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RESEARCH ARTICLE

General and specific combining ability studies in brinjal

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SUMMARY

24 F_1 hybrids developed by crossing 6 lines and 4 tester in line x tester design were subjected to combining ability analysis for yield and other characters. Both additive and non additive gene actions were observed for all the characters. Among the ten parents, the general good combiners were Arka sheel and Arka shirish. These parents also had high gca effects for average fruit weight, fruit length, number of fruits per clusters, number of leaves, number of branches at one month after transplanting, plant height at final harvest and seedling height at transplanting. In 24 crosses (Arka sheel x Green round and Arka sheel x Kudachi A) having positive x positive gca effects reveals that the high sca effects in these crosses was mainly through additive gene effects. Therefore, the best option for improvement is the identification of transgressive segregants based on sca effects which may lead to isolation of promising lines of high total yield in brinjal.

Key Words : Brinjal, Combining ability, gca, sca effects

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Combining ability: The knowledge of combining ability, a concept first proposed by Sprague and Tatum (1942) in corn is useful in selection of parents, which can produce superior hybrids. It is also useful in measuring hybrid performance and genetic architecture of metric traits. They coined two terms: General combining ability (gca) and specific combining ability (sca). General combining ability (gca) is the average performance of a line in a series of hybrid combinations and specific combining ability is the deviation of certain crosses from the average performance of the lines.

Earliest studies concerned to brinjal combining ability were reported by Odland and Noll (1948). They reported that, the hybrid combination between lower yielding parents produced more yields. Regarding the combining ability of parental lines in brinjal, two aspects were worth considering. One is that in several cases the best hybrids were obtained by crossing widely different varieties, while only in a few instances wide crosses resulted in partial sterility in the hybrids. This should be of particular interest to workers in India, where a great number of varieties possessing considerable genetic variability exist. The other aspect is that the hybrids of high productivity may result from parents of very low productivity.

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MATERIAL AND METHODS

The experiment was conducted in the vegetable section of seed unit, University of Agricultural Sciences (UAS), Dharwad, which is situated in the agro climatic zone-8 (Northern transitional zone) of Karnataka state. 6 lines and 4 testers were chosen based on their morphological and other characters and crossed in a line x tester design.

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussions have been presented under following sub heads:

Analysis of variance :

Analysis of variance for combining ability (Table1) reveals the presence of both additivity and non additivity in 17 characters studied, which was indicated but the significance for both the gca and sca variance. The earliest records instances of artificial hybridization for improvement of egg plant were in 1989 in USA by Bailey and Munson (Bailey and Munson, 1981). None of the hybrids in their experiment exhibited heterosis but were intermediate between the parents. The first positive report of heterosis in egg plant came from Munson (1982).

The variance due to sca was higher in magnitude than gca for all the traits except for fruit diameter. Further, the values of gca variance and sca variance for all the traits supports the predominance of non-additivity gene effects in governing expression of all these characters. These results are similar with the findings of Singh *et al.* (2003) in brinjal and offers greater scope for heterosis breeding.

General combining ability (gca) effects

Among the ten parents, the highest gca effect for yield per plant (462.40) was observed in Arka sheel followed by Arka shirish (150.15) exhibited significant gca effects (Table 2). These parents also had high gca effects for average fruit weight, fruit length, number of fruits per clusters, number of leaves, number of branches at one month after transplanting, plant height at final harvest and seedling height at transplanting. Whereas, Arka nidhi exhibited significant gca effect in desired direction for the traits average fruit weight, fruit length, days to first picking, days to 50 per cent flowering, number of branches at final harvest, number of branches at one month after transplanting, plant height at final harvest at one month after transplanting, at seedling stage and days to germination.

As Arka sheel, Arka shirish and Arka nidhi were superior for most of the traits, as inter mating population involving all possible combination among themselves subjected to mating in early generation will be expected to offer the maximum promise in breeding for trait yield.

