



Combining ability analysis in okra (*Abelmoschus esculentus*)

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ABSTRACT

An experiment on okra [*Abelmoschus esculentus* (L.) Moench] was conducted with 20 genotypes in 17 line × 3 testers fashion during 2012-2013 to procure 51 F₁s and 51 F₂s in RBD with three replications at HRC, Department of Horticulture, SVPUA&T, Meerut, to study the combining ability of various agronomic and economically important traits for genetic improvement and their effect in the population. Among the parents under study IC 218872 for plant height, VRO 5 for days to flowering, plant height, length of internode and yield/plant showed higher gca effect, whereas crosses IC 306053 × Parbhani Kranti (PK), C 7801 × Parbhani Kranti (PK), Azad Bhindi 2 × Parbhani Kranti (PK), BO 2 × Azad Krishna, FB 10 × Parbhani Kranti (PK) and VRO 1668 × Azad Krishna were showed significant positive effect for more than one character indicating their utility in further breeding programme. The best parents and their crosses are utilized in breeding programme for the improvement of yield components.

Key words: ANOVA, GCA, Line × Testers, Okra, SCA

Okra [*Abelmoschus esculentus* (L.) Moench], an important vegetable crop of India, belongs to Malvaceae family and grown in *kharif* and *zaid* seasons. Its green edible fruits are consumed for vegetable purpose, in the tropical and sub-tropical regions of the world, grown successfully both in the plains and hills (Singh *et al.* 2004). It is predominantly a self-fertilized crop but natural crossing to the extent of 6.75% has been reported (Purewal and Randhawa 1947). It is an interesting crop to breeders and the geneticists, for its monadelphous condition of the stamens and large flowers are amenable to easy emasculation and its capsule bears large number of seeds. Being a short duration crop two generations can be grown in one year. Combining ability refers to the ability of a genotype to transfer its superiority to its crosses; the gca variance provides and estimate to additive genetic variance, which is required for the estimation of narrow sense heritability (Jindal *et al.*, 2009). It also provides information about the gene action involved in the expression of various quantitative characters and thus, helps in deciding the breeding procedure for genetic improvement of such traits.

MATERIALS AND METHODS

The experimental materials for present investigation comprised 20 parents (17 lines and 3 testers) of okra which were sown in a line × tester fashion during *kharif*, 2012. The seed was collected from Indian Institute of Vegetable

Research (IIVR), Varanasi, (UP). The germplasm stock maintained at the Horticulture Research Centre (HRC), Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut by providing good agronomic practices to keep the crop in good condition. All the homozygous parents were sown during the *zaid* season. All the possible 51 F₁ crosses, excluding reciprocals were made among these 20 parents. For building up of the F₂ population of these F₁ crosses. All the 51 F₁s were sown during the next *kharif* season. All these F₁s were selfed for procuring the F₂ seeds. The parents were also maintained through selfing.

All the 51 F₁s and F₂s along with 20 parents were sown in a randomized block design (RBD) with three replications during the season of *kharif*. Parents and F₁s were sown in single rows while F₂s in double rows, with ten plants in each row. The rows were 5 m long and spaced 50 cm apart. The plant to plant spacing was maintained at 50 cm. The observations were recorded on randomly selected five plants in each parent and F₁ and 10 plants in each F₂ populations from each replication. The selected plants were tagged and properly labeled before flowering for recording the observations, viz. days to flowering, plant height, number of branches per plant, number of first fruiting node, length of first fruiting node, length of internode, length of fruit, width of fruit, number of fruits/plant and yield/plant. The combining ability analysis was carried out by the procedure suggested by Griffing (1956). The experimental method-II and Model-I of Robinson (1965) and Robinson (1966) was taken up for the material under study.

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RESULTS AND DISCUSSION

Before subjecting the data for various genetic analyses, the analysis of variance was done for all the characters to test the significance among the genotypes under study for all the characters under study (Table 1). The combining ability analysis was carried out separately for F_1 s and F_2 s population and results are presented in Table 2. Variance due to males, females and interactions were found highly significant for all the characters except number of branches/plant, number of first fruiting node and width of fruit. The magnitude of sca variance was higher than gca variance. The gca effects for all the characters in both F_1 s and F_2 population are presented in Table 2. Early flowering was considered to be desirable character, with negative values of gca effect were put under the desirable group. The gca effect ranged from 1.99 (BO 2) to 2.68 (IC 69302) in F_1 and from 2.27 (BO 2) to 2.62 (IC 69302) in F_2 . Lines BO 2, Azad Bhindi 1, EC 169367, IC 306053 and C 7801 in F_1 and BO 2, EC 169367, IC 306053, Azad Bhindi 2 and SC 108 in F_2 population show significant and negative gca effects therefore lines were classified as good general combiners for early flowering. Considering tallness as desirable trait, parents with positive gca effects were considered to be better general combiners. The gca effect range 10.75 (FB 10) to 15.03 (IC 218872, VRO 5) in F_1 and from 6.37 (Azad Bhindi 2) to 7.85 (FB 10) in F_2 population. Suggesting that IC 218872, VRO 5, EC 169367, SC 108, IC 69302 in F_1 and FB 10, IC 218872, SC 108, EC 169367, IIHR 4 in F_2 were the best general combiners for tallness. The estimates of gca for number of branches/plant ranged from 0.44 (EC 169367, C 7801) to 0.56 (IIHR 4) in F_1 and from 0.43 (BO 2) to 0.90 (IIHR 4) in F_2 population. Suggesting that IIHR 4, Azad Bhindi 2, IC 306053, SC 108, BO 2 and IIHR 4, IC 218872, EC 169367, IC 11527, IC 69302 were best combiners for high number of branches/plant in F_1 and F_2 respectively. Considering minimum numbers of first fruiting node as desirable character, parents with negative gca effects were considered to be better general combiners. The gca effect range from 1.45 (IC 218872) to 0.88 (IC 11527) in F_1 and ranged from 0.86 (IC 218872) to 0.80 (IC 69302) in F_2

