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Line × Tester Analysis for the Study of Combining Ability in Eggplant (*Solanum melongena* L.)

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Abstract Combining ability studies in brinjal for growth, yield attributes and reaction to bacterial wilt were conducted during 2010-2013 with series of experiments using 40 F_1 hybrids derived from line × tester crosses of eight female and five male parents. The estimates of SCA variance were of greater magnitude than those of GCA variances for all the traits. The relative contributions of female × males were more for all traits except for number of fruits per plant. Among 40 F_1 hybrids $L_3 \times T_3$ and $L_1 \times T_3$ possessed highly significant *sca* effects for fruit yield per plant. Whereas $L_3 \times T_2$ (-14.09) by $L_5 \times T_1$ (-14.92) and $L_7 \times T_4$ (-13.99) crosses had high and significantly negative *sca* effects for bacterial wilt resistance.

Keywords Line × tester analysis, Combining ability, Eggplant.

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Introduction

The success of hybridization depends upon the selection of suitable parental genotypes and performance of their cross combinations. Selection made on phenotypic performance alone does not lead to expected degree of heterosis. Study of relative performance of general combining ability of parents and specific combining ability of hybrids for various characters influencing quality aspects, yield and its attributes is very much useful inselecting parents for producing superior hybrids. Respectively, in breeding program for quantitative characters.

Amongst several methods to study the combining ability, line × tester analysis provides information

Table 1. Analysis of variance (mean sum of squares) for 12 characters in 8 × 5 line × testers analysis in brinjal. * Significant at 5% level; **Significant at 1% level.

Characters	Replication	Treatment	Parents	Lines	Testers	Lines × Testers
Degrees of freedom	2	52	12	7	4	1
Days to 50% flowering	0.15	122.19**	161.31**	175.85**	166.73**	37.85**
Plant height 120 DAT (cm)	43.45	407.51**	372.12**	352.68**	466.44**	130.90**
Number of primary branches	0.04	6.08**	5.28**	3.55**	6.53**	12.45**
Number of secondary branches	0.43	24.32**	30.21**	26.2219**	43.62**	4.52**
Number of flowers per cluster	0.31	5.73**	6.76**	6.44**	8.74**	1.08**
Number of fruits per cluster	0.07	2.49**	3.68**	3.57**	4.53**	1.01**
Number of fruits per plant	3.72	208.58**	318.01**	305.32	417.58	8.58
Fruit length (cm)	0.53	123.13**	144.96**	192.42**	85.76**	49.48**
Fruit diameter (mm)	4.55	866.42**	1504.08**	1354.81**	2139.46**	7.40*
Fruit weight (g)	6.03	3656.30**	5724.65**	3418.01**	9234.28**	7832.51**
Yield per plant (g)	20289.91	2382311.35**	816354.46**	409449.59**	837778.54**	3578992.22**
Bacterial wilt (%)	239.71	1044.24**	2279.67**	13.16**	29.72	27145.03**

Table 1. Continued.

Characters	Parents vs Crosses	Crosses	Error	GCA	SCA	GCA/SCA
Degrees of freedom	1	39	104	12.63**	14.15**	0.89
Days to 50% flowering	11.33**	113.00**	1.11	33.11**	108.55**	0.30
Plant height 120 DAT (cm)	197.05**	423.80**	7.16	0.41*	2.04**	0.20
Number of primary branches	0.07	6.47**	0.18	1.35*	7.01**	0.19
Number of secondary branches	2.89**	23.06**	0.27	0.40**	1.40***	0.28
Number of flowers per cluster	0.66*	5.55**	0.12	0.14**	0.50**	0.28
Number of fruits per cluster	6.74**	2.02**	0.04	9.51*	55.49**	0.17
Number of fruits per plant	94.61**	177.83**	4.43	15.13**	12.84**	1.17
Fruit length (cm)	71.42**	117.75**	0.26	94.57**	72.92**	1.29
Fruits diameter (mm)	18.58**	691.96**	1.68	192.43*	945.69**	0.20
Fruit weight (g)	3105.36**	3034.01**	6.52	137922.57	984845.13**	0.14
Yield per plant (g)	733427.04**	2906423.32**	40801.2	55.86**	78.84**	0.71
Bacterial wilt (%)	5367.94**	553.23**	362.36	12.63**	14.15**	0.89

