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Fruitful Genetics: Unravelling Heterosis, Inbreeding Depression and Heritability in Okra (*Abelmoschus esculentus* (L.) Moench) for Enhanced Yield Traits

Lalji N. Gediya[1*], Rajesh R. Acharya[2], Mihir M. Pandya[3] and Rutvik Joshi[4]
[1]Ph.D. (Genetics and Plant Breeding), Main Vegetable Research Station, AAU, Anand (Gujarat), India.
[2]Research Scientist (Veg.), Main Vegetable Research Station, AAU, Anand (Gujarat), India.
[3]Assistant Professor, Main Vegetable Research Station, AAU, Anand (Gujarat), India.
[4]Student, Main Vegetable Research Station, AAU, Anand (Gujarat), India.

(Corresponding author: Lalji N. Gediya)*
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ABSTRACT: The study aimed to assess heterosis, inbreeding depression, and narrow sense heritability in okra regarding fruit yield and associated traits. Six generations from four crosses were evaluated for various characteristics. Promising outcomes were observed in specific crosses: GAO 5 × AOL 12-59 displayed significant heterobeltiosis for fruit yield and early flowering, while GAO 5 × Kashi Kranti showed positive heterobeltiosis for fruits per plant. Desirable inbreeding depression, signifying earliness, was evident in Pusa Sawani × AOL 10-22 and GAO 5 × AOL 13-144 for days to flowering. Traits like plant height, internodes on the main stem, fruit characteristics, and yield exhibited high narrow sense heritability, suggesting the potential for improved varieties through additive gene action in okra breeding programs.

Keywords: Okra, Heterobeltiosis, Inbreeding Depression, Narrow Sense Heritability.

INTRODUCTION

Okra, scientifically known as *Abelmoschus esculentus* (L.) Moench, is an annual vegetable grown in tropical and subtropical regions worldwide (Charrier, 1984). Belonging to the Malvaceae family, it's cultivated for its green, non-fibrous fruits, commonly consumed in various dishes. Rich in vitamins and minerals (Aykroyd, 1941), it holds nutritional value and medicinal properties. In India, it's called Bhindi and is a significant export. Despite being frost-sensitive, it thrives in warm climates (Siemonsma, 1982). The need for improved cultivars arises due to low productivity, especially in open-pollinated varieties. Efforts are underway to develop high-yielding varieties resistant to diseases for specific agro-climatic conditions, aiming to enhance overall productivity.

Heterobeltiosis is found more useful in formulating future hybrid development programme (Fonseca and Patterson 1968). Likewise, it also helpful in identification of promising cross combinations for improvement of the crop through conventional breeding strategies. It may lead to increase in yield, reproductive ability, adaptability to different biotic and abiotic stresses, general vigour and quality. Inbreeding depression leads to decreased fitness and vigour due to expression of deleterious effects of recessive genes generally hidden under heterozygosity. The estimation of heritability serves as a useful guide to the breeder by knowing the proportion of variation due to environment or genotypic (broad sense heritability) or additive (narrow sense heritability) effects (Warner, 1952).

MATERIALS AND METHODS

The experimental material for present investigation comprised of four families using combination of six parents *viz.*, Pusa Sawani × AOL 10-22 (cross I), GAO 5 × AOL 13-144 (cross II), GAO 5 × AOL 12-59 (cross III) and GAO 5 × Kashi Kranti (cross IV). All the parents of these four crosses were selected from diverse genetic stocks available at Main Vegetable Research Station (MVRS), Anand Agricultural University (AAU), Anand. The seeds of B_1 and B_2 were produced by crossing F_1 with each of the parent and seeds of F_2 were produced by selfing.

Each of the four family (cross) were raised in a Compact Family Block Design with three replications during summer 2020 at MVRS, AAU, Anand. Parents and F_1 in single row, B_1 and B_2 in two rows while, F_2 in four rows. Each row 3.0 m long with 60 and 30 cm inter-row and intra-row spacing, respectively. Each row accommodated ten plants.

Character Studied. Observations were recorded on nine characters *viz.*, days to flowering, plant height (cm), length of internode (cm), branches per plant, fruit length (cm), fruit weight (g), fruits per plant, fruit yield per plant (g) and mucilage content (mg/g) on five random plants in each replication for P_1, P_2 and F_1; ten plants for B_1 and B_2; and twenty plants for each of F_2.