population suggesting that IC 218872, SC 108, SKY/TD/RS 113, FB 10, Azad Bhindi 2 in F_1 and IC 218872, KS 312, VRO 5, SC 108, IC 306053 in F_2 were the best combiners for minimum number of first fruiting node. The estimates of gca effects range from 5.06 (VRO 238) to 3.50 (SKY/TD/RS 113) in F_1 and from 3.03 (C 7801) to 2.31 (VRO 5) in F_2 population suggesting that VRO 238, VRO 1668, VRO 5, IIHR 4, IC 218872 in F_1 and C 7801, IC 218872, IC 306053, IC 11527, KS 312 in F_2 were the best combines for the minimum length of first fruiting node. Considering longest as desirable trait, parent with positive general combining ability effect were considered to be better general combiners. The gca effects range from -0.95 (KS 312) to 2.27 (FB 10) in F_1 and from 0.94 (IIHR 4) to 0.84 (IC 69302, FB 10) in F_2 . Suggesting that FB 10, Azad Bhindi 2, IIHR 4, VRO 3, VRO 5 in F_1 and IC 69302, FB 10, VRO 238, VRO 5, IC 218872, BO 2 F_2 were the best combines for the maximum length of internodes. Length of fruit ranged from -1.48 (VRO 3) to 1.63 (SC 108) in F_1 and from 1.48 (VRO 3) to 1.63 (SC 108) in F_2 population. Suggested that SC 108, SKY/TD/RS 113, VRO 238, Azad Bhindi 2, IC 69302 in F_1 and SC 108, VRO 1668, VRO 3, EC 169367, IIHR 4 in F_2 were the best combiners for the maximum length of fruits. In width of fruit the negative value of gca effects are desirable for this trait. The range of gca effect varied from 0.43 (VRO 5) to 0.72 (VRO 1668) in F_1 and from 0.34 (IC 306053) to 0.38 (IC 218872) in F_2 population. Suggested that VRO 5, IC 11527, EC 169367, FB 10, VRO 5 and IC 306053, VRO 5, VRO 238, FB 10, SC 108 were the best combiners for minimum width of fruits in F_1 and F_2 respectively. In number of fruits/plant the positive value of gca effects are desirable for this character. The range of gca effect varied from 3.03 (EC 169367) to 3.31 (BO 2) in F_1 and from 1.54 (IC 11527, C 7801) to 1.24 (VRO 3) in F_2 population. Suggested that BO 2, FB 10, VRO 238, VRO 3, SC 108 and VRO 3, IC 306053, VRO 238, IIHR 4, IC 69302 were the best combiners for maximum number of fruits per plant in F_1 and F_2 populations respectively. In fruit yield/plant the positive value of gca effects are desirable for this trait. The gca ranged varied from 22.63 (VRO 238) to 20.93 (VRO 5) in F_1 and from 17.96

Table 1 ANOVA table for combining ability

Source of variation	df	Gene-ration	Days to flowering	Days to height (cm)	Number of branches/plant	No. of first fruiting node	Length of first fruiting node	Length of internode	Length of fruits	Width of fruits	No. of fruits/plant	Yield/plant (g)
Replications	2	F1	0.11	0.37	0.05	0.40	0.32	0.02	0.01	0.00	0.18	1.05
	2	F2	0.11	0.05	0.18	0.02	0.09	0.01	0.04	0.00	0.05	2.30
Lines	16	F1	20.15**	653.41**	0.81**	4.06**	66.70**	5.95**	7.03**	0.77**	42.38**	1767.69**
	16	F2	16.07**	135.16**	1.14**	2.38**	22.94**	2.17**	4.14**	0.33**	7.07**	541.98**
Testers	2	F1	8.16**	1643.30**	0.63	15.40**	55.49**	10.06**	0.49	0.91**	362.67**	15268.71**
	2	F2	17.57**	784.36**	0.31	12.49**	27.95**	17.75**	7.23**	0.02	136.71**	7854.80**
Lines × Testers	32	F1	25.02**	207.35**	0.74*	3.85**	41.59**	3.56**	4.97**	0.68**	37.97**	1952.11**
	32	F2	24.85**	147.60**	1.44	2.68**	37.93**	4.54**	4.04**	0.19**	13.42**	624.60**
Error	100	F1	0.60	0.80	0.29	0.40	0.54	0.41	0.13	0.02	0.42	10.32
	100	F2	1.06	0.73	0.26	0.29	0.53	0.31	0.07	0.00	0.35	3.04

