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ESTIMATION OF HETEROSIS AND INBREEDING DEPRESSION IN OKRA (*ABELMOSCHUS ESCULENTUS* (L.) MOENCH)

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Abstract

Six generations *i.e.* P_1, P_2, F_1, F_2, BC_1 and BC_2 of four crosses *viz.,* Hisar Naveen x Varsha Uphar, HB-25-2 × HB-32, HB-40 × HB-27, HB-1157 × Pusa Sawani were used to estimate heterosis and inbreeding depression for growth, yield and yield contributing traits in okra. In general, four crosses showed a wide range of heterotic effects for yield and yield attributing characters showing the importance of both additive and non-additive genes. HB-40 × HB-27 showed significant heterobeltiosis for almost all the fruit yield and its contributing traits particularly, 22.67 per cent for fruit yield per plant (g) and 13.68 per cent for fruits per plant. High heterotic cross combinations for different characters showed high inbreeding depression in the F_2 generation ranged from -1.67 (days to fifty per cent flowering) to 37.16 (fruit yield per plant) in cross Hisar Naveen x Varsha Uphar. This may be due to most part of heterobeltiosis accounted for dominance and dominance × dominance type of epistatic interactions and less for additive × dominance type of gene effect. These findings useful for the improvement of fruit yield and its quality traits while handling the segregating generation for the development of improved varieties in okra.

Key words: Six generations, heterosis, heterobeltosis, dominance, okra**.**

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] being an often cross-pollinated crop exists greater variability in this crop (Swarup, 1977). India is the center of diversity for okra provides a range of variation for its genetic improvement in yield. The productivity of this crop should be increased by improving the genetic architecture through hybridization and recombination. Of the various approaches to overcome this problem, exploitation of heterosis is considered as one of the desirable and sustainable approach. Heterosis reveals the type of gene action involved and it helps in the selection of suitable breeding methodology and parameters, which are employed for crop improvement programme. However, direct use of heterosis in okra is limited. From economic point of view, retention of heterosis in further generations is more practical, which implies that the degree of inbreeding depression should be low. Indeed knowledge of heterosis of yield and its component characters should be placed greater emphasis for the improvement of this crop (Singh *et al*., 2003; Koundinya *et at.,* 2013).

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Inbreeding reduces the mean phenotypic value of various fitness-related traits and the phenomenon is known as inbreeding depression (Stebbins, 1958; Wright, 1977). In general, inbreeding depression and heterosis are associated with changes in heterozygosity and homozygosity for several reasons (Falconer, 1989). First, homozygotes may have reduced fitness value for traits that are controlled by directionally dominant alleles and second, increasing homozygosity increases the chances of the expression of deleterious recessive alleles. It would be essential to have information on various genetic parameters mentioned above. Aware *et al*., (2014) and Neetu *et al.,* (2015) reported the heterosis and inbreeding depression in okra.

Therefore, the aim of the present investigation is to spot out the best heterotic combinations giving high degree of useful heterosis with low inbreeding depression in further generations.

Materials and Methods

The experimental material comprised of eight diverse parents namely, Hisar Naveen, Varsha Uphar, HB 25-2, HB 32, HB 40, HB 27, HB- 1157, Pusa Sawani were collected from Department of Vegetable Science CCSHAU, Hisar except Pusa Sawani from IARI, New Delhi, were crossed to produce four hybrids during *kharif* 2015. The hybrids namely, Hisar Naveen x Varsha Uphar, HB 25-2 × HB 32, HB 40 × HB 27 and HB 1157 × Pusa Sawani were raised during spring summer 2016 to get F_2. The experimental materials comprised of six generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) for each of the four crosses were sown during rainy season 2016 in Compact Family Block Design at spacing of 60 × 30 cm replicated thrice. Each replication consisted two rows for each of non-segregating generations (P_1, P_2 and F_1), ten rows for each of BC_1 and BC_2 generations and twenty-five rows of each F_2 generation. Each row was three meters long accommodating ten plants thereby maintaining 20 plants of each non-segregating generations (P_1, P_2 & F_1), 100 plants of each back cross (BC_1 & BC_2) and 250 plants of each F_2 in every replication. The experiment was conducted with normal package of practices and need based plant protection measures. The estimation of heterosis and inbreeding depression were analyzed as per the standard procedure suggested by Singh and Narayanan (1993).

