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Heterosis Studies in Okra [*Abelmoschus esculentus* (L.) Moench] through Line X Tester Mating Design

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ABSTRACT

Realizing the hybrid okra to increase productivity, the present experiment was undertaken with a fixed model i.e., line x tester mating system involving five line and four testers to identify the best heterotic combination. All 20 F₁ hybrids and along with their 9 parents and standard control (Arka Anamika) were evaluated in randomized block design with three replications. The results of the present study indicated the existence of significant differences among the lines, testers and hybrids. The heterosis over better parent varied from -10.41 per cent to 4.93 per cent for days to 50 per cent flowering, -17.68 per cent and 10.41 per cent for plant height at maturity, -16.89 per cent to 12.80 per cent for number of branches per plant, -22.05 per cent and 11.29 per cent for fruit length, -34.90 per cent and 10.19 per cent for fruit girth, -23.99 per cent and 20.16 per cent for average fruit weight, -6.15 per cent to 17.99 per cent for number of fruits per plant, -22.37 per cent to 6.74 per cent for number of seeds per fruit, -0.78 per cent and 30.85 per cent for 100 seed weight, -0.78 per cent and 29.85 per cent for fruit yield per plant. The superior hybrids identified through heterosis study were Krishnagiri local × Arka Abhay followed by Krishnagiri local × Arka Anamika and Karimangalam local × Arka Anamika.

Key words: *Abelmoschus esculentus*, F₁ hybrids, Heterosis, Hybrid vigour

Okra is one of the important vegetable crops in India. It is multipurpose and multifarious crops, it is extensively grown for its tender pods, which are used as a very popular, tasty and gelatinous vegetable. It is a powerhouse of valuable nutrients. Okra mucilage has medicinal applications when used as a plasma replacement or blood volume expander. The mucilage of okra binds cholesterol and bile acid carrying toxins dumped into it by the liver. It contains high fibre, which “helps to stabilize blood sugar by regulating the rate at which sugar is absorbed from the intestinal tract”. The high quantity of folic acid within okra performs a huge role within the neural tube formation of the foetus through the fourth to the 12th week of pregnancy [1]. Okra has been called “a perfect villager’s vegetable” because of its robust nature, dietary fibre, and distinct Seed protein balance of both lysine and tryptophan amino acids (unlike the proteins of cereals and pulses) [2-3]. Despite its recognized potential and significant area and consumption in the country, it is being neglected because of non-availability of high yielding open-pollinated varieties. Yield plateau seems to have been reached in open-pollinated varieties of okra. To break the yield barriers in existing open pollinated varieties of okra, a hybridization- based breeding

strategy would be desirable. Heterosis breeding has been the most successful approach in increasing the productivity in okra. The line x tester analysis developed by Kempthorne has been used in this present study to estimate the genetic potentialities of the parents in hybrid combination [4]. The presence of heterosis in okra was first demonstrated by Vijayaraghavan and Warriar [5]. The presence of sufficient hybrid vigour is an important prerequisite for successful production of hybrid varieties.

MATERIALS AND METHODS

The experimental material consisted of nine genotypes received from germplasm bank maintained at Department of Vegetable Science, Tamil Nadu Agriculture University, Coimbatore. The genotypes represented wider genetic diversity, five genotypes Annamalai local (L₁), Krishnagiri local (L₂), Karimangalam local (L₃), Chidambaram local (L₄), Cuddalore local (L₅) were used as lines and four genotypes viz., Varsha Uphar (T₁), Arka Anamika (T₂), Arka Abhay (T₃), MDU-1 (T₄) were used as testers were crossed in a line x tester mating design resulting 20 F₁ hybrids. All the 20 F₁ hybrids and their 9 parents and standard control (Arka Anamika) were laid out in a randomized block design in three replications during two seasons February to April 2019 and December to February 2020 at the Plant Breeding farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar (Tamil Nadu), India. Inter and Intra row spacing of 60 and 30 cm was

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provided and normal cultural and agronomical practices were followed as per the recommendation and need based plant protection measures were taken up to maintain healthy crop stand. The observations were recorded on ten randomly selected plants in each replication. The characters namely days to 50 per cent flowering, plant height at maturity, number of branches per plant, fruit length, fruit girth, average fruit weight, number of fruits per plant, number of seeds per fruit, 100 seed weight and fruit yield per plant were studied. The analysis of heterosis was

carried out by the formula suggested by Wynne *et al.* [6].

