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Research Article

Combining ability studies in okra (*abelmoschus esculentus* (l.) moench) for yield and its component characters

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Abstract
The present experiment was conducted with 28 F_1s developed through diallel hybridization technique excluding reciprocals along with eight parents in RBD with three replications. The *gca* and *sca* mean squares were significant for all the traits except *gca* mean square for fruit length. The ratio of *gca* and *sca* variances indicated the preponderance of non-additive gene effect for inheritance of all the traits. Genotypes AOL-09-25 and GO-2 showed good general combining ability for fruit yield appear to be worthy for exploitation of segregation and varietal development. The estimates of *sca* effects revealed that the cross combinations AOL-09-25 x AOL-09-26, GO-2 x AOL-09-28 and AOL-08-10 x AOL-08-2 were observed most promising for fruit yield and some of its related traits.

Key words
Abelmoschus esculentus (L.) Moench, combining ability, diallel analysis, fruit yield

Introduction:

Okra [*Abelmoschus esculentus* (L.) Moench] also known as ladies finger is an important vegetable crop being native of tropical Africa. One of the major problem in okra cultivation in India is lack of location specific high yielding varieties. In often cross-pollinated crops like okra, improvement in the past was based on selection in locally adapted populations. During recent past, exploitation of hybrid vigour and selection of parents on the basis of combining ability effects have opened a new line of approach in crop improvement. Application of biometrical techniques like diallel analysis has appeared to be the best and vastly useful breeding tool, which gives generalized picture of genetics of the characters under study. Understanding the nature of gene action could be helpful in predicting the effectiveness for selection in a population. Clear- cut knowledge of the type of gene action and magnitude and composition of genetic variance is of fundamental importance to a plant breeder. Furthermore, the combining ability studies are useful for the evaluation of newly developed lines for their parental usefulness and to know the gene actions involved in the inheritance of various characters. Hence, the present investigation was undertaken to study the gene action in different quantitative traits and to study the combining ability for yield and its components in okra.

Material and method

The materials for the present investigation comprised eight diverse genotypes of okra namely, AOL-08-10, AOL-09-24, AOL-08-2, AOL-09-25, AOL-09-26, AOL-09-27, GO-2 and AOL-09-28. All the genotypes were crossed in half diallel fashion during *kharif* 2009. Eight parents and 28 hybrids in a total of 36 genotypes were evaluated in a Randomized Block Design (RBD) with three replications at Main Vegetable Research Station, Anand Agricultural University, Anand, Gujarat during *kharif* 2010. Each plot consisted of 10 plants. Inter and intra raw spacing was kept 60 and 30 cm, respectively. All the recommended package of practices was adopted to raise a good crop. The observations were recorded on 5 competent plants for 12 quantitative traits *viz.,* days to first flowering, days to first picking, plant height (cm), number of nodes per plant, length of internode (cm), number of primary branches per plant, stem girth (cm), fruit length, fruit girth (cm), fruit weight (g), number of fruits per plant and fruit yield per plant (g). Combining ability analysis was performed according to Model – I, Method – II proposed by Griffing (1956).

Result and discussion

The mean squares due to *gca* and *sca* for different traits are presented in Table 1. The *gca* and *sca* mean squares were observed significant for all the traits except *gca* mean square for fruit length. This indicated that both additive and non-additive gene actions played important role for the inheritance of these traits. Whereas, for fruit length only *sca* mean square was observed significant indicating the importance of non-additive gene action for the expression of this trait. The *sca* variance component was observed to be higher than the respective *gca* variance component for all the traits indicating the predominance of non-additive gene action for the inheritance of all the traits. Similar findings were also obtained by Weerasekara *et al.* (2008) for days to first flowering, plant height, primary branches per plant, fruit length, fruit girth, fruit weight, fruits per plant, fruit yield per plant; Pal and Sabesan *et al.* (2009) for days to first flowering, primary branches per plant, fruits per plant, fruit yield per plant; Singh *et al.* (2009) for fruit weight; Wammanda *et al.* (2010) for plant height, length of internode, primary branches per plant, fruit length, fruit girth, fruits per plant, fruit yield per plant and Reddy *et al.* (2012) for primary branches per plant, length of internode, fruit length, fruit girth, fruit weight.