Table-2 GCA effect for 10 characters of okra

Parent	Days to flowering		Plant height (cm)		Number of branches/plant		No. of first fruiting node		Length of first fruiting node	
	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
<i>Lines</i>										
IC 218872	-0.43	0.18	15.03**	5.29**	0.00	0.57**	-1.45**	-0.86**	-1.95**	-2.47**
IC 306053	-1.65**	-1.38**	-5.52**	-1.82**	0.33	0.01	0.77**	-0.42*	-0.28	-1.58**
IC 11527	0.35	0.51	-10.08**	-5.37**	-0.22	0.24	0.88**	-0.08	-0.39	-1.47**
EC 169367	-1.76**	-1.82**	14.59**	2.85**	-0.44*	0.35*	0.44*	0.03	2.27**	-0.47*
SC 108	0.57*	-1.16**	7.25**	4.52**	0.33	0.01	-1.12**	-0.53**	2.61**	-0.36
VRO 5	2.57**	1.95**	15.03**	-2.59**	-0.22	-0.21	-0.34	-0.64**	-3.28**	2.31**
C 7801	-0.65*	-0.27	-0.30	1.63**	-0.44*	-0.32*	0.44*	-0.31	0.16	-3.03**
BO 2	-1.99**	-2.27**	-0.41	0.63*	0.33	-0.43**	0.22	0.25	2.94**	-0.03
VRO 3	-0.43	0.29	-3.19**	-1.93**	0.00	-0.21	0.10	0.36*	-1.73**	1.53**
KS 312	1.12**	0.18	-3.97**	-0.15	-0.22	-0.10	0.77**	-0.75**	1.05**	-1.14**
IIHR 4	2.35**	1.73**	-5.52**	2.74**	0.56**	0.90**	0.22	0.25	-2.28**	0.31
IC 69302	2.68**	2.62**	6.70**	-3.04**	0.00	0.12	0.22	0.80**	2.61**	-0.36
SKY/TD/RS 113	-0.54*	0.07	-3.41**	1.52**	-0.11	-0.32*	-0.78**	0.47**	3.50**	0.42
FB 10	-0.10	0.62	-10.75**	7.85**	-0.11	-0.32*	-0.45*	0.47**	0.61*	2.08**
Azad Bhindi 2	-1.88**	-1.38**	-6.75**	-6.37**	0.44*	0.01	-0.34	-0.08	3.39**	1.53**
VRO 1668	0.35	0.51	-4.19**	-2.48**	-0.11	0.01	0.55**	0.36*	-4.17**	1.97**
VRO 238	-0.54*	-0.38	-4.52**	-3.26**	-0.11	-0.32*	-0.12	0.69**	-5.06**	0.75**
<i>Testers</i>										
Parbhani Kranti (PK)	0.35	-0.27	0.67*	-3.94**	0.12	-0.08	-0.61**	-0.53**	-0.99**	0.17
Azad bhindi 1 (AB 1)	-0.44	-0.41	-5.98**	3.90**	-0.09	0.00	0.17	0.08	-0.10	-0.81**
Azad Krishna (AK)	0.09	0.67*	5.31**	0.04	-0.03	0.08	0.44*	0.45*	1.09**	0.64*
SE	0.210	0.280	0.250	0.230	0.150	0.140	0.170	0.150	0.200	0.200
CD (P=0.05)	0.466	0.622	0.555	0.511	0.333	0.311	0.378	0.333	0.444	0.444
<i>Length of internode Length of fruits Width of fruits No. of fruits/plant Yield/plants (g)</i>										
<i>Lines</i>										
IC 218872	0.05	0.17	0.22	-0.36**	0.16**	0.38**	-2.80**	-0.10	-17.85**	-4.29**
IC 306053	-0.28	-0.27	-0.10	-1.10**	0.06	-0.34**	-0.25	1.01**	-1.52*	-6.63**
IC 11527	-0.06	-0.05	-0.55**	-0.20*	-0.32**	0.34**	-2.14**	-1.54**	0.48	-3.74**
EC 169367	-0.39	-0.27	-1.27**	0.64**	-0.29**	0.02	-3.03**	-0.99**	15.26**	-0.07
SC 108	-0.50*	0.06	1.63**	0.30**	-0.14**	-0.16**	1.31**	0.12	8.15**	2.93**
VRO 5	0.27	0.39*	-0.43**	-0.57**	-0.43**	-0.21**	1.08**	0.01	20.93**	-1.85*
C 7801	-0.39	-0.27	-0.08	-0.62**	-0.14**	0.00	-0.14	-1.54**	12.82**	11.82**
BO 2	-0.61**	0.17	-0.14	-0.33**	-0.09	-0.02	3.31**	0.01	11.82**	3.59**
VRO 3	0.27	-0.83**	-1.48**	0.93**	-0.15**	0.07**	2.64**	1.24**	-6.63**	-17.96**
KS 312	-0.95**	-0.05	-1.34**	0.15	-0.08	0.07**	0.20	0.12	-15.41**	4.71**
IIHR 4	0.83**	-0.94**	-0.40**	0.50**	0.18**	0.07**	-0.14	0.79**	-10.07**	-0.41
IC 69302	-0.84**	0.84**	0.55**	1.35**	0.11*	0.19**	-0.14	0.68*	17.37**	2.15**
SKY/TD/RS 113	-0.28	-0.16	1.13**	-0.26*	0.05	0.07**	-2.03**	-1.43**	-12.63**	15.93**
FB 10	2.27**	0.84**	0.12	-0.57**	-0.20**	-0.19**	3.20**	0.12	12.37**	6.26**
Azad Bhindi 2	1.27**	-0.05	0.79**	-0.67**	0.02	-0.09**	-1.69**	0.01	3.59**	-8.07**
VRO 1668	-0.39	-0.16	0.26	0.92**	0.72**	0.00	-2.47**	0.68*	-16.07**	-0.52
VRO 238	-0.28	0.61**	1.10**	-0.09	0.54**	-0.19**	3.08**	0.79**	-22.63**	-3.85**
<i>Testers</i>										
Parbhani Kranti (PK)	-0.47*	-0.56**	0.08	0.26**	0.15**	-0.02	-2.67**	-1.64**	-19.34**	-11.17**
Azad bhindi 1 (AB 1)	0.06	-0.05	-0.11	0.17*	-0.11*	0.02	0.01	0.01	5.33**	-2.19**
Azad Krishna (AK)	0.41*	0.61**	0.03	-0.43**	-0.04	0.01	2.66**	1.63**	14.01**	13.36**
SE	0.180	0.150	0.100	0.070	0.040	0.010	0.180	0.160	0.590	0.480
CD (P= 0.05)	0.400	0.333	0.222	0.155	0.089	0.022	0.400	0.355	1.397	1.066

