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Line x tester analysis for combining ability in okra [*Abelmoschus esculentus* (L.) Moench]

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ABSTRACT

Eight lines and four testers of okra were evaluated for general and specific combining ability through line x tester mating method. The gene action was observed predominantly additive for days to 50 % flowering, days to first picking, number of nodes per plant, plant height, number of branches per plant, fruit length and fruit yield per plant, while predominance of non-additive gene action was observed for internodal length and fruit girth. The parents Pant Bhindi and D-1-87-5 were good general combiners for fruit yield per plant, number of nodes per plant and number of fruits per plant. KS-404 and BO-13 also were found good general combiners for early flowering and picking. Similarly, BO-13 and IC-990049 for shorter internodal length, Chhodawadi and Parbhani Kranti for tall plant, Pant Bhindi and EC-329372 for more number of branches per plant, Parbhani Kranti for fruit length, Chhodawadi and Pant Bhindi for fruit girth were found good general combiners. None of the crosses was proved to be good for fruit yield per plant.

Key words : Combining ability, Gca, Sca, Gene action, L x t analysis, Okra

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] is one of the most important vegetable crops of India. The information about combining ability is of immense helping to the plant breeders in choice of suitable parents for hybridization programme and provides valuable information regarding cross combinations to be exploited commercially. The nature and magnitude of gene action will enable the breeder in deciding suitable breeding methodology to be adopted in the crop improvement programmes. Therefore, present investigation was undertaken to estimate combining ability for fruit yield and its component characters in okra.

MATERIALS AND METHODS

Eight lines (females) *viz*., Chhodawadi, HRB-108-2, D-1-87-5, KS-404, Pant Bhindi, BO-13, EC-329372 and IC-990049 were crossed with four testers (males) namely; JOL-1, GO-2, Parbhani Kranti and HRB-55 in a line x tester fashion during summer season of 2005 to produce 32 F_1 hybrids. The experimental material, consisting of 44 entries including 12 parents (8 lines and 4 testers) and their 32 crosses, was planted in a Randomized Block Design with three replications during *kharif* season of 2005 at Instructional Farm, Junagadh Agricultural University, Junagadh. Each entry was represented by a single row plot of 10 plants, spaced at 45 x 30 cm. All the recommended agronomic practices and plant protection measures were followed to raise the good crop. The observations were recorded on five randomly selected competitive plants for fruit yield and its component characters (Table 1). The data were analyzed for combining ability following Kempthorne (1957).

RESULTS AND DISCUSSION

The analysis of variance for combining ability (Table 1) revealed that mean squares due to lines were significant for all the traits. Mean squares due to testers were also significant for all the characters except number of nodes per plant, number of branches per plant and fruit yield per plant, which indicated the existence of genetic diversity among the parents. However, mean squares due to lines were larger in magnitude than those due to testers for all the traits except internodal length and fruit length, indicating comparatively much diversity among the lines than the testers for these characters. While, line x tester interaction mean squares were significant for days to 50 % flowering, days to first picking, number of nodes per plant, internodal length, fruit length, fruit girth and number of fruits per plant, when tested against error mean squares. The lower magnitude of variances in the line x tester interaction suggested greater uniformity among the crosses than parents. Whereas, mean squares due to lines for days to 50 % flowering, days to first picking, number of nodes per plant, fruit girth and number of fruits per plant were significant when tested against line x tester interaction. The mean squares due to testers and line x tester

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Table 1: Analysis of variance for combining ability for ten characters in okra

Source of variance	d.f.	Days to 50 % flowering	Days to first picking	No. of nodes per plant	Internodal length (cm)	Plant height (cm)	No. of branches per plant	Fruit length (cm)	Fruit girth (cm)	No. of fruits per plant	Fruit yield per plant (g)
Hybrids	31	6.966**	6.966**	28.795**	0.902**	343.391**	0.421**	1.160**	0.171**	16.858**	5644.504**
Lines (L)	7	21.494**++	21.494**++	111.565**++	1.196**	799.215**	1.432**	0.702*	0.325**+	63.878**++	23790.780**
Testers (T)	3	5.375**	5.375**	1.969	1.297**	477.369*	0.062	1.217**	0.202**	0.468	411.375
L x T	21	2.351*	2.351*	5.038**	0.747**	172.310	0.136	1.304**	0.116**	3.526**	343.335
Error	62	1.127	1.127	1.095	0.033	123.776	0.118	0.244	0.033	1.570	551.324
Estimates of genetic components of variance											
$\sigma^2 l$	-	1.595	1.595	8.877	0.037	52.242	0.108	@	0.017	5.029	1953.954
$\sigma^2 t$	-	0.126	0.126	@	0.023	12.711	@	@	0.004	@	2.835
$\sigma^2 lt$ (σ^2 SCA)	-	0.408	0.408	1.314	0.238	16.178	0.006	0.353	0.028	0.652	@
σ^2 GCA	-	0.616	0.616	2.874	0.028	25.888	0.034	@	0.008	1.592	653.208
σ^2 GCA/σ^2 SCA	-	1.510	1.510	2.187	0.118	1.600	5.667	@	0.286	2.442	@

