

Studies on combining ability in okra [*Abelmoschus esculentus* (L.) Moench]

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ABSTRACT

A line x tester analysis in okra was carried out with 20 parents (17 lines x 3 testers) and their 51 F_1 's, in two different seasons. The combining ability variances indicated the preponderance of non-additive gene action for all the characters. Studies indicated the scope of heterosis breeding in crop improvement in okra. The lines *viz.*, VRO-5, VRO-6, Arka Abhay, IC-218844 and testers like Arka Anamika proved to be the good general combiner and Arka Abhay x Arka Anamika, was the good specific combiner for most of the yield and yield attributing traits.

Key words : Combining ability, Line x tester, Okra, Heterosis, Okra

Okra [*Abelmoschus esculentus* (L.) Moench] is an important vegetable crop in the tropics and subtropics parts of the world. There is tremendous scope for improvement in okra. The success of any crop improvement programme depends upon the nature and magnitude of gene action as determined in the form of lines with high combining ability. The lines which produce good progenies on crossing are of immense value to the breeder. Combining ability is an effective tool to identify the suitable parents and crosses for their use in effective crop improvement programme (Sprague and Tatum, 1942). The concept of combining ability plays a pivotal role together with *per se* performance of parents, hybrids and heterotic response helps breeders in selecting potential parents, which combine well in producing promising hybrids for systematic breeding programme. In present research work, the combining ability was carried out through line x tester in order to sort out good combiners that can be utilised in the production of commercial hybrids.

MATERIALS AND METHODS

The present investigation was carried out at Institute of Agriculture Sciences, Banaras Hindu University, Varanasi, in a Randomized Block Design with three replications during two crop seasons. All the recommended practices were followed during experimentation. The experimental material consisted of 51 F_1 's, involving 17 lines (IC – 128883, VRO – 5, VRO-6, AC-108, IC – 45806, IC – 218877, IC – 218844, Arka Abhay, IC – 43720, IIVR – 342, IC – 140906, IIVR – 198, EC – 305612, IIVR – 435, IIVR – 401, SA – 2 and

IC – 140934) and 3 testers (Arka Anamika, Pusa Sawani and Parbhani Kranti). Observations were recorded on fifteen characters *viz.*, plant height (cm), stem diameter (cm), number of branches/plant, number of nodes/plant, internodal length (cm), days to first flowering, days to 50 per cent flowering, number of fruits/plant, single fruit weight (g), fruit length (cm), fruit diameter (cm), fruit yield/plant (g), number of seeds/fruit, number of ridges/fruit and ascorbic acid content (mg/100g). Combining ability analysis was worked out in line x tester design as suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

The analysis of variance (Table 1 and 2) for combining ability indicated that mean sum of square due to lines (females) were highly significant for all the characters indicating genetic diversify among the lines, this highest contribution by these characters towards combining ability. Variation in tester was also significant for 13 characters. The female x male interaction component also emerged significant for all the 15 characters, which proved that the combining ability contributed heavily in the expression of these traits. Similar findings were reported by Singh and Singh (2003), Kumar *et al.* (2005) and Singh *et al.* (2009).

Estimates of GCA effects (Table 3) showed that it was difficult to pickup a good combiner for all the characters together as the combining ability effect were not consistent yield attributing traits. It was not possible because of low or negative association of characters, whereas overall results indicated that seven lines and one tester having positive significant GCA effects for fruit

Table 1: Analysis of variance (mean square) for combining ability for 15 characters in okra