(VRO 3) to 15.93 (SKY/TD/RS 113) in F₂ generation. Suggested that VRO 5, IC 69302, EC 169367, C 7801, FB 10 in F₁ and SKY/TD/RS 113, C 7801, FB 10, KS 312, SC 108 in F₂ population were found to be good general combiners for the fruit yield/plant. Similar results were found by Singh *et al.* (2012), El-Gendy *et al.* (2012) and Vachhani *et al.* (2012).

The estimate of sca effects for all the characters under study among with their standard errors are presented in Table 3. SCA effect ranged from 4.79 (KS 312 × Parbhani Kranti) to 3.80 (KS 312 × Azad Krishna) in F₁ and from 5.12 (VRO 1668 × Azad Krishna) to 4.44 (VRO 3 × Azad Krishna) in F₂ populations. Cross combination KS 312 × Parbhani Kranti, VRO 1668 × Azad Krishna, IC 11527 × Azad Krishna, IC 69302 × Parbhani Kranti and VRO 3 × Azad Bhindi 1 in

F₁ and cross combination VRO 1668 × Azad Krishna, IC 169367 × Azad Krishna, IIHR 4 × Parbhani Kranti, IC 69302 × Parbhani Kranti and C 7801 × Azad Bhindi 1 in F₂ population were found good specific combiner for earliness. For Plant height the sca effect ranged from 16.89 (VRO 1668 × Parbhani Kranti) to 12.44 (IC-306053 × Parbhani Kranti) in F₁ and from 11.90 (IC 69302 × Azad Bhindi 1) to 17.29 (IC 11527 × Azad Krishna) in F₂ population. Cross combination IC 306053 × Parbhani Kranti, C 7801 × Parbhani Kranti, SC 108 × Azad Krishna, EC 169367 × Azad Bhindi 1 and VRO 3 × Parbhani Kranti in F₁ and IC 11527 × Azad Krishna, Azad Bhindi 2 × Parbhani Kranti, VRO 1668 × Azad Bhindi 1, VRO 238 × Azad Bhindi 1, IC 69302 × Parbhani Kranti in F₂ population showed significant and positive sca effects for tallness. For number of branches

Table 3 SCA effects for 10 characters of okra

Cross	Days to flowering		Plant height (cm)		Number of branches/plant		No. of first fruiting node		Length of first fruiting node	
	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
IC 218872 × PK	-0.24	-0.51	-0.78*	5.61**	0.43*	0.41	1.73**	0.53**	6.32**	8.94**
IC 218872 × AB-1	2.88**	2.96**	3.54**	-3.24**	-0.35	-0.33	-1.73**	-0.08	-5.56**	-2.75**
IC 218872 × AK	-2.65**	-2.45**	-2.76**	-2.37**	-0.08	-0.08	0.00	-0.45*	-0.76*	-6.20**
IC 306053 × PK	-0.01	1.05**	12.44**	-6.61**	0.43*	0.30	-0.50	1.08**	2.65**	1.72**
IC 306053 × AB-1	-1.23**	-2.15**	-4.58**	4.21**	-0.02	1.22**	0.39	-1.19**	-2.90**	-3.30**
IC 306053 × AK	1.24**	1.10**	-7.87**	2.41**	-0.41	-1.52**	0.11	0.10	0.24	1.58**