Statistical Analysis. Heterobeltiosis was calculated based on formula given by Fonseca and Patterson 1968.

$$\text{Heterobeltiosis}\ (\%) = \frac{(\overline{F}_1 - \overline{BP})}{\overline{BP}} \times 100$$

Inbreeding depression was computed by using the following formulae:

$$\text{Inbreeding depression}\ (\%) = \frac{\overline{F_1} - \overline{F_2}}{\overline{F_1}} \times 100$$

The narrow sense heritability (h^2_{ns}) from the estimates of basic generations was calculated by the formula suggested by Warner (1952).

$$h^2_{ns} = \frac{2VF_2 - (VB_1 + VB_2)}{VF_2}$$

Where,

VF_2, VB_1 and VB_2 are the variances of F_2, B_1 and B_2 generations, respectively

RESULT AND DISCUSSION

The heterobeltiosis, inbreeding depression and heritability (Table 1) were not computed in those cases, where, analysis of variance exhibited non-significant values. In some cases, narrow sense heritability were not calculated due to abnormal values (negative or more than 100 %) obtained which might be due to high environmental influence or sampling error or both and because it was worked out from estimated variance of population/generations. Heterobeltiosis and inbreeding depression in different characters is graphically presented in Fig. 1 and 2, respectively.

Days to flowering. Negative and highly significant heterobeltiosis was found in the cross 3 (-6.02 %) which was considered desirable for this trait, while, positive and significant heterobeltiosis and inbreeding depression was detected in the cross 1 (3.90 % and 3.71 %), respectively. The heritability estimates were observed low in the cross 2 (9.25 %) and moderate in the cross 4 (39.17 %).

Plant height. Cross 1 (-8.47 %), Cross 2 (-16.80 %) and Cross 4 (-16.55) exhibited negative and significant heterosis over better parent. Significant and positive inbreeding depression was observed for the cross 2 and 4. The cross 2 (79.12 %) exhibited maximum estimate of heritability followed by cross 3 (45.42 %).

Length of internode. All four crosses recorded significant and negative heterosis for fruit length. The crosses 2 and 3 manifested significant and positive inbreeding depression, while, cross 4 exhibited significant and negative inbreeding depression. The narrow sense heritability estimates were observed very high for the cross 2(114 %).

Branches per plant. Negative and significant heterobeltiosis was exhibited by the cross1 (-22.08 %). Positive and significant inbreeding depression was observed for the cross 2 (19.03 %), cross 3 (38.24 %) and cross 4 (26.62 %). Two crosses exhibited moderate and remaining showed high narrow sense heritability.

Fruit length. None of the crosses manifested positive and significant heterosis over better parent. On the contrary, negative and significant heterobeltiosis was exhibited by the cross 3 (18.91 %). The cross 1 (52.04 %) and cross 4 (66.32 %) exhibited high heritability estimates.

Fruit weight. None of the crosses recorded significant heterobeltiosis in either direction. Positive and significant inbreeding depression was observed for the cross1 (18.47 %), cross 3 (18.25 %) and cross 4 (9.65 %). The estimate of narrow sense heritability was observed very high for the cross 3 (115.92 %).

Fruits per plant. Positive and significant heterobeltiosis was detected in the cross 4 (8.76 %). Positive and highly significant inbreeding depression was observed for the cross 2 (11.49 %) and cross 4 (12.83 %). Two crosses exhibited moderate and remaining showed very high narrow sense heritability.

Fruit yield per plant. The cross 1(-8.66 %) and cross 4 (-12.76 %) exhibited negative and significant heterobeltiosis. Significant and positive inbreeding depression was observed in the cross 2 (20.91 %), cross 3 (21.07 %) and cross 4 (13.60 %). The heritability estimate was high for the cross 4 (50.43 %).

DISCUSSION

Highly significant estimate of heterobeltiosis for early flowering was observed for the cross 3 (-6.02 %) therefore this trait may be exploited through heterosis breeding. Present findings are in accordance with the results obtained earlier by Jogi *et al.* (2018); Kerure and Pitchaimuthu (2019). The length of internode resides important character in okra as shorter internodes restricts plant height from extra tall and imparts suitable height. For length of internode, all four crosses exhibited negative and significant heterosis over better parent, this result is consistent with chavan *et al.* (2018); Srikanth *et al.* (2019). For fruits per plant, cross 4 (8.76) %) depicted significant heterobeltiosis in desirable direction. Similar findings were also reported by Srikanth *et al.* (2019). On the basis of findings on heterobeltiosis, the cross GAO 5 × AOL 12-59 was found promising for fruit yield and most of its component traits.

Inbreeding depression is an important criterion in crop improvement programme. Positive and significant inbreeding depression was recorded for days to flowering and in the crosses 1 and 2. It predicts better chances to obtain desirable segregants for earliness in the subsequent filial generations of these crosses. In context to literatures on inbreeding depression. Rajput (2014) observed positive inbreeding depression for days to flowering. Negative and significant inbreeding depression for plant height was considered desirable in okra breeding programme.