The parent with good general combining ability for trait also exhibited good per se performance. This is true with the parent Arka sheel for total yield and other traits average fruit weight, fruit diameter, number of leaves, number of branches at one month after transplanting, at peak flowering seedling height at transplanting, number of fruits per plant and flower per inflorescence Kumar and Pathnia (2003) also suggests the importance of combining ability in breeding programme either for varietal improvement or for evolving of a hybrid. However, the parent Arka sheel was the top general combiner for many characters but top ranking parents for days to 50 per cent flowering and days to first picking recorded medium rank in per se performance. Similar results were reported by Ingale and Patil (1997) and Maury *et al*. (1993) in bottle gourd.

Table 1: Analysis of variance for combining ability

Sr. No.	Characters/observations	Replication	Crosses	Mean sum of squares			Error	Contribution of percentage			Random effect	
				Lines	Testers	L x T		Line	Tester	L x T	gca variance	sca variance
	Degrees of freedom	1	23	5	3	15	23					
1.	Days to germination	0.0833	2.03	3.833	1.5833	1.533	0.0399	40.85	10.12	49.02	0.0192	0.7467
2.	Seedling ht at transplanting	1.6875	22.30	40.594	13.79	17.907	0.0427	39.57	8.07	52.37	0.1663	8.9325
3.	Plant height at 1 months after transplanting	0.5633	43.06	49.634	39.436	41.600	0.4403	25.06	11.94	63.00	0.0554	20.5801
4.	Plant height at final harvest	2.8373	36.85	143.39	21.934	4.3263	2.2495	84.58	7.76	7.66	1.2305	1.0384
5.	Number of branches after 1 month of transplanting	0.5764	6.09	16.18	4.050	3.1331	0.0707	57.77	8.68	33.55	0.119	1.5312
6.	Number of branches at peak flowering	6.1633	28.65**	51.83	5.51	25.53**	8.5094	39.33	2.51	58.16	0.1173	8.5208
7.	Number of branches at final harvest	0.0533	11.6561**	21.000	10.59	8.75**	0.1246	39.17	11.86	48.98	0.1098	4.3143
8.	Number of leaves at grand growth stage	1.5769	7805.27	10969.10	23133.71	3684.97	0.4077	30.55	38.66	30.79	155.86	1842.28
9.	Days to 50% flowering	0.020	20.23**	23.78	14.40	20.20**	0.23	25.56	9.29	65.15	0.0008	9.98
10.	Number of flowers per inflorescence	1.5408	0.6292**	0.6455**	0.2786	0.6939**	0.1461	22.30	5.78	71.92	-0.0024	0.2739
11.	Number of fruits per cluster	0.2408	0.2513**	0.4148	0.0653	0.2339**	0.0356	35.89	3.39	60.72	0.007	0.0992
12.	Days to 1st picking	2.0833	22.46**	44.78	10.50	17.41**	0.1703	43.34	6.10	50.56	0.1909	8.6232
13.	Fruit length	0.0507	8.6303	33.995	3.0362	1.2941	0.1194	85.63	4.59	9.78	0.2775	0.5874
14.	Fruit diameter	0.2174	0.7583	2.706	0.2465	0.2115	0.2392	77.57	4.24	18.19	0.0207	-0.0139
15.	Average fruit weight	0.0213	784.42	1754.832	2018.0169	214.243	0.4352	48.63	33.56	17.81	21.5695	106.904
16.	Number of fruit per plant	0.3675	22.91**	10.94	48.30	21.83**	0.25	10.39	27.49	62.13	0.041	10.78
17.	Yield per plant	15.1875	265747.12	585951.5	529907.18	10618.3	49.144	47.93	26.01	26.06	6036.24	53065.58

** Indicate significance of value at P=0.01

Table 2: Estimates general combining ability (gca) effects of brinjal parents for different traits