IC 11527 × PK	3.65**	4.16**	4.33**	-7.39**	-0.01	1.08**	0.73**	0.75**	-2.24**	-1.73**
IC 11527 × AB-1	0.44	0.63	4.98**	-9.90**	0.20	-0.67**	0.61*	-0.86**	4.55**	-0.08
IC 11527 × AK	-4.09**	-4.78**	-9.31**	17.29**	-0.19	-0.41	-1.33**	0.10	-2.31**	1.80**
EC 169367 × PK	2.76**	2.49**	-14.67**	2.39**	0.21	0.63*	0.17	0.31	-5.24**	-0.39
EC 169367 × AB-1	-0.45	-0.37	8.31**	4.54**	0.09	-1.11**	0.72**	0.37	2.88**	1.25**
EC 169367 × AK	-2.31**	-2.12**	6.35**	-6.93**	-0.30	0.48**	-0.89**	-0.67**	2.35**	-0.86**
SC 108 × PK	2.76**	0.16	-4.00**	-1.61**	0.43*	-0.03	-0.94**	0.20	0.43	0.16
SC 108 × AB-1	-0.78*	0.96*	-6.35**	-1.12**	0.31	-0.11	1.27**	0.59**	2.55**	1.14**
SC 108 × AK	-1.98**	-1.12**	10.35**	2.74**	-0.75**	0.14	-0.33	-0.78**	-2.98**	-1.31**
VRO 5 × PK	0.76*	1.38**	-11.78**	1.16**	-0.01	-0.14	1.61**	-0.03	-0.01	-7.50**
VRO 5 × AB-1	-1.45**	-1.15**	8.20**	1.32**	-0.13	0.44*	-0.17	1.03**	-2.23**	5.14**
VRO 5 × AK	0.69*	-0.23	3.58**	-2.48**	0.14	-0.30	-1.44**	-1.01**	2.24**	2.36**
C 7801 × PK	1.99**	1.93**	10.56**	-3.39**	-0.79**	0.30	-1.83**	1.31**	-4.79**	0.16
C 7801 × AB-1	-2.23**	-2.93**	-5.80**	3.76**	-0.24	0.22	1.05**	-0.97**	4.66**	-1.52**
C 7801 × AK	0.24	0.99*	-4.76**	-0.37	1.03	-0.52**	0.78*	-0.34	0.13	1.36**
BO 2 × PK	-0.68*	-1.07**	7.33**	2.94**	0.43*	-0.25	-1.27**	-0.58*	-0.24	0.16
BO 2 × AB-1	-1.90**	-1.26**	-7.69**	-0.24	-0.35	0.33	1.27**	1.14**	2.55**	0.48*
BO 2 × AK	2.58**	2.33**	0.35	-2.71**	-0.08	-0.08	0.00	-0.56**	-2.31**	-0.64*
VRO 3 × PK	1.43**	-0.95*	7.44**	5.16**	-0.24	0.19	-1.16**	-0.36	-2.57**	-0.39
VRO 3 × AB 1	-3.45**	-3.48**	-6.91**	-1.01**	-0.35	0.44*	-0.28	0.70**	0.88**	3.59**
VRO 3 × AK	2.02**	4.44**	-0.54	-4.15**	0.59**	-0.63**	1.44**	-0.34	1.69**	-3.20**
KS 312 × PK	-4.79**	-2.84**	2.89**	-2.28**	-0.01	-0.59**	0.17	0.42	0.32	-4.73**
KS 312 × AB 1	0.99**	-0.04	-1.13**	1.21**	-0.46**	0.33	-0.95**	0.48*	-0.56*	1.92**
KS 312 × AK	3.80**	2.88**	-1.76**	1.07**	0.48**	0.25	0.78**	-0.90**	0.24	2.80**
IIHR 4 × PK	-3.35**	-3.40**	5.11**	3.83**	0.21	-0.59**	0.39	-1.58**	4.99**	-0.17
IIHR 4 × AB 1	1.77**	2.07**	-4.24**	3.32**	0.42	0.33	-0.39	0.14	-3.23**	2.14**
IIHR 4 × AK	1.58**	1.33**	-0.87*	-7.15**	-0.63**	0.25	0.00	1.44**	-1.76**	-1.97**
IC 69302 × PK	-3.68**	-3.29**	-0.44	6.27**	-0.24	0.19	1.06**	-0.14	-2.90**	4.16**
IC 69302 × AB-1	3.10**	2.52**	5.54**	-11.90**	-0.35	-0.56**	-0.39	-0.08	1.55**	-3.52**

