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Full Length Research Article

Estimation of Heterosis for Flowering and Yield Attributes in Bhendi (*Abelmoschus esculentus* (L.) Moench)

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Abstract

A set of seven parents viz., G_1 (Arka Anamika), G_2 (Aruna), G_3 (Varsha Uphar), G_4 (Pusa-5), G_5 (MDU-1), G_6 (Kashi Kranti), G_7 (Ankur-41) with their 21 F_1 hybrids obtained through half-diallel mating design without reciprocals were investigated to estimate the magnitude of heterosis for flowering and yield attributing characters. In the population, observations were recorded for various characters viz., days to first flowering, days to first fruit harvest, fruit length, fruit girth, fruit weight, fruit yield per plant and number of immature seeds per fruit. Desirable heterosis for days to first flowering was observed in the cross G_4 x G_5 (-22.28 per cent). The crosses G_2 x G_3 and G_2 x G_7 showed the maximum desirable heterosis for days to first fruit harvest (-19.01 per cent). The fruit length was recorded maximum in the cross G_3 x G_7 (21.45 per cent). For the traits like fruit girth, fruit weight, fruit yield per plant the maximum of 15.07 per cent, 71.37 per cent and 153.02 per cent of standard heterosis was resulted in the cross G_3 x G_5 respectively. The cross G_5 x G_7 resulted in -16.15 per cent of desirable heterosis for number of immature seeds per fruit. Thus, the following hybrids G_2 x G_4, G_2 x G_6, G_3 x G_5, G_3 x G_7 and G_5 x G_7 were recorded for desirable standard heterosis for the maximum characters including fruit yield per plant.

***Key words*:** *Abelmoschus esculentus*, Half-diallel analysis, Heterosis, Flowering, Yield attributes

Bhendi [*Abelmoschus esculentus* (L.) Moench] is a versatile vegetable crop from Malvaceae family with chromosome no: 2n=2x=130. It is usually known as bhendi, lady's finger, Okra and gumbo is a fast-growing vegetable of tropical and sub-tropical regions of the world. It is especially valued for its fresh, thin, luxuriant green and tender fruits, which are used as a vegetable in different parts of the world. Okra is an often-cross pollinated crop due to protogynous nature of flowers. The cultivated type of okra which is used for breeding programmes is amphidiploid or allotetraploid in nature. Bhendi is known as powerhouse of valuable nutrients because it is having low calories and is fat-free. Its 100 g edible part contains 89.6 g moisture, 1.9 g protein, 0.2 g fibre, 6.4 g other carbohydrates, 66 mg calcium, 53 mg magnesium, 56 mg phosphorous, 0.35 mg iron, 6.98 mg sodium, 103 mg potassium, 0.19 mg copper, 30 mg sulphur, 88 IU vitamin A, 0.07 mg thiamine, 0.1 mg riboflavin, 0.6 mg nicotinic acid, 13 mg vitamin C and 0.7 g mineral [1]. The fruit of okra is botanically known as capsule and it is having anti-goiter property due to the presence of considerable amount of iodine in its tender edible fruits [2]. The crude fibre in okra is used in the jute, textile and paper industry. Okra has good medicinal value with its antispasmodic, demulcent, diaphoretic, diuretic, emollient, stimulated and vulnerary properties. The ease in emasculation, high fruit set, short duration makes commercial exploitation of heterosis in okra easy. For genetic improvement of the crop genetic diversity study is prerequisite which is followed by hybridization to make cross combinations to identify suitable crosses and parents for exploitation of heterosis. The term heterosis was coined by Shull [3] which refers to a superiority or inferiority of F_1 hybrids in one or more characters over its parents. Hence the present study carried out to estimate the magnitude of standard heterosis and to find out the superior hybrid combination for further exploitation.

MATERIALS AND METHODS

The current investigation was carried out at Vegetable Unit, Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar, during December to February, 2022. The experimental materials comprised of seven parents viz., G_1 (Arka Anamika), G_2 (Aruna), G_3 (Varsha Uphar), G_4 (Pusa-5), G_5 (MDU-1), G_6 (Kashi Kranti), G_7 (Ankur-41) with their twenty-one F_1 hybrids, were raised at spacing of 45 x 30 cm in randomized block design (RBD) with three replications. The parent G_1 (Arka Anamika) considered as

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standard check for this experiment. The present investigation was undertaken by adopting half-diallel mating design. Five plants of each genotype in each replication were randomly selected for recording the observations on days to first flowering, days to first fruit harvest, fruit length, fruit girth, fruit weight, fruit yield per plant and number of immature seeds per fruit.