about *gca* of parents and sca of the hybrids and further it is useful in providing information on gene action which is of great value to the vegetable breeder in adopting the appropriate breeding procedures. The present investigation was therefore undertaken to study combining ability in a line × tester analysis in brinjal.

Materials and Methods

The experiment was conducted at Department of Horticulture, GKVK, Bangalore during 2010-13. The pure genotypes viz., Arka Shirish (L_1), Arka Kusumakar (L_2), Mattugulla (L_3), Very Green Long (L_4), Raidurg Green Round (L_5), Malapur Local (L_6), Green Round (L_7) and Green Long (L_8) were used as female parents (lines) and five resistant testers (IIHR-3 (T_1), IIHR-7 (T_2), WCGR (T_3), IIHR-322 (T_4) and IIHR-555 (T_5) as male parents (testers). Seedling of 13 parents and 40 crosses were transplanted in a randomized block design with three replications having 20 plants in each row at spacing of 60 cm between and within rows. The plants were artificially inoculated at the concentration of 5×10^6 cfu per ml. Recommended cultural practices were followed during the crop season. Ob-

Table 2. Estimates of general combining ability **(gca)** effects of 8 lines and 5 testers for various characters. *Significant at 5% level; ** Significant at 1% level. Arka Shirish (L_1), Arka Kusumakar (L_2), Mattugulla (L_3), Very Green Long (L_4), Raidurg Green Round (L_5), Malapur Local (L_6), Green Round (L_7), Green Round (L_7),, IIHR-3 (T_1), IIHR-7 (T_2), WCGR (T_3), IIHR-322 (T_4), IIHR-555(T_5).

Parents	Days to 50% flowering	Plant height at harvest (cm)	Number of primary branches	Number of secondary branches	Number of flowers per cluster	Number of fruits per cluster
L_1	5.20**	10.52**	-0.55**	0.95**	0.26**	0.42**
L_2	-1.06**	5.43**	0.75**	1.65**	0.60**	0.60**
L_3	-2.66	0.05	-0.19	-0.41**	0.19*	-0.33**
L_4	0.80**	4.69**	-0.12	0.17	-0.70**	-0.05
L_5	-1.93**	-10.22**	0.03	1.37**	0.71**	0.08
L_6	9.80**	-2.94**	-0.44**	-2.47**	-1.74**	-1.00**
L_7	-4.46**	-5.37**	-0.03	-1.36**	0.10	-0.10
L_8	-5.66**	-2.15**	0.55	0.01	0.56**	0.37**
SEm ±	0.27	0.69	0.11	0.13	0.09	0.05
Testers						
T_1	-3.11*	-6.72**	-0.98**	-0.92**	0.21**	0.24**
T_2	-0.28	7.29**	0.55**	0.77**	0.68**	0.24**
T_3	0.34	-1.81**	-0.55**	-1.07**	-0.61**	-0.41**
T_4	2.17**	2.17**	0.18*	0.01	-0.11	0.10
T_5	0.88**	-0.93	0.79**	1.19**	-0.16*	-0.08
SEm±	0.21	0.54	0.08	0.1	0.072	0.04

Table 2. Continued.

