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

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Abstract
The experiment was undertaken to study the combining ability for yield and its attributing traits in okra. Information on the magnitude of combining ability was obtained for fruit yield per plant and its related components following line x tester mating design involving 11 diverse varieties/strains (6 lines and 5 testers). The 11 parents and their 30 resultant F_1s were sown in a Randomized Block Design with three replications. Combining ability analysis revealed that the magnitudes of non-additive variance weres higher for fruit yield per plant and its contributing traits indicating the predominant role of non-additive gene action (except plant height in which additive gene action was there in the inheritance of that particular trait) in the inheritance of the traits. Among females; GO-2 (8.08) and JOL-2K-19 (6.62), while among males; EC-169513 (9.78) were good general combiners for fruit yield per plant and related traits. The hybrid JOL-2K-19 x AOL-13-73 (31.32) showed high sca effects for fruit yield per plant alonwith desirable sca effects for a number of branches per plant, numbers of fruits per plant and numbers of nodes per plant.

Keywords: Combining ability, gene action, fruit yield, okra

Introduction
Vegetables are prime importance in human diet, as they provide cheaper source of nutrients like carbohydrates, minerals, vitamins, proteins and dietary fibers. The fruits of okra are rich source of vitamin A, C and minerals *viz.;* Ca, Mg, I and Fe. The seeds of okra are good source of protein (20%) and vegetable oil (14%). The average nutritive value (ANV) of okra is 3.21%, which is higher than tomato, brinjal and cucurbitaceous vegetables (Sharma and Arora, 1993) [8]. It is an important annual vegetable crop grown for its immature, green and non-fibrous edible fruits in the tropical and subtropical regions of the world. In addition to fruits, leaves are also consumed in some African countries. The oil content of the seed is quite high (18-20%) and the oil yield from okra crop is 794 kg/ha (Mays *et al*., 1990) [5].
It is a member of the *Malvaceae* family, which includes fiber crops such as cotton (*Gossypium* spp.) and Kenaf (*Hibiscus cannabinus*). Presently accepted binomial of okra is *Abelmoschus esculentus* (L.) Moench, formerly referred as *Hibiscus esculentus* L.
The combining ability is the important genetic tool, which provides a guideline for an assessment of the relative breeding potential of the parents or identifying the best combiners, which may be hybridized either to exploit heterosis or to accumulate fixable genes. In order to identify potential crosses for further exploitation, it is important to have prior information about heterosis and nicking ability of the parents involved, since it helps in the identification of superior parents with good general combining ability and crosses with high and desirable specific combining ability effects (Singh *et al*., 1991) [9].

Materials and Methods
The present investigation on "heterosis and combining ability in okra [*Abelmoschus esculentus* (L.) Moench]" was undertaken with a view to study the heterosis, nature of gene action and combining ability for different characters of okra parents and hybrids. The experimental materials comprised of 11 parents (6 lines and 5 testers) and their 30 resultant hybrids derived from line x tester mating and one check variety (GJOH-4). These 42 genotypes were sown in a Randomized Block Design with three replications at the Vegetable Research Station, Junagadh Agricultural University, Junagadh during summer 2018.

The observations on five randomly selected plants were recorded for ten characters (except days to 50% flowering and days to first picking) *viz*., plant height (cm), number of branches per plant, number of nodes per plant, fruit girth (cm), fruit length (cm), internodal length (cm), number of fruits per plant and fruit yield per plant (g).

Results and Discussion

The character-wise results in respect of analysis of variance for combining ability for ten characters is presented in Table 1. Analysis of variance for combining ability in respect of ten characters showed significant mean squares due to lines for all the traits except fruit girth. Mean squares due to testers also significant for all the characters except days to first picking, number of nodes per plant and fruit length, which indicated the existence of genetic variability among the parents. Significant mean squares due to lines x testers interaction were observed for all the characters.

