	8.13**	0.50
$L_6 \times T_2$	-1.43	-0.87	1.27	-4.36**	1.65**	1.73**	-4.33	-0.28	-0.15*	1.82*	-5.74**	-0.07
$L_6 \times T_3$	1.86	0.60	-7.06**	2.92	-0.95**	-1.19**	-8.61*	5.38**	0.34**	1.08	-2.38**	-0.42
$L_7 \times T_1$	-1.82	-1.39*	3.98**	-1.22	0.08	0.52	18.50**	1.90*	0.43**	0.67	3.09**	-0.28
$L_7 \times T_2$	0.56	-0.20	0.33	-0.03	-1.47**	-0.82**	-11.77**	-1.61	-0.33**	0.04	-2.11*	-0.29
$L_7 \times T_3$	1.26	1.60**	-4.32**	1.25	1.38**	0.30	-6.70	-0.28	-0.10	-0.72	-0.97	0.57
SEm±	0.95	0.52	1.12	1.54	0.34	0.28	3.91	0.94	0.06	0.83	0.87	0.32

* Significant @ 5% level; ** Significant @ 1% level

combiner for yield per plant turned out to be the cross $L_4 \times T_2$ (0.66), followed by $L_7 \times T_1$ (0.43). A negatively significant SCA effect was recorded in the cross $L_6 \times T_1$ (-2.91), followed by $L_3 \times T_3$ (-2.56) for number of seeds per fruit. For plant height, the highest significant SCA effect was noticed in the cross $L_4 \times T_2$ (11.59), followed by $L_6 \times T_1$ (8.13). SCA effect for number of primary branches was highest in the cross $L_2 \times T_1$ (1.57), followed by $L_3 \times T_2$ (1.37). These results are in conformity with findings of Dharwad *et al*, (2011).

The lines L_3 and L_4, and the testers T_1 and T_2 were good general combiners for most of the traits studied, and these may be exploited in further breeding programmes.

Among the crosses, L_4 x T_2 and L_3 x T_3 were good specific combiners for most of the yield attributing traits, and can be exploited for heterosis breeding and further subjected to selection to isolate desirable genotypes in Manjarigota type brinjal.

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