Parents	Number of fruits per plant	Fruit length (cm)	Fruit diameter (mm)	Fruit weight (g)	Yield per plant (g)	BW (%)
Lines						
L_1	0.64	4.44**	-7.87**	9.14**	427.03**	-11.98**
L_2	1.38*	3.52**	-7.55**	-11.65**	-245.72**	-14.95**
L_3	0.27	-4.06**	14.17**	11.83**	194.34**	11.56**
L_4	3.87**	7.09**	-12.61**	7.00**	605.08**	12.46**
L_5	-2.56**	-4.81**	4.70**	-10.19**	-430.35**	0.589
L_6	-7.47**	-5.34**	19.52**	19.23**	-113.18*	-10.47**
L_7	-0.37	-4.07**	-3.72**	-21.00**	-579.75**	10.62**
L_8	4.23**	3.22**	-6.63**	-4.36	133.55*	2.18*
SEm±	0.54	0.13	0.33	0.65	52.15	1.01
Testers						
T_1	1.69**	0.45**	-7.17**	-17.16**	-318.89**	5.39**
T_2	1.83**	1.94**	-6.92**	-7.35**	-40.87	-3.84**
T_3	-4.63**	-5.11**	11.90**	4.06**	-253.80**	1.78*
T_4	0.51	0.61**	-3.13**	0.26	52.13	-1.69*
T_5	0.58	2.10**	5.33**	20.19**	561.44**	-1.63*
SEm±	0.42	0.1	0.26	0.52	41.23	0.63

servations were recorded on five competitive plants on 13 quantitative parameters (Table 1). The analysis of general and specific combining ability was done as per Kempthrone [1].

Results and Discussion

The analysis of variance revealed highly significant difference among the genotypes indicating great wealth of variability among the genotypes selected for all the economic traits (Table). The analysis of variance for combining ability revealed significant variance for parents vs crosses for all the characters except number of primary branches, whereas variance for line × testers were highly significant for all the characters except number of fruits per plant. These estimates indicated considerable variation in males, females, crosses, parents and parents vs crosses. The variance due to GCA and SCA were prominent for all the characters in the present investigation. The variance due to SCA was higher than that of GCA suggesting the predominance of non-additive gene action in the expression of characters and thus offers scope for improvement through heterosis breeding. This is further strengthened by the significance of GCA and SCA variances and their ratios. These findings are in agreement with Kale et al. result of [2].

The estimates of general combining ability effect for various characters are presented in Table 2. None

Table 3. Estimates of specific combining ability *(sca)* effects for 40 brinjal hybrids for various characters. *significant at 5% level ; **Significant at1% level.