contd.

Table 3 (Continued)

	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
IC 69302 × AK	0.58	0.77	-5.09**	5.63**	0.59**	0.37	-0.67**	0.22	1.35**	-0.64*
SKY/TD/RS 113 × PK	-2.46**	-2.73**	2.33**	-5.95**	-0.46*	-0.37	-0.61**	-0.80**	0.88**	-1.61**
SKY/TD/RS 113 × AB-1	-1.34**	-1.26**	-3.69**	4.54**	0.42	-0.11	0.27	-0.41	-2.34**	1.03**
SKY/TD/RS 113 × AK	3.80**	3.99**	1.35**	1.41**	0.03	0.48*	0.33	1.22**	1.46**	0.58*
FB 10 × PK	2.10**	2.05**	-7.00**	4.05**	-0.46*	-0.37	0.39	0.20	5.76**	-1.95**
FB 10 × AB 1	-0.78*	-0.15	0.98*	2.54**	0.76**	-0.78	0.27	0.25	-5.45**	-0.30
FB 10 × AK	-1.31**	-1.90**	6.02**	-6.59**	-0.30	1.14**	-0.67**	-0.45*	-0.31	2.25**
Azad Bhindi 2 × PK	-1.12**	-0.62	-2.33**	9.61**	0.32	-1.03**	0.61**	-0.25	2.65**	0.94**
Azad Bhindi 2 1 × AB	1.99**	1.85**	2.31**	-11.24**	-0.46*	0.22	-0.84**	-0.52*	1.44**	-4.75**
Azad Bhindi 2 × AK	-0.87**	-1.23**	0.02	1.63**	0.14	0.81**	0.22	0.77**	-4.09**	3.80**
VRO 1668 × PK	1.65**	2.16**	-16.89**	-6.61**	-0.12	-0.03	0.73**	-1.36**	-4.12**	2.16**
VRO 1668 × AB 1	3.10**	2.96**	11.42**	6.88**	0.42	0.22	-0.73**	0.70*	2.66**	0.14
VRO 1668 × AK	-4.76**	-5.12**	5.46**	-0.26	-0.30	-0.19	0.00	0.66**	1.46**	-2.31**
VRO 238 × PK	-0.79**	0.05	5.44**	-7.17**	-0.12	0.30	-1.27**	0.31	-1.90**	0.05
VRO 238 × AB 1	-0.67**	-1.15**	-4.91**	6.32**	0.09	-0.11	-0.39	-1.30**	-1.45**	-0.63**
VRO 238 × AK	1.46**	1.10**	-0.54	0.85*	0.03	-0.19	1.67**	0.99**	3.35**	0.58**
SE	0.300	0.400	0.350	0.330	0.210	0.200	0.240	0.210	0.280	0.280
CD (P=0.05)	0.599	0.799	0.699	0.659	0.420	0.400	0.480	0.420	0.559	0.559
	<i>Length of internode</i>		<i>Length of fruits</i>		<i>Width of fruits</i>		<i>No. of fruits/plant</i>		<i>Yield/plants (g)</i>	
IC 218872 × PK	-0.31	-0.33	-0.21	-1.42**	-0.36**	-0.05	0.45	-0.80**	23.34**	18.06**
IC 218872 × AB 1	0.16	1.16**	0.24	0.74**	1.00**	0.32**	1.10**	0.55*	-34.33**	7.41**
IC 218872 × AK	0.14	-0.84**	-0.03	0.68**	-0.64**	-0.27**	-1.55**	0.25	10.99**	-25.47**
IC 306053 × PK	0.69*	0.45*	1.97**	-0.64**	-0.43**	-0.06	6.23**	0.42	18.01**	8.73**
IC 306053 × AB 1	-0.84**	-0.73**	-0.78**	1.79**	0.66**	0.07	-1.12**	0.10	14.01**	2.08**
IC 306053 × AK	0.14	0.27	-1.19**	-1.15**	-0.24**	-0.02	-5.10**	-0.52*	-32.01**	-10.80**
IC 11527 × PK	0.80*	0.23	-0.68**	1.09**	0.15*	0.19**	1.45**	0.31	-5.33**	7.17**
IC 11527 × AB 1	-0.39	-0.61**	0.84**	-1.78**	-0.03	-0.25*	-3.57**	-0.67**	25.01**	-3.48**
IC 11527 × AK	-0.41	0.39	-0.17	0.69**	-0.13*	0.06	2.12**	0.37	-19.68**	-3.69**
EC 169367 × PK	-0.86**	0.45*	0.58**	0.48**	-0.07	-0.26**	-1.33**	1.75**	-25.10**	6.50**
EC 169367 × AB 1	0.27	-0.06	2.03**	-0.06	0.65**	0.37**	3.32**	1.10**	8.56**	-3.14**
EC 169367 × AK	0.59**	-0.39	-2.61**	-0.42**	-0.58**	-0.12*	-1.99**	-2.86**	16.54**	-3.36**
SC 108 × PK	0.58*	-0.22	-0.49**	0.03	0.07	-0.01	5.01**	1.31**	15.34**	8.84**
SC 108 × AB 1	0.05	-0.73**	-0.37**	0.19	0.06	-0.12*	0.99**	0.66**	-14.66**	-8.81**
SC 108 × AK	-0.63*	0.94**	0.86**	-0.21*	-0.14*	0.13**	-5.99**	-1.97**	-0.68	-0.03
VRO 5 × PK	-1.20**	0.12	0.23	-0.64**	-0.10	-0.02	-3.44**	0.42	-30.10**	-5.05**
VRO 5 × AB 1	1.61**	0.94**	-1.78**	-0.08	0.22**	-0.19**	-1.12**	-0.56*	14.23**	-0.03
VRO 5 × AK	-0.41	-1.06**	1.54**	0.72**	-0.11*	0.22**	4.56**	0.14	15.88**	5.08**
C 7801 × PK	0.14	0.78**	-0.64**	0.20	0.21**	0.13*	-3.22**	-1.03**	-23.66**	5.95**
C 7801 × AB 1	-0.06	-1.39**	0.61**	0.00	-0.14*	0.16**	2.43**	2.33**	8.01**	-7.03**
C 7801 × AK	-0.08	0.61*	0.03	-0.20	-0.07	-0.29**	0.78*	-1.30**	15.65**	1.08
BO 2 × PK	0.36	-0.99**	-0.25	-1.25**	-0.10	-0.05	-2.33**	0.42	4.34**	5.84**
BO 2 × AB 1	0.83*	-0.17	-1.67**	1.21**	-0.11*	0.02	2.32**	3.44**	-38.33**	-10.81**
BO 2 × AK	-1.19**	1.16**	1.92**	0.04	0.22**	0.03	0.01	-3.86**	33.99**	4.97**
VRO 3 × PK	-1.53**	-0.66*	1.22**	-0.27*	0.08	0.10*	-3.99**	0.20	5.78**	2.06*
VRO 3 × AB 1	0.27	1.50**	-0.12	0.75**	-0.33**	-0.04	0.32	-0.78**	28.45**	11.41**
VRO 3 × AK	1.25**	-0.84**	-1.10**	-0.48**	0.24**	-0.06	3.67**	0.59*	-34.24**	-13.47**
KS 312 × PK	0.69*	2.23**	0.51**	-0.83**	-0.08	-0.04	-1.22**	0.97**	-0.44	14.06**

contd.

Table 3 (Concluded)