Source of variation	d.f.	Plant height (cm)	Stem diameter (cm)	Number of branches/plant	Number of nodes/plant	Inter nodal length (cm)	Days to first flowering	Days to 50% flowering	Number of fruits/plant	Single fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit yield/plant (g)	Number of seeds/fruit	Number of ridges/fruit	Ascorbic acid (mg/100g)
Replication	2	69.150	0.042	0.002	5.516	1.075	5.676	2.431	3.864	0.850	0.221	0.000	696.811	92.098	0.000	0.939
Females	16	441.477**	0.198**	1.391**	18.252**	5.139**	18.923**	43.202**	12.167**	3.961**	1.494**	0.024**	2245.409**	215.134**	0.301**	12.513**
Males	2	615.453**	0.121*	0.512*	84.522**	24.246**	17.923**	1.494	1.849	10.916**	0.286**	0.078**	2491.898**	230.256**	0.009**	12.654**
Female x Male	32	468.006**	0.194**	0.791**	23.089**	6.573**	16.956**	13.809**	3.012**	3.032**	1.397**	0.024**	752.913**	146.457**	0.009**	2.370**
Error	100	35.677	0.037	0.122	1.233	1.129	1.146	1.531	1.016	0.404	0.027	0.010	143.975	17.699	0.001	0.702

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

Table 2: Estimates of general combining ability effects of parents (lines and testers) for 15 characters in okra

Parents	Plant height (cm)	Stem diameter (cm)	Number of branches/plant	Number of nodes/plant	Inter nodal length (cm)	Days to first flowering	Days to 50% flowering	Number of fruits/plant	Single fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit yield/plant (g)	Number of seeds/fruit	Number of ridges/fruit	Ascorbic acid (mg/100g)
IC - 128883	-2.42	-0.22**	0.10	-1.06**	0.54	1.42**	0.53	1.79**	-0.74**	0.06	0.06*	8.37*	2.87*	-0.04**	-0.01
VRO-5	-14.36**	-0.01	0.35**	0.14	-0.67*	1.42**	1.20**	1.53**	1.50**	0.73**	0.03	26.12**	3.56**	-0.04**	2.80**
VRO-6	4.06*	0.02	-0.10	0.86**	-0.29	-1.25**	-1.14**	0.60*	0.51**	0.25**	-0.04	19.28**	-0.79	-0.04**	1.68**
AC-108	-3.06	-0.03	-0.30**	-0.12	-0.36	1.20**	-0.14	0.99**	0.54**	0.08	0.06*	14.63**	-7.79**	-0.04**	-1.00**
IC-45806	-7.33**	-0.13*	-0.19	-0.29	-0.73*	1.20**	-1.03**	0.60*	0.24	0.05	-0.01	9.51**	1.30	-0.04**	0.15
IC-218877	-0.29	-0.03	0.32**	-0.89**	0.46	0.42	-1.79**	-1.21**	-0.92**	-0.21**	0.06*	-21.15**	6.37**	-0.04**	-0.62**
IC-218844	1.76	0.13*	-0.52**	-1.27**	-0.14	-1.47**	-3.25**	-2.61**	0.32	0.62**	0.06*	-24.05**	-7.05**	-0.04**	-0.09
Arka Abhay	-0.41	-0.07	-0.44**	0.04	0.05	0.75*	-1.80**	1.28**	0.17	-0.19**	0.03	14.81**	2.98*	-0.04**	0.62**
IC-43720	-0.31	-0.10	0.09	-0.72*	0.49	-3.25**	-4.47**	-0.73*	-0.63**	-0.14**	-0.01	-14.13**	-1.58	0.71**	-0.95**
IIVR-342	8.36**	0.11*	0.09	-0.34	1.19**	-0.36	0.08	-0.42	-0.29	-0.21**	-0.07*	-7.12*	8.21**	-0.04**	-1.78**
IC-140906	1.67	0.02	-0.59**	-1.24**	1.07**	1.08**	1.86**	-1.45**	-0.63**	-0.22**	-0.07*	-21.08**	1.29	-0.04**	-0.64**
IIVR-198.00	8.12**	0.21**	-0.33**	4.82**	-1.66**	0.75*	0.20	-0.97**	-0.96**	-0.69**	0.06*	-19.94**	2.83*	-0.04**	0.51*
EC - 305612	6.42**	0.22**	0.17	0.33	0.58*	0.31	1.42**	0.73*	0.49**	-0.50**	-0.01	13.79**	0.77	-0.04**	0.46*
IIVR-435	1.38	-0.09*	1.02**	-0.14	0.04	-0.80**	1.20**	-0.01	-0.32	-0.41**	-0.11*	-4.34	-4.72**	-0.04**	-2.02**
IIVR-401	12.63**	0.28**	0.17	1.03**	0.03	-1.25**	0.42	-0.35	0.70**	0.01	-0.01	4.01	-5.11**	-0.04**	0.79**
SA-2	-5.21**	-0.13*	0.23*	-1.20**	0.54	-2.03**	1.64**	0.09	0.02	0.01	-0.01	0.29	-7.31**	-0.04**	0.30
IC-140934	-11.03**	-0.20**	-0.08	0.04	-1.12**	1.86**	5.08**	0.15	-0.01	0.76**	-0.01	1.01	4.17**	-0.04**	-0.21
SE \pm F	1.64	0.05	0.10	0.30	0.29	0.29	0.34	0.28	0.17	0.05	0.03	3.29	1.15	0.01	0.23
Arka Anamika	3.84**	0.05*	0.10**	1.41**	-0.75**	-0.23*	-0.20	-0.15	0.10	0.05*	0.02*	-1.23	-0.47	-0.01**	-0.32**
Pusa Sawani	-2.94**	-0.04*	-0.01	-1.11**	0.61**	0.67**	0.12	-0.07	0.41**	0.03	0.03**	7.52**	-1.85**	0.00	-0.26**
Prabhani Kranti	-0.90	-0.01	-0.10**	-0.29**	0.14	-0.44**	0.08	0.22*	-0.50**	-0.09**	-0.05**	-6.29**	2.32**	0.01**	0.57**
S.E. \pm	0.58	0.02	0.03	0.11	0.10	0.10	0.12	0.10	0.06	0.02	0.01	1.16	0.41	0.00	0.08