The estimates of *gca* effects (Table 2) revealed that none of the parents was found good general combiner simultaneously for all the traits studied. Two parents *viz.*; AOL-09-25 and GO-2 were observed to be good general combiners for fruit yield per plant. In addition to fruit yield, parent AOL-09-25 was also observed to be good general combiner for traits like days to first flowering, days to first picking, plant height, length of internode, fruit length and fruit girth. While, parent GO-2 was also observed to be good general combiner for traits like plant height, nodes per plant, stem girth and fruits per plant. Thus, these two parents were observed to be good combiners for fruit yield along with most of the other yield contributing traits. Thus both the parents could be considered in future breeding programme to generate more number of desirable segregants for fruit yield and its component traits. Rest of all the parents except AOL-08-10 were average combiners for fruit yield per plant. The parent AOL-08-2 was good general combiner for plant height and length of internode. While, parent AOL-09-27 found good general combiner for days to first flowering, days to first picking and fruit girth. The parent, AOL-09-26 found good general combiner for primary branches per plant and stem girth. While, parent AOL-08-10 was observed to be good general combiner for days to first flowering and fruit weight. These parents may be utilized in the component breeding programme. On the other hand, AOL-09-28 and AOL-09-24 were observed to be average or poor combiners for most of the traits.

The estimates of specific combining ability effects (Table 3) indicated that none of the hybrids was found to be superior for all the traits under investigation. However, seven crosses registered significant and positive *sca* effects for fruit yield per plant. Of these, top three were AOL-09-25 x AOL-09-26, GO-2 x AOL-09-28 and AOL-08-10 x AOL-08-2. All the top three crosses which exhibited high *sca* effects for fruit yield involved at least one good general combiner (Table 4). Such type of results were also obtained by Desai (1990), Patel *et al.* (1990), Poshiya and Vashi (1995), Pawar *et al.* (1999), Prakash *et al.* (2002), Pal and Sabesan (2009) and Dabhi *et al.* (2010). These hybrids could be exploited through heterosis breeding and and may also give transgressive segregants in subsequent generations and, therefore, it would be worthwhile to use them for improvement in fruit yield *per se.*

The results on *per se*, *gca* and *sca* effects (Table 4) revealed that the crosses with high *sca* effects for fruit yield involved good x average, average x good, average x average and poor x average general combiners. This indicated the role of additive and non-additive gene actions in the genetic control of these traits. The presence of additive gene action would enhance the chances for making improvement through simple selection. For exploitation of dominance and epistatic effects, it appears worthwhile to intermate the selected progenies in early segregating generations, which would result 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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Table 1 Mean square due to general and specific combining ability for yield and its component characters in okra

Sources of variation	d.f.	Days to first flowering	Days to first picking	Plant height (cm)	Nodes per plant	Length of internode (cm)	Primary branches per plant	Stem girth (cm)	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Fruits per plant	Fruit yield per plant (g)
gca	7	28.03**	18.43**	703.57**	7.49*	1.04**	4.58**	0.18**	0.71	0.094**	2.22**	5.08*	1362.78*
sca	28	7.65**	7.64**	209.01**	7.22**	0.37**	1.07**	0.04**	0.85**	0.021**	2.84**	10.57**	3559.22**
error	70	0.51	2.73	66.44	2.65	0.084	0.13	0.016	0.36	0.003	0.70	1.78	498.19
σ^2 *gca*		0.04	0.24	5.81	0.074	0.007	0.012	0.0014	0.032	0.00008	0.019	0.16	43.59
σ^2 *sca*		0.42	2.25	54.63	1.65	0.069	0.11	0.013	0.298	0.002	0.44	1.47	409.63
σ^2 *gca*/ σ^2 *sca*		0.09	0.11	0.11	0.04	0.10	0.11	0.11	0.11	0.04	0.04	0.11	0.11

*,** Significant at 5 % and 1 % levels, respectively.