Since the mean squares due to lines, testers and line x tester interactions do not provide clear cut picture regarding relative magnitudes of additive and non-additive genetic components, the unbiased variance due to both of general ($\hat{\sigma}^2_{\mathrm{GCA}}$) and specific ($\hat{\sigma}^2_{\mathrm{SCA}}$) combine ability were estimated along with $\hat{\sigma}^2_{\mathrm{GCA}}/\hat{\sigma}^2_{\mathrm{SCA}}$ ratio. Estimates of genetic components of variance revealed that the variance due to testers ($\hat{\sigma}^2_t$) were higher than the variance due to lines ($\hat{\sigma}_l^2$) for days to 50% flowering, number of branches per plant, number of fruits per plant and fruit girth indicating equal role of testers and lines towards total additive genetic variance. Estimates of $\hat{\sigma}^2_{\mathrm{GCA}}$ and $\hat{\sigma}^2_{\mathrm{SCA}}$revealed that the magnitudes of SCA variances were higher than the due to GCA variance for all the characters except plant height suggesting involvement of non-additive gene actions in the inheritance of these characters. In the present study, the ratio of $\hat{\sigma}^2_{\mathrm{GCA}}/\hat{\sigma}^2_{\mathrm{SCA}}$was lower than unity for all the characters except plant height, inferring predominance of non-additive gene action in governing these traits.

The importance of non-additive genetic variances for fruit yield per plant has been reported by several workers such as Kachhadia *et al*. (2011), Medagam *et al.* (2012), Ready *et al.* (2013), Katagi *et al.* (2015), Jupiter *et al.* (2017), Tapus *et al.* (2017) and Hadiya *et al.* (2018) [3, 6, 7, 4, 2, 10, 1].

The character wise estimates of general combining ability effects for each parent are presented in Table 2 and indicated that the merit of the parents differs significantly for different characters. In the present study, highly significant general combining ability (gca) effects were observed for all the characters studied. An overall appraisal of gca effects for the material used in the present study indicated that none of the parents was good general combiner for all the characters studied. The best general combiner for various characters were; IC-90107 and HRB-55 for days to 50% flowering, HRB-55 and EC-169513 for days to first picking, GO-2, EC-169513 and AOL-08-5 for plant height, GO-2, JOL-2K-19, AOL-08-5, AOL-13-133 and AOL-13-73 for number of branches per plant, AOL-08-5 and IC-90107 for number of nodes per plant, HRB-108-2, AOL-08-5 and EC-169513 for internodal length, JOL-2K-19, AOL-08-5 and EC-169513 for number of fruits per plant, GO-2 and VRO-6 for fruit length, JOL-09-07, AOL-13-73 for fruit girth, GO-2, JOL-2K-19 and EC-169513 for fruit yield per plant.

The character wise estimates of specific combining ability (sca) effects of 30 hybrids are presented in Table 3. Estimates of sca effects for days to 50% flowering revealed that 12 crosses expressed significant sca effects. Out of these, significant crosses, 6 and 6 crosses had negative and positive sca effects, respectively. The range of sca effects was from -7.76 (HRB-108-2 x Kashi Kranti) to 4.07 (JOL-2K-19 x AOL-13-73).

The estimates of sca effects, 4 cross combinations showed significant effects for days to first picking. Out of these significant crosses, 2 and 2 showed negative and positive sca effects, respectively. The range of estimate sca effect for days to first picking was -3.51 (HRB-108-2 x AOL-13-133) to 3.21 (HRB-108-2 x Kashi Kranti). The cross combinations, HRB-108-2 x AOL-13-133 (-3.51) and VRO-6 x EC-169513 (-3.04) showed significant and negative sca effects for days to first picking.

The results on sca effects indicated that 9 crosses showed significant sca effects. The corresponding range was -8.69 (HRB-55 x EC-169513) to 8.29 (HRB-55 x AOL-13-133) for this trait. The five crosses showed significant and positive sca effects for plant height.

