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

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Abstract : Combining ability effects were estimated for different characters of okra in a line x tester mating design comprises 6 lines and 4 testers and their 24 F_1 hybrids. Parents and F_1 crosses differed significantly for general combining ability and specific combining ability effects for all the characters respectively. Lines *viz.*, VRO-3, VRO-4, VRO-5, VRO-6 and Parbhani Kranti and testers *viz.,* Hisar Unnat, Arka Anamika, BS-14 and BS-12 were the best general combiners for plant height, number of branches/plant, days to 50% flowering, number of seeds/fruit, average fruit weight, number of fruits/plant and fruit yield whereas, the best specific crosses were VRO-3 x BS-14, VRO-4 x Arka Anamika, VRO-5 x BS-12, Varsha Uphar x Hisar Unnat, Varsha Uphar x BS-14 and Parbhani Kranti x Hisar Unnat for plant height, number of branches/plant, node at which 1st flower appear, internodal length, number of seeds/fruit, fruit length, number of fruits/plant and fruit yield. Lines VRO-3, VRO-4, VRO-5, VRO-6 and Parbhani Kranti and testers Hisar Unnat, Arka Anamika, BS-14 and BS-12 were the best combiners are expected to accumulate additive genes that can be exploited in development of open pollinated varieties and the cross VRO-3 x BS-14, VRO-4 x Arka Anamika, VRO-5 x BS-12, Varsha Uphar x Hisar Unnat, Varsha Uphar x BS-14 and Parbhani Kranti x Hisar Unnat showed highest specific combining ability for green fruit yield and its components and are potential source for screening of high yielding F_1 hybrid varieties.

Key Words: Line x Tester, gca, sca, Okra

Introduction

Okra [A*belmoschus esculentus* (L.) Moench] is an important vegetable crop for both internal market and export purpose, which is grown for its tender green fruits during summer and rainy season throughout India. The genetic improvement of yield and its contributing characters require the selection of appropriate breeding procedures which is dependent upon the general combining ability (gca) of parents and specific combining ability (sca) of hybrids. The general combining ability is the manifestation of additive gene action for the selection of parents, while the specific combining ability in respect of a particular character in the hybrid is the capitalization of non-additive gene action. The present investigation was, thus, conducted to study the combining ability in respect of fruit yield and its component traits in elite lines of okra under sub-tropical conditions of Jammu.

Materials and Methods

The material consisted of F_1 population of 24 cross combinations developed by crossing six lines *viz.,* VRO-3, VRO-4, VRO-5, VRO-6, Varsha Uphar and Parbhani Kranti with four testers *viz.*, Hisar Unnat, Arka Anamika, BS-14 and BS-12 for comparison. Cross combinations were attempted in line x tester design for precise estimation of gene action. Twenty four hybrids with ten parents were evaluated in randomized block design with three replications during summer 2006 at Vegetable Experimental Farm, S. K. University of Agricultural Sciences & Technology (J), Chatha, Jammu. Each entry was sown at 45 x 30 cm spacing, accommodating 30 plants in three rows per replication of 3.0 m length. All the recommended package of practices was followed for raising a healthy crop. The observations were recorded from 5 randomly selected competitive plants from each entry on eleven parameters *viz*., plant height (cm), number of branches/plant, days to 50% flowering, node at which 1st flower appear, internodal length (cm), number of seeds/fruit, fruit length (cm), fruit width (cm), average fruit weight (g), number of pods/plant and fruit yield q/ha. The data were analyzed statistically for all the characters. The combining ability analysis was calculated by the method suggested by Kempthorne (1957).

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Results and Discussion

The analysis of variance showed highly significant differences among the treatments for all the parameters studied. The parents differed significantly for all the characters except number of branches/plant. Parent vs hybrid also differed significantly for all the parameters except plant height and internodal distance. The mean sum of square due to lines and testers were significantly for all the traits except days to 50% flowering and node at which 1st flower appear in lines; and number of branches/plant and days to 50% flowering in testers. However, variance due to line x tester interactions and hybrids were significant for all the characters. Dhankar and Dhankar (2001) also observed significant difference in the variance due to line, tester, line x tester and hybrid for fruit yield, number of fruits/plant, days to 50% flowering, number of branches/plant, plant height and internodal distance.