Each node bears flower which may lead to fruit formation, so higher number of internodes on main stem indirectly increase the yield. For this trait, negative and significant inbreeding depression was observed in the crosses 1 and 4 which was considered desirable. Shorter internodes are preferred because it restricts plant height from being extra tall and imparts suitable height, crosses 2 and 3 revealed positive and significant inbreeding depression for this trait was agreed with Sabesan *et al.* (2016). Higher branches per plant was considered desirable as it increases the yield. None of the crosses illustrated negative and significant inbreeding depression for this trait. For branches per plant, none of the crosses depicted significant inbreeding depression in negative direction for fruit length, fruit weight, fruits per plant and fruit yield per plant, these results were comparable with Modha (2009).

High heritability was recorded for plant height, length of internode, branches per plant and fruits per plant in the cross 4, which were supported by Rambabu *et al*. (2019); Rathod *et al.* (2019). The higher values of narrow sense heritability indicated that the character may be governed by genes acting in an additive manner. In crop like okra, high narrow sense heritability estimates may be helpful for the development of improved varieties by fixation of additive gene action.

Table 1: Magnitude of heterobeltiosis (%), inbreeding depression (%) and heritability in narrow sense (%) for different characters in four crosses of okra.

Source	Pusa Sawani × AOL 10-22 (C1)	GAO 5 × AOL 13-144 (C2)	GAO 5 × AOL 12-59 (C3)	GAO 5 × Kashi Kranti (C4)
	(%)	(%)	(%)	(%)
	Days to flowering			
HB	3.90**	1.37	-6.02**	-1.46
ID	3.71**	3.37*	0.92	-3.57
h^2ns	-	9.25	-	39.17
	Plant height			
HB	-8.47*	-16.80**	3.00	-16.55**
ID	4.24	10.90**	11.21**	-0.66
h^2ns	-	79.12	45.42	-
	Length of internode			
HB	-21.61**	-15.27**	-7.56*	-41.19**
ID	-4.41	37.07**	35.49**	-36.18**
h^2ns	-	114	-	-
	Branches per plant			
HB	-22.08*	-16.04	17.67	-4.23
ID	3.74	19.03*	38.24**	26.62**
h^2ns	47.62	54.50	53.20	31.62
	Fruit length			
HB	-8.35*	-2.28	4.10	-6.58
ID	-4.99	-4.27	18.91**	-3.25
h^2ns	52.04	-	-	66.32
	Fruit weight			
HB	-9.56	-0.50	-4.18	1.83
ID	18.47**	9.55	18.25**	9.65*
h^2ns	-	-	115.92	-
	Fruits per plant			
HB	-6.69	-10.64**	-6.45	8.76*
ID	-2.34	11.49**	0.30	12.83**
h^2ns	48.46	98.09	41.35	98.18
	Fruit yield per plant			
HB	-8.66**	-10.26	1.65	-12.76*
ID	7.10	20.91**	21.07**	13.60*
h^2ns	-	-	-	50.43
	Mucilage content			
HB	-20.47**	-17.93**	-16.10**	--
ID	-0.59	11.26**	-0.87	--
h^2ns	28.57	43.16	-	

*, ** Significant at 0.05 and 0.01 level of probability, respectively
HB = Heterobeltiosis; ID = Inbreeding depression; h^2ns = Heritability in narrow sense; - Abnormal value of heritability

