Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(6): 2103-2106
Received: 19-09-2018
Accepted: 20-10-2018

S Lokeswari
Department of Vegetable Science, College of Horticulture, Dr. Y.S.R Horticultural University, Venkataramannagudem, West Godavari, Andhra Pradesh, India

P Ashok
Scientist, Department of Horticulture, Horticultural research station, Dr. Y.S.R Horticultural University, Venkataramannagudem, West Godavari, Andhra Pradesh, India

RVSK Reddy
Director of Extension, Dr. Y.S.R Horticultural University, Venkataramannagudem, West Godavari, Andhra Pradesh, India

K Sasi Kala
Assistant Professor, Department of Agronomy, Dr. Y.S.R Horticultural University, Venkataramannagudem, West Godavari, Andhra Pradesh, India

Correspondence
S Lokeswari
Department of Vegetable Science, College of Horticulture, Dr. Y.S.R Horticultural University, Venkataramannagudem, West Godavari, Andhra Pradesh, India

Studies on combining ability and gene action for yield and yield contributing characters in okra (*Abelmoschus esculentus* (L.) Moench)

S Lokeswari, P Ashok, RVSK Reddy and K Sasi Kala

Abstract
The present investigation was undertaken to study the combining ability of the parents and crosses for yield and yield contributing traits in okra using fifteen hybrids resulted from crossing of six parents in half- diallel mating design**.** The genotypes were evaluated in Randomized Block Design with three replications at college of horticulture, Dr. Y.S.RHU, Venkataramannagudem. Combining ability analysis revealed that magnitude of specific combining ability variance was greater than general combining ability variance suggesting the predominance of non-additive gene action for all the characters studied. Combining ability analysis revealed that the parental line ACC-3 being the high general combiner for plant height, fruit length and fruit yield per plant is recommended for use in breeding programmes to improve yield in okra. The high specific combining crosses, ACC-17 × ACC-43, ACC-3 × ACC-41 and ACC-41 × ACC-43 were identified as promising for yield and yield contributing characters.

Keywords: Okra, combining ability, gene action, general combining ability

Introduction
Vegetables play a significant role in human diet by making it balance and supply the most important natural compounds. Okra [*Abelmoschus esculentus* (L). Moench] belongs to the family Malvaceae. Okra is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. It is generally an annual plant. It is also known as lady's finger or *bhindi*, originated in tropical Africa. Because of its richness in nutrition, taste, medicinal and industrial value okra is one of the most popular vegetables in all section of people. Okra is cultivated for its fruits or pods containing round, white seeds. The fruits are harvested when immature and eaten as a vegetable. Roots and stems are used for clarification of sugar cane juice to make gur, and roasted ripe seeds are used as a substitute for coffee in some countries. In India the area under okra cultivation is 5.01 lakh hectares, with a total production of 59.72 lakh tonnes (NHB, 2018) [7]. The major okra growing state in the country is West Bengal followed by Bihar, Odisha, Gujarat, Maharashtra, Andhra Pradesh and Uttar Pradesh. The ultimate goal of any okra breeding programme is the maximization of marketable yield. Combining ability analysis is one of the powerful tools available to estimate the combining ability effects and aids in selecting the desirable parents and crosses (Subhan *et al.*, 2003; Rashid *et al*., 2007) [12, 8]. Among various techniques, genetic analysis formulated by Griffing (1956) [1], provides a workable approach to evaluate newly developed cultivars for their parental usefulness and to assess the gene action involved in various attributes, so as to design an efficient breeding plan, for further genetic upgrading of the existing material. It also helps in the assessment of relative breeding potential of the parents or identifying best combiners in crops (Khattak *et al.*, 2004) [6] which could be utilized either to exploit heterosis in F_1 or for the accumulation of fixable genes to evolve a variety. Diallel analysis is one of the most powerful tools for characterizing the genetic architecture of plant materials, estimating the general combining ability (*gca*) of parents and selecting desirable parents and crosses with high specific combining ability (*sca*) for the exploitation of heterosis (Sarker *et al*., 2002) [10]. Among various diallel forms, the half-diallel technique that includes one set of single cross progeny and the parents has certain advantages over others, giving maximum information about the genetic architecture of a trait, parents and allelic frequencies (Kearsey, 1965) [5].

