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Analysis of Combining Ability Status and Nature of Gene Action among Hybrids for Yield and Quality Traits in Okra [*Abelmoschus esculentus* (L.) Moench]

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ABSTRACT

The present investigation entitled "Heterosis breeding for yield and quality attributes in okra [Abelmoschus esculentus (L.) Moench]" was carried out during rainy season of 2007 and summer season of 2008 where twenty diverse genotypes of okra were crossed in line x tester mating design in RBD with 17 lines and three testers to estimate the general combining ability (GCA), specific combing ability (SCA) and gene action. The lines like Arka Abhay, VRO-5, VRO - 6, JBS -2 and testers like Pusa Sawani proved to be the good general combiner and VRO – 6 x Pusa Sawani was the good specific combiner for most of the yield and yield attributing traits during both the seasons.

Key words: *Heterosis, Line x tester mating, RBD, General combining ability, Specific combing ability.*

INTRODUCTION

India has emerged as the second largest producer of vegetables after China. The total area under vegetable crops is about 8.5 million hectares, while the total production of vegetables has gone up from 125.89 to 146.55 million tonnes, from 2007-08 to 2010-11. The Indian Council of Medical Research (ICMR) has recommended consumption of about 300 g vegetables (125 g leafy vegetables, 100 g root and tuber vegetables and 75 g other vegetables) per capita per day. The regular consumption of vegetables decreases the level of cholesterol, provides protection against respiratory diseases, intestinal disorders and reduces accumulation of carcinogenic substances in human body. This study had the objective to determine the combining ability to study the gene action governing the inheritance of fruit yield and quality and to identify good general and specific combiners for desired traits in okra for the production of the promising hybrids. In addition we are also interested in identifying high yielding, early maturing disease resistant hybrids with better fruit quality for commercial cultivation.

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MATERIAL AND METHODS

The present investigation entitled "Heterosis breeding for yield and quality attributes in okra [*Abelmoschus esculentus* (L.) Moench]" was carried out during rainy season of 2007 and summer season of 2008 to generate information on 20 parents and 51 F_1s were evaluated to study the general combining ability (GCA), specific combing ability (SCA) and gene action. The combining ability analysis was carried out as per the method suggested by Griffing[5].

RESULTS AND DISCUSSION

The result of the experiment reveals that for plant height among lines, BO-2 expressed maximum positive significant gca for plant height both, in summer as well as in rainy season. For stem diameter, the line BO – 2 expressed maximum positive significant gca effect, in both the two seasons. For number of branches per plant among lines DOV – 91 - 4 was found to be the best general combiner.

For number of leaves per plant, HRB – 55 among lines and Pusa Sawani in testers were found to be the best performers. For internodal length HRB - 55 was the best female parent, while among hybrids, Arka Abhay × Pusa Sawani was the best specific combination. For days taken to first flowering Pusa Makhmali was the best female in rainy season, while during summer season, HRB – 9 - 2 was the best performer. In rainy season, JBS - 2 was the best line, while in summer season crop, DOV – 91 - 4 was the most valuable line and good general combiner for earliness.

In rainy season crop, for number of fruits per plant, COS - 2206 was found to perform the best, while in summer season, Larm - 1 was the good general combiner for the trait.

For single fruit weight, Arka Abhay was good general combiner and for fruit length in both the seasons, best female was IIVR – 342. For fruit diameter JBS – 2 and HRB – 55 were best performers, while in case of fruit yield per plant, VRO-5 and Arka Abhay were found good general combiners. In rainy season crop, for number of seeds per fruit JBS - 2 and in summer season crop, BO - 2 was best combiner for number of seeds per fruit. For vitamin 'C' Content Arka Abhay and VRO - 5 were found to be good general combiners.

Many other workers also have reported similar findings in okra[7,11,9,16,14,2,4,17,15].