* and ** indicate significance of values at P=0.05 and 0.01, respectively against error mean squares.
+, ++ indicates significance of values at P=0.05 and 0.01, respectively against L x T interactions mean squares.
@ Estimates negative.

interaction were non-significant, when tested against line x tester interaction mean squares. This indicated the involvement of both additive and non-additive types of gene actions in the inheritance of these characters. Similar findings were reported by Borgaonkar *et al*. (2006) and Dahake and Bangar (2006).

Estimation of genetic components of variance revealed that the variances due to lines ($\sigma^2 l$) were higher than the variances of testers ($\sigma^2 t$) for days to 50 % flowering, days to first picking, number of nodes per plant, internodal length, plant height, number of branches per plant, fruit girth, number of fruits per plant and fruit yield per plant indicating the greater role of lines towards total additive genetic variance (σ^2gca). For rest of the traits, contribution of testers was predominant as compared to lines. Estimates of σ^2gca and σ^2sca revealed that the magnitudes of gca variance were higher than those due to sca variance for days to 50 % flowering, days to first picking, number of nodes per plant, plant height, number

Table 2: Estimate of general combining ability (gca) effects of the parents for ten characters in okra

Parents	Days to 50% flowering	Days to first picking	No.r of nodes per plant	Internodal length (cm)	Plant height (cm)	No. of branches per plant	Fruit length (cm)	Fruit girth (cm)	No. of fruits per plant	Fruit yield per plant (g)
Lines										
Chhodawadi	2.06**	2.06**	-2.29**	0.43**	19.51**	0.08	-0.37*	-0.23**	-1.21**	-32.69**
HRB-108-2	-1.19**	-1.19**	0.42	-0.18**	-4.33	-0.29*	0.20	-0.01	-0.96**	-13.85
D-1-87-5	0.15	0.15	2.66**	0.24**	-1.38	-0.11	0.16	-0.12*	2.55**	45.81**
KS-404	-1.69**	-1.69**	-0.71*	-0.20**	-3.23	-0.37**	-0.14	0.10	-0.67	-0.02
Pant Bhindi	0.81*	0.81*	5.20**	-0.06	1.01	0.58**	0.06	-0.13*	3.59**	62.23**
BO-13	-1.35**	-1.35**	-0.38	-0.33**	-1.46	-0.24*	0.19	0.15*	-0.21	4.81
EC-329372	1.23**	1.23**	0.09	0.42**	-5.46	0.44**	-0.32	0.27**	0.70	13.90
IC-990049	-0.02	-0.02	-4.99**	-0.31**	-4.66	-0.10	0.22	-0.03	-3.80**	-80.19**
S.E. ±	0.31	0.31	0.30	0.05	3.21	0.10	0.14	0.05	0.36	6.78
Testers										
JOL-1	-0.06	-0.06	-3.39	-0.29	-1.65	-0.06	0.09	-0.06	-0.01	-4.65
GO-2	0.35	0.35	0.09	0.06	-2.04	0.06	-0.03	-0.05	0.18	3.10
Parbhani Kranti	0.35	0.35	0.30	0.27**	6.64**	-0.02	0.24*	-0.03	-0.02	-2.31
HRB-55	-0.65**	-0.65**	-0.01	-0.04	-2.95	0.02	-0.30**	0.14**	-0.16	3.85
S.E. ±	0.22	0.22	0.21	0.04	2.27	0.07	0.10	0.04	0.26	4.79

* and ** indicates significance of values at P=0.05 and 0.01, respectively.

of branches per plant, number of fruits per plant and fruit yield per plant suggesting involvement of additive gene action in the inheritance of these characters. Whereas, for internodal length, fruit length and fruit girth; the sca variances were higher than the gca variances, which indicated greater role of non-additive gene action in the control of these characters. The σ^2gca/ σ^2sca ratio was more than one in case of days to 50 % flowering, days to first picking, number of nodes per plant, plant height, number of branches per plant and number of fruits per plant suggesting the preponderance of additive gene action in inheritance of these six traits. These findings are in close infirmity with the findings of several researchers *viz.*, Mitra and Das (2003) and Yadav *et al*. (2007) reported preponderance of gca over sca for different traits. Kumar *et al*. (2006) and Arora and Ghai (2007) reported preponderance of sca over gca for different characters. Importance of both additive and non-additive gene actions was reported by Borgaonkar *et al*. (2006), Dahake and Bangar (2006) and Singh *et al*. (2006).