Table 2. General combining ability (*gca*) effects for different characters in okra

Parents	Days to first flowering	Days to first picking	Plant height (cm)	Nodes per plant	Length of internode (cm)	Primary branches per plant	Stem girth (cm)	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Fruits per plant	Fruit yield per plant (g)
AOL-08-10	-1.03**	-0.61	-8.34**	-0.16	-0.36**	-0.83**	-0.01	0.39	-0.04*	0.69*	-0.39	-22.96**
AOL-09-24	0.40	-0.34	-6.68*	-0.41	-0.14	0.80**	-0.20**	-0.27	0.10	-0.11	-0.94*	-1.34
AOL-08-2	-0.23	-0.24	8.47**	0.03	0.37**	0.03	-0.13**	-0.23	-0.02	-0.61*	-0.73	-11.55
AOL-09-25	-2.43**	-2.01**	7.34**	-0.68	0.56**	-0.88**	-0.06	0.41*	0.07**	0.47	-0.19	14.60*
AOL-09-26	2.67**	1.82**	2.37	0.10	0.09	0.43**	0.15**	0.00	-0.08**	-0.50	0.65	4.15
AOL-09-27	-1.57**	-1.11*	-4.51	-0.28	-0.15	-0.31**	0.03	-0.22	0.15**	0.35	0.15	3.75
GO-2	0.63**	0.66	11.30**	2.03**	-0.04	-0.41**	0.20**	-0.08	-0.13**	0.03	1.19**	14.59*
AOL-09-28	1.57**	1.82**	-9.95**	-0.61	-0.33**	0.90**	0.03	0.01	-0.05**	-0.31	0.27	9.28
S. E. (gi) ±	0.23	0.55	2.72	0.54	0.09	0.12	0.04	0.20	0.02	0.28	0.44	7.44

*,** Significant at 5 % and 1 % levels, respectively.

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Table 3. Specific combining ability (*sca*) effects for different characters in okra