Materials and Methods
Based on the fruit yield, quality and with good consumer acceptance, six lines of okra (ACC-3, ACC-16, ACC-17, ACC-40, ACC-41 and ACC-43) were selected as parents for hybridization to generate the F_1 hybrids for the purpose of studying combining ability in okra.

Six parental lines were crossed manually using the standard procedure of hand emasculation and pollination in all possible combinations excluding reciprocals in half-diallel fashion, resulting in 15 single crosses. The reciprocal crosses were avoided presuming absence of maternal effect in the experimental material. The experimental material consisted of 15 single cross F_1 hybrids along with their six parental lines and two commercial or standard checks [Arka Anamika and Mona 002 (Private hybrid)] were evaluated in a randomized block design with three replications at the College of Horticulture, Venkataramannagudem during *kharif*, 2017 to study the general combining ability (*gca*) effects of parents and specific combining ability (*sca*) effects of hybrids for yield and yield contributing charectars like for plant height, number of primary branches per plant, internodal length of main stem, fruit length, fruit girth, number of fruits per plant, number of seeds per fruit, fruit yield per plant. The data on these parameters were subjected to statistical analysis to draw logical conclusions.

Results and Discussion

Analysis of variance for combining ability (Table 1) reveals that significance of genotype effect ($P<0.01$) indicated a wide range of variability among the genotypes for most of the characters under study. Sum of squares were highly significant ($P<0.01$) for both *gca* and *sca* for plant height, number of primary branches per plant, internodal length of main stem, fruit length, fruit girth, number of fruits per plant, number of seeds per fruit, fruit yield per plant. This indicates that both the additive and non-additive components of heritable variance are responsible for variation observed for these traits.

Gene Action

The estimates of *gca* and *sca* variances, their ratios and gene action are presented in Table. 2. General combining ability is generally associated with additive gene action, while specific combining ability is due to dominance and epistasis. In the present investigation, it was found that *sca* variances were higher than *gca* variances for all the characters, which indicated the predominance of non-additive gene action. Hence, heterosis breeding and recombination breeding with postponement of selection at later generations are ideal to improve these traits.

General combining ability and specific combining ability effects

Two types of combining ability, general and specific, have been recognized in quantitative genetics. Specific combining ability is defined as the deviation in the performance of hybrids from the expected productivity based upon average performance of lines involved in hybrid combination, where as the general combining ability is defined as the average performance of a line in a series of crosses. General combining ability is due to genes, which are largely additive in their effects and specific combining ability is due to the genes with dominance or epistatic effect.

Table 1: Analysis of variance for combining ability for various quantitative characters of okra

S. No.	Characters	Mean sum of Squares									
		Replications	Treatments	Parents	Hybrids	Parent Vs Hybrids	Error	Total	GCA	SCA	Error
		(2)	(20)	(5)	(14)	(1)	(40)	(62)	(5)	(15)	(40)
1	Plant height (cm)	10.09	114.45**	113.93**	103.75**	266.90**	9.42	220.03	453.77**	78.95**	25.03
2	No. of primary branches per plant	0.03	0.42**	0.22**	0.51**	0.23**	0.02	0.15	0.20**	0.12**	0.01
3	Internodal length of main stem	0.00	6.59**	8.19**	6.38**	1.47**	0.04	2.15	5.61**	1.06**	0.01
4	Fruit length (cm)	1.14	4.21**	6.48**	2.82**	12.29**	0.52	1.73	2.74**	0.96**	0.17
5	Fruit girth (cm)	0.19	1.13**	2.06**	0.74**	2.07**	0.13	0.45	0.83**	0.23**	0.04
6	Number of fruits per plant	4.40	33.02**	19.42**	35.13**	71.34**	1.51	11.77	28.13**	5.30**	0.50
7	Number of seeds per fruit	66.43*	37.75**	22.87	43.93**	25.52	13.82	23.23	13.51*	12.27**	4. 61
8	Fruit yield per plant (g)	1974.76	20935.81**	11640.72**	20339.00**	75766.51**	1723.19	7928.93	10289.71**	5874.90**	574.40

*, ** Significant @ 5% and 1% level respectively.