RESULTS AND DISCUSSION

The analysis of variance indicated that existence of significant differences among the lines, testers and hybrids. The mean sum of squares due to lines and testers were significant for all the characters studied (Table 1). The variance due to line \times testers and hybrids were also significant for all traits.

Table 1 Analysis of variance of line \times tester analysis for various characters in okra

Source of variance	Replication	Line	Tester	L \times T	Error
DF	2	4	3	12	56
Days to 50 per cent flowering	2.1256	39.6279**	6.3056**	5.0347**	0.1516
Plant height at maturity	2.2276	1370.4349**	49.5986**	111.4766**	0.1474
Number of branches per plant	0.3874	0.7791**	0.6192**	0.1233	0.1342
Fruit Length	0.0799	37.6752**	40.7053**	5.0628**	0.2127
Fruit girth	0.1045	3.7398**	9.0323**	0.9103**	0.1434
Average fruit weight	2.1147	30.2065**	94.6360**	8.2803**	0.0753
Number of fruits per plant	1.8664	11.4110**	54.5568**	5.2629**	0.1324
Number of seeds per plant	2.2581	46.8457**	161.7566**	10.3592**	0.0988
100 seed weight	1.1542	7.4959**	1.7297**	0.1447**	0.1566
Fruit yield per plant	2.1978	18615.1667**	30080.0889**	1696.5229**	0.2141

Table 2 Estimation of heterosis (%) over better parent and standard parent for days to 50% flowering, plant height at maturity, number of branches per plant, fruit length in okra

Crosses	Days to 50% flowering		Plant height at maturity (cm)		Number of branches per plant		Fruit length (cm)	
	HB	SH	HB	SH	HB	SH	HB	SH
Annamalainagar local \times Varsha Uphar	4.27 **	12.10**	9.01**	25.83**	-8.98	-19.45*	-0.02	-21.36**
Annamalainagar local \times Arka Anamika	-2.85	4.45**	9.34**	26.07**	-12.51	-12.51	-2.51**	-21.52**
Annamalainagar local \times Arka Abhay	1.40	10.18**	9.56**	26.32**	-4.72	-13.33	-22.05**	-21.82**
Annamalainagar local \times MDU-1	-0.27	11.56**	9.13**	25.83**	-1.04	-21.92**	5.47	-22.27**
Krishnagiri local \times Varsha Uphar	-8.99**	-4.31**	-17.68**	-4.98**	-17.06*	-13.88	-18.72**	-18.79**
Krishnagiri local \times Arka Anamika	4.93**	4.93**	5.73**	8.27**	4.49	8.49	5.27**	5.27**
Krishnagiri local \times Arka Abhay	-10.41**	-2.65**	5.76**	8.31**	5.80	9.86	11.29**	11.62**
Krishnagiri local \times MDU-1	-5.67**	5.52**	-10.29**	2.44**	-14.95	-11.69	-22.05**	-22.12**
Karimangalam local \times Varsha Uphar	-4.66**	3.45**	-8.71**	5.38**	-11.29	-9.59	0.37	3.88
Karimangalam local \times Arka Anamika	3.00**	0.25	1.41**	6.07**	1.08	3.01	1.99	5.56**
Karimangalam local \times Arka Abhay	-3.07**	5.33**	1.48**	6.14**	-15.05	-13.42	4.73*	8.40**
Karimangalam local \times MDU-1	-6.32**	4.80**	-6.18**	7.14**	-15.95*	-14.34	-6.12**	-2.83
Chidambaram local \times Varsha Uphar	0.61	12.97**	2.51**	28.38**	-8.05	-18.63*	0.00	-21.35**
Chidambaram local \times Arka Anamika	-4.18**	7.59**	3.91**	30.14**	-18.26*	-18.26*	-0.98	-0.98
Chidambaram local \times Arka Abhay	-1.68*	10.40**	3.14**	29.17**	-3.41	-12.15	-0.85	-0.56
Chidambaram local \times MDU-1	0.37	12.71 **	-3.47**	20.89**	-1.23	-19.27*	3.10	-23.22**
Cuddalore local \times Varsha Uphar	-4.03**	0.91	-8.57 **	5.54**	-21.36*	-22.01**	-14.23**	-11.93**
Cuddalore local \times Arka Anamika	2.02**	2.78**	-10.71**	0.71*	-14.89	-14.89	-3.60	-1.01
Cuddalore local \times Arka Abhay	-4.64**	3.62**	-4.88**	7.28**	-11.97	-12.69	1.93	4.65*
Cuddalore local \times MDU-1	-6.50**	4.60**	10.41**	26.07**	-20.07*	-20.73*	-18.76**	-16.59**