Crosses	DAFF	PLHT	NPBRS	NSBRS	NFLC	NFRC
$L_1 \times T_1$	-7.28**	-2.01	1.68**	2.91**	0.23	0.22
$L_1 \times T_2$	0.55	-6.96**	-1.41**	-2.98**	-0.40	-0.08
$L_1 \times T_3$	1.59*	-11.58**	-1.33**	-4.10**	1.86**	-0.70**
$L_1 \times T_4$	2.42**	13.32**	1.12**	2.87**	1.39**	0.76**
$L_1 \times T_5$	2.71**	7.23**	-0.05	1.29**	0.64**	-0.21
$L_2 \times T_1$	-3.35**	-4.91**	-0.65*	1.71**	-0.03	0.41**
$L_2 \times T_2$	0.15	5.06**	-0.90**	0.41	-0.10	0.63**
$L_2 \times T_3$	1.85**	11.70**	0.39	-0.10	0.79**	-0.13
$L_2 \times T_4$	0.35	4.48**	1.41**	0.01	0.01	-0.26*
$L_2 \times T_5$	0.98	-16.33**	-.0.253**	-0-2.03**	-0.65**	-0.65
$L_3 \times T_1$	-2.08**	11.32**	0.70**	3.34**	-0.46*	-0.49**
$L_3 \times T_2$	4.75**	-10.15**	0.16	-0.41	0.86**	-0.30*
$L_3 \times T_3$	-1.87**	-4.17**	0.70**	0.06	-0.03	-0.26*
$L_3 \times T_4$	2.62**	-15.77**	-1.06**	-2.62**	0.33	0.89**
$L_3 \times T_5$	-3.41**	18.77**	-0.50*	-0.36	-0.70**	0.17
$L_4 \times T_1$	2.11**	-11.57**	-0.37	-3.50**	-1.37**	-0.82**
$L_4 \times T_2$	-5.71**	-1.49	-0.80**	0.06	0.59**	0.41**
$L_4 \times T_3$	0.65	2.18	-1.13**	-1.15**	-0.13	0.01
$L_4 \times T_4$	1.49*	17.85**	0.96**	2.15**	1.29**	0.69**
$L_4 \times T_5$	1.45*	-6.96**	1.35**	2.44**	-0.38	-0.29
$L_5 \times T_1$	6.85**	-3.43*	-0.83**	-3.06**	-0.11	0.41**
$L_5 \times T_2$	3.01**	-3.44*	-1.00**	-0.66*	-0.71**	-0.79**
$L_5 \times T_3$	-4.94**	12.76**	2.87**	5.18**	1.78**	1.39**
$L_5 \times T_4$	-5.77**	0.33	0.60*	1.29**	-0.08	-0.28*
$L_5 \times T_5$	0.85	-6.21**	-1.64**	-2.74**	-0.86**	-0.73
$L_6 \times T_1$	2.45**	-3.24*	-0.52*	-0.82**	2.21**	-0.24
$L_6 \times T_2$	0.28	3.77*	1.27**	1.27**	-1.29*	-0.24
$L_6 \times T_3$	1.32*	-3.55*	-0.84**	0.09	-0.09	0.41**
$L_6 \times T_4$	-5.17**	1.55	-0.08	1.20**	-0.55**	0.01
$L_6 \times T_5$	1.11	1.46	0.17	-1.74**	-0.28	0.08
$L_7 \times T_1$	3.38**	0.92	-1.26**	-2.96**	-1.77**	-0.54**
$L_7 \times T_2$	-0.78	5.90**	2.60**	0.68*	0.81**	0.83**
$L_7 \times T_3$	-1.74**	1.84	1.41**	2.95**	1.12**	0.08
$L_7 \times T_4$	-1.24*	-11.44**	-1.92**	-2.20**	-0.64**	-0.91**
$L_7 \times T_5$	0.38	2.76	-0.83**	1.52**	0.48*`	0.53
$L_8 \times T_1$	-2.08**	12.92**	1.24**	2.39**	1.31**	1.05**
$L_8 \times T_2$	-2.25**	7.31**	0.07	1.62**	0.24	-0.45**
$L_8 \times T_3$	3.12**	-9.17**	-2.07**	-2.93**	-1.57**	-0.80**
$L_8 \times T_4$	5.29**	-10.33**	-1.02**	-2.71**	-1.75**	-0.88**
$L_8 \times T_5$	-4.08**	-0.72	1.77**	1.63**	1.76**	1.09
SEm ±	0.61	1.54	0.24	0.3	0.20	0.12

Table 3. Continued.