Sr. No.	Parents/ characters	Days to germination	Seedling height	Plant height at after one month of tra	Plant height at final harvest	No. of branches at after one month tra	No. of branches at peak flowering	No. of branches at final harvest	No. of leaves at grand growth stage	Days to 50% flowering	No. of fowers/ inflo	No. of fruits/ cluster
	Lines (female)											
1.	Arka nidhi	0.89**	2.14**	2.52**	7.39**	1.12**	-1.07**	0.87**	-67.96**	-3.44**	-0.41**	-0.25**
2.	Arka sheel	-0.33**	1.99**	-0.33	0.51	0.74**	2.76*	-2.05**	32.34**	0.56**	0.16	0.15*
3.	Arka shirish	0.04	1.71**	2.87**	0.34	1.68**	-4.24**	-1.77**	22.68**	1.06**	-0.09	0.27**
4.	Budihal local	-0.96**	-0.80**	-3.37**	-2.06**	-0.66**	-0.27	1.62**	22.32**	0.31	0.31*	-0.03
5.	Mullubadne	0.79**	-3.06**	-2.18**	-5.47**	-0.78**	2.31*	1.52**	3.52**	0.31	-0.21	0.15*
6.	Hittalu local	-0.33**	-1.97**	0.48	-0.71	-2.11**	0.51	-0.20	-12.91**	1.19**	0.24	-0.28**
	Testers (males)											
1.	Malapur local	0.29**	-0.29**	-1.54**	1.31**	0.72**	-0.68	-0.11	-45.80**	-0.52**	0.12	0.05
2.	Kudchi A	0.29**	0.83**	2.46**	0.88	-0.31**	0.78	-0.96**	40.58*	1.56**	0.12	-0.08
3.	Kudachi B	-0.13*	0.85**	0.25	-0.55	0.19*	0.33	-0.22*	-29.21**	-0.94**	-0.05	-0.05
4.	Green round	-0.46**	-1.40**	-1.17**	-1.64**	-0.60**	0.43	1.29**	34.43**	-0.10	-0.20	0.07
	S.E.$\pm$ (g_i) for lines	0.0706	0.0731	0.2346	0.5303	0.0940	1.0313	0.1248	0.2258	0.1726	0.1351	0.0667
	C.D. @ 5%	0.181	0.187	0.603	1.363	0.241	2.65	0.32	0.580	0.44	0.347	0.171
	C.D. at 1%	0.084	0.294		2.138	0.379	4.15	0.50	0.910	0.69	0.544	0.26
	S.E.$\pm$ (g_i) for testers	0.0576	0.0597	0.1915	0.4330	0.0767	0.8421	0.1019	0.1843	0.1409	0.1103	0.0545
	C.D. @ 5%	0.183	0.189	0.609	1.377	0.244	2.16	0.32	0.586	0.44	0.35	0.17
	C.D. at 1%	0.336	0.348	1.118	2.529	0.448	4.91	0.59	1.076	0.822	0.64	0.31

Table 2: Contd……..

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Sr. No.	Parents/ characters	Days to 1st picking	Fruit length	Fruit diameter	Average fruit weight	No. of fruit/pl	Yield/pl
	Lines (female)						
1.	Arka nidhi	-4.42**	1.73**	-0.33	5.35**	-1.79**	-137.85**
2.	Arka sheel	-0.54**	0.40**	0.68**	23.67**	0.39**	462.40**
3.	Arka sirish	1.08**	3.01**	-0.78**	1.00**	1.34**	150.15**
4.	Budihal local	1.21**	-1.45**	0.01	0.80**	-0.49*	-20.48**
5.	Mullubadne	0.33*	-1.60**	0.67**	-11.45**	-0.54**	-166.73**
6.	Hittalu local	2.33**	-2.09**	-0.25	-19.37**	1.09**	-287.48**
	Testers (males)						
1.	Malapur local	-1.00**	0.47**	0.09	-17.14**	0.04	-248.94**
2.	Kudchi A	1.25**	-0.15	-0.10	14.38**	-2.61**	83.90**
3.	Kudachi B	-0.25*	-0.64**	-0.14	1.21**	0.30	-75.35**
4.	Green round	0.00	0.32**	0.15	1.55**	2.27**	240.40**
	S.E.$\pm$ (g_i) for lines	0.1459	0.1222	0.1729	0.2332	0.041	2.4785
	C.D. @ 5%	0.37	0.313	0.444	0.599	0.105	6.370
	C.D. at 1%	0.58	0.492	0.697	0.940	0.16	9.993
	S.E.$\pm$ (g_i) for testers	0.1191	0.0997	0.1412	0.1904	10.786	2.0237
	C.D. @ 5%	0.37	0.317	0.449	0.605	34.32	6.437
	C.D. at 1%	0.69	0.582	0.824	1.112	63.00	11.81