Out of 30 crosses, 25 crosses exhibited significant sca effects. Out of these, 12 crosses were significant with positive values. The range of sca effects was observed from -0.41 (HRB-108-2 x AOL-13-73) to 0.66 (VRO-6 x EC-169513) for number of branches per plant (Table 4). While, estimates of sca effects for numbers of nodes per plant revealed that only two crosses; JOL-2K-19 x AOL-13-73 (3.15) and JOL-2K-19 x EC-169513 (1.79) expressed significant and positive sca effects.

A perusal of sca effects revealed that 20 cross combinations expressed significant sca effects for intermodal length, of which, 10 crosses had significant and negative sca effects. The range of sca effects was observed from -1.79 (AOL-08-5 x AOL-13-73) to 1.63 (GO-2 x AOL-13-73) for internodal length.

Estimates of sca effects showed that 21 crosses noticed significant sca effects of which, 11 crosses had significant and positive sca effects. The corresponding range was observed -3.04 (HRB-55 x EC-169513) to 3.47 (JOL-2K-19 x AOL-13-73) for number of fruits per plant.

For fruit length, out of 30 crosses, 6 crosses showed significant and positive sca effects. The highest significant and positive sca effect was recorded by the hybrid AOL-08-5 x Kashi Kranti (1.86) followed by JOL-2K-19 x EC-169513 (1.20), VRO-6 x IC90107 (0.89), HRB-55 x AOL-13-133 (0.81), HRB-55 x AOL-13-73 (0.79) and GO-2 x AOL-13-73(0.67) (Table 6). There was no one cross found significant sca effect for fruit girth. The corresponding range was -0.22 (AOL-08-5 x AOL-13-73) to 0.22 (AOL-08-5 x Kashi Kranti).

With regard to sca effects for fruit yield per plant, 16 hybrids showed significant effects. Out of them, 9 crosses showed significant and positive sca effects. The sca effects ranged from -35.75 (HRB-55 x EC-169513) to 31.32 (JOL-2K-19 x AOL-13-73). In which, cross JOL-2K-19 x AOL-13-73 was found to be the best combination for fruit yield per plant. The cross JOL-2K-19 x AOL-13-73 involved good x average general combiner.

Table 1. Analysis of variance for combining characters in okra ability for tencharacters in okra

Source of variation	d. f.	Days to 50% flowering		Days to First picking		Plant Height (cm)		No. of branches per plant		No. of nodes per plant		Internodal length (cm)		No. of fruits per plant		Fruit Length (cm)		Fruit Girth (cm)		Fruit yield Per plant (g)	
Crosses	29	21.004	**	13.428	**	157.640	**	0.372	**	6.177	**	3.355	**	13.763	**	2.221	**	0.084	*	1190.244	**
Lines	5	9.904	**	19.860	*	423.835	**++	0.227	**	8.903	**	7.864	**+	11.910	**	3.265	**	0.076		861.312	**
Testers	4	20.488	**	8.872		277.759	**+	0.525	**	3.016		0.486	**	15.870	**	0.668		0.117	*	954.590	**
Lines x Testers	20	23.882	**	12.732	**	67.067	**	0.378	**	6.128	**	2.801	**	13.805	**	2.271	**	0.079	*	1319.608	**
Error	58	2.160		5.010		11.886		0.012		1.380		0.079		0.540		0.293		0.044		123.259	
Estimates of genetic component of variance																					
$\hat{\sigma}_l^2$	-	0.516	**	0.990	*	27.463	**	0.014	**	0.501	**	0.519	**	0.758	**	0.198	**	0.002		49.203	**
$\hat{\sigma}_t^2$	-	1.018	**	0.214		14.770	**	0.028	**	0.090		0.022	**	0.851	**	0.020		0.004	*	46.185	**
$\hat{\sigma}_{lt}^2$	-	7.240	**	2.574	**	18.391	**	0.122	**	1.582	**	0.907	**	4.421	**	0.659	**	0.011	*	398.782	**
$\hat{\sigma}_{GCA}^2$	-	0.790		0.567		20.540	**	0.022		0.277		0.248	*	0.809		0.101		0.003	*	47.557	
$\hat{\sigma}_{SCA}^2$	-	7.240	**	2.574	**	18.391	**	0.122	**	1.582	**	0.907	**	4.421	**	0.659	**	0.011	*	398.782	**
$\hat{\sigma}_{GCA}^2\ \hat{\sigma}_{SCA}^2$	-	0.109		0.220		1.116		0.180		0.175		0.273		0.182		0.153		0.272		0.119	