Estimation of heterobeltiosis and standard heterosis for yield and contributing traits are presented in (Table 2-4). For days to 50 per cent flowering 11 crosses over better parent and 2 crosses over standard parent recorded negative and significant heterosis. Heterobeltiosis varied from -10.41 per cent to 4.93 per cent and standard heterosis ranged from -4.31 per cent to 12.97 per cent. The cross Krishnagiri local \times Arka Abhay (-10.41 per cent) recorded the maximum heterobeltiosis and the cross Krishnagiri local \times Varsha Uphar (-4.31 per cent) recorded the maximum standard Heterosis.

For plant height at maturity, 8 crosses over better parent and only one cross over standard parent recorded negative and significant heterosis. Heterobeltiosis ranged from -17.68 per cent to 10.41 per cent and standard heterosis ranged from -4.98 per cent to 30.14 per cent. The cross Krishnagiri local \times Varsha Uphar recorded the maximum heterobeltiosis (-17.68 per cent) and standard heterosis (-4.98 per cent). For number of branches per plant, none of the hybrids registered positive significant

heterobeltiosis and Standard heterosis. For fruit length, 3 crosses over better parent and 5 crosses over standard parent recorded Positive and significant heterosis. Heterobeltiosis ranged from -22.05 per cent to 11.29 per cent and standard heterosis ranged from -23.22 per cent to 11.62 per cent. The cross Krishnagiri local \times Arka Abhay recorded the maximum heterobeltiosis (11.29 per cent) and standard heterosis (11.62 per cent). For fruit girth, only one cross over better parent and 4 crosses over standard parent recorded positive and significant heterosis. Heterobeltiosis ranged from -34.90 per cent to 10.19 per cent and standard heterosis ranged from -36.60 per cent to 23.44 per cent. The only hybrid Krishnagiri local \times Arka Abhay recorded the positive significant heterobeltiosis (10.19 per cent) and maximum positive significant standard heterosis (23.44 per cent).

For average fruit weight, 5 crosses over better parent and 4 crosses over standard parent recorded positive and significant heterosis. Heterobeltiosis ranged from -23.99 per cent to 20.16

per cent and standard heterosis ranged from -25.21 per cent to 22.12 per cent. The cross Krishnagiri local × Arka Abhay recorded the maximum heterobeltiosis (20.16 per cent) and standard heterosis (22.12 per cent). For number of fruits per plant, 15 crosses over better parent and 8 crosses over standard parent recorded positive and significant heterosis.

Heterobeltiosis ranged from -6.15 per cent to 17.99 per cent and standard heterosis ranged from -7.15 per cent to 19.64 per cent. The cross Chidambaram local × MDU-1 recorded the maximum heterobeltiosis (17.99 per cent) and the cross Krishnagiri local × Arka Anamika recorded the maximum standard heterosis (19.64 per cent).

