Annals of the Sri Lanka Department of Agriculture 2010. 12: 167-174.

A STUDY ON COMBINING ABILITY AND HETEROSIS IN OKRA (*Abelmoschus esculentus* (L.) Moench)

D.G.S. RATNAPALA, W.D. JAYALATHA and M.K. DHARMASENA
Fruit Crops Research and Development Center, Kananwila, Horana, Sri Lanka

ABSTRACT

A 5x5 half diallel analysis was performed using local genotypes to estimate the combining ability and heterosis with respect to yield and selected yield components. The combining ability analysis was done using the method 2, model 1, of Griffing's Approach. A farmer variety ET 8 was the best general combiner for fruit yield per plant, fruit weight and fruit length while ok15, also a farmer variety was the best combiner for number of fruits per plant, earliness of flowering and harvesting period. According to the results obtained by this research the cross combinations ok2 x ok 15, ET8 x ok5 and ok2 x ok5 showed significant specific combining ability effects and highly significant heterobeltiosis for fruit yield per plant and number of fruits per plant.

KEYWORDS: Combining ability, Heterosis, Okra

INTRODUCTION

Okra is one of the most important vegetables grown throughout the year in Sri Lanka. Lack of high yielding varieties of good quality with disease tolerance is the major constraint in cultivation of okra. Although presently all the recommended varieties are inbreds, feedback from farmers show that they are more willing to grow hybrid varieties due to their high yielding ability. Hence, it is important to develop hybrid varieties to the local market. Emasculation and pollination processes are easier in okra due to large flowers, monoadelphous stamens and due to the high number of seed production in single pollination. This helps the breeder to make crosses through manual hybridization. As the hybrid vigour has been reported with as much as 86% increased yield, exploitation of heterosis has been attempted (Elmaksoud *et al.*, 1986). Also the knowledge of combining ability helps in identifying the best combiners, which may be hybridized either to exploit heterosis or to accumulate fixable genes through selection. This study was conducted with the objective of studying the combining ability of 5 genetically different local inbred lines having moderate yields, in a 5x5 half diallel analysis. The heterosis of cross combination of these inbred lines was studied for identification of promising cross combinations.

MATERIALS AND METHODS

Five genetically different local inbred lines, namely ET8, ok15 (Farmer varieties) ok2, ok5 (breeding lines) and the recommended variety MI5 were used for this study. These parents were selected from an initial study of 14 different inbred lines (3 farmer varieties, 4 introductions, 5 breeding lines and 2 recommended varieties) and their 91 cross combinations. The 5 parental

lines were crossed in all possible combinations in a half diallel design for the study conducted at Fruit Crop Research and Development Centre, Horana. Five parents and ten cross combination were laid out in a randomized complete block design (RCBD) with 3 replications during 2008 *yala* season. A spacing of 90 x 60 cm and 3.6 m length rows were used per genotype. Fertilizer application was done according to the Department of Agriculture recommendations (DOA, 2007). Four seeds were planted in each hill and 2 weeks after seeds sowing extra seedlings were thinned out to maintain 2 plants per hill. Twelve plants of each genotype were used for recording the observations on days to 50% flowering, number of fruits per plant, fruit weight per plant, harvesting period and plant height. Fruit weight and fruit length were also recorded from 10 randomly selected fruits harvested from 12 plants in each genotype.

The mean value of characters recorded on all the genotypes were subjected to analysis of variance. The characters with significant variances for genotypes were used for combining ability analysis using 'model I method II Diallel mating design of Griffing's Approach' (Griffing, 1956; Nadarajan and Gunesekeran, 2005). This includes, the calculation of analysis of variance for general combining ability (gca), specific combining ability (sca) and combining ability effects. The magnitude of heterosis was calculated using the difference between F1 performances over that of the better parent (heterobeltiosis) as a percentage (Nadarajan and Gunesekeran, 2005).

RESULTS AND DISCUSSION

The analysis of variance shows significant differences for variances of all the characters except for plant height (Table 1). This indicates that the parents (genotypes) tested have genetic variability for all the characters except plant height. The analyses of variance for combining ability (variances due to general combining ability and specific combining ability) for 6 characters are given in table 2. The estimates of the gca effects of 5 parents and the sca effects of cross combinations are presented in table 3 and 4 respectively.

The concept of combining ability is a measure of additive and non-additive gene action. The general combing ability effect involves additive gene action where as specific combing ability effect presents only non-additive gene action. The presence of non-additive gene action offers basis for exploration of heterosis.