*, ** Significant @ 5% and 1% levels, respectively against error mean square,
+, ++ Significant @ 5% and 1% levels, respectively against line x tester interactions mean square

Table 2: Estimation of general combining ability effects for ten characters in okra

Parents	Days to 50% flowering		Days To first picking		Plant Height (cm)		No. of branches per plant		No. of nodes per plant		Inter nodal length (cm)		No. of fruits per plant		Fruit length (cm)		Fruit Girth (cm)		Fruit yield per plant (g)	
LINES																				
GO-2	0.278		-0.233		6.468	**	0.116	**	-0.587		-0.096		-0.961	**	0.446	**	-0.078		8.080	**
VRO-6	0.878	*	1.433	*	0.488		-0.088	**	-0.707	*	0.561	**	-0.468	*	0.471	**	0.053		-1.876	
JOL-2K-19	-0.522		-0.033		-0.152		0.066	*	0.293		0.454	**	0.732	**	-0.629	**	0.046		6.628	*
HRB-55	-1.122	**	-1.433	*	0.768		-0.138	**	0.153		0.556	**	0.352		-0.091		-0.083		-2.262	
HRB-108-2	0.878	*	1.233	*	-9.699	**	-0.101	**	-0.487		-1.326	**	-0.854	**	-0.448	**	0.084		-12.815	**
AOL-08-5	-0.389		-0.967		2.128	*	0.146	**	1.333	**	-0.150	*	1.199	**	0.251		-0.022		2.244	
S.E. (gi) ±	0.37		0.57		0.89		0.03		0.30		0.07		0.19		0.14		0.05		2.86	
TESTERS																				
AOL-13-133	0.189		0.844	*	-3.392	**	0.253	**	-0.427		0.167	**	-1.384	**	0.192		-0.010		-7.294	**
AOL-13-73	1.189	**	-0.600		-0.298		0.076	**	-0.077		0.007		0.260		-0.028		-0.090	*	3.297	
Kashi Kranti	0.633	*	0.456		-3.326	**	-0.024		-0.327		-0.048		-0.201		0.165		0.047		-7.112	**
EC 169513	-0.422		-0.822	*	6.197	**	-0.155	**	0.290		-0.250	**	1.221	**	-0.043		0.111	**	9.784	**
IC-90107	-1.589	**	0.122		0.819		-0.149	**	0.540	*	0.124	*	0.104		-0.286	**	-0.058		1.325	
S.E. (gj) ±	0.34		0.52		0.81		0.03		0.28		0.06		0.17		0.13		0.04		2.61	
S.E. (gi - gj) ±	0.49		0.74		1.14		0.03		0.39		0.09		0.24		0.18		0.07		3.70	

*, ** Significant @ 5% and 1% levels, respectively

Table 3: Estimation of specific combining ability effects for ten characters in okra