Heterosis refers to the superiority of F_1 hybrid in one or more characters over its parents. Heterosis is also called as hybrid vigour. Mid-parent heterosis and Better-parent heterosis (Heterobeltiosis) were estimated with the help of following formula.

$$\text{Heterosis over mid parent} = \frac{\overline{F}1 - \overline{MP}}{\overline{MP}} \times 100$$

Where,

$$\overline{MP} = \frac{P1 + P2}{2}$$

$$\textit{Heterosis over better parent (Heterosisbeltiosis)} = \frac{\overline{F}1 - \overline{BP}}{\overline{BP}} \times 100$$

Inbreeding depression refers to decrease in fitness and vigour in F_2 due to inbreeding. Inbreeding depression is estimated when both F_1 and F_2 populations of the same cross are available. It is estimated with the help of following formula

$$\text{Inbreeding depression} = \frac{\overline{F}1 - \overline{F_2}}{\overline{F_1}} \times 100$$

Where,

$\overline{F}1$ = Mean value of F_1 hybrid

$\overline{MP}$ = Mid-parent value (average value) of both the parents of hybrid

$\overline{BP}$ = Mean value of better performing parent

$\overline{F_2}$ = Mean value of F_2 population

The significance was tested using the formulae suggested by Wynne *et al*., (1970).

Results and Discussion

The findings of the present investigation on heterosis and inbreeding depression are presented in Table 1. In case of fruit yield per plant, two out of four crosses *viz.,* HB-25-2 × HB-32 and HB-40 × HB-27 displayed highly significant average heterosis as well as heterobeltiosis in desired direction. It was further observed that the cross combinations who had significant relative heterosis or heterobeltiosis for fruit yield per plant (30.54% and 24.67%) in general, occupied significant relative heterosis or heterobeltiosis for number of fruit per plant (12.44% and 16.96%), fruit length (9.7% and 19.04%), fruit diameter (13.71% and 9.6%), internodal length (-14.15% and 24.84%). This indicated that yield-contributing traits had positive association with fruit yield per plant therefore; population improvement and selection programme should be adapted for improvement of fruit yield. The heterotic effects for fruit yield per plant and its related traits was also reported by Kumar and Pathania (2011); Hazem *et al.,* (2013); Pathak and Prabhat (2014); Katagi *et al.,* (2015); Dubey *et al*., (2014); Spaldon *et al*., (2015).

The significant and negative mid parent heterosis as well as heterobeltiosis for first fruiting node and inter-nodal length was depicted by the all crosses. Similar findings were reported by Mehta *et al*., (2007) and Kumar and Pathania (2011).

Among the four crosses two crosses namely, Hisar Naveen x Varsha Uphar and HB-25-2 × HB-32 exhibited significant mid-parent and better- parent heterosis for days to fifty per cent flowering (3.45% and 4.43%) remaining two crosses exhibited negative heterosis for both mid parent and better-parent heterosis. For branches per plant all, four crosses showed positive with significant heterosis. For plant height and nodes per plant, Hisar Naveen x Varsha Uphar cross exhibited significant mid-parent heterosis and heterobeltiosis in negative direction (-1.16% and 2.55%) while other crosses showed significant heterosis in positive direction. These results are in accordance with the findings of Kumar *et al.,* (2005) for plant height and number of branches per plant.

The magnitude of mean performance of F_2 populations for fruit yield per plant showed significant inbreeding depression in all four crosses studied, revealed the presence of undesirable transgressive segregants (Aakanksha *et al*., 2014).All four crosses manifested

Table 1: Estimates of heterosis and inbreeding depression for growth, yield and yield contributing traits in four crosses of okra.