General combining ability effects

For plant height, (Table 3) three parents ACC-17(6.58), ACC-43(5.14), and ACC-3(5.05), manifested positively significant *gca* effects, while ACC-17(0.16), ACC-16(0.10) and ACC-43(0.07) manifested positively significant *gca* effects for number of primary branches per plant. For internodal length, ACC-40 (-1.50) and ACC-41(-0.39) manifested significant *gca* effects in desirable negative direction. For fruit length, two parents ACC-43(0.70) and ACC-3(0.32) manifested positively significant *gca* effects. For fruit girth, parents ACC-3(0.34) and ACC-16(0.33) manifested positively significant *gca* effects. For number of fruits per plant, parents ACC-17(2.01), ACC-16(1.05) and ACC-43(0.55) manifested significant *gca* effects in positive direction. None of the parental lines were found to be high general combiners for number of seeds per fruit. For fruit yield per plant, parental line ACC-16(24.67), ACC-3(23.09), ACC-43(19.12), ACC-16(1.84), ACC-3(1.74), and ACC-43(1.43) manifested positively significant *gca* effects.

From the results of the *gca* effects, it is evident that the magnitude of *gca* effects was relatively higher in some of the parental lines for certain characters like plant height, number fruits per plant and fruit yield per plant. High *gca* effects for some or all of these characters in okra were also reported by Wammanda *et al*. (2010) [13], Jaiprakashnarayan *et al*. (2008a; 2008b) [2, 3], Singh *et al*. (2009) [11], Jindal *et al*. (2009) [4] and Reddy *et al*. (2011) [9]. High *gca* effects are attributed to additive or additive × additive gene effects, which represents the fixable genetic components of variance, which can be exploited through hybridization and selection programmes. (Griffing, 1956) [1].

Specific combining ability effects

Specific combining ability effects helps in identification of superior cross combinations (good specific combiners) for commercial exploitation of heterosis.

Table 2: Components of heritable variation and their ratios for various quantitative characters of okra

Character	σ^2gca	σ^2sca	σ^2gca / σ^2sca
Plant height (cm)	53.59	53.92	0.99
No. of primary branches per plant	0.02	0.11	0.20
Internodal length of main stem	0.69	1.04	0.67
Fruit length (cm)	0.32	0.78	0.41
Fruit girth (cm)	0.09	0.18	0.53
Number of fruits per plant	3.45	4.79	0.72
Number of seeds per fruit	1.11	7.66	0.14
Fruit yield per plant (g)	1214.41	5300.50	0.22

σ^2gca= General combining ability variance;
σ^2sca = Specific combining ability variance

Table 3: General combining ability effects of parents for various quantitative characters of okra

Characters	ACC-3	ACC-16	ACC-17	ACC-40	ACC-41	ACC-43
Plant height (cm)	5.05**	1.57	6.58**	-12.11**	-6.23**	5.14**
No. of primary branches per plant	-0.04	0.10**	0.16**	-0.28**	-0.00	0.07*
Internodal length of main stem	0.61**	0.14**	0.69**	-1.50**	-0.39**	0.44**
Fruit length (cm)	0.32*	0.02	-0.16	-1.03**	0.13	0.70**
Fruit girth (cm)	0.34**	0.33**	0.08	-0.47**	-0.21**	-0.07
Number of fruits per plant	0.38	1.05**	2.01**	-3.40**	-0.61*	0.55*
Number of seeds per fruit	-0.24	-1.35	-0.59	0.28	2.41**	-0.50
Fruit yield per plant (g)	23.09**	24.67**	8.71	-69.33**	-6.26	19.12*