* and ** Indicate significance of value at P=0.05 and 0.01, respectively

Table 3: Estimates of specific combining ability (sca) effects of brinjal hybrids for different traits

Sr. No.	Hybrids/ Characters	Days to germination	Seedling height	Plant height at after one month of tra	Plant height at final harvest	No. of branches at after one month tra	No. of branches at peak flowering	No. of branches at final harvest	No. of leaves at grand growth stage	Days to 50% flowering
1.	AN x ML	-1.29**	-4.34**	-1.59**	-0.33	1.04**	1.03	-1.94**	33.19**	-4.48**
2.	AN x KA	1.71**	1.75**	4.31**	0.35	-.28	-1.43	2.91**	-36.84**	3.94**
3.	AN x KB	0.12	0.22	-0.37	-0.10	-1.83**	-0.88	-1.22**	25.10**	-2.06**
4.	AN x GR	-0.54**	2.37**	-2.35**	0.07	1.06**	1.28	0.26	-21.44**	2.60**
5.	AS x ML	-0.17	0.41**	1.26*	0.74	1.22**	-2.69	-0.02	-24.51**	-2.98**
6.	AS x KA	0.83**	-5.40	-1.64**	-0.62	0.05	2.64	-2.17**	28.26**	-0.06
7.	AS x KB	-0.75**	2.32**	-3.42**	1.16	-0.25	-0.71	3.70**	31.90**	-1.56**
8.	AS x GR	0.08	2.67**	3.80**	-1.27	-1.01**	0.76	-1.52**	-35.64**	4.10**
9.	AR x ML	-0.54**	3.54**	-4.84**	0.03	-0.77**	-0.89	0.21	-13.15**	2.52**
10.	AR x KA	-0.54**	3.62**	7.76**	-1.35	1.06**	0.04	-1.04**	6.37**	-0.56
11.	AR x KB	0.88**	-2.70**	-3.72**	-0.27	-0.34	-2.31	-0.38	-50.34**	2.94**
12.	AR x GR	0.21	-4.45**	0.80	1.59	0.05	3.16	1.21**	57.12**	-4.90**
13.	BL x ML	0.46**	-0.05	5.80**	1.02	-0.10	5.63*	2.31**	17.71**	2.77**
14.	BL x KA	-0.54**	0.18	-3.30**	0.65	0.50*	3.77	-2.94**	21.28**	-0.31
15.	BL x KB	0.13	1.36**	2.17**	-0.74	0.35	-3.88	-0.67*	-63.33**	-2.31**
16.	BL x GR	0.21	-1.49**	-4.67**	-0.93	-0.76**	-5.52*	1.31**	24.33**	-0.15
17.	MB x ML	0.71**	0.06	-3.19**	-2.97	-0.91**	0.56	-1.59**	10.91**	1.77**
18.	MB x KA	-0.29	-1.00**	-4.79**	0.06	-1.83**	-2.21	2.26**	-59.87**	-2.31**
19.	MB x KB	0.12	-1.03**	3.43**	1.99	2.67**	2.24	-0.67*	49.52**	3.19**
20.	MB x GR	-0.54**	1.97**	4.55**	0.92	0.06	-0.59	0.01	-0.57	-2.65**
21.	HL x ML	0.83**	0.68*	2.55**	1.52	-0.48*	-3.64	1.03**	-24.16**	-0.10
22.	HL x KA	-1.17**	0.86**	-2.35**	0.90	0.50*	-2.81	0.98**	40.81**	-0.69
23.	HL x KB	-0.25	-0.17	1.92**	-2.03	-0.60**	5.54*	-0.75**	7.15**	-0.19
24.	HL x GR	0.58**	-1.07**	-2.12**	-0.38	0.59**	0.91	-1.27**	23.79**	0.98**