Crosses	NFPP	FRLT	FRDM	FRWT	FYPL	BW
$L_1 \times T_1$	9.11**	6.83**	7.01**	32.02**	1724.91**	21.453**
$L_1 \times T_2$	-1.6	0.47	3.10**	20.33**	353.64**	-4.834*
$L_1 \times T_3$	-3.80**	-6.12**	-6.29**	-43.54**	-1383.73**	-5.191*
$L_1 \times T_4$	0.91	-0.37	-0.52	4.00**	109.03	-6.987**
$L_1 \times T_5$	-4.61**	-0.81**	-0.52	-12.82**	-803.86**	-4.441
$L_2 \times T_1$	4.35**	-3.16**	-3.30**	6.38**	310.18**	7.216**
$L_2 \times T_2$	1.77	6.25**	1.85*	13.12**	477.69**	1.857
$L_2 \times T_3$	-0.08	-3.79**	0.81	-18.46**	-400.21**	-2.214
$L_2 \times T_4$	-1.48	1.60**	5.18**	1.21	-63.06	2.543
$L_2 \times T_5$	-4.56**	-0.88**	-5.13**	-2.25	-324.60**	-5.688*
$L_3 \times T_1$	-0.93	-1.36**	-5.13**	-23.83**	-658.62**	0.059
$L_3 \times T_2$	-5.59**	-1.92**	-2.72**	-22.34**	-855.79**	-14.097**
$L_3 \times T_3$	-1.10	5.46**	-6.79**	99.57**	2401.79**	3.673
$L_3 \times T_4$	9.70**	-0.53	-3.31**	-42.18**	-641.62**	9.297**
$L_3 \times T_5$	-2.06	-1.64**	21.27**	-11.20**	-245.75*	1.069
$L_4 \times T_1$	-10.97**	-2.55**	-13.72**	-14.33**	-1254.87**	-6.423**
$L_4 \times T_2$	0.63	0.40	-13.72**	11.71**	323.66**	4.533*
$L_4 \times T_3$	2.77*	-4.95**	2.56**	-45.58**	-1258.38**	-4.96*
$L_4 \times T_4$	9.29**	2.44**	2.13**	4.63**	883.59**	4.531
$L_4 \times T_5$	-1.72	4.65**	5.60**	43.38**	1305.98**	3.32
$L_5 \times T_1$	-1.72	-0.50	-17.06**	-5.81**	-307.56*	-14.92**
$L_5 \times T_2$	-2.98*	-2.06**	3.66**	-17.99**	-692.74**	-6.96**
$L_5 \times T_3$	11.89**	3.88**	3.66**	16.59**	1396.31**	12.49**
$L_5 \times T_4$	0.49	0.01	5.66**	11.74**	327.94**	12.10**
$L_5 \times T_5$	-7.68**	-1.31**	-2.38**	-4.53**	-723.93**	-2.70
$L_6 \times T_1$	-2.80*	-1.44**	-5.48**	-21.45**	-588.60**	-6.42**
$L_6 \times T_2$	-0.45	-3.27**	2.019**	-22.87**	-535.88**	5.37*
$L_6 \times T_3$	2.56*	4.71**	3.33**	-9.09**	-47.06	-1.538
$L_6 \times T_4$	1.93	0.64*	3.33**	29.97**	892.92**	0.663
$L_6 \times T_5$	-1.23	-0.64*	2.52**	23.45**	278.62*	2.925
$L_7 \times T_1$	-8.22**	0.01	-9.00**	20.78**	9.19	-1.151
$L_7 \times T_2$	9.70**	1.16**	-6.67**	21.36**	1173.70**	8.08**
$L_7 \times T_3$	-2.78*	3.93**	-6.58**	-9.54**	-300.76*	6.76**
$L_7 \times T_4$	-9.32**	-2.78**	13.86**	-9.15**	-741.15**	-13.99**
$L_7 \times T_5$	10.62**	-2.32**	13.86	-23.45**	-140.77	0.291
$L_8 \times T_1$	11.18**	2.20**	8.39**	6.24**	765.37**	0.198
$L_8 \times T_2$	-1.48	-1.05**	6.14**	-3.33*	-244.28*	9.76**
$L_8 \times T_3$	-9.44**	-3.12**	7.23**	10.07**	-407.94**	-9.02**
$L_8 \times T_4$	-11.52**	-1.00**	-7.44**	-0.23	-767.46**	-8.15**
$L_8 \times T_5$	11.26**	2.97**	-0.25	-12.76**	654.12**	7.22**
SEm ±	`1.21	0.29	0.75	1.47	116.62	2.27