Days to 50% flowering

The variance due to gca and sca were significant exhibiting importance of additive and non additive gene actions in the inheritance of days to 50% flowering. The ratio of gca variance and sca variance is greater than unity

indicating the major role of the additive gene action for days to 50% flowering. The parent ok 15 alone exhibited significant negative gca effect of 2.50 which shows as a better character i.e. earliness of flowering. Parents ok5, MI5 and ET8 gave non significant gca effects. The crosses ok5 x MI5, ok15 x MI5 and ET8 x ok15 gave significant negative sca effects.

Table 1. Analysis of variance for genetic variability

Component	*Genotypes*	*Replication*	*Error*
df	14	2	28
1. Plant height (cm)	433.22	272.75	245.38
2. Days to 50% flowering	24.22**	13.26	5.7
3. Fruit length (cm)	1.14**	1.59	0.26
4. Fruit weight (g)	6.72**	1.29	1.08
5. No. of fruits per plant	136.94**	9.16	5.13
6. Fruit yield per plant (g)	28931.75**	7432.74	4169.78
7. Harvesting period (days)	53.76**	3.35	8.28

* Significant at P = 0.05 ** Significant at P = 0.01

Table 2. Analysis of variance for combining ability for the six characters

Characters	*gca*	*sca*	*Error*
df	4	10	28
1. Days to 50% flowering	15.5**	4.98**	1.89
2. Fruit length (cm)	0.86**	0.18*	0.09
3. Fruit weight (g)	5.43**	3.11**	0.20
4. No. of fruits per plant	17.37**	56.66**	1.71
5. Fruit yield per plant (g)	6295.35**	10983.34**	1389.92
6. Harvesting period (days)	47.08**	5.80**	2.76

* Significant at P = 0.05 ** Significant at P = 0.01 sca - specific combining ability gca - general combining ability

Table 3 - Estimates of gca effects of the five parents

Characters	*ET8*	*Ok2*	*Ok5*	*Ok15*	*MI5*	*SE*
1. Days to 50% flowering	0.07	1.45**	0.30	-2.50**	0.21	0.47
2. Fruit length (cm)	0.56**	-0.24*	-0.08	0.08	-0.33**	0.09
3. Fruit weight (g)	1.57**	-0.38	-0.39	-0.26	-0.52*	0.20
4. No. of fruits per plant	0.62	0.95*	-0.31	1.35**	-2.59**	0.44
5. Fruit yield per plant (g)	31.12*	-11.55	12.21	14.45	-46.23**	12.6
6. Harvesting period (days)	1.59**	-2.15**	1.24*	2.66**	-3.33**	0.56

* Significant at P = 0.05 ** Significant at P = 0.01

Fruit length

The gca and sca variance were significant indicating importance of both additive and non additive gene action, as reported by Balakrishnan *et al.* (2009). The ratio of gca and sca variance was greater than unity implying a major role of additive gene action. ET8 was outstanding with highly

significant positive gca effect of 0.56. However, none of the cross combinations with ET8 showed significant positive sca effect which may be due to the lack of complementation of parental genes.

Table 4. Estimates of sca effects of the ten cross combinations

Crosses	*Days to 50% flowering*	*Fruit length*	*Fruit weight*	*N.o of Fruits per plant*	*Fruit yield per plant*	*Harvesting period (days)*
ET8xOK2	-1.37	-0.91**	-0.84*	1.02	63.11*	1.40
ET8xOK5	-0.38	-0.07	-0.66*	9.57**	107.73**	1.31
ET8xOK15	-2.42*	0.003	-0.36	0.32	59.23*	-0.19
ET8xMI5	1.4	-0.12	-1.76**	-0.4	-7.96	-3.65**
OK2xOK5	-0.6	0.48*	0.21	5.35**	68.51*	2.08
OK2xOK15	0.2	0.20	0.37	12.29**	120.99**	1.33
OK2xMI5	0.63	0.07	1.06**	-0.06	23.64	-0.9
OK5xOK15	2.35*	0.20	0.01	-10.05**	-14.65	-1.06
OK5xMI5	-3.82**	0.39	-0.05	3.9**	67.18*	2.94*
OK15xMI5	-3.05**	0.21	-0.27	4.24**	60.45*	2.51*
SE	0.95	0.20	0.31	0.90	25.73	1.15

* Significant at P = 0.05 ** Significant at P = 0.01

Fruit weight

The gca and sca variances were significant, indicating importance of both additive and non additive gene action. Similar results were obtained by Ranjani *et al.* (2001). However, the ratio of gca to sca variance was greater than unity implying a major role of additive gene action. The parent ET8 alone exhibited significant positive gca effect of 1.57. However, none of the crosses with ET8 gave positive sca effect. This may be due to the lack of complementation of the parental gene. This is in line with the findings of Balakrishnan *et al.* (2009).