RESULTS AND DISCUSSION

The information about magnitude of heterosis is a prerequisite for the development of any hybrid. The magnitude of heterosis act as a relevant guide for the screening of appropriate parents which can manifest promising heterotic result during standard check and hence can consider for commercial utilization. Therefore, the evaluation of hybrids, standard heterosis is to be given more importance than the other two types of heterosis. Hence, the hybrids were evaluated on the basis of standard heterosis. In case of standard heterosis, many crosses identified as significant towards the desired direction viz., days to first flowering 21 crosses, days to first fruit harvest 21 crosses, fruit length 5 crosses, fruit girth 9 crosses, fruit weight 15 crosses, number of immature seeds per fruit 2 crosses and fruit yield per plant 7 crosses.

The analysis of variance (Table 1) showed the parents exhibited significant difference for all the characters studied, which indicates the presence of considerable variability among the parents. All the genotypes were significant for all the characters. The analysis of variance was significant for all the characters, there by showing high specific combining ability. The variance due to hybrids was significant for all the characters. The ratio between GCA and SCA variance indicates the presence of non-additive gene action for all the characters (Table 2).

Table 1 Analysis of variance for different characters in okra

S. No.	Characters	Source of variation		
		Replication MSS	Genotype MSS	Error MSS
		d.f. (2)	d.f. (27)	d.f. (54)
1	Days to first flowering	1.1713	14.9814**	0.7367
2	Days to first fruit harvest	1.2050	14.9819**	0.7709
3	Fruit length (cm)	0.1411	26.3784**	0.0871
4	Fruit girth (mm)	0.0536	0.6066**	0.0335
5	Fruit weight (g)	2.1970	67.5851**	1.6034
6	No. of immature seeds / fruit	3.3476	36.0384**	2.0763
7	Fruit yield / plant (g)	587.5000	19810.4336**	4591.3574

*, **Significant at 5% & 1% level respectively

Table 2 Analysis of variance in combining ability for different characters in okra

Source of variation	d.f	Days to first flowering	Days to first fruit harvest	Fruit length	Fruit girth	Fruit weight	No. of immature seeds / fruit	Fruit yield / plant
GCA	6	8.8375**	8.2167**	19.0256**	0.3013**	32.8904**	20.7473**	12693.8037**
SCA	21	3.8959**	4.0730**	5.8690**	0.1739**	19.5679**	9.5169**	4863.4175**
Error	54	0.2456	0.2570	0.0290	0.0112	0.5345	0.6921	1530.4525
Variance due to gca		0.9547	0.8844	2.1107	0.0322	3.5951	2.2284	1240.3723
Variance due to sca		3.6503	3.8160	5.8400	0.1627	19.0334	8.8248	3332.9648
gca/sca ratio		0.2615	0.2318	0.3614	0.1981	0.1889	0.2525	0.3722

*, **Significant at 5% & 1% level respectively

Swaminathan *et al.* [4], Bobby and Nadarajan [5] and Devaraj and Nadarajan [6] suggested the need of computing standard heterosis for commercial exploitation of hybrid vigour. Therefore, the evaluation of hybrids, standard heterosis is to be given more importance than the other two types of heterosis. Hence, the hybrids were evaluated on the basis of standard heterosis (Table 3).

The standard heterosis for days to first flowering ranges from -22.28 percent to -4.40 per cent. All the twenty-one hybrids were significant in desirable direction.

The twenty-one hybrids resulted the significant and negative standard heterosis for days to first fruit harvest. The standard heterosis ranges from -19.01 per cent to -3.86 per cent.

The standard heterosis for fruit length ranges from 21.45 per cent to -39.12 per cent. The following five hybrids viz., $G_3 \times G_7$ (21.45 per cent), $G_3 \times G_5$ (11.23 per cent), $G_1 \times G_2$ (10.38 per cent), $G_2 \times G_6$ (6.04 per cent) and $G_2 \times G_4$ (3.63 per cent) showed significant standard heterosis in desirable direction.

The standard heterosis for fruit girth ranged from 15.07 per cent to -13.21 per cent. Among twenty-one hybrids, the nine hybrids were significant and positive in standard heterosis. The top three crosses namely, $G_3 \times G_5$ (15.07 per cent), $G_3 \times G_7$ (8.49 per cent) and $G_2 \times G_3$ (7.23 per cent) showed significant and positive standard heterosis.