	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
KS 312 × AB 1	-0.17	-0.61**	0.90**	-0.47**	-0.13*	0.00	-4.24**	-2.34**	-15.10**	-2.59**
KS 312 × AK	-0.52*	-1.61**	-1.41**	1.30**	0.21**	0.04	5.45**	1.37**	15.54**	-11.47**
IIHR 4 × PK	1.58**	-0.55*	0.53**	0.43**	0.55**	0.16**	2.12**	1.31**	26.23**	7.50**
IIHR 4 × AB-1	0.05	0.94**	0.85**	-0.98**	-0.59**	0.13*	3.43**	1.99**	-0.10	8.86**
IIHR 4 × AK	-1.63**	-0.39	-1.39**	0.55**	0.04	-0.29**	-5.55**	-3.30**	-26.12**	-16.36**
IC 69302 × PK	-0.42	0.34	-0.24	0.14	0.20**	0.34**	-0.22	-0.58*	-11.22**	-10.39**
IC 69302 × AB 1	0.72**	0.16	0.54**	0.63**	-0.78**	0.11*	-2.57**	-1.23**	14.78**	-3.37**
IC 69302 × AK	-0.30	-0.50*	-0.30*	-0.77**	0.59**	-0.45**	2.78**	1.81**	-3.57**	13.75**
SKY/TD/RS 113 × PK	0.03	-0.33	-0.09	1.05**	-0.05	-0.14*	1.01**	-0.47	3.45**	-0.16
SKY/TD/RS 113 × AB 1	-1.17**	-1.84**	0.13	0.44**	-0.66**	0.23**	0.99**	-1.45**	-8.88**	-3.14**
SKY/TD/RS 113 × AK	1.14**	2.16**	-0.04	-1.49**	0.71**	-0.09	-1.99**	1.92**	5.43**	3.31**
FB 10 × PK	0.47	-0.99**	-0.78**	1.09**	-0.36**	0.12*	1.12**	-1.03**	39.12**	6.84**
FB 10 × AB 1	0.27	1.16**	-0.46**	-1.81**	0.26**	-0.38**	0.10	-1.34**	-26.55**	-7.14**
FB 10 × AK	-0.75	-0.17	1.23**	0.72**	0.10	0.26**	-1.22**	2.37**	-12.57**	0.31
Azad Bhindi 2 × PK	-1.86**	1.23**	-0.02	1.19**	0.48**	0.02	0.67*	-0.25	-2.44*	-33.83**
Azad Bhindi 2 1 × AB	1.27**	-0.28	-1.37**	0.92**	-0.49**	-0.22**	-3.01**	-3.23**	21.90**	11.19**
Azad Bhindi 2 × AK	0.59*	-0.95**	1.39**	-2.11**	0.01	0.19**	2.34**	3.48**	-19.46**	22.64**
VRO 1668 × PK	0.14	0.34	-0.12	-0.30*	0.25**	-0.17**	-0.55*	0.42	-38.77**	-17.72**
VRO 1668 × AB 1	-1.73**	0.50*	-0.77**	-0.27*	0.11*	-0.04	-1.24**	-0.90**	11.56**	5.97**
VRO 1668 × AK	1.59**	-0.84**	0.89**	0.56**	-0.36**	0.21**	1.78**	0.48	27.21**	11.75**
VRO 238 × PK	0.69*	-2.10**	-1.53**	-0.35**	-0.44**	-0.28**	-1.77**	-3.36**	1.45	-24.39**
VRO 238 × AB 1	-1.17**	0.05	1.15**	-1.22**	0.29**	-0.18**	1.88**	2.33**	-8.55**	2.63**
VRO 238 × AK	0.48	2.05**	0.38*	1.58**	0.15*	0.46**	-0.10	1.03**	7.10**	21.75**
SE	0.250	0.220	0.140	0.100	0.050	0.040	0.250	0.230	0.940	0.680
CD (P=0.05)	0.500	0.440	0.280	0.200	0.100	0.080	0.500	0.460	1.872	1.359

per plant sca effects varied from 0.79 (C 7801 × Parbhani Kranti) to 1.03 (C 7801 × Azad Krishna) in F₁ and from 1.52 (IC 306053 × Azad Krishna) to 1.22 (IC 306053 × Azad Bhindi 1) in F₂ population. Cross combination C 7801 × Azad Krishna, FB 10 × Azad Bhindi 1, IC 69302 × Azad Krishna, VRO 3 × Azad Krishna, KS 312 × Azad Krishna in F₁ and IC 306053 × Azad Bhindi 1, FB 10 × Azad Krishna, IC 11527 × Azad Bhindi 1, Azad Bhindi 2 × Azad Krishna and EC 169367 × Parbhani Kranti in F₂ population showed significant and positive sca effect found to be good specific cross combinations for higher number of branches/plant. For number of first fruiting node the sca effect ranged from 1.83 (C 7801 × Parbhani Kranti) to 1.73 (IC 218872 × Parbhani Kranti) in F₁ and from 1.58 (IIHR 4 × Parbhani Kranti) to 1.44 (AIIHR 4 × Azad Krishna) in F₂ population. Cross combinations C 7801 × Parbhani Kranti, IC 218872 × Azad Bhindi 1, VRO 5 × Azad Krishna, IC 11527 × Azad Krishna and BO 2 × Parbhani Kranti in F₁ and IIHR 4 × Parbhani Kranti, VRO 1668 × Parbhani Kranti, VRO 238 × Azad Bhindi 1, IC 306053 × Azad Bhindi 1 and VRO 5 × Azad Krishna in F₂ population were found to be good specific cross combination for minimum number of first fruiting node. In

length of first fruiting node the sca effects ranged from 5.56 (IC 218872 × Azad Bhindi 1) to 6.32 (IC 218872 × Parbhani Kranti) in F₁ and from 7.50 (VRO 5 × Parbhani Kranti) to 8.94 (IC 218872 × Parbhani Kranti) in F₂ population. Cross combination IC 218872 × Azad Bhindi 1, FB 10 × Azad Bhindi 1, EC 169367 × Parbhani Kranti, C 7801 × Parbhani Kranti, VRO 1668 × Parbhani Kranti, in F₁ and VRO 5 × Parbhani Kranti, IC 218872 × Azad Krishna, Azad Bhindi 2 × Azad Bhindi 1, KS 312 × Parbhani Kranti and IC 69302 × Azad Bhindi 1 in F₂ population were found to be good specific cross combination for minimum length of first fruiting node. For length of internodes the range of sca effects varied from 1.86 (Azad Bhindi 2 × Parbhani Kranti) to 1.61 (VRO 5 × Azad Bhindi 1) in F₁ and from 2.10 (VRO 238 × Parbhani Kranti) to 2.23 (KS-312 × Parbhani Kranti) in F₂ population. Cross combination VRO 5 × Azad Bhindi 1, VRO 1668 × Azad Krishna, IIHR 4 × Parbhani Kranti, Azad Bhindi 2 × Azad Bhindi 1, VRO 3 × Azad Krishna in F₁ and KS 312 × Parbhani Kranti, SKY/TD/RS 113 × Azad Krishna, VRO 238 × Azad Krishna, VRO 3 × Azad Bhindi 1, Azad Bhindi 2 × Parbhani Kranti in F₂ population found that good combiners. For length of fruit