Table 3 : Contd.……..

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Sr. No.	Hybrids/ Characters	No. of flowers/ inflo	No. of ruits/ cluster	Days to 1st picking	Fruit length	Fruit diameter	Average fruit weight	No. of fruit/pl	Yield/pl
1.	AN x ML	-0.07	-0.03	-4.25**	1.17**	0.29	2.76**	-3.31**	157.19**
2.	AN x KA	0.03	0.00	4.00**	-1.31**	-0.27	-5.29**	0.64	19.85**
3.	AN x KB	0.10	0.17	-2.50**	-0.42	-0.34	14.19**	5.92**	124.60**
4.	AN x GR	-0.05	-0.15	2.75**	0.57*	0.32	-11.67**	-3.25**	-301.65**
5.	AS x ML	-0.05	-0.23	-0.63*	-0.36	-0.03	-14.02**	-0.49	-410.00**
6.	AS x KA	0.25	-0.20	-0.37	-0.53*	0.12	-0.45	1.16**	112.10**
7.	AS x KB	0.02	-0.33*	-1.88**	1.05**	-0.25	3.60**	-1.15**	48.35**
8.	AS x GR	-0.23	0.75**	2.88**	-0.16	0.16	10.87**	0.48	249.60**
9.	AR x ML	-0.70*	0.55**	0.75*	-0.02	-0.60	-10.75**	2.76**	-62.81**
10.	AR x KA	-0.70*	-0.02	-0.50	0.75**	0.03	-7.04**	1.31**	49.35**
11.	AR x KB	0.67*	-0.25	3.50**	-0.26	0.21	3.98**	-2.40**	-16.40**
12.	AR x GR	0.72*	-0.27	-3.75**	-0.47	0.37	13.81**	-1.67**	29.85**
13.	BL x ML	1.10**	-0.25	0.12	-0.26	-0.10	7.34**	-0.61	56.81**
14.	BL x KA	0.00	-0.22	-0.13	1.22**	-0.06	7.36**	-1.76**	-106.02**
15.	BL x KB	-0.23	0.35*	1.88**	0.05	0.23	-4.57**	-3.88**	-290.27**
16.	BL x GR	-0.88**	0.13	-1.88**	-1.01**	-0.07	-10.13**	6.25**	339.48**
17.	MB x ML	-0.37	0.07	4.00**	-0.00	-0.34	7.89**	0.64	119.06**
18.	MB x KA	0.33	0.20	-3.75**	-0.23	0.13	2.36**	0.99*	60.23**
19.	MB x KB	-0.60*	0.07	0.75*	-0.06	0.06	-11.32**	-1.93**	-114.02**
20.	MB x GR	0.65*	0.35*	-1.00**	0.30	-0.53		0.30	-65.27**
21.	HL x ML	0.08	-0.10	0.00	-0.52*	0.11	6.78**	1.01*	139.11**
22.	HL x KA	0.08	0.23	0.75*	0.10	0.05	3.05**	-2.34**	-135.52**
23.	HL x KB	0.05	-0.00	-1.75**	-0.36	0.09	-5.89**	3.45**	247.73**
24.	HL x GR	-0.20	-0.12	1.00**	0.78**	-0.25	-3.95**	-2.12**	-252.02**

* and ** Indicate significance of value at P=0.05 and 0.01, respectively

Specific combining effects (Table 3) :

Number of fruits and fruit weight are the important traits of yield. Evidences suggest that heterosis of a complex character, such as yield in the present investigation is much regulated by the hybrid vigor, expressed by its component character, for the number of fruits per plant (Sinha and Khanna, 1975).