Table 3 Estimation of heterosis (%) over better parent and standard parent for Fruit girth, average fruit weight, number of fruits per plant in okra

Crosses	Fruit girth (cm)		Average fruit weight (g)		Number of fruits per plant	
	HB	SH	HB	SH	HB	SH
Annamalainagar local × Varsha Uphar	2.02	-28.44**	-3.78**	-17.29**	11.24**	-0.24
Annamalainagar local × Arka Anamika	-17.40**	-17.40**	-13.81**	-13.81**	5.78**	5.78**
Annamalainagar local × Arka Abhay	-25.22**	-16.22**	-21.17**	-21.28**	3.77**	5.94**
Annamalainagar local × MDU-1	-29.03**	-35.60**	-5.92**	-25.21**	15.40**	-6.13**
Krishnagiri local × Varsha Uphar	-28.22**	-19.80**	-16.57**	-15.21**	-9.02	-7.15**
Krishnagiri local × Arka Anamika	6.74	19.25**	19.78**	21.73**	17.23**	19.64**
Krishnagiri local × Arka Abhay	10.19*	23.44**	20.16**	22.12**	16.68**	19.12**
Krishnagiri local × MDU-1	-34.90**	-27.27**	-23.99**	-22.75**	3.76**	-1.78
Karimangalam local × Varsha Uphar	-18.05**	-13.76*	-9.55**	-10.28**	1.75**	1.67
Karimangalam local × Arka Anamika	4.63	10.12**	11.43**	11.43**	13.08**	13.08**
Karimangalam local × Arka Abhay	5.07	17.71**	8.83**	8.67**	8.94**	11.21**
Karimangalam local × MDU-1	-17.35**	-13.02*	-21.33**	-21.97**	-6.15*	-6.22**
Chidambaram local × Varsha Uphar	-2.49	-20.17**	4.38**	-10.28**	5.25**	-5.60**
Chidambaram local × Arka Anamika	-23.57**	-23.57**	-3.74**	-3.74**	-0.77	-0.77
Chidambaram local × Arka Abhay	-16.08**	-5.98	-2.67*	-2.81*	-0.07	2.01
Chidambaram local × MDU-1	-4.96	-13.76*	-5.38**	-24.78**	17.99**	-4.01**
Cuddalore local × Varsha Uphar	-22.51**	-27.14**	-1.32	-15.18**	11.55**	0.05
Cuddalore local × Arka Anamika	6.60	6.60	0.03	0.03	7.84**	7.84**
Cuddalore local × Arka Abhay	-4.35	7.16	0.35	0.20	0.96	3.07**
Cuddalore local × MDU-1	-19.88**	-24.68**	-0.38	-20.80**	16.07**	-5.39**

Table 4 Estimation of heterosis (%) over better parent and standard parent for number of seeds per fruit, 100 seed weight, total yield per plant in okra