The estimates of gca effects (Table 2) revealed that none of the parents was found as good general combiner simultaneously for all the traits studied. However, parents D-1-87-5 and Pant Bhindi appeared to be good general combiners for fruit yield per plant and its component traits *viz.*, number of nodes per plant, fruit girth and number of

Table 3 : Estimates of specific combining ability (sca) effects of the hybrids for ten characters in okra

Sr. No.	Crosses	Days to 50% flowering	Days to first picking	No. of nodes per plant	Internodal length (cm)	Plant height (cm)	No. of branches per plant	Fruit length (cm)	Fruit girth (cm)	No. of fruits per plant	Fruit yield per plant (g)
1.	Chhodawadi x JOL-1	-0.02	-0.02	1.26	0.55**	-12.02	0.14	-0.54	-0.23	0.70	6.90
2.	Chhodawadi x GO-2	-0.44	-0.44	-0.72	-1.04**	4.70	-0.11	0.74*	0.38**	0.24	2.81
3.	Chhodawadi x P.K.	-0.10	-0.10	0.58	-0.23	-5.64	0.04	0.13	0.07	-0.43	-7.10
4.	Chhodawadi x HRB-55	0.56	0.56	-1.12	0.72**	12.95	-0.07	-0.32	-0.22	-0.52	-2.60
5.	HRB-55 x JOL-1	-0.77	-0.77	-2.45**	0.13	-1.18	-0.16	-0.03	0.06	-1.09	-7.94
6.	HRB-55 x GO-2	0.15	0.15	1.74*	-0.41**	0.54	0.19	-0.34	-0.16	2.72**	18.31
7.	HRB-55 x P. K.	0.48	0.48	1.47*	0.16	-2.81	-0.13	-0.20	0.01	-1.75*	-19.27
8.	HRB-55 x HRB-55	0.15	0.15	-0.76	0.12	3.45	0.10	0.57	0.09	0.12	8.90
9	D-1-87-5 x JOL-1	-0.10	-0.10	1.32	-0.59**	1.14	-0.01	0.08	0.15	0.47	0.40
10.	D-1-87-5 x GO-2	-0.85	-0.85	0.34	0.47**	2.12	-0.26	-0.19	0.09	-0.46	8.65
11.	D-1-87-5 x P. K.	1.81*	1.81*	-1.37*	0.42**	-1.09	0.42	1.41**	0.03	0.27	3.06
12.	D-1-87-5 x HRB-55	-0.85	-0.85	-0.29	-0.30*	-2.17	-0.15	-1.31**	-0.27*	-0.29	-12.10
13.	KS-404 x JOL-1	-0.27	-0.27	-1.49*	-0.30*	2.72	0.06	-0.79*	-0.11	-0.57	-4.10
14.	KS-404 x GO-2	1.31	1.31	-0.60	0.57**	-8.90	0.07	0.16	-0.07	-0.97	-11.19
15.	KS-404 x P. K.	-1.35	-1.35	1.73*	0.14	10.83	-0.11	0.31	-0.09	1.43	9.23
16.	KS-404 x HRB-55	0.31	0.31	0.36	-0.40**	-4.65	-0.02	0.32	0.27*	0.11	6.06
17.	Pant Bhindi x JOL-1	-0.44	-0.44	0.94	0.01	4.49	-0.29	-0.07	-0.05	0.56	7.98
18.	Pant Bhindi x GO-2	-0.19	-0.19	0.29	0.17	3.20	0.46*	0.04	0.11	-0.27	-3.44
19.	Pant Bhindi x P. K.	0.15	0.15	-0.41	-0.65**	-5.14	-0.06	-0.14	-0.12	0.53	2.98
20.	Pant Bhindi x HRB-55	0.48	0.48	-0.81	0.47**	-2.55	-0.10	0.17	0.06	-0.83	-7.52
21.	BO-13 x JOL-1	0.73	0.73	-1.05	-0.26*	-4.38	-0.01	1.08**	0.23	-0.71	-10.27
22.	BO-13 x GO-2	-0.69	-0.69	-0.33	0.20	2.14	0.01	0.07	0.03	-0.17	6.98
23.	BO-13 x P. K.	-0.35	-0.35	-0.13	0.01	10.33	-0.18	-0.92*	-0.11	-0.63	-1.94
24.	BO-13 x HRB-55	0.31	0.31	1.51*	0.05	-8.08	0.18	-0.24	-0.14	1.51	5.23
25.	EC-329372 x JOL-1	0.15	0.15	1.01	-0.05	7.42	0.11	0.48	0.00	-0.05	-0.35
26.	EC-329372 x GO-2	0.40	0.40	-0.20	0.00	-9.67	-0.28	-0.29	-0.36**	-1.28	-17.77
27.	EC-329372 x P. K.	0.73	0.73	-1.64*	0.49**	3.99	0.14	-0.47	0.15	0.99	8.98
28.	EC-329372 x HRB-55	-1.27	-1.27	0.83	-0.44**	-1.75	0.03	0.28	0.21	0.33	9.15
29.	IC-990049 x JOL-1	0.73	0.73	0.46	0.52**	1.82	0.17	-0.21	-0.05	0.67	7.40
30.	IC-990049 x GO-2	0.31	0.31	-0.52	0.04	5.87	-0.08	-0.19	-0.01	0.18	-4.35
31.	IC-990049 x P. K.	-1.35	-1.35	-0.22	-0.33*	-10.47	-0.13	-0.13	0.06	-0.42	4.06
32.	IC-990049 x HRB-55	0.31	0.31	0.28	-0.22	2.79	0.03	0.53	-0.01	-0.43	-7.10
S.E. ±		0.61	0.61	0.60	0.11	6.42	0.20	0.29	0.11	0.72	13.56