Hybrids	Days to 50% flowering		Days to first picking		Plant height (cm)		No. of branches per plant		No. of nodes per plant		Inter nodal length (cm)		No. of fruits per plant		Fruit Length (cm)		Fruit Girth (cm)		Fruit yield per plant (g)
	1		2		3		4		5		6		7		8		9		10
GO-2 x AOL-13-133	3.611	**	1.956		-1.768		0.290	**	1.187		-0.277		0.344		-0.419		-0.111	-6.342	
GO-2 x AOL-13-73	-0.722		-0.267		3.271		0.168	*	-0.763		1.633	**	0.967	*	0.675	*	0.159	7.954	
GO-2 x Kashi Kranti	-1.500		-1.322		-2.801		0.268	**	-0.013		0.188		-0.839		-0.558		-0.182	-8.991	
GO-2 x EC-169513	-1.444		-0.044		3.877		-0.402	**	0.070		-1.660	**	1.139	**	-0.314		0.048	15.277	*
GO-2 x IC-90107	0.056		-0.322		-2.579		-0.324	**	-0.480		0.116		-1.611	**	0.616		0.086	-7.897	
VRO-6 x AOL-13-133	-0.322		2.956	*	-1.154		-0.307	**	-0.993		0.417	*	-0.616		-0.057		0.054	11.540	
VRO-6 x AOL-13-73	-1.656		-2.267		-0.882		0.171	*	0.057		-0.174		0.207		-0.517		-0.146	-14.690	*
VRO-6 x Kashi Kranti	3.233	**	0.011		-2.788		-0.229	**	0.307		-0.568	**	-0.532		-0.363		0.150	28.352	**
VRO-6 x EC-169513	-1.711	*	-3.044	*	0.523		0.668	**	-0.410		-0.177		-0.621		0.038		-0.213	-14.974	*
VRO-6 x IC-90107	0.456		2.344		4.301	*	-0.304	**	1.040		0.442	**	1.562	**	0.898	**	0.155	-10.228	
JOL-2K-19 x AOL-13-133	-5.922	**	-0.578		-1.048		0.140	*	-2.093	*	0.123		-1.016	*	-0.063		0.008	-22.747	**
JOL-2K-19 x AOL-13-73	4.078	**	2.200		2.591		0.318	**	3.157	**	-0.667	**	3.473	**	0.003		-0.049	31.326	**
JOL-2K-19 x Kashi Kranti	-1.700	*	-1.856		-5.014	*	-0.282	**	-0.393	*	-0.412*		-2.866	**	-1.473	**	-0.177	-23.592	**
JOL-2K-19 x EC-169513	0.689		0.089		4.330	*	-0.152	*	1.790*		1.090	**	2.512	**	1.205	**	0.203	24.665	**
JOL-2K-19 x IC-90107	2.856	**	0.144		-0.859		-0.024		-1.460	*	-0.134		-2.104	**	0.328		0.015	-9.652	
HRB-55 x AOL-13-133	1.344		-0.511		8.299	**	0.210	**	1.347		0.521	**	2.164	**	0.815	*	0.144	20.546	**
HRB-55 x AOL-13-73	1.011		0.267		-1.762		-0.212	**	-0.803		-0.469	**	-2.580	**	0.795	*	0.074	-19.194	**

Hybrids	1	2	3	4	5	6	7	8	9	10
HRB-55 x Kashi Kranti	0.233	0.211	7.499**	-0.179**	-0.053	0.636**	1.381**	0.458	0.046	19.458**
HRB-55 x EC-169513	2.289**	2.156	-8.690**	-0.198**	-1.270	-0.412*	-3.041**	-1.184**	-0.177	-35.755**
HRB-55 x IC-90107	-4.878**	-2.122	-5.346**	0.379**	0.780	-0.276	2.076**	-0.884**	-0.086	14.945*
HRB-108-2 x AOL-13-133	-0.656	-3.511**	-2.468	-0.393**	-0.513	-0.813**	-1.696**	-0.131	-0.024	-11.374
HRB-108-2 x AOL-13-73	-1.656	-1.400	2.104	-0.416**	0.437	1.473**	0.793	-0.015	0.190	0.062
HRB-108-2 x Kashi Kranti	-7.767	3.211*	1.066	0.384**	0.087	-0.731**	0.654	0.069	-0.065	-12.736
HRB-108-2 x EC-169513	-0.711	0.156	0.977	0.415**	0.770	0.907**	1.366**	0.364	0.072	24.928**
HRB-108-2 x IC-90107	3.789**	1.544	-1.679	0.009	-0.780	-0.837**	-1.118*	-0.286	-0.173	-0.879
AOL-08-5 x AOL-13-133	-1.944*	-0.311	-1.861	0.060	1.067	0.028	0.818	-0.144	-0.071	8.377
AOL-08-5 x AOL-13-73	-1.056	1.467	-5.322**	-0.029	-2.083**	-1.796**	-2.860**	-0.941**	-0.228	-5.457
AOL-08-5 x Kashi Kranti	0.500	-0.256	2.039	0.038	1.067	0.886**	2.201**	1.866**	0.228	-2.491
AOL-08-5 x EC-169513	0.889	0.689	-1.017	-0.332**	-0.950	0.191	-1.354**	-0.109	0.068	-14.141*
AOL-08-5 x IC-90107	-2.278**	-1.589	6.161**	0.263**	0.900	0.690**	1.196**	-0.672*	0.003	13.712*
S.E. (sij) ±	0.84	1.29	1.99	0.06	0.67	0.16	0.42	0.31	0.12	6.41
Sij-Skl	1.20	1.82	2.81	0.09	0.96	0.22	0.60	0.44	0.17	9.06
Sij-Sik	1.42	2.16	3.33	0.11	1.13	0.27	0.71	0.52	0.20	10.72