The perusal of the data on general combining ability effects (Table 1) of the lines and testers indicated that Parbhani Kranti and VRO-6 among lines and BS-12 and BS-14 among testers were the best general combiner for plant height whereas, VRO-4 and Arka Anamika were the best general combiner for number of branches /plant among lines and testers. For days taken to 50% flowering, VRO-3 among lines and Hisar Unnat and BS-14 among testers were the best general combiners. Among the testers, BS-14 and BS-12 were the best general combiners for flowering at early node, whereas, VRO-6 among lines and Hisar Unnat among testers were best general combiners for shorter internodal length. The lines, Varsha Uphar, Parbhani Kranti and testers, BS-12 and BS-14 were the best general combiners for fruit length. The lines, Parbhani Kranti and VRO-6 and testers Arka Anamika and BS-12 were the good general combiners for fruit width. For average fruit weight, the lines, VRO-6, VRO-3 and Varsha Uphar and the testers, BS-12 and Hisar Unnat were the best general combiners. For number of fruits/plant, VRO-5 and VRO-4 among lines and BS-14 and Arka Anamika among testers were the best general combiners. On the basis of fruit yield VRO-5, VRO-4 and VRO-6 among lines and BS-14 among testers were proved to be best general combiners.Based on *per se* performance and general combining ability effects of the lines/testers, the lines viz., VRO-5, VRO-6, VRO-4 and Parbhani Krantiand testers viz., Hisar Unnat, BS-14 and BS-12 appeared desirable parents which could be used in hybridization programme.

For specific combining ability effects (Table 2) among 24 $F1^s$, VRO-5 x Arka Anamika, Parbhani Kranti x Hisar Unnat, Parbhani Kranti x BS-12 and Varsha Uphar x BS-14 were the good specific combiners for plant height, whereas, VRO-4 x Arka Anamika, VRO3 x BS-14, VRO-4 x Hisar Unnat and VRO-5 x BS-12 were good specific combiners for number of branches/plant. The best specific combinations include at least one or some time both good general combining parents. The crosses Varsha Uphar x Arka Anamika, VRO-4 x BS-14, Varsha Uphar x Hisar Unnat and VRO-4 x BS-14 were the top ranking combination which expressed high specific combining ability effects for early flowering. The crosses VRO-6 x BS-12, VRO-4 x Arka Anamika, Varsha Uphar x Hisar Unnat, VRO-3 x Arka Anamika and VRO-6 x BS-14 stood best combinations for flowering at early node based on specific combining ability effects. The crosses VRO-4 x BS-12, Varsha Uphar x Hisar Unnat, VRO3 x BS-14 and Parbhani Kranti x Arka Anamika expressed high specific combining ability effects for shorter internodal length. The crosses showing better performance for the characters

Table 1. Estimates of general combining ability (gca) effects for 11 traits in okra