Crosses	Number of seeds per fruit		100 seed weight (g)		Total yield per plant (g)	
	HB	SH	HB	SH	HB	SH
Annamalainagar local × Varsha Uphar	2.01**	-7.67**	-0.15	18.81**	-0.78**	-10.88**
Annamalainagar local × Arka Anamika	1.63**	1.63**	3.30	12.12*	1.63**	1.63**
Annamalainagar local × Arka Abhay	0.66	-1.32**	7.28	16.45**	0.55**	0.77**
Annamalainagar local × MDU-1	0.72	-13.18**	-4.94	3.17	5.97**	-4.83**
Krishnagiri local × Varsha Uphar	-10.40**	-7.28**	17.56**	39.87**	6.66**	6.68**
Krishnagiri local × Arka Anamika	3.73**	7.34**	16.78**	37.74**	24.60**	24.63**
Krishnagiri local × Arka Abhay	5.40**	9.07**	22.60**	44.60**	29.85**	30.13**
Krishnagiri local × MDU-1	-12.37**	-9.31**	14.58**	35.14**	5.26**	5.28**
Karimangalam local × Varsha Uphar	1.43**	-4.64**	18.14**	40.57**	-0.07	-0.09
Karimangalam local × Arka Anamika	2.76**	2.76**	19.74**	41.08**	22.34**	23.24**
Karimangalam local × Arka Abhay	6.74**	4.64**	16.65**	37.45**	18.19**	18.44**
Karimangalam local × MDU-1	-1.09*	-7.01**	6.66	25.68**	14.05**	14.03**
Chidambaram local × Varsha Uphar	0.55	-5.96**	2.62	22.10**	16.59**	4.72**
Chidambaram local × Arka Anamika	0.34	0.34	1.79	4.73	18.21**	18.21**
Chidambaram local × Arka Abhay	-4.30**	-6.18**	14.57**	17.95**	15.12**	15.36**
Chidambaram local × MDU-1	-3.22**	-9.48**	-0.79	2.08	0.87**	-9.41**
Cuddalore local × Varsha Uphar	-9.09**	-17.71**	16.73**	38.89**	13.22**	1.69**
Cuddalore local × Arka Anamika	-5.88**	-5.88**	31.61**	36.47**	12.13**	12.13**
Cuddalore local × Arka Abhay	0.88	-1.10*	32.61**	37.51**	7.72**	7.95**
Cuddalore local × MDU-1	0.16	-12.30**	24.49**	29.08**	5.05**	-5.66**

For number of seeds per fruit, 7 crosses over better parent and 5 crosses over standard parent recorded positive and

significant heterosis. Heterobeltiosis ranged from -22.37 per cent to 6.74 per cent and standard heterosis ranged from -17.71

per cent to 9.07 per cent. The cross Karimangalam local \times Arka Abhay recorded the maximum heterobeltiosis (6.74 per cent) and the cross Krishnagiri local \times Arka Abhay recorded maximum standard heterosis (9.07 per cent).

For 100 seed weight, 12 crosses over better parent and 17 crosses over standard parent recorded positive and significant heterosis. Heterobeltiosis ranged from -0.78 per cent to 30.85 per cent and standard heterosis ranged from 2.08 per cent to 44.60 per cent. The cross Cuddalore local \times Arka Abhay recorded the maximum heterobeltiosis (32.61 per cent) and the cross Krishnagiri local \times Arka Abhay recorded maximum standard heterosis (44.60 per cent).

For fruit yield per plant, 19 crosses over better parent and 16 crosses over standard parent recorded positive and significant heterosis. Heterobeltiosis ranged from -0.78 per cent to 29.85 per cent and standard heterosis ranged from -4.83 per cent and 30.13 per cent. The cross Krishnagiri local \times Arka Abhay recorded the maximum heterobeltiosis (29.85 per cent) and standard heterosis (30.13 per cent). Similar findings were reported by Nagesh *et al.* [7], Nama *et al.* [8], Senthilkumar and Sreeparvathy [9] reported heterosis for days to 50 per cent

flowering, plant height at maturity, fruit length. Patel and Patel [10] reported standard heterosis in desirable direction for number of branches per plant, fruit girth, average fruit weight, number of fruits per plant and number of seeds per fruit. Jain and Patel [11] reported standard heterosis in desirable direction for 100 seed weight.

CONCLUSION

Based on overall performance of heterosis, fifteen hybrids registered significant standard heterosis for fruit yield per plant. It was maximum with Krishnagiri local \times Arka Abhay followed by Krishnagiri local \times Arka Anamika and Karimangalam local \times Arka Anamika. The hybrid Krishnagiri local \times Arka Abhay was identified as the best hybrid since it had significant standard heterosis for all the traits except plant height and number of branches per plant. The next best hybrid was Krishnagiri local \times Arka Anamika and Karimangalam local \times Arka Anamika since it possessed desirable standard heterosis for all the traits except days to 50 per cent flowering, plant height and number of branches per plant.

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