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

Table 3 : Estimates of specific combining ability effects of hybrids (F₁) for 15 characters in okra

Hybrids	Plant height (cm)	Stem diameter (cm)	Number of branches/pl ant	Number of nodes/plant	Inter nodal length (cm)	Days to first flowering	Days to 50 % flowering	Number of fruits/plant	Single fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit yield/plant (g)	Number of seeds/fruit	Number of ridges of fruit	Ascorbic acid (mg/100 g)
IC - 128883 × AA	2.74	0.02	-0.32*	0.22	-0.23	1.23**	-0.47	-0.05	0.15	-0.10	0.05	4.16	-4.55**	0.01	0.94**
IC - 128883 × PS	6.35**	0.15*	-0.20	-0.52	1.24**	-1.67**	0.55	0.14	-0.20	0.19**	0.04	-4.36	1.76	0.00	-2.35**
IC - 128883 × PK	-9.09**	-0.18*	0.52**	0.29	-1.01*	0.44	-0.08	-0.08	0.05	-0.09	-0.09*	0.19	2.79	-0.01	1.41**
VRO - 5 × AA	-17.48**	-0.39**	0.01	2.52**	-2.02**	0.23	1.20*	0.50	-1.00	1.56**	-0.02	-11.18*	-4.77**	0.01	0.16
VRO - 5 × PS	18.09**	0.44**	0.32*	-0.02	0.90*	-0.67	0.88	-0.81*	1.59**	-0.69**	-0.03	34.00**	5.57**	0.00	-0.17
VRO - 5 × PK	-0.61	-0.06	-0.36*	-2.51**	1.13**	0.44	2.08**	0.31	-0.60*	-0.87**	0.05	-22.82**	-0.80	-0.01	0.01
VRO - 6 × AA	4.00	-0.15*	-0.48**	0.45	0.93*	-2.10**	-1.14*	-1.20**	-1.17**	-0.45**	-0.05	-14.72**	-4.63**	0.01	-0.58
VRO - 6 × PS	0.27	0.04	0.43**	0.74	-0.93*	0.99*	2.88**	0.52	0.68**	0.63**	0.04	9.67*	4.28**	0.00	0.52
VRO - 6 × PK	-4.27	0.11	0.05	-1.18**	0.00	1.11**	-1.75**	0.67	0.49	-0.18**	0.01	5.05	0.35	-0.01	0.06
AC - 108 × AA	3.89	0.04	0.42**	1.66**	-0.70	-1.22**	-3.14**	0.31	-0.26	-0.15*	-0.15**	-11.09*	1.47	0.01	-0.11
AC - 108 × PS	-4.81**	-0.07	-0.17	-1.39**	0.77	-0.45	1.55**	-1.13	0.66**	-0.07	0.14**	20.05**	-2.65	0.00	0.07
AC - 108 × PK	0.92	0.03	-0.25	-0.27	-0.08	1.67**	1.59**	0.82*	-0.40	0.22**	0.01	-8.96	1.18	-0.01	0.04
IC - 45806 × AA	11.09**	0.14*	-0.06	0.09	0.84*	1.12**	1.42**	-0.07	0.44	0.08	0.01	6.33	7.91**	0.01	0.42