Parent	Plant height (cm)	No. of branches/ plant	Days to 50% flowering	Node at which 1st flower appear	Internodal distance (cm)	No. of seeds/ fruit	Fruit length (cm)	Fruit width (cm)	Average fruit weight (g)	No. of fruits/ plant	Yield (q/ha)
Line											
VRO-3	2.27	0.04	-2.19**	-0.14	0.17	-0.80	-1.23**	-0.05**	0.64**	-1.22**	-3.54*
VRO-4	2.60	0.44**	-0.03	0.19*	0.30**	0.32	-1.51**	0.03**	-0.14	1.54**	13.90**
VRO-5	-5.94**	-0.43**	0.06	0.06	-0.18	8.37**	-1.69**	0.00	-0.86**	2.85**	14.49**
VRO-6	2.94*	0.02	-0.53	0.15	-0.30**	-5.64**	0.26	0.05**	0.80**	-0.78**	3.46*
Varsha Uphar	-13.66**	-0.13	1.64**	-0.11	0.14	0.31	1.76**	-0.12**	0.57**	-2.31**	-14.68**
Parbhani Kranti	11.79**	0.04	1.06**	-0.15	-0.12	-2.55**	1.41**	0.10**	-1.00**	-0.07	-13.63**
SE for line	1.48	0.08	0.32	0.10	0.11	0.45	0.15	0.01	0.17	0.27	1.48
Tester											
Hisar Unnat	-14.21**	0.10	-0.75**	0.14	-0.20*	8.21**	-0.16	-0.03**	0.45**	-0.76**	-1.65
Arka Anamika	2.36*	0.47**	0.08	0.22**	0.12	-0.19	-1.63**	0.08**	-0.60**	0.49*	-1.81
BS-14	4.77**	-0.05	-0.64*	-0.20*	0.14	-10.77**	0.24*	-0.11**	-0.66**	1.39**	4.53**
BS-12	7.08**	-0.52**	1.31**	-0.16*	-0.06	2.75**	1.54**	0.06**	0.80**	-1.12**	-1.07
SE for tester	1.15	0.07	0.25	0.08	0.08	0.16	0.11	0.01	0.13	0.21	1.15

Table 2. Estimates of specific combining ability (sca) effects for 11 traits in okra

Cross	Plant height (cm)	No. of branches/ plant	Days to 50% flower-ing	Node at which 1st flower appear	Internodal distance (cm)	No. of seeds/ fruit	Fruit length (cm)	Fruit width (cm)	Average fruit weight (g)	No. of fruits/ plant	Yield (q/ha)
VRO-3 x H U	0.26	-0.45**	0.42	-0.37*	-0.37*	-2.96**	-0.64*	-0.09**	0.67*	-0.86	-0.51
VRO-3 x A A	-6.51*	-0.29*	0.92	-0.39*	-0.15	-3.72**	1.23**	0.02*	-1.47**	0.56	-14.58**
VRO3 x BS-14	3.35	0.84**	-1.69**	0.16	-0.41*	-2.98**	0.43	-0.09**	0.35	0.52	12.21**
VRO-3 x BS-12	2.90	-0.10	0.36	0.59**	0.63**	9.67**	-1.01**	0.16**	0.45	-0.23	2.88
VRO-4 x H U	-8.57**	0.41**	2.25**	-0.14	0.40*	3.08**	-1.29**	0.15**	-0.41	1.04*	5.15*
VRO-4 x A A	2.26	0.91**	2.42**	-0.55**	0.15	12.32**	2.61**	-0.06**	0.44	0.99*	14.41**
VRO-4 x BS-14	5.61**	-0.83**	-1.86**	0.43*	0.09	-7.77**	-0.56*	-0.07**	0.23	0.16	4.10
VRO-4 x BS-12	0.70	-0.50**	-2.81**	0.26	-0.64**	-7.62**	-0.76**	-0.03**	-0.26	-2.19**	-23.66**
VRO-5 x H U	3.40	-0.11	-0.83	0.36*	0.38*	0.19	-0.99**	0.02*	0.30	-4.40**	-55.80**
VRO-5 x A A	13.23**	-0.29*	0.67	0.21	0.27	-1.73*	0.61*	0.01	0.56	-0.05	6.36*
VRO-5 x BS-14	-5.78*	0.10	0.06	-0.30	-0.32	-5.79**	-1.41**	-0.10**	-0.35	1.98**	9.51**
VRO-5 x BS-12	-10.86**	0.37*	0.11	-0.27	-0.32	7.33**	1.71**	0.07**	-0.51	2.47**	19.85**
VRO-6 x H U	-10.87**	0.30*	-1.25*	0.31	0.00	0.88	1.51*	-0.14**	-1.35**	1.67**	-1.21
VRO-6 x A A	0.36	-0.07	-1.08	0.66**	-0.06	-0.72	-0.46	0.23**	-0.97**	1.65**	7.12**
VRO-6 x BS-14	4.35	-0.35*	2.64**	-0.39*	0.20	15.86**	-0.52*	0.05**	0.02	-1.65**	-14.39**
VRO-6 x BS-12	6.17*	0.12	-0.31	-0.57**	-0.14	-16.02**	-0.53*	-0.14**	2.30**	-1.67**	8.48**
V U x H U	5.03	0.05	-2.75**	-0.40*	-0.44*	8.19**	-0.47	0.04**	1.35**	0.49	20.44**
V U x A A	-4.04	-0.12	-3.25**	-0.09	-0.12	-7.50**	-2.36**	-0.09**	-0.07	-1.96**	-20.71**
V U x BS-14	6.85**	0.00	2.47**	0.20	0.26	-3.09**	1.94**	0.12**	-0.41	0.28	-1.38
V U x BS-12	-7.83**	0.07	3.53**	0.29	0.29	2.39**	0.90**	-0.07**	-0.87**	1.19*	1.65
P K x H U	10.75**	-0.12	2.17**	0.24	0.02	-9.38**	1.89**	0.01	-0.55	2.06**	11.92**
PK x A A	-5.29*	-0.15	0.33	0.16	-0.39*	1.36	-1.71**	-0.10**	1.50**	-1.19*	7.41**
PK x BS-14	-14.37**	0.24	-1.61**	-0.09	0.18	3.77**	0.13	0.09**	0.16	-1.29**	-10.13**
PK x BS-12	8.92**	0.04	-0.89	-0.30	0.18	4.25**	-0.31	0.01	-1.10	0.42	-9.20**
SE for cross	2.56	0.15	0.55	0.17	0.19	0.77	0.26	0.01	0.29	0.48	2.56