of the parents proved to be good general combiner for all the characters. The female parent L_2 (-1.06), L_5 (-1.93), L_7 (-4.46) and L_8 (-5.66) possessed significant negative *gca* effect for days to fifty per cent flowering . For yield per plant the female parents L_1, L_3, L_4 and L_8 had significant positive *gca* effects. The female lines L_2, L_1 and L_6 showed highly significant negative *gca* effects for bacterial wilt incidence. Among male parents T_2 showed significant *gce* effects for plant height, number of primary and secondary branches, number of flowers per clusters, number of fruits per clusters, fruit length and bacterial wilt incidence. This indicates that no single line had shown good general combining ability for all the traits . Similar results were noticed by Bavage [3]. The selected parents were found to possess high general combining ability.

The specific combining ability effects of crosses are presented in (Table 3). The *sca* effect is an useful index to determine the usefulness of a particular cross combination for exploitation of heterosis. The crosses $L_1 \times T_1$ for days to 50% flowering, fruit length and fruit yield per plant, $L_3 \times T_3$ for fruit weight and fruit yield per plant, $L_4 \times T_2$ for days to 50% flowering, $L_5 \times T_3$ for number of primary branch, number of secondary branches, number of fruits per cluster, number of fruits per plant, fruit yield per plant, $L_7 \times T_5$ for number of fruits per plant and $L_1 \times T_3$ number of fruits per cluster showed significant desirable *sca* effect. These results are in conformity with earlier reports [4, 5]. On the contrary, Singh and Kumar [6], Chadha and Hegde [7], Lawande et al. [8]. reported additive gene action for yield per plant. Among the 40 crosses, thirteen crosses exhibited negative significant *sca* effects for bacterial wilt disease. The highest negative *sca* effect was observed in the cross $L_3 \times T_2$ (-14.09), $L_5 \times T_1$ (-14.92), $L_7 \times T_4$ (-13.99), $L_7 \times T_3$ (-9.02), $L_7 \times T_4$ (-8.15), $L_5 \times T_2$ (-6.96), $L_2 \times T_5$ (-5.688), $L_1 \times T_4$ (-6.987), $L_1 \times T_3$ (-5.191) and $L_1 \times T_2$ (-4.834) bacterial wilt and hence these hybrids are suitable for the development of commercial bacterial wilt resistant hybrids. Similar results of high *sca* effects for various characters were observed in the earlier studies [9, 10].

References

1. Kempthrone O (1957) An introduction to genetic statistics. John Wiley and Sons Inc, New York and London, pp 458—471.
2. Kale PB, Mankar SW, Dod VN, Wankhade RV (1992) Combining ability in eggplant (*Solanum melongena* L.). Crop Res, pp 140—145.
3. Bavage MS (2002) Heterosis and combining ability in round fruited brinjal (*Solanum melongena* L.). MSc (Ag) thesis. Univ Agric Sci, Dharwad.
4. Patil RS, Shinde SR (1985) Combining ability studies for different characters in eggplant. J Maharashtra Agric Univ 10 : 179.
5. Padmanabham V, Jagadish CA (1996) Combining ability studies on yield potential of round fruited brinjal (*Solanum melongena* L.). Ind J Genet 56 : 141—146.
6. Singh B, Kumar N, (1988) Studies on hybrid vigor and combining ability in brinjal (*Solanum melongena* L.). Veg Sci 15 : 72—78.
7. Chadha ML, Hegde RK (1989) Combining ability studies in brinjal. The Ind J Hort 47 : 44—52.
8. Lawande KE, Gadakh SR, Kale PN, Joshi VR (1992) Generation mean analysis in brinjal. J Moharashtra Agric Univ 17 : 62—63.
9. Biradar AB, Dumbre AD, Navale PA (2005) Combining ability studies in brinjal (*Solanum melongena* L.). J Maharashtra Agric Univ 30 : 342.
10. Aswani RC, Khandelwal RC (2005) Combining ability studies in brinjal. Ind J Hort 62 : 37—40.