IC - 45806 × PS	-1.57	-0.10	-0.18	0.28	0.00	-1.78**	-1.23*	0.06	-0.94**	-0.20**	0.01	-12.76**	-8.37**	0.00	-0.44
IC - 45806 × PK	-9.51**	-0.03	0.24	-0.37	-0.84*	0.67	-0.19	0.01	0.50*	0.12*	-0.02	6.43	0.46	-0.01	0.03
IC - 218877 × AA	-2.91	-0.10	-0.14	-1.31**	0.44	-1.77**	-0.14	0.65	0.53*	0.00	0.05	12.72**	-7.95**	0.01	0.28
IC - 218877 × PS	-1.31	0.13	-0.46**	0.31	0.15	0.33	-0.45	0.74	-0.55*	0.12*	-0.06	-3.60	9.33**	0.00	0.32
IC - 218877 × PK	4.22	-0.03	0.60**	0.99*	-0.59	1.44**	0.59	-1.38**	0.03	-0.13*	0.01	-9.12	-1.38	-0.01	-0.61
IC - 218844 × AA	-15.50**	0.04	0.01	-2.40**	-0.93*	-1.88**	2.31**	-0.65	2.71**	1.50**	0.15**	17.28**	6.07**	0.01	-0.15
IC - 218844 × PS	9.87**	0.20**	0.39**	1.63**	0.25	0.22	-0.67	-0.43	-1.86**	-1.38**	-0.06	-24.13**	0.25	0.00	0.32
IC - 218844 × PK	5.63*	-0.23**	-0.39**	0.77	0.68	1.67**	-1.63**	1.08**	-0.85**	-0.13*	-0.09*	6.85	-6.32**	-0.01	-0.17
Arka Abhay × AA	20.20**	0.54**	0.13	3.66**	-1.04*	0.90*	2.53**	0.59	-1.26**	0.05	-0.02	-9.74*	8.97**	0.01	-0.99**
Arka Abhay × PS	0.60	-0.07	-0.56**	-0.25	0.22	0.99*	-0.78	-0.49	-0.21	-0.37**	-0.03	-10.32*	-8.22**	0.00	-0.32
Arka Abhay × PK	-20.80**	-0.47**	0.43**	-3.41**	0.83*	-1.89**	-1.75**	-0.10	1.47**	0.32**	0.05	20.06**	-0.75	-0.01	1.31**
IC - 43720 × AA	-11.64**	-0.06	-0.04	-0.51	-0.94*	-5.10**	-2.14**	-2.13**	-0.06	-0.03	0.01	-19.54**	8.59**	-0.21*	-0.08
IC - 43720 × PS	6.80**	0.13	0.51**	0.85	0.12	4.99**	-1.45**	1.26**	-0.37	0.39**	0.01	4.34	-0.43	-0.02*	0.16
IC - 43720 × PK	4.83*	-0.07	-0.47**	-0.34	0.82*	0.11	3.59**	0.87*	0.44	-0.36**	-0.02	15.19**	-8.16**	0.23*	-0.07
IIVR-342 × AA	-12.20**	-0.04	-0.24	-3.72**	2.45**	0.01	-1.03*	0.29	-0.44	-0.56**	0.18**	-2.05	2.14	0.01	0.14
IIVR-342 × PS	12.10**	0.02	0.44**	4.84**	-3.11**	-0.23	-0.01	0.41	1.08**	0.06	-0.03	13.10**	-0.42	0.00	-0.55
IIVR-342 × PK	0.10	0.02	-0.20	-1.12*	0.67	0.22	1.03*	-0.70	-0.64*	0.51**	-0.15**	-11.05	-1.72	-0.01	0.41