*,** Significant at 5 and 1 percent levels, respectively

For plant height, among 15 crosses, one cross expressed positively significant *sca* effects. (Table 4). Range of *sca* effects varied from -14.13 (ACC-16×ACC-43) to 10.10 (ACC-16×ACC-17).The crosses ACC-16×ACC-17(10.10), ACC-17×ACC-43(9.40) and ACC-41×ACC-43 (8.98) were the top three high specific combiners for this trait. For number of primary branches per plant (Table 4), six crosses expressed positively significant *sca* effects. With regards to *sca* effects of crosses, it ranged from -0.65 (ACC-3×ACC-17) to 0.47 (ACC-41×ACC-43). The crosses, ACC-41×ACC-43(0.47), ACC-17×ACC-43(0.44), and ACC-3×ACC-16(0.42), were the top three high specific combiners for this trait. For internodal length of main stem (Table 4), five crosses expressed positively significant *sca* effects. Estimation of *sca* effects ranged from -1.45 (ACC-3×ACC-43) to 1.99 (ACC-3×ACC-41). The crosses, ACC-3×ACC-43(-1.45), ACC-16×ACC-41(-0.88) and ACC-40×ACC-43(-0.87) were the top three high specific combiners for this trait. Among 15 crosses, four crosses expressed positively significant *sca* effects for fruit length (Table 4). The estimates of *sca* effects in hybrids varied from -1.14 (ACC-16×ACC-17) to 1.45(ACC-41×ACC-43). The crosses, ACC-41×ACC-43(1.45), ACC-17×ACC-41(1.10) and ACC-3×ACC-41(0.92), were the top three high specific combiners for this trait. For fruit girth (Table 5), three crosses expressed positively significant *sca* effects. With regards to *sca* effects of crosses, it ranged from -0.42 (ACC-40×ACC-41) to 0.86 (ACC-17×ACC-40). The cross ACC-17×ACC-40(0.86) and ACC-16×ACC-40(0.67), were the high specific combiners for this trait. For number of fruits per plant (Table 5), six crosses expressed positively significant *sca* effects. Range of *sca* effects varied from -0.20 (ACC-3×ACC-17) to 3.76 (ACC-3×ACC-41). The crosses ACC-3×ACC-41(3.76), ACC-17×ACC-43 (2.97) and ACC-16×ACC-43 (2.93), were the top three high specific combiners for these traits. For number of seeds per fruit (Table 5), one cross expressed positively significant *sca* effects. The spectrum of variation for *sca* effects in hybrids was from -5.19 (ACC-16×ACC-17) to 7.17 (ACC-17×ACC-41). The crosses ACC-16×ACC-17 (-5.19), ACC-3×ACC-40 (-3.05) and ACC-16×ACC-40 (-2.14), were the top three high specific combiners for this trait. For fruit yield per plant (Table 5), six crosses expressed positively significant *sca* effects. The estimates of *sca* effects in hybrids varied from -72.98 (ACC-40×ACC-41) to 98.31 (ACC-17×ACC-43). The crosses ACC-17×ACC-43 (98.31), ACC-3×ACC-41(97.62) and ACC-41×ACC-43 (93.89) were the top three high specific combiners for this trait.

Table 4: Specific combining ability effects of hybrids for yield and yield contributing characters in okra

Entry	Plant height (cm)	Number of primary branches per plant	Internodal length of main stem (cm)	Fruit length (cm)
ACC-3 × ACC-16	-2.78	0.42**	-0.26*	-0.21
ACC-3 × ACC-17	-0.18	-0.65**	-0.11	-0.44
ACC-3 × ACC-40	-10.88*	0.07	-0.20	0.06
ACC-3 × ACC-41	0.37	0.29**	1.99**	0.92*
ACC-3 × ACC-43	1.59	-0.25**	-1.45**	-0.01
ACC-16 × ACC-17	10.10*	-0.12	0.12	-1.14**
ACC-16 × ACC-40	-0.33	0.19*	-0.31*	0.79*
ACC-16 × ACC-41	-5.48	-0.06	-0.88**	-0.06
ACC-16 × ACC-43	-14.13**	0.10	0.18	-0.03
ACC-17 × ACC-40	2.06	-0.11	1.41**	0.07
ACC-17 × ACC-41	5.11	0.35**	0.24*	1.10**
ACC-17 × ACC-43	9.40	0.44**	0.79**	0.47
ACC-40 × ACC-41	8.35	-0.34**	-0.59**	0.78
ACC-40 × ACC-43	8.16	-0.22*	-0.87**	0.46
ACC-41 × ACC-43	8.98	0.47**	1.39**	1.45**

*,** Significant at 5 and 1 percent levels, respectively

Table 5: Specific combining ability effects of hybrids for yield and yield contributing characters in okra

Entry	Fruit girth (cm)	Number of fruits per plant	Number of seeds per fruit	Fruit yield per plant(g)
ACC-3 × ACC-16	0.08	0.10	2.46	12.62
ACC-3 × ACC-17	-0.18	-0.20	0.44	3.58
ACC-3 × ACC-40	0.25	-0.78	-3.05	-28.54
ACC-3 × ACC-41	0.17	3.76**	2.55	97.62**
ACC-3 × ACC-43	-0.32	-1.07	-0.72	-71.14**
ACC-16 × ACC-17	-0.20	0.47	-5.19*	-13.20
ACC-16 × ACC-40	0.67**	1.55*	-2.14	82.58**
ACC-16 × ACC-41	0.11	0.76	0.06	0.45
ACC-16 × ACC-43	-0.32	2.93**	2.72	56.42*
ACC-17 × ACC-40	0.86**	0.26	-0.43	29.28
ACC-17 × ACC-41	0.58**	1.47*	7.17**	80.51**
ACC-17 × ACC-43	0.35	2.97**	2.03	98.31**
ACC-40 × ACC-41	-0.42*	-2.45**	0.02	-72.98**
ACC-40 × ACC-43	-0.29	-1.28	-1.92	-40.40
ACC-41 × ACC-43	0.37	1.60*	2.01	93.89**