The estimates of sca effects for 24 crosses for number of fruits per plant revealed that the crosses Arka sheel x Green round (23.9), Arka sheel x Kudachi A (19.7) and Budihal local x green round (28.6) for number of fruits exhibited significant sca effect. The cross Budihal local x Green round (28.8) had higher per se performance for number of fruits per plant. However, the gca effects were higher in Green round for number of fruits per plant indicating that green round was a good general combiner high gca effects for some characters in brinjal had also been reported by Prakash *et al.* (1994) and Varshney *et al.* (1999), while the cross Budihal local x Green round with high sca effects for number of fruits had positive x positive general combiner. The cross Arka sheel Kudachi A with sca effect for number of fruits had parents of high positive x negative gca effect, while Arka sheel x Green round with sca effect for number of fruits had parents of positive x positive gca effects. Heterosis in the cross involving low x high combiners might be due to dominant x additive type of interaction which is partially fixable and the cross involving both the parents as poor combiners showing high sca must be due to intra interallelic interactions (Kumar and Pathania. 2003). The results are in agreement with Varshney *et al.* (1999).

The next best crosses with desirable high sca effects for this trait were Arka nidhi x Kudachi B and Arka Shirish x Malapur local. For fruit weight the crosses Arka sheel x Kudachi A (107 g), Arka sheel x Green round (105. 49 g) and Arka sheel x Kudachi A (107 g) for fruit weight exhibited though they got higher fruit weight but their corresponding sca effects were low. These results are similar to those of Bulgundi (2000) and Mallikarjun (2002). This indicates that crosses having highest per se need not have the highest sca effects.

The crosses Arka Shirish x Green round and Arka sheel x Green round exhibited high sca effects. However, the gca effects were higher in Arka sheel for fruit weight indicating that Arka sheel was a good general combiner. Similar results were reported by Sawant *et al.* (1991), Varshney *et al.* (1999) and Mallikarjun (2002). While, the cross Arka Shirish x Green round with high sca effects for fruit weight had positive x positive general combiner, the cross Arka sheel x Green round with sca effect for fruit weight had positive x positive general combiner. High general combining ability of parents, therefore, seems to be reliable criterion for the prediction of specific combining ability. Similar results were observed by Prakash *et al.* (1994) and Kumar and Pathania (2003).

The high total yield per plant is the ultimate criteria of the breeder. In the present study the top three crosses with high per se performance Arka sheel x Green round, Arka sheel x Kudachi A and Budihal local x Green round have also exhibited high sca effects for yield, while the cross Arka sheel x Green round also exhibited significant sca effects for number of fruits, fruit weight, seedling height, plant height at one month after transplanting and fruits per cluster. The next best cross Arka sheel x kudachi A also exhibits significant sca effects for number of leaves, days to 50 per cent flowering, days to first picking, number of fruits and yield per plant. The cross Arka sheel x Green round and Arka sheel x Kudachi A involved positive x positive general combiners with common parent Arka sheel having highest and significant gca effect, demonstrated its value as good general combiner for the total yield per plant.

Further, these two crosses (Arka sheel x Green round and Arka sheel x Kudachi A) having positive x positive gca effects reveals that the high sca effects in these crosses was mainly through additive gene effects. Therefore, the best option for improvement is the identification of transgressive segregants based on sca effects which may lead to isolation of promising lines of high total yield in brinjal. A similar result was observed by Varshney *et al.* (1999), Choudhary and Malhotra (2000) and Mallikarjun (2002).

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