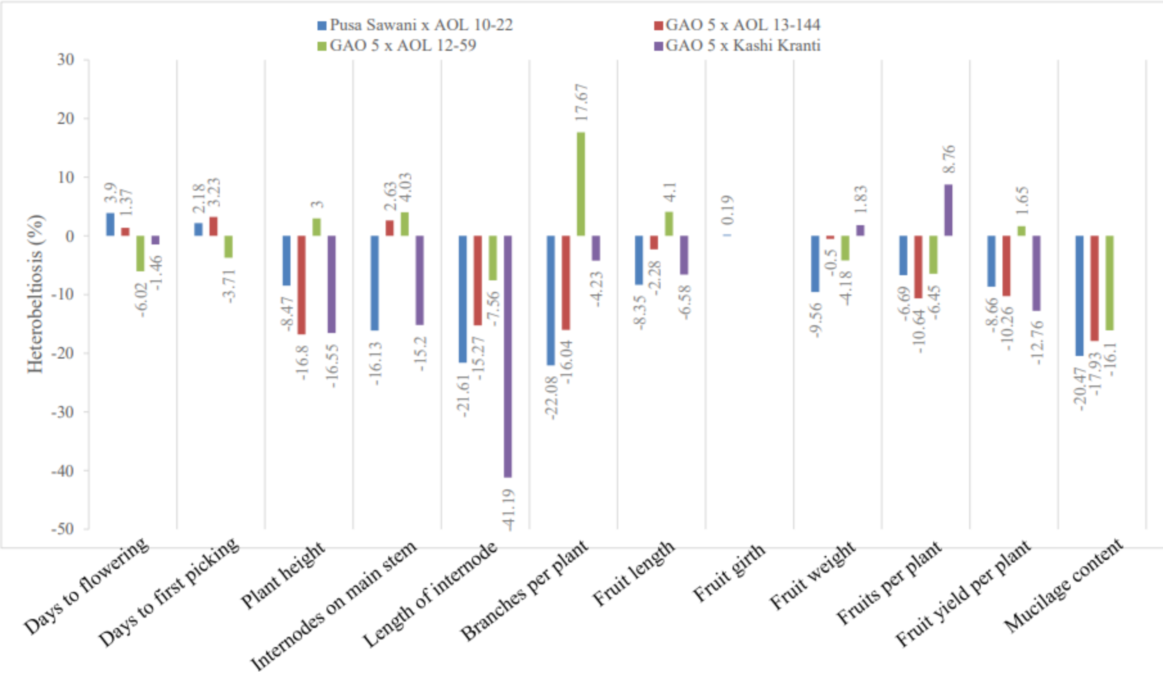

Fig. 1. Graphical representation of per cent heterobeltiosis for different characters in four crosses of okra.

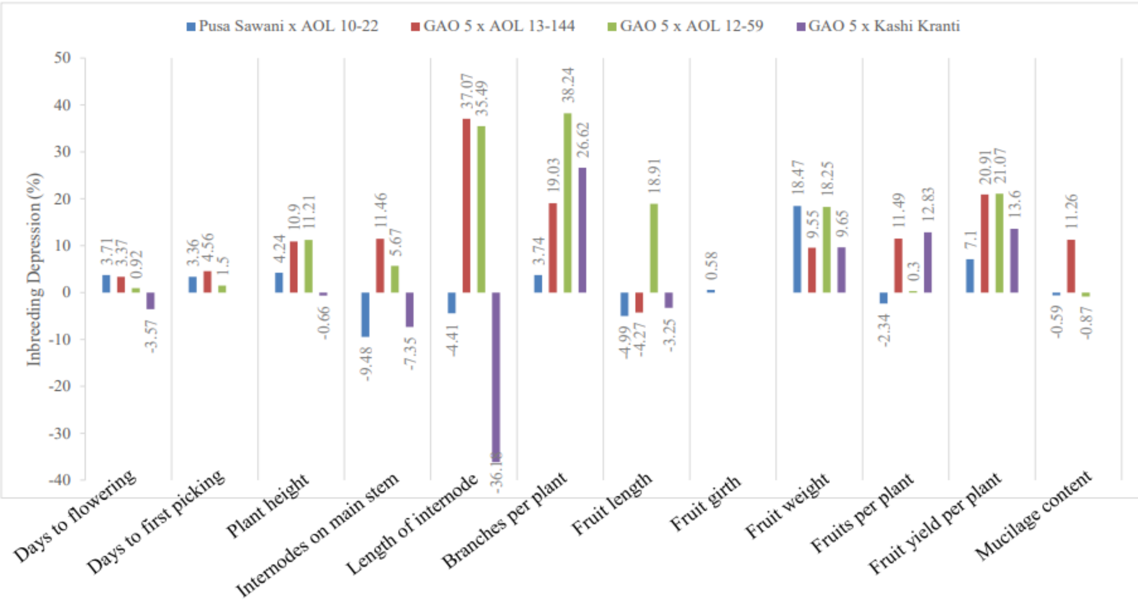

Fig. 2. Graphical representation of per cent inbreeding depression for different characters in four crosses of okra.

CONCLUSIONS

Significant estimates of desirable heterobeltiosis for early flowering was observed for the cross GAO 5 × AOL 12-59 (-6.02 %). All four crosses showed negative and significant heterobeltiosis for length of internode, which was considered desirable. For fruits per plant, cross GAO 5 × Kashi Kranti depicted positive and significant heterobeltiosis (8.76 %). The cross GAO 5 × AOL 12-59 found to be promising for fruit yield and most of its component traits along with early flowering and first picking. Significant and positive inbreeding depression was found for days to flowering in the crosses Pusa Sawani × AOL 10-22 (3.71 %) and GAO 5 × AOL 13-144 (3.37 %) which was considered desirable for earliness.

High narrow sense heritability was recorded for plant height, internodes on main stem, length of internode, branches per plant, fruit length, fruit girth, fruit weight, fruits per plant and fruit yield per plant indicating that these characters were largely governed by genes acting in additive manner. Higher narrow sense heritability predicts higher selection efficiency so the plant breeder can go for selection of individual or group of characters. In crop like okra, high narrow sense heritability estimates may be helpful for the development of improved varieties by fixation of additive gene action.

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Conflict of Interest. None.

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