In rainy season, the cross combinations, VRO – 6 x Pusa Sawani for plant height and stem diameter, BO - 2 × Prabhani Kranti for number of branches per plant, HRB - 55 × Prabhani Kranti for number of leaves per plant, IIVR-435 × Punjab - 7 for internodal length, Pusa Makhmali x Pusa Sawani for days to first flowering, Punjab Padmini x Pusa Sawani for days to 50 per cent flowering, Larm – 1 x Punjab - 7 for number of fruits per plant and vitamin 'C' content, JBS - 2 x Pusa Sawani for single fruit weight, Arka Abhay x Pusa Sawani for fruit length and IIVR – 435 x Pusa Sawani for fruit diameter, Arka Abhay x Punjab - 7 for fruit yield per plant and HRB – 9-2 x Pusa Sawani for number of seeds per fruit had significant desirable sca effects.

However in summer season, the most promising hybrids on the basis of sca effects were, VRO – 6 x Pusa Sawani for plant height and fruit yield per plant, Arka Abhay x Punjab – 7 for stem diameter, BO - 2 × Prabhani Kranti for number of branches per plant and number of leaves per plant, Arka Abhay x Pusa Sawani for internodal length, fruit length and vitamin 'C' content, VRO- 5 × Pusa Sawani for days to first flowering, Punjab Padmini x Punjab - 7 for days to 50 per cent flowering and fruit diameter, HRB - 55 × Prabhani Kranti for number of fruits per plant, JBS - 2 × Prabhani Kranti for single fruit weight and Arka Anamika x Punjab - 7 for number of seeds per fruit expressed high significant sca effects.

In rainy season, taking into account the above criteria, the cross VRO – 5 x Pusa Sawani was found to be the most desirable combination for plant height and stem diameter. Larm – 1 x Pusa Sawani for number of branches per plant, HRB - 55 × Prabhani Kranti for number of leaves per plant, Arka Abhay x Pusa Sawani for internodal length, Pusa Makhmali x Pusa Sawani for days to first flowering, Larm – 1 x Punjab - 7 for number of fruits per plant, Arka Abhay x Punjab - 7

for single fruit weight and fruit yield per plant, JBS – 2 x Pusa Sawani for fruit length and fruit diameter, HRB -9- 2 for number of seeds per fruit and VRO - 6 × Prabhani Kranti for vitamin 'C' content remained most desirable combinations for respective characters.

However, during summer season, the most desirable cross combinations based on *per se* performance and SCA effects were, HRB – 55 x Pusa Sawani for plant height, HRB - 55 × Prabhani Kranti for stem diameter and number of fruits per plant, HRB – 9 – 2 x Punjab - 7 for number of branches per plant, Arka Abhay x Pusa Sawani for internodal length, VRO-5 × Pusa Sawani for days to first flowering and fruit diameter, IIVR-435 × Prabhani Kranti for days to 50 per cent flowering, JBS - 2 × Prabhani Kranti for single fruit weight, IIVR - 342 × Punjab - 7 for fruit length, VRO – 6 x Pusa Sawani for fruit yield per plant and vitamin 'C' content and Arka Anamika x Punjab - 7 for number of seeds per fruit. Dahake and Bangar[2]. also reported that Pusa Sawani was the best combiner and could be used as a parent in exploiting heterosis for fruit yield.

Few other crosses were also found to have good common sca effects and *per se* performance for one or two most desirable traits. The crosses involving high × high, high × low and low × low combiners some had better *per se* performance and sca effects. High × high combiners may be due to additive and additive × additive type of gene actions, which are fixable in nature[5]. However, in majority of the cases, the crosses exhibiting high sca effects were found to have either both or one of the parents as good general combiner for the character under study. These findings are in conformity with the results of Pratap *et al*[13], Dhankar *et al.*[3],and Singh *et al.*[14], and reveal occurrence of high sca estimates not only in crosses involving high × high combiner parents but also in other combinations like high × low and low × low combiner parents.

Desirable sca effects for earliness in yield and yield related traits were also reported by Sharma and Mahajan. for assessing superiority of hybrid taking its' sca effects into account. Poshiya and Vashi[12]; Pal and Hossain[10]; Sood and Kalia[16]; Kumar *et al.*[8]; Dahake *et al.*[2]; Adeniji and Kehinde[1]; Eswaran *et al.*[4]; Srivastava *et al.* [17]and Weerasekara *et al.*[19], observed specific combining ability in okra for different crosses for different traits.