Table 1 Contd.....

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Hybrids	Plant height (cm)	Stem diameter (cm)	Number of branches/plant	Number of nodes/plant	Internodal length (cm)	Days to first flowering	Days to 50% flowering	Number of fruits/plant	Single fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit yield/plant (g)	Number of seeds/fruit	Number of ridges/fruit	Ascorbic acid (mg/100g)
IC - 140906 × AA	-8.41**	-0.25**	0.31*	-0.59	-0.18	1.56**	-0.47	-0.41	-0.16	-0.35**	-0.02	-4.12	-1.97	0.01	0.34
IC - 140906 × PS	11.23**	0.24**	-0.05	1.54**	-0.84*	-1.34**	-0.78	-0.52	0.16	0.27**	-0.03	-7.70	-1.43	0.00	0.11
IC - 140906 × PK	-2.81	0.01	-0.26	-0.95*	1.01*	-0.22	1.25*	0.93*	0.00	0.09	0.05	11.82*	3.40*	-0.01	-0.45
IIVR-198 × AA	12.81**	0.22**	-0.22	1.35**	-0.18	0.90*	1.20*	-0.27	0.04	-0.32**	-0.05	-1.19	0.61	0.01	0.35
EC - 305612 × PS	-2.09	0.08	-0.77**	-1.84**	1.45**	-0.56	0.66	2.02**	0.07	0.71**	-0.09*	19.12**	5.36**	0.00	2.01**
EC - 305612 × PK	-3.56	-0.12	-0.12	-1.26**	0.39	-0.78	1.70*	-1.26**	-0.19	-0.30**	0.18**	-12.73**	-4.91**	-0.01	-1.65**
IIVR-435 × AA	-2.76	-0.11	0.16	0.88*	-0.85*	-2.22**	-0.80	0.48	-0.21	0.07	0.01	2.51	6.17**	0.01	0.78*
IIVR-435 × PS	-3.55	-0.11	0.61**	-1.36**	1.24**	2.55**	1.88**	-0.13	-0.58*	-0.51**	0.01	-11.38*	2.18	0.00	-0.71*
IIVR-435 × PK	6.31**	0.22**	-0.78**	0.48	-0.39	-0.33	-1.08*	-0.35	0.79**	0.44**	-0.02	8.87	-8.35**	-0.01	-0.07
IIVR-401 × AA	7.16**	0.06	-0.65**	-1.83**	1.30**	-0.10	-0.36	1.09**	-0.46	-0.02	-0.09*	6.89	-3.31*	0.01	0.24
IIVR-401 × PS	-17.96**	-0.28**	-0.24	-2.14**	0.37	0.99*	-0.34	-0.49	1.43**	0.00	0.11**	7.18	-2.93	0.00	-0.05
IIVR-401 × PK	10.80**	0.22**	0.89**	3.97**	-1.67**	0.89*	0.70	-0.60	-0.96**	0.02	-0.02	-14.07**	6.24**	-0.01	-0.19
SA - 2 × AA	-10.44**	-0.20**	0.28*	-3.60**	1.95**	0.34	-1.92**	0.01	1.01**	0.05	0.01	12.34**	-11.24**	0.01	-0.01
SA - 2 × PS	0.70	-0.03	0.00	3.56**	-2.78**	-0.23	0.44	-0.06	-0.63*	0.50**	0.01	-11.08*	-0.99	0.00	0.14
SA - 2 × PK	9.73**	0.23**	-0.28*	0.04	0.82*	-0.11	1.48**	0.05	-0.39	-0.55**	-0.02	-1.26	12.24**	-0.01	-0.13
IC - 140934 × AA	13.82**	0.20**	-0.07	0.02	1.01*	6.78**	5.31**	1.62**	0.05	-0.90**	0.01	17.79**	-3.05	0.01	-1.36**
IC - 140934 × PS	-7.71**	-0.30**	0.37**	0.61	-1.00*	-3.12**	-3.01**	-0.95*	0.10	0.96**	0.01	-12.36**	-8.04**	0.00	0.75*
IC - 140934 × PK	-6.11**	0.10	-0.30*	-0.64	-0.01	-3.67**	-2.30**	-0.67	-0.15	-0.06	-0.02	-5.44	11.09**	-0.01	0.61
SE ± F ₁	2.32	0.07	0.14	0.43	0.41	0.42	0.48	0.39	0.25	0.06	0.04	4.65	1.63	0.01	0.32