*, ** Significant @ 5% and 1% levels, respectively

Conclusion

It is concluded from the present study that the importance of non-additive gene action for all yield components except plant height in the present study indicated that heterosis breeding is the best possible option for improving these traits in okra. The gcs effects of the parents EC-169513 indicated that the parent was good general combiner for fruit yield per plant and other yield attributing traits. While, sca effects of the hybrid revealed that hybrid JOL-2K-19 x AOL-13-73 was found to be the best combination for fruit yield per plant and other yield attributing traits like number of fruits per plant, number of nodes per plant.

References

1. Hadiya HN, Mali SC, Gamit AM, Sangani JL. Combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench]. J. Pharmacog. Phytochem. 2018; 7(5):2525-2528.
2. Jupiter S, Waikhom S, Kandasamy R. Study on combining ability in okra [*Abelmoschus esculentus* (L.) Moench]. Asian J. Hort. 2017; 12(1):41-45.
3. Kachhadia VH, Vachhani JH, Jivani LL, Shekhat HG, Dangaria CJ. Heterosis for fruit yield and yield components over environments in okra [*Abelmoschus esculentus* (L.) Moench]. Res. on Crops. 2011; 12(2):568-573.
4. Katagi A, Tirakannanvar S, Jagadeesha RC. Combining ability through diallel analysis in okra [*Abelmoschus esculentus* (L.) Moench]. Green Farming. 2015; 6(1):26-29.
5. Mays DA, Buchanan W, Bradford BN, Giordano PM. Fuel production potential of several agricultural crops. Ad. New Crops, 1990, 260-263.
6. Medagam TR, Kadiyala H, Mutyala G, Hameedunnisa B. Heterosis for yield and yield components in okra. Chilean J. Agric. Res. 2012; 72(3):316-325.
7. Reddy MA, Sridevi O, Salimath PM, Nadaf HL. Combining ability for yield and yield components through diallel analysis in Okra [*Abelmoschus esculentus* (L.) Moench]. J Agric. Vet. Sci. 2013; 5(2):01-06.
8. Sharma BR, Arora SK. Improvement of okra. Advances in horticulture. Vegetable crops part-I. (Eds) Chadha, K. L. and Kalloo, G. J., Malhotra Publishing House, New Delhi. 1993; 5:343-364.
9. Singh D, Sharma BR, Singh HC. Genetical analysis to predict the breeding potential in an intervarietal cross in okra [*Abelmoschus esculentus* (L.) Moench] for improvement in fruit and seed yield. In Golden Jubilee Symposium on Genetic Research and Education: Current Trends and Next Fifty Years. Abstr. 1991; 2:605.
10. Tapus P, Desai RT, Choudhary R. Genetic Architecture, Combining Ability and Gene Action Study in Okra [*Abelmoschus esculentus* (L.) Moench]. Int. J Curr. Microbiol. App. Sci. 2017; 6(4): 851-858.