Table 1. a: Estimates of general combining ability effects of parents (lines and testers) for 15 characters in okra during Rainy season

Parents	Plant height (cm)	Stem diameter (cm)	Number of branches/ plant	Number of leaves/ 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	Vitamin 'C' (mg/100g)
COS - 2206	-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
Arka Abhay	-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**
Punjab Padmini	-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**
Arka Anamika	-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
Barkha Bahar	-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**
JBS – 2	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
VRO-5	-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**
Pusa Makhmali	-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-435	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**
VRO – 4	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**
HRB – 55	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*
Larm – 1	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*
DOV – 91 - 4	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**
BO – 2	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**
HRB - 9 - 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
IIVR – 342	-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 ± 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
Pusa Sawani	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**
Punjab – 7	-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**
SE ± M	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

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

Table 1.b: Estimates of specific combining ability effects of hybrids (F_1s) for 15 characters in okra during Rainy season

Hybrids	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	Vitamin 'C' (mg/100g)
COS – 2206 x PS	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**
COS – 2206 × P-7	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**
COS – 2206 × 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**
Arka Abhay x PS	-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
Arka Abhay × P-7	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
Arka Abhay × 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 x PS	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 × P-7	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
Punjab Padmini x PS	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
Punjab Padmini × P-7	-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
Punjab Padmini × 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
Arka Anamika x PS	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
Arka Anamika × P-7	-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
Arka Anamika × 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
Barkha Bahar x PS	-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
Barkha Bahar × P-7	-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
Barkha Bahar × 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
JBS – 2 x PS	-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
JBS – 2 × P-7	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
JBS – 2 × 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

Where, PS-Pusa Sawani; P- 7 – Punjab – 7; PK-Prabhani Kranti

Table 1.b: Continued….

Hybrids	Plant height (cm)	Stem diameter (cm)	Number of branches/ plant	Number of leaves/ 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	Vitamin 'C' (mg/100g)
VRO-5 x PS	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**
VRO-5 × P-7	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
VRO-5 × 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**
Pusa Makhmali x PS	-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
Pusa Makhmali × P-7	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
Pusa Makhmali × 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-435 x PS	-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-435 × P-7	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-435 × 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
VRO – 4 x PS	-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
VRO – 4 × P-7	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
VRO – 4 × 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
HRB – 55 x PS	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
HRB – 55 × P-7	-27.02**	-0.48**	-0.44**	-6.83**	1.95**	-1.01*	-0.12	-0.14	-0.44	-0.63**	-0.06	-9.78*	4.73**	0.00	0.19
HRB – 55 × PK	14.21**	0.25**	0.65**	5.48**	-1.77**	0.11	-1.08*	0.41	0.40	0.95**	0.11**	10.97*	-5.34**	-0.01	-0.54
Larm – 1 x PS	5.64*	0.05	0.88**	3.10**	-1.84**	1.24**	-2.36**	-0.77*	0.11	-0.41**	-0.09*	-6.39	-0.45	0.01	-0.36
Larm – 1 × P-7	-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**
Larm - 1× 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**
DOV – 91 – 4 x PS	-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*
DOV – 91 – 4 × P-7	-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*
DOV – 91 – 4 × 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

Table 1.b : Continued….

Hybrids	Plant height (cm)	Stem diameter (cm)	Number of branches/ plant	Number of leaves/ 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	Vitamin 'C' (mg/100g)
BO – 2 x PS	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
BO – 2 × P-7	-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
BO – 2 × 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
HRB - 9 – 2 x PS	-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
HRB - 9 – 2 × P-7	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
HRB - 9 – 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
IIVR – 342 x PS	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**
IIVR – 342 × P-7	-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*
IIVR – 342 × 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