* and ** indicate of significance of values at P = 0.05 and 0.01, respectively, AA = Arka Anamika, PS = Pusa Sawani, PK = Prabhani Kranti.

yield per plant in which VRO-5 and VRO-6 are most useful lines. Among these, VRO-5 also emerged as good general combiner for number of fruits per plant, fruit length, fruit yield per plant and ascorbic acid content. However, IIVR-401 for plant height and stem diameter, IIVR-435 for number of branches per plant, VRO-5 for fruit yield per plant, ascorbic acid content and single fruit weight, IIVR-198 for number of nodes per plant and internodal length, IC-43720 for days to first flowering and days to 50 per cent flowering, IC-128883 for number of fruits per plant, IC-140934 for fruit length, IC-218844 for fruit diameter and AC-108 for number of seeds per fruit were most promising general combiners. Similar findings were reported by Srivastava *et al.* (2008) and Singh *et al.* (2009).

In the present study, none of the cross combination to have high SCA (Table 3) for all the characters under study. The cross combinations, Arka Abhay x Arka Anamika for plant height and stem diameter, IIVR-401 x Prabhani Kranti for number of branches per plant, IIVR-198 x Prabhani Kranti for number of nodes per plant, IIVR-342 x Pusa Sawani for internodal length, IC-43720 x Arka Anamika for days to first flowering, AC-108 x Arka Anamika for days to 50 per cent flowering, EC-305612 x Pusa Sawani for number of fruits per plant and ascorbic acid content, IC-218844 x Arka Anamika for single fruit weight, VRO-5 x Arka Anamika for fruit length and IIVR-342 x Arka Anamika for fruit diameter, VRO-5 x Pusa Sawani for fruit yield per plant and SA-2 x Arka Anamika for number of seeds per fruit had high significant desirable SCA effects. The hybrid,

Arka Abhay x Arka Anamika was found to be the most desirable combination for plant height and stem diameter, EC-305612 x Arka Anamika for number of branches per plant, IIVR-198 x Prabhani Kranti for number of nodes per plant, VRO-5 x Arka Anamika for internodal length, IC-43720 x Arka Anamika for days to first flowering, EC-305612 x Pusa Sawani for number of fruits per plant, VRO-5 x Pusa Sawani for single fruit weight and fruit yield per plant, IC-218844 x Arka Anamika for fruit length and fruit diameter, SA-2 x Arka Anamika for number of seeds per fruit and Arka Abhay x Prabhani Kranti for ascorbic acid content. Dahake and Banger (2006); Adeniji and Kehinde (2007); Eswaran *et al.* (2007); Srivastava *et al.* (2008) and Weerasekara *et al.* (2008) observed specific combining ability (SCA) in okra for different crosses for different traits.

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