HU – Hisar Unnat, AA – Arka Anamika, VU- Varsha Uphar, PK – Parbhani Kranti

determining early flowering, flowering at early node and shorter internodal length involved the parents with high x average, average x low, high x low, low x low, low x high and high x high general combining ability effects. It indicates that for the expression of early flowering, flowering at early node and short internode length, early x early, early x late, late x early and late x late flowering, node at which 1st flower appear and internodal length parental combinations were involved. Therefore, the characters seem to be controlled by both additive and non-additive gene effects, hence cyclic method of improvement could be used to select the early flowering, flowering at early node and shorter internodal length recombinants in segregating generations and also in multiple crossing programme to improve the early flowering, flowering at early node and shorter internodal length.

Four were promising crosses of which VRO-4 x Arka Anamika and Varsha Uphar x BS-14 had the highest specific combining ability effects for fruit length, whereas, for fruit width, among 9 crosses expressing significant specific combining ability effects, VRO-6 x Arka Anamika, VRO-3 x BS-12, VRO-4 x Hisar Unnat and Varsha Uphar x BS-14 was the best cross. Further, the cross VRO-6 x BS-12, Parbhani Kranti x Arka Anamika, Varsha Uphar x Hisar Unnat and VRO-3 x Hisar Unnat had the highest positive specific combining ability along with superior performance for average fruit weight. The cross, VRO-5 x BS-12, Parbhani Kranti x Hisar Unnat, VRO-5 x BS-14 and VRO-6 x Hisar Unnat were the best performing crosses for number of fruits/ plant. In these crosses involved the parents with high x low, low x low, high x high general combining ability effects indicating the presence of both additive and non-additive gene action for more number of fruits/plant

The crosses with high specific combining ability effects for fruit yield (q/ha) were Varsha Uphar x Hisar Unnat, VRO-5 x BS-12, VRO-4 x Arka Anamika, VRO3 x BS-14, Parbhani Kranti x Hisar Unnat and VRO-5 x BS-14. These crosses involved low x low, high x average, low x high and high x high general combining ability effects indicating the presence of both additive and non-additive gene effects for controlling fruit yield. These results are in agreement with Svagama *et al*. (1992) and Dhankar *et al*. (1996). Some parents with positive and significant general combining ability produced hybrids with negative and significant specific combining ability indicating the role of complementary gene action (Basak and Dana, 1971).