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

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

Parents	Plant height (cm)	Stem diameter (cm)	Number of branches/ plant	Number of leaves/ 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	Vitamin 'C' (mg/100g)
COS - 2206	-4.90**	-0.06	-0.02	-1.10**	-0.12	-0.98**	-0.07	-0.93**	-1.49**	0.16	0.01	-19.61**	10.60**	-0.05**	1.17**
Arka Abhay	-11.71**	0.02	0.16**	-0.82*	-0.76**	0.35	2.93**	0.23	1.00**	0.38**	-0.03	10.38**	6.96**	-0.05**	1.94**
VRO-6	0.15	0.05	0.20**	-0.53	0.45**	-0.98**	-0.07	0.30*	0.98**	0.13	-0.03	10.77**	-1.13	-0.05**	1.90**
Punjab Padmini	-1.04	0.04	0.02	-0.01	-0.30**	2.69**	2.05**	-0.27*	0.73**	0.29**	-0.03	3.15	-8.66**	-0.05**	-0.87**
Arka Anamika	-1.92	0.01	0.10	-1.43**	0.62**	2.80**	1.71**	-0.18	-0.15	0.27**	-0.09**	-3.66*	0.52	-0.05**	-0.75**
Barkha Bahar	0.34	0.01	0.39**	-0.71	0.22*	0.35	1.60**	-0.39**	-1.24**	-0.47**	-0.03	-13.18**	5.68**	-0.05**	-0.49*
JBS – 2	1.42	0.01	-0.35**	-0.59	0.28*	2.35**	2.71**	-0.50**	0.12	0.49**	0.11**	-4.66**	-2.56*	-0.05**	-0.12
VRO-5	-0.13	-0.09	-0.03	-0.42	0.40**	1.58**	0.82*	0.11	0.60**	-0.08	-0.03	6.65**	-1.35	-0.05**	1.19**
Pusa Makhmali	-2.85	-0.11**	-0.02	-0.86*	0.54**	0.24	-0.40	-0.23	-0.51**	-0.33**	-0.03	-5.60**	-4.63**	0.72**	-1.16**
IIVR-435	5.86	-0.03	-0.15*	1.08**	0.02	0.13	-0.95**	-0.01	-0.17	-0.22*	-0.07*	-1.31	6.26**	-0.05**	-1.83**
VRO – 4	-1.45	0.04	-0.40**	-1.81**	0.81**	1.69**	-1.18**	0.87**	-0.35*	-0.17	-0.02	5.10**	-2.35*	-0.05**	-0.57*
HRB – 55	7.42**	0.12**	-0.14*	3.37**	-0.78**	0.80*	-0.07	1.34**	-0.59**	-0.95**	0.07*	7.31**	2.34*	-0.05**	0.39
Larm – 1	5.13**	0.14**	0.06	0.64	0.09	1.24**	-0.95**	1.31**	-0.25	-0.34**	0.01	10.37**	-0.01	-0.05**	0.35
DOV – 91 - 4	-2.38	-0.16**	0.46**	0.87*	-0.11	-1.76**	-2.18**	-0.12	0.32*	0.09	0.04	1.54	-5.33**	-0.05**	-2.12**
BO – 2	9.94**	0.15**	-0.18**	2.94**	-0.57**	-3.76**	-2.29**	-0.27*	1.20**	-0.44**	0.04	6.10**	-6.63**	-0.05**	0.77**
HRB - 9 – 2	-0.18	-0.15**	0.35**	0.81*	-0.30**	-4.65**	-3.40**	-0.90**	-0.50**	0.19*	0.04	-11.80**	-6.47**	-0.05**	0.51*
IIVR – 342	-3.68*	0.02	-0.45**	-0.43	-0.43**	-3.09**	-0.29	-0.36**	0.29*	0.97**	0.04	-1.54	6.76**	-0.05**	-0.31
SE ± F	1.70	0.04	0.06	0.41	0.11	0.31	0.35	0.13	0.14	0.09	0.03	1.70	1.14	0.01	0.24
Pusa Sawani	1.11	0.02*	0.15**	0.93**	-0.45*	0.00	-0.41**	0.38**	0.21**	0.02	0.03**	5.50**	2.05**	-0.01**	-0.22**
Punjab – 7	-1.23*	-0.04**	-0.07**	-0.99**	0.36**	0.73**	0.81**	-0.16**	-0.04	-0.01	0.00	-2.08**	-3.90**	0.00	-0.20*
Prabhani Kranti	0.13	0.02*	-0.08**	0.06	0.10*	-0.73**	-0.41**	-0.21**	-0.17**	-0.02	-0.03**	-3.42**	1.85**	0.01**	0.41**
SE ± M	0.60	0.01	0.02	0.14	0.04	0.11	0.12	0.05	0.05	0.03	0.01	0.60	0.40	0.00	0.08