Number of fruits per plant

The variances due to sca and gca effects were significant, showing the presence of both additive and non additive gene action. However, the high magnitude of sca variance (ratio of gca variance and sca less than unity) implies the major role of non-additive gene action for this character. This is in conformity with the results of Mehta *et al.* (2007) and Pal and Sabesan (2009). Parents ok15 and ok2 gave significant positive gca effects while crosses ok2 x ok15, ET8 x ok5, ok2 x ok5, ok15 x MI5 and ok5 x MI5 gave significant positive sca effects. Parents ok5 and MI5 with poor gca produced hybrids with high sca effect which could be attributed to complementary gene action.

Fruit yield per plant

The variances due to gca and sca effects were significant indicating importance of additive and non additive gene action in determining the inheritance of the character. The role of non-additive gene action is predominant since the ratio of gca variance and sca variance is less than unity. This is in conformity with the results of Ranjani *et al.* (2001) and Balakrishnan *et al.* (2009). Parent ET8 gave significant positive gca effect while cross combinations ok2 x ok15, ET8 x ok5, ok2 x ok5, ok5 x MI5, ET8 x ok2, ok15 x MI5 and ET8 x ok15 showed significant positive sca effects. Thus the cross ok2 x ok15 was the best specific combination followed by ET8 x ok5 and ok2 x ok5.

Harvesting period

Harvesting period describes the economic life span of the crop. The combining ability analysis indicated significant gca and sca variance and the ratio of gca and sca variance was greater than unity indicating a greater role of additive gene action. Parent ok15, ET8 and ok5 gave significant positive effects while the cross combinations ok5 x MI5 and ok15 x MI5 gave significant positive harvesting periods.

Heterosis

The heterosis reveals the type of gene action involved and it helps in selection of suitable parameters, which are employed in crop improvement. The heterosis of cross combination over better parent (Heterobeltiosis) are presented in table 5.

Results indicate that most of the cross combinations have earliness of flowering than the better parent (varied from -1.16 to -11.66). Similar results were obtained by Mehta *et al.* (2007). Ok15 x MI5, ok5 x MI5 and ok2 x ok15 gave significant negative heterotic values which indicate early flowering. Early flowering is considered as a better character. In the case of fruit length all the crosses showed negative heterotic values ranging from -1.15 to -16.82. Out of 10 cross combinations most of the crosses exhibited negative heterotic values for fruit weight ranging from -2.61 to -36.72. Similar negative heterotic values for fruit weight was reported by Weerasekara *et al.* (2009). When consider number of fruits per plant maximum heterosis of 74.6% over better parent was given by the cross ET8 x ok5. Ok 2 x ok15 and ok2 x ok5 gave heterosis over better parent 69% and 62% respectively. Mahajan and Sharma (1979) suggested the number of fruits per plant be given more consideration in selecting superior types, which is the main character, in giving the maximum fruit yield per plant.

Table 5 - Mean values of parents & cross combinations and heterobeltiosis for five characters

Parent & Crosses	*Characters*									
	Days to 50% flowering		*Fruit length (cm)*		*Fruit weight (g)*		*No of fruits per plant*		*Fruit yield per plant (g)*	
	Mean	*HBT%*	*Mean*	*HBT%*	*Mean*	*HBT %*	*Mean*	*HBT %*	*Mean*	*HBT%*
ET8	60.0		13.43		17.97		18.67		338.04	
ET8xOK2	59.0	-5.29	11.17	-16.82**	13.37	-36.72**	25.3	35.67**	469.53	38.89**
ET8xOK5	59.6	-1.16	12.17	-9.38**	13.53	-24.70**	32.6	74.60**	537.93	59.10**
ET8xOK15	54.0	-2.35	12.40	-7.66*	13.97	-22.2**	25.0	33.00**	491.67	45.44**
ET8xMI5	61.0	1.66	11.87	-11.61**	12.32	-31.40**	20.3	8.70	363.78	7.61
OK2	62.3		11.37		12.30		15.3		225.63	
OK2xOK5	60.0	-3.73	11.93	-1.40	12.30	-2.61	28.68	62.00**	456.03	53.59**
OK2xOK15	58.0	-6.90*	11.8	-0.25	12.00	-4.98	37.3	69.00**	510.75	68.69**
OK2xMI5	61.6	-1.59	11.26	-2.00	13.17	5.36	21.0	37.00**	352.71	56.32*
OK5	60.3		11.50		12.63		17.7		296.91	
OK5xOK15	59.0	-2.15	11.96	-1.15	12.23	-6.42	13.7	-37.0**	398.88	31.7
OK5xMI5	56.0	- 10.54**	10.97	-9.33*	12.07	-3.44	23.7	33.00**	420.03	41.46*
OK15	55.3		11.83		13.07		22.0		302.76	
OK15xMI5	54.0	- 11.66**	11.30	-4.48	11.97	-4.24	25.67	16.68	415.53	37.24*
MI5	62.6		11.43		12.50		13.7		222.75	