the range of sca effects varied from 2.61 (EC 169367 × Azad Krishna) to 2.03 (EC 169367 × Azad Bhindi 1) in F₁ and from 2.11 (Azad Bhindi 2 × Azad Krishna) to 1.79 (IC 306053 × Azad Bhindi 1) in F₂ population. Cross combination EC 169367 × Azad Bhindi 1, IC 06053 × Parbhani Kranti, BO 2 × Azad Krishna, VRO 5 × Azad Krishna, Azad Bhindi 2 × Azad Krishna in F₁ and IC 306053 × Azad Bhindi 1, VRO 238 × Azad Krishna, KS 312 × Azad Krishna, BO 2 × Azad Bhindi 1, Azad Bhindi 2 × Parbhani Kranti in F₂ population found to be good specific combiner for length of fruit. For width of fruit the range of sca effect varied from 0.78 (IC 69302 × Azad Bhindi 1) to 1.00 (IC 218872 × Azad Bhindi 1) in F₁ and from 0.45 (IC 69302 × Azad Krishna) to 0.46 (VRO 238 × Azad Krishna) in F₂ population. Cross combinations IC 69302 × Azad Bhindi 1, SKY/TD/RS 113 × Azad Bhindi 1, IC 218872 × Azad Krishna, IIHR 4 × Azad Bhindi 1, EC 169367 × Azad Krishna in F₁ and IC 69302 × Azad Krishna, FB 10 × Azad Bhindi 1, C 7801 × Azad Krishna, IIHR 4 × Azad Krishna, IC 218872 × Azad Krishna in F₂ population found to be good specific combiner for minimum width of fruit. For number of fruits per plant the range of sca effects varied from 5.99 (SC 108 × Azad Krishna) to 6.23 (IC 306053 × Parbhani Kranti) in F₁ and from 3.86 (BO 2 × Azad Krishna) to 39.12 (FB-10 × Parbhani Kranti) in F₂ population. Cross combination IC 306053 × Parbhani Kranti, Azad Krishna, SC 108 × Parbhani Kranti, VRO 5 × Azad Krishna, VRO 3 × Azad Krishna in F₁ and FB 10 × Parbhani Kranti, BO 2 × Azad Bhindi 1, FB 10 × Azad Krishna, VRO 238 × Azad Bhindi 1, C 7801 × Azad Bhindi 1 in F₂ population showed the positive and significant sca effects found to be good specific combiners. For fruit yield per plant the sca effect range from 38.77 (VRO 1668 × Parbhani Kranti) to 39.12 (FB 10 × Parbhani Kranti) in F₁ and from 33.83 (Azad Bhindi 2 × Parbhani Kranti) to 22.64 (Azad Bhindi 2 × Azad Krishna) in F₂ population. Cross combination FB 10 × Parbhani Kranti, BO 2 × Azad Krishna, VRO 3 × Azad Bhindi 1, VRO 1668 × Azad Krishna, IIHR 4 × Parbhani Kranti in F₁ and Azad Bhindi 2 × Azad Krishna, VRO 238 × Azad Krishna, IC 218872 × Parbhani Kranti, IC 69302 × Azad Krishna, VRO 1668 × Azad Krishna in F₂ population showed the positive and significant sca effect. These were found to be specific combiners for fruit yield/plant similar result found by Rewale *et al.* (2003), Dhankar *et al.* (2001) and Bendale *et al.* (2004).

It was concluded that GCA effect reflected that the combination namely VRO 5, IC 69302, EC 169367, C 7801, FB 10 in F₁ and SKY/TD/RS 113, C 7801, FB 10, KS 312, SC 108 in F₂ population were found to be good general combiners for the fruit yield/plant along with other components. In sca the cross combination namely FB 10 × Parbhani Kranti, BO 2 × Azad Krishna, VRO 3 × Azad Bhindi 1, VRO 1668 × Azad Krishna, IIHR 4 × Parbhani Kranti in F₁ and Azad Bhindi 2 × Azad Krishna, VRO 238 × Azad Krishna, IC 218872 × Parbhani Kranti, IC 69302 × Azad Krishna, VRO 1668 × Azad Krishna in F₂ population showed the positive and significant sca effect. These were found to be specific combiners for fruit yield/plant, which is

desirable for fruit quality. Therefore, this cross may be used for further improvement in okra breeding programme. Similar results have also been reported by Singh *et al.* (2001), Shekhawat *et al.* (2005), Kumar *et al.* (2009), Vachhani *et al.* (2012), Reddy *et al.* (2012), Hazen *et al.* (2013), Jaiprakashnarayan *et al.* (2008) and Wammanda *et al.* (2010).

The crosses showing high sca effects involved parents as good general combiners. They could be exploited in practical breeding programme. The crosses which exhibited high sca, involving one good combiner and other moderate combiner, such a combination may throw up desirable transgressive segregates, if the additive genetic system is present in the good combiner and complementary effect is present in the crosses, effect. It is suggested that a breeding procedure which may accumulate the fixable type of gene effects and at the same time maintain considerable heterozygosity for exploiting the dominance gene effects might prove most beneficial in improving the population under study.

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