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

Table 2. b: Estimates of specific combining ability effects of hybrids (F_1's) for 15 characters in okra during Summer season

Hybrids	Plant height (cm)	Stem diameter (cm)	Number of branches/ plant	Number of leaves/ 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	Vitamin 'C' (mg/100g)
COS – 2206 x PS	-2.62	-0.16**	0.08	-0.43	0.75**	-2.33**	-2.48**	0.37	-9.00**	-0.29*	-0.09*	1.43	1.10	0.01	-0.31
COS – 2206 × P-7	5.42*	0.09	0.04	0.39	0.04	-0.06	-0.03	-0.46*	0.18	0.61**	0.13**	-1.56	1.96	0.00	-0.06
COS – 2206 × PK	-2.81	0.07	-0.12	0.04	-0.80**	2.39**	2.52**	0.09	-0.09	-0.32*	-0.04	0.12	-3.06	-0.01	0.36
Arka Abhay x PS	-13.77**	-0.21**	-0.06	-0.64	-2.15**	-0.67	-1.48**	-0.30	1.25**	0.99**	0.04	7.35**	1.78	0.01	0.93**
Arka Abhay × P-7	7.13**	0.28**	0.26**	1.31*	0.64**	0.61	-0.03	-0.46*	-0.67**	-1.02**	-0.14**	-9.91**	3.37*	0.00	-0.36
Arka Abhay × PK	6.64**	-0.07	-0.20*	-0.67	1.50**	0.06	1.52**	0.76**	-0.58**	0.03	0.10*	2.57	-5.15**	-0.01	-0.57
VRO-6 x PS	0.24	-0.08	-0.37**	-1.63**	0.58**	-4.33**	-1.48**	-0.27	1.17**	0.74**	0.14**	7.32**	-1.10	0.01	0.23
VRO-6 × P-7	5.35*	0.05	0.18*	2.15**	-0.80**	1.94**	0.97	1.61**	-0.48*	0.21	-0.04	12.16**	3.56*	0.00	-0.58
VRO-6× PK	-5.58*	0.03	0.19*	-0.52	0.23	2.39**	0.52	-1.34**	-0.69**	-0.95**	-0.10*	-19.49**	-2.46	-0.01	-0.80*
Punjab Padmini x PS	-1.17	0.04	0.38**	-0.45	-0.10	-2.00**	1.41**	1.60**	-0.35	-0.49**	-0.16**	13.21**	-0.33	0.01	-0.43
Punjab Padmini × P-7	0.77	-0.01	-0.06	0.63	-0.05	0.27	-2.81**	-0.46*	0.46*	0.37**	0.16**	-1.18	1.86	0.00	0.05
Punjab Padmini × PK	0.40	-0.03	-0.32**	-0.18	0.15	1.73**	1.41**	-1.14**	-0.11	0.12	0.00	-12.03**	-1.53	-0.01	0.37
Arka Anamika x PS	4.74	-0.03	-0.34**	-1.40*	1.01**	1.89**	-0.26	-0.45*	0.76**	-0.33*	0.01	2.19	4.29**	0.01	-1.85**
Arka Anamika × P-7	-2.42	0.06	0.18*	0.25	0.10	-3.50**	-0.48	-0.11	-0.26	-0.37**	0.13**	-4.00	-12.72**	0.00	0.67*
Arka Anamika × PK	-2.32	-0.03	0.16*	1.14*	-1.11**	1.61**	0.74	0.57**	-0.50*	0.70**	-0.14**	1.81	8.43**	-0.01	1.19**
Barkha Bahar x PS	-2.68	-0.06	-0.29**	-0.85	0.54**	1.33**	-0.15	-1.11**	0.28	0.14	0.04	-7.93**	-7.74**	0.01	0.05
Barkha Bahar × P-7	0.49	0.09	-0.11	-0.27	0.03	1.61**	0.63	0.30	-0.17	0.24	0.06	1.88	4.65**	0.00	0.17
Barkha Bahar × PK	2.19	-0.03	0.40**	1.12	-0.57**	-2.94**	-0.48	0.81**	-0.11	-0.38**	-0.10*	6.06*	3.10	-0.01	-0.21
JBS – 2 x PS	-6.89**	0.10	-0.25**	-2.11**	0.82**	0.33	-1.26*	0.50**	-1.64**	0.71**	0.11**	-8.18**	-3.17	0.01	-0.28
JBS – 2 × P-7	4.95*	-0.11	0.27**	2.54**	-0.82**	-0.30	0.52	-0.02	-0.93**	-0.89**	-0.17**	-6.04*	-5.31**	0.00	0.20
JBS – 2 × PK	1.95	0.00	-0.02	-0.43	0.00	0.06	0.74	-0.48*	2.57**	0.18	0.06	14.21**	8.47**	-0.01	0.09
VRO-5 x PS	14.28**	0.24**	-0.04	2.86**	-0.70**	0.11	0.96	1.42**	0.82**	-0.18	-0.06	21.85**	6.96**	0.01	1.47**
VRO-5 × P-7	0.92	0.03	-0.32**	-0.59	0.49**	0.39	0.41	-0.30	-1.17**	-0.32*	0.06	-12.61**	-5.32**	0.00	-0.78*