For fruit weight, standard heterosis ranged from 71.37 per cent to -32.39 per cent. The fifteen hybrids showed the significant and positive standard heterosis. The four hybrids secure the top rank among the fifteen hybrids, they are $G_3 \times G_5$ (71.37 per cent), $G_1 \times G_2$ (48.06 per cent), $G_3 \times G_7$ (46.63 per cent) and $G_4 \times G_6$ (42.74 per cent) showed significant and positive standard heterosis. The standard heterosis for the crosses ranges from -16.15 per cent to 19.89 per cent. The crosses viz., $G_5 \times G_7$ (-16.15 per cent) and $G_5 \times G_6$ (-9.83 per cent) showed the negative and significant standard heterosis for number of immature seeds per fruit.

The standard heterosis for the trait, fruit yield per plant ranged from 153.02 per cent ($G_3 \times G_5$) to 5.08 per cent ($G_1 \times G_6$). Among all hybrids, seven hybrids were resulted in positive and significant standard heterosis. The superior three hybrids among the seven were $G_3 \times G_5$ (153.02 per cent), $G_2 \times G_6$ (110.23 per cent) and $G_2 \times G_3$ (99.12 per cent) exhibited the positive and significant standard heterosis [7-10].

CONCLUSION

The following hybrids, $G_2 \times G_4$, $G_2 \times G_6$, $G_3 \times G_5$, $G_3 \times G_7$ and $G_5 \times G_7$ were recorded for desirable standard heterosis for the maximum characters including fruit yield per plant. Thus, the present study concluded that the above-mentioned cross combinations may be used for further exploitation of breeding programme.

Table 3 Heterosis for hybrids

Genotypes	Days to first flowering SH (d_{iii})	Days to first fruit harvest SH (d_{iii})	Fruit length (cm) SH (d_{iii})	Fruit girth (cm) SH (d_{iii})	Fruit weight (cm) SH (d_{iii})	No. of immature seeds / fruit SH (d_{iii})	Fruit yield / plant (g) SH (d_{iii})
$G_1 \times G_5$	-4.40**	-3.86**	10.38**	4.38	48.06**	19.88**	8.17
$G_1 \times G_7$	-17.61**	-14.25**	-5.71**	5.75*	15.95*	-2.00	17.35
$G_1 \times G_4$	-14.25**	-12.22**	-4.50**	5.81*	10.43	-1.33	32.58
$G_1 \times G_5$	-16.84**	-14.94**	-20.24**	-5.86*	11.86	-0.02	10.89
$G_1 \times G_6$	-15.80**	-12.67**	-39.12**	-13.21**	-21.06**	8.94**	5.08
$G_1 \times G_7$	-18.39**	-16.07**	-16.78**	-2.68	13.70*	1.98	63.64*
$G_2 \times G_7$	-21.76**	-19.01**	-10.38**	7.23**	23.17**	7.85**	99.12**
$G_2 \times G_4$	-13.46**	-11.54**	3.63**	5.21*	14.93*	12.20**	76.51*
$G_2 \times G_5$	-9.58**	-8.15**	-32.53**	-9.15**	-32.39**	-1.00	22.42
$G_2 \times G_6$	-16.32**	-14.25**	6.04**	6.90**	28.02**	2.65	110.23**
$G_2 \times G_7$	-21.50**	-19.01**	-0.54	1.97	19.84**	0.94	22.90
$G_3 \times G_4$	-16.84**	-14.48**	-6.57**	-6.30*	1.43	7.30*	11.85
$G_3 \times G_5$	-16.84**	-14.71**	11.23**	15.07**	71.37**	19.89**	153.02**
$G_3 \times G_6$	-16.05**	-13.36**	-6.76**	1.59	-1.02	0.00	18.09
$G_3 \times G_7$	-7.25**	-4.76**	21.45**	8.49**	46.63**	-0.81	65.21*
$G_4 \times G_5$	-22.28**	-17.20**	-7.01**	0.27	31.29**	-3.00	24.87
$G_4 \times G_6$	-21.76**	-18.78**	-11.76**	5.21*	42.74**	-5.96*	33.74
$G_4 \times G_7$	-18.38**	-15.39**	-6.57**	1.92	31.49**	-1.00	37.63
$G_5 \times G_6$	-18.13**	-14.48**	-20.59**	5.10*	28.34**	-9.83**	74.36*
$G_5 \times G_7$	-16.32**	-13.81**	-10.05**	-7.95**	18.73**	-16.15**	49.15
$G_5 \times G_7$	-17.61**	-15.39**	-4.84**	1.97	22.09**	7.93**	10.34

*, **Significant at 5% & 1% level respectively; ns – non significant

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