* and ** indicates significance of values at P=0.05 and 0.01, respectively. P. K. = Pabhani Kranti.

Table 4 : Top ranking five specific combiners for fruit yield per plant and their *per se* performance and its gca status of parents in okra

Sr. No.	Crosses	sca effects	*Per se* performance ($\overline{X}$)	gca status	
				Female	Male
1.	HRB-108-2 x GO-2	18.31	351.00	A	A
2.	KS-404 x Parbhani Kranti	9.23	350.33	A	A
3.	EC-329327 x HRB-55	9.15	370.33	A	A
4.	EC-329327 x Parbhani Kranti	8.98	364.00	A	A
5.	HRB-108-2 x HRB-55	8.90	342.33	A	A

A=Desired non-significant gca

fruits per plant. Pant Bhindi was also found as good general combiner for number of branches per plant. The male parents HRB-108-2, KS-404 and BO-13 were identified as good general combiners for earliness and shorter internodal length. The parents Chhodawadi and Parbhani Kranti were found as good general combiners for tall plant. Parbhani Kranti only proved to be good general combiner for long fruits. These good general combiners could be used in transferring economic characters in breeding programme.

The results of specific combining ability (Table 3) indicated that none of the hybrids was consistently good for all the characters studied. As regards to fruit yield per plant, none of the crosses exhibited significant and positive sca effects for this character because non-significant of the line x tester interaction mean squares for fruit yield per plant. Considering desired sca effects, the best cross combinations were HRB-108 -2 x GO-2 for number of nodes per plant and number of fruits per plant, Chhodawadi x GO -2 for internodal length, Pant Bhindi x GO -2 for number of branches per plant,D-1-87-5 x Parbhani Kranti for fruit length and EC-329372 x GO-2 for fruit girth. None of the desired sca effects were appeared for days to 50 % flowering, days to first picking and plant height. Thus, lines possessing the high gca effects may be used as potential parents in hybridization programmes for the improvement of desired traits as well as the crosses having high sca effects may be utilized for obtaining high heterotic effect through heterosis breeding.

The best five crosses showing high sca effects for fruit yield coupled with *per se* performance and status of gca parents are present in Table 4. All the crosses were classified as average x average combiners on the basis of their gca effects for fruit yield may be due to the presence of genetic diversity among the parents and there could be some complementation indicating importance of non-additive gene effects.

The crosses with high sca effects for fruit yield and its components involved good x good, good x average, average x average, average x poor and poor x poor general combiners. This reflected the role of both additive and non-additive gene actions in the genetic control of these characters. The presence of additive gene action would be enhanced the chances for making improvement through simple selection. For exploitation of non-additive effects, it appears worthwhile to intermate the selected progenies in early segregating generations, which would be resulted in the accumulation of favourable genes for the characters. Hence, biparental mating or few cycles of recurrent selection followed by pedigree selection may give fruitful results.

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