Table 2.b : Continued…

Hybrids	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	Vitamin 'C' (mg/100g)
VRO-5 × PK	-15.21**	-0.26**	0.36**	-2.27**	0.21	-0.50	-1.37**	-1.12**	0.36	0.49**	0.00	-9.23**	-1.64	-0.01	-0.69*
Pusa Makhmali x PS	-9.09**	0.12*	0.65**	1.63**	-1.15**	0.11	-1.48**	-0.37	-0.27	0.37**	0.04	-6.41**	3.70*	-0.09**	-0.34
Pusa Makhmali × P-7	5.39*	0.05	0.07	0.15	-0.12	1.72**	-0.37	1.68**	0.54**	0.26*	-0.14**	19.60**	2.12	-0.06**	0.04
Pusa Makhmali × PK	3.78	-0.17**	-0.72**	-1.79**	1.27**	-1.83**	1.85**	-1.31**	-0.27	-0.63**	0.10*	-13.19**	-5.83**	0.16**	0.30
IIVR-435 x PS	-9.37**	-0.20**	-0.38**	-4.31**	1.41**	2.22**	3.41**	-0.35	-0.58**	-0.31*	0.05	-8.47**	-4.62**	0.01	-0.21
IIVR-435 × P-7	8.40**	0.16**	0.47**	3.88**	-1.37**	-1.17**	-0.81	0.39*	1.06**	-0.15*	0.01	12.54**	4.10*	0.00	-0.72*
IIVR-435 × PK	0.97	0.04	-0.09	0.43	-0.04	-1.05*	-2.59**	-0.03	-0.48*	0.46**	-0.06	-4.08	0.52	-0.01	0.93**
VRO – 4 x PS	-2.09	-0.13*	0.46**	-0.05	-0.11	-2.00**	-1.71**	-0.60**	0.03	-0.42**	-0.07	-5.54*	-1.41	0.01	0.04
VRO – 4 × P-7	3.15	0.09	-0.25**	0.27	-0.09	-0.73	0.41	-0.92**	-0.13	0.61**	0.05	-9.07**	-4.32**	0.00	0.32
VRO – 4 × PK	-1.05	0.04	-0.21**	-0.21	0.20	2.73**	1.29*	1.52**	0.10	-0.18	0.02	14.61**	5.73**	-0.01	-0.36
HRB – 55 x PS	12.84**	0.22**	-0.03	3.03**	-0.69**	2.22**	1.52**	-1.28**	-0.26	-0.28*	0.04	-14.15**	-1.07	0.01	0.30
HRB – 55 × P-7	-22.22**	-0.49**	-0.48**	-6.41**	1.50**	0.16	-0.03	-0.57**	-0.22	-0.62**	-0.14**	-6.85**	7.86**	0.00	0.12
HRB – 55 × PK	9.38**	0.26**	0.50**	3.38**	-0.81**	-2.39**	-1.48**	1.85**	0.48*	0.89**	0.10*	21.00**	-6.79**	-0.01	-0.43
Larm – 1 x PS	6.86**	0.14*	0.37**	3.60**	-0.89**	2.44**	1.41**	1.59**	-0.11	-0.62**	0.01	13.32**	-6.45**	0.01	1.45**