Crosses	Days to first flowering	Days to first picking	Plant height (cm)	Nodes per plant	Length of internode (cm)	Primary branches per plant	Stem girth (cm)	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Fruits per plant	Fruit yield per plant(g)
AOL-08-10 x AOL-09-24	2.11**	1.42	3.14	0.63	-0.08	-0.02	-0.08	0.29	0.06	-0.69	-0.10	11.60
AOL-08-10 x AOL-08-2	-1.92**	-1.01	6.92	1.42	-0.03	0.65*	0.20*	0.93*	0.05	-1.22	2.75**	107.82**
AOL-08-10 x AOL-09-25	0.61	-0.58	-2.48	1.87	-0.63**	0.96**	0.16	-0.78	0.04	-1.56*	-0.19	-14.42
AOL-08-10 x AOL-09-26	-0.15	-1.08	6.29	2.70*	-0.35	-0.05	0.30**	1.22**	0.04	0.76	5.42**	-38.13*
AOL-08-10 x AOL-09-27	5.08**	2.86*	-0.60	1.70	-0.30	1.09**	-0.09	-1.35**	-0.13**	-1.10	-0.65	8.98
AOL-08-10 x GO-2	-4.12**	-3.91**	16.71**	1.52	0.33	-0.38	0.18	1.68**	0.06	2.24**	-3.59**	-10.90
AOL-08-10 x AOL-09-28	1.28*	4.92**	-26.47**	-5.20**	0.10	-1.32**	-0.26**	0.92	0.14**	1.69*	-0.14	-30.55
AOL-09-24 x AOL-08-2	-0.02	-0.28	-0.34	-2.04	0.47*	-0.23	0.12	-1.13*	-0.07	-0.66	2.56*	25.65
AOL-09-24 x AOL-09-25	-1.82**	-2.51	6.33	-3.18*	1.54**	0.83**	0.00	0.14	0.14**	2.96**	2.06*	85.27**
AOL-09-24 x AOL-09-26	2.41**	3.66**	2.30	2.38	-0.55*	-2.17**	-0.17	0.67	-0.01	-1.21	-1.03	10.91
AOL-09-24 x AOL-09-27	4.31**	3.59**	7.26	0.30	0.17	-0.93**	-0.12	-1.12*	-0.25**	-1.84**	-1.29	-30.36
AOL-09-24 x GO-2	1.11*	-1.18	-15.25*	0.86	-0.82**	1.47**	0.17	0.50	-0.24**	-0.55	2.06*	-29.89
AOL-09-24 x AOL-09-28	0.51	-0.34	3.74	0.96	-0.12	0.22	-0.01	-0.34	0.05	-1.52*	-2.32	14.70
AOL-08-2 x AOL-09-25	4.48**	3.06*	5.52	-1.99	0.79**	-0.40	-0.11	-0.63	-0.16**	-1.62*	-0.33	-12.63
AOL-08-2 x AOL-09-26	0.71	0.89	-7.83	-3.85**	0.83**	0.42	-0.28**	0.22	-0.05	1.16	-3.81**	-54.82**
AOL-08-2 x AOL-09-27	-1.39*	-1.51	17.71**	2.36	0.10	-0.14	0.05	-1.08*	0.02	-1.64	-1.69	-34.98*
AOL-08-2 x GO-2	2.75**	2.39	-2.17	0.80	-0.37	1.71**	0.15	0.07	0.11*	-0.62	0.50	-9.67
AOL-08-2 x AOL-09-28	1.48**	-0.11	14.93**	1.69	0.19	-0.68*	0.13	0.65	-0.05	0.79	0.43	-21.64
AOL-09-25 x AOL-09-26	2.25**	2.32	11.10	5.00**	-0.87**	0.58*	0.45**	-0.45	-0.22**	1.42*	6.31**	143.18**
AOL-09-25 x AOL-09-27	-0.52	0.26	7.65	2.37	-0.32	0.44	-0.07	0.21	0.19**	1.99**	2.57	-44.76*
AOL-09-25 x GO-2	-1.72**	-1.51	-10.25	-4.12**	0.65**	-0.98**	-0.16	0.03	-0.15**	0.54	-3.65**	-31.12
AOL-09-25 x AOL-09-28	-1.99**	-3.34*	5.26	-0.38	0.31	-0.61*	-0.23*	0.36	-0.04	-3.27**	-2.53	-53.12**
AOL-09-26 x AOL-09-27	0.05	0.09	13.04*	-0.61	0.72**	-0.47	0.10	-0.26	0.07	0.27	1.96	44.42*
AOL-09-26 x GO-2	-0.15	-2.34	-27.79**	-3.97**	-0.24	-0.34	-0.29**	-0.94	0.07	-0.75	-4.31**	18.04
AOL-09-26 x AOL-09-28	1.25*	1.49	-5.40	0.17	-0.23	1.12**	0.08	-0.07	0.24**	0.14	-3.21**	-65.28**
AOL-09-27 x GO-2	-4.59**	-4.41**	14.02*	2.28	0.04	0.87**	0.20*	1.52**	0.04	2.65**	5.06**	98.12**
AOL-09-27 x AOL-09-28	0.48	-0.24	0.29	-1.25	0.33	1.91**	0.24*	-0.06	-0.23**	0.34	1.16	42.23*
GO-2 x AOL-09-28	-1.72**	-2.01	28.99**	4.04**	0.26	-1.41**	0.13	-1.21*	0.05	-2.13**	7.34**	117.77**
S. E. (s_{ij}) ±	0.56	1.30	6.43	1.28	0.22	0.28	0.099	0.47	0.04	0.66	1.05	17.61

*,** Significant at 5 % and 1 % levels, respectively.

Table 4. Top ranking significant 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(g) ($\bar{X}$)	*gca* status
1.	AOL-09-25 x AOL-09-26	143.18**	453.99	G x A
2.	GO-2 x AOL-09-28	117.77**	433.27	G x A
3.	AOL-08-10 x AOL-08-2	107.82**	370.42	P x A
4.	AOL-09-27 x GO-2	98.12**	408.08	A x G
5.	AOL-09-24 x AOL-09-25	85.27**	390.61	A x G
6.	AOL-09-26 x AOL-09-27	44.42*	349.42	A x A
7.	AOL-09-27 x AOL-09-28	42.23*	352.36	A x A

*,** Significant at 5 % and 1 % levels, respectively.
G-Good general combiner (Desired significant *gca*), A-Average general combiner (Desired non-significant *gca*), P-Poor general combiner (Non-desired significant *gca*)