The parent VRO-4, VRO-5 and VRO-6 showed a close relationship between performance and general combining ability effects but such relationship could

not be performed by Arka Anamika, BS-14 and BS-12 which were in agreement of Swami Rao (1977). From this, it was deducted that combining ability of parents could not always be judged by the *per se* performance accurately. Therefore, both general combining ability and *per se* performance of breeding lines should be considered together for assessing their breeding potentiality. None of the cross combinations showed simultaneous significant specific combining ability effects favourably for all the characters which is akin to the finding of Pratap *et al*. (1981). This may be due to complementation of favourable genes. The good combiners when crossed did not produce good hybrid.

To confirm whether the crosses were really the best performers as indicated on the basis of specific combining ability effects the best crosses based on *per se* performance and specific combining ability effects were selected. The best performing F_1 hybrid were Varsha Uphar x Hisar Unnat and VRO-5 x BS-14 (fruit yield), VRO-5 x BS-14 and Parbhani Kranti x Hisar Unnat (number of fruits/plant), VRO-6 x BS-12 (average fruit weight), VRO-6 x BS-14 (number of seeds/fruit), VRO-5 x Arka Anamika (plant height), Varsha Uphar x Arka Anamika and Varsha Uphar x Hisar Unnat (early flowering); and VRO-6 x BS-12 (flowering at early node) are potential source for development of F_1 hybrid varieties.

सारांश

संयोजन क्षमता प्रभाव भिण्डी की एक लाइन x परीक्षक मेंटिग डिजाइन 6 लाइनों और 4 परीक्षकों और उनके 24 F_1 संकर शामिल में विभिन्न पात्रों के लिए अनुमान लगाया गया था। माता–पिता और F_1 पार सामान्य संयोजन करने की क्षमता और विशिष्ट संयोजन क्रमशः सभी वर्णो के लिए क्षमता प्रभाव के लिए काफी मतभेद था। अर्थात वीआरओ–3, वीआरओ–4, वीआरओ–5, वीआरओ–6 और परभानी क्रांति और परीक्षकों अर्थात लाइन्स, हिसार उन्नत, अर्का अनामिका, बी–14 और बीएस–12 पौधों की ऊँचाई के लिए सबसे अच्छा सामान्य कम्बाइनर थे, संख्या शाखाओं/पौध के 50% फूल, बीज/फल की संख्या, औसत फल का वजन, फल/पौध और फल उपज की संख्या दिन, सर्वश्रेष्ठ विशिष्ट पार वीआरओ–3 x बी एस–14, वीआरओ–4 x अर्का अनामिका, वीआरओ–5 x बीएस–12, वर्षा उपहार x हिसार उन्नत, वर्षा उपहार बीएस–14 और परभानी क्रांति पौधों की ऊँचाई के लिए हिसार उन्त, नोड, जो प्रथम फूल दिखाई, नोड की के बीच की लंबाई, बीज की संख्या शाखाओं की संख्या/फल, फलों की लंबाई, फल/पौधा और फल उपज की संख्या, वीआरओ–3, वीआरओ–4, वीआरओ–5, वीआरओ–6 और परभानी क्रांति और हिसार उन्नत, अर्का अनामिका, बी–14 और बीएस–12 परीक्षकों लाइन्स थे सबसे अच्छा कम्बाइनर एडेटिव जीन है कि विकास में इस्तेमाल किया जा सकता है। जमा की उम्मीद कर रहे हैं खुले परागण किस्मों और पार वीआरओ–3 x बीएस–14, वीआरओ–4 x अर्का अनामिका, वीआरओ–5 x बीएस–12, वर्षा उपहार x हिसार उन्नत, वर्षा उपहार बीएस–14 x परभानी क्रांति x हिसार उन्त के उच्चतम से पता चला विशिष्ट हरे फलों की उपज और उसके घटकों के लिए क्षमता के संयोजन और उच्च उपज F1 संकर किस्मों की स्क्रीनिंग के लिए संभावित स्रोत हैं।

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