* Significant at P = 0.05 ** Significant at P = 0.01

HBT% - Heterobeltiosis percentage

In the analysis of the fruit yield per plant the crosses ok2 x ok15, ET8 x ok5, ok2 x MI5, ok2 x ok5 and ET8 x ok15 gave appreciable amount of heterosis over better parent (significant) to the extent of 68.69%, 59.1%, 56.32%, 53.59% and 45.44% respectively. Maximum heterosis of 56.48% over better parent was observed by Weerasekara *et al.* (2008).

CONCLUSIONS

ET8 was the best combiner for fruit yield per plant, fruit length and fruit weight. Ok15 was the best combiner for number of fruits per plant, earliness of flowering and harvesting period, indicating its role in breeding of high yield with early maturity and increasing number of fruits per plant. Hybrid vigour can be exploited in okra for increasing fruit yield through increasing number of fruits per plant. The cross combination ok2 x ok15, ET8 x ok5 and ok2 x ok5, which have given significant sca effects and highly significant heterotic values for number of fruits per plant and fruit yield per plant with good quality can be recommended for further studies in adaptability before consideration for release.

ACKNOWLEDGEMENTS

Authors wish to acknowledge the valuable assistance provided by Dr. Amitha Bentota, senior research officer, RRDC, Bombuwela for data analysis. Thanks are also due to Miss. T.R. Diwakara for assistance in the preparation of manuscript.

REFERENCES

Balakrishnan, D., E. Sreenivasan, V.V. Radhakrishnan, R. Sujatha and K. V. Suresh Babu. 2009. Combining ability in bhindi (*Abelmoschus* spp.). Electronic Journal of Plant Breeding. 1: 52-55.

DOA. 2007. Fertilizer recommendation for horticultural crops. Department of Agriculture, Peradeniya. 13 p.

Elmaksoud, M.A., R.M. Helai and M.H. Mohammed. 1986. Studies on intervarietal cross and hybrid vigour in okra. Annals of Agriculture Science. 29(1): 431-438.

Griffing, B., 1956. Concept of general and specific combining ability in relation to diallel crossing systems. Australian Journal of Biological Sciences. 9: 463–493.

Mahajan, Y.P. and B. R. Sharma. 1979. Parent off spring correlations & heritability of some characters in okra. Scientia Horticulture. 10 (2): 135-139.

Mehta N., B.S. Asati and S.K. Mamidwar. 2007. Heterosis and gene action in Okra. Bangladesh Journal of Agricultural Research. 32(3): 421-432.

Nadarajan, N. and M. Gunasekaran. 2005. Quantitative genetics and biometrical techniques in plant breeding. Kalyani Publishers, India. Edition 1. 57 and 111-117 pp.

Pal, A.K. and T. Sabesan. 2009. Combining ability through diallel analysis in Okra (*Abelmoschus esculentus* (L.) Moench). Journal of Electronic Journal of Plant Breeding. 1: 84-88.

Ranjani, B., P. Manju, P. Manikantan Nair and P. Saraswathy. 2001. Combing ability in okra (*Abelmoschus esculentus* (L.) Moench). Journal of Tropical Agriculture. 39: 98-101.

Weerasekara, D., R.C. Jagadeesha, M.C. Wali, P.M. Salimath, I.K. Kalappanawar. 2008. Heterosis for yield and yield components in okra. Karnataka Journal of Agricultural Science. 21(4): 578-579.

Weerasekara, D., R.C. Jagadeesha, R.M. Hosamani, M.C. Val, I.K. Kalappanavar and P.M. Salimath. 2009. Combining ability and heterosis of yield and yield related characters in okra. Annals of the Sri Lanka Department of Agriculture. 11: 183-197.