Larm – 1 × P-7	-2.90	-0.01	-0.38**	-2.31**	0.83**	-1.28**	-1.81**	0.16	0.27	0.67**	-0.07	4.03	6.37**	0.00	-0.23
Larm - 1× PK	-3.96	-0.13*	0.00	-1.29*	0.06	-1.16**	0.41	-1.75**	-0.17	-0.05	0.06	-17.35**	0.08	-0.01	-1.21**
DOV – 91 – 4 x PS	1.04	-0.03	0.47**	2.97**	-1.18**	-1.22**	-0.71	-1.11**	-0.36	0.48**	0.07	-13.94**	1.57	0.01	0.58
DOV – 91 – 4 × P-7	-2.35	-0.07	-0.08	-2.35**	0.93**	1.05*	2.41**	-0.64**	-0.05	-0.49**	-0.10*	-6.50**	2.62	0.00	-0.73*
DOV – 91 – 4 × PK	1.32	0.10	-0.40**	-0.62	0.26	0.17	-1.71**	1.75**	0.41*	0.02	0.03	20.45**	-4.19*	-0.01	0.15
BO – 2 x PS	3.95	0.06	-0.68**	-1.90**	1.17**	0.11	-0.26	0.00	-0.12	0.04	-0.03	-0.01	-0.47	0.01	0.09
BO – 2 x P-7	-13.48**	-0.28**	-0.20*	-2.21**	0.02	2.72**	1.52**	-1.09**	0.96**	-0.79**	0.10*	-4.77	-3.24*	0.00	-0.09
BO – 2 x PK	9.53**	0.23**	0.88**	4.11**	-1.19**	-2.83**	-1.26*	1.09**	-0.84**	0.75**	-0.07	4.78*	3.71*	-0.01	0.00
HRB - 9 – 2 x PS	-0.63	-0.04	-0.02	-0.04	-0.03	0.33	1.18*	0.03	0.58**	0.01	-0.13**	3.76	4.25**	0.01	-0.32
HRB - 9 – 2 × P-7	4.25	0.08	0.60**	2.04**	-0.81**	-1.39**	-0.03	1.41**	-0.27	0.71**	0.10*	10.53**	-3.56*	0.00	0.20
HRB - 9 – 2 × PK	-3.62	-0.04	-0.59**	-2.00**	0.85**	1.06*	-1.15*	-1.44**	-0.31	-0.72**	0.03	-14.29**	-0.68	-0.01	0.12
IIVR – 342 x PS	4.37	0.02	0.02	-0.27	0.73**	1.44**	1.41**	0.32	-1.11**	-0.57**	-0.03	-5.80*	2.71	0.01	-1.40**
IIVR – 342 × P-7	-2.75	-0.02	-0.20*	0.52	-0.51**	-1.95**	-0.48	-0.50**	0.87**	0.96**	0.00	1.74	-4.00*	0.00	0.62
IIVR – 342 × PK	-1.62	-0.01	0.18*	-0.26	-0.22	0.50	-0.93	0.18	0.23	-0.40**	0.03	4.06	1.28	-0.01	0.77*
SE ± F_1	2.40	0.06	0.08	0.57	0.16	0.44	0.50	0.19	0.20	0.13	0.04	2.41	1.61	0.01	0.33

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

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