*,** Significant at 5 and 1 percent levels, respectively

In general, relatively higher magnitude of *sca* effects were observed in many crosses for plant height, number of fruits per plant and fruit yield per plant. (Table 4 and 5), which may probably be due to the formation of superior gene re-combinations. The negative *sca* effects observed in some of the crosses for different characters might be due to the presence of unfavorable gene combinations in the parents for the respective traits. These best specific combiners having the highest magnitude of significant *sca* effects in favorable direction are recommended for heterosis breeding. The intercrossing of these materials could, therefore, generate a population with a large gene pool, where genetic linkages and genetic blocks could be broken.

Conclusion

Analysis of variance for combining ability revealed significance of mean squares for both *gca* and *sca* for majority of the traits under study indicating that both additive and non-additive components of heritable variance are involved in the inheritance of majority of the traits. The parental line ACC-3 was found to be the high general combiner for majority of the characters under study. Specific combining ability analysis revealed that out of the fifteen crosses evaluated, the crosses ACC-17 × ACC-43, ACC-3 × ACC-41 and ACC-41 × ACC-43 were found to be high specific combiners and could be utilized in recombination breeding programme with single plant selection in the passing generations to coin the additive gene action to evolve true breeding lines or varieties with higher fruit yield and good fruit quality.

References

1. Griffing B. Concept of general and specific combining ability in relation to diallel crossing system. Australian Journal of Biological Sciences. 1956; 9:463-93.
2. Jaiprakashnarayan RP, Prashanth SJ, Mulge R and Madalageri MB. Study on heterosis and combining ability for earliness and yield parameters in okra (*Abelmoschus esculentus* (L.) Moench). The Asian Journal of Horticulture. 2008a; 3(1):136-41.
3. Jaiprakashnarayan RP, Prashanth SJ, Mulge R, Madalageri MB, Nataraj SK. Studies on heterosis and combining ability for growth parameters in okra (*Abelmoschus esculentus* (L.) Moench). The Asian Journal of Horticulture. 2008b; 3(1):21-26.
4. Jindal SK, Arora D, Ghai TR. Heterobeltiosis and combining ability for earliness in okra (*Abelmoschus esculentus* (L.) Moench). Crop Improvement. 2009; 36(1):1-5
5. Kearsay KJ, Biometrical analysis of a random mating population: A comparison of five experimental designs. Heredity. 1965. 20:205-233.
6. Khattak GSS, Ashraf M, Zamir R. Gene action for synchrony in pod maturity and indeterminate growth habit in mungbean (*Vigna radiata* L. Wilczek). Pakistan Journal of Botany. 2004; 36(3):589-594.
7. NHB, 2018. National Horticulture Board. New Delhi. www.nhb.gov.in
8. Rashid M, Cheema AA, Ashraf M. Line × tester analysis in basmati rice. Pakistan Journal of Botany. 2007; 39:2035-2042.
9. Reddy MT, Haribabu K, Ganesh M, Begum H. Combining ability analysis for growth, earliness and yield attributes in okra. Thai Journal of Agricultural Science. 2011; 44(3):207-218.
10. Sarker U, Biswas PS, Prasad B, Mian MA. Heterosis and genetic analysis in rice hybrids. Pakistan Journal of Biological Sciences. 2002; 5(1):1-5.
11. Singh DR, Singh PK, Syamal MM, Gautam SS. Studies on combing ability in okra. India Journal of Horticulture. 2009; 66(2):271-80.
12. Subhan M, Qasim M, Ahmed RD, Khan MU, Khan MA, Ameen MA. Combining ability for yield and its components in upland cotton. Asian Journal of Plant Science. 2003; 2:519-522.
13. Wammanda DT, Kadams AM and Jonah PM. Combining ability analysis and heterosis in a diallel cross of okra (*Abelmoschus esculentus* (L.) Moench). African Journal of Horticulture. 2010; 5(16):2108-21015.