Sr. No.	Characters	Heterosis and Inbreeding depression (%)	Hisar Naveen × Varsha Uphar	HB-25-2 × HB-32	HB-40 × HB-27	HB-1157 × Pusa Sawani
1	Days to fifty percent flowering	MP heterosis	0.15**	0.91*	-3.9	-3.17*
		BP heterosis	3.45*	4.43*	-2.2	-2.29
		Inbreeding depression	-1.67**	-3.13**	-2.6**	-8.65**
2	Branches per plant	MP heterosis	26**	14.28*	33.33**	28.69*
		BP heterosis	16.66*	-1.88	23.63*	21.31*
		Inbreeding depression	26.56**	12.37**	18.57*	38.96*
3	Plant height (cm)	MP heterosis	-1.16*	18.04*	5.58*	11.11**
		BP heterosis	-3.53	7.41**	3.56	0.97**
		Inbreeding depression	12**	19.91**	-6.63	27.64**
4	First fruiting node	MP heterosis	-18.84	-18.96*	-11.23*	-15.2*
		BP heterosis	-8.19*	-4.08*	-9.78**	0
		Inbreeding depression	9.52	-21.84**	4.13	-38.49**
5	Nodes per plant	MP heterosis	-2.55	14.21*	12.02	8.1**9
		BP heterosis	-6.14**	4.24	9.5*	5.47*
		Inbreeding depression	5.77*	2.95*	6.84*	15.81*
6	Inter-nodal length (cm)	MP heterosis	-17.22*	-14.15*	-24.84	-21.57**
		BP heterosis	-14.36*	-6.61*	-19.14	-21.21
		Inbreeding depression	-11.74**	2.02	-8.77**	-17.41**
7	Fruit length (cm)	MP heterosis	7.52**	9.7*	19.04**	2.02*
		BP heterosis	4.56*	4.28*	13.87	0.74
		Inbreeding depression	7.24**	3.5**	11.6**	4.02**
8	Fruit diameter (cm)	MP heterosis	7.28**	13.71**	9.6**	7.14*
		BP heterosis	5.65*	9.82*	6.72*	2.27**
		Inbreeding depression	3.68**	9.52**	8.34*	-4.01
9	Fruit weight (g)	MP heterosis	5.69**	17.48**	6.77**	5.4**
		BP heterosis	3.26*	11.54*	5.44**	5.2*
		Inbreeding depression	18.2**	6.24*	17.04*	9.04**
10	Fruits per plant	MP heterosis	3.97**	12.44**	16.96	8.95**
		BP heterosis	4.43**	6.37*	13.68*	6.32
		Inbreeding depression	24.16**	25.87**	23.36**	19.68*
11	Fruit yield per plant (g)	MP heterosis	8.89**	30.54	24.65	15.45**
		BP heterosis	1.85*	17.81*	22.67*	12.69
		Inbreeding depression	37.16**	30.29**	35.82**	26.56**

MP-Mid- parent, BP- Better- parent. *, ** Significance at 5% and 1% levels respectively.

significant and positive high average heterosis and heterobeltiosis for fruit yield per plant also showed positive significant inbreeding depression. This indicated that degree of inbreeding depression expressed by the F_2 to the amount of heterosis in F_1 populations was somewhat related for fruit yield per plant.

The results further revealed that the crosses that depicted significant inbreeding depression for fruit yield per plant also exhibited positive inbreeding depression for fruit length, number of fruits per plant, plant height and number of branches per plant. For days to fifty per cent flowering three crosses *i.e.* Hisar Naveen × Varsha Uphar (-1.67%), HB 40 × HB 27 (-2.6%) and HB 1157 × Pusa Sawani (-8.65%) had negative inbreeding depression, however for inter-nodal length cross HB-25-2 × HB-32 showed positive inbreeding depression (2.02 %), this suggested the chances of getting desirable transgressive segregants for earliness in crosses which expressed significant and positive inbreeding depression. These crosses might be useful for getting dwarf stature in segregating generations In general, most of the crosses, those exhibited positive inbreeding depression for fruit yield per plant components like fruit length, fruit diameter, number of fruits per plant, and number of branches per plant also exhibited positive inbreeding depression for fruit yield per plant. This revealed that the expression of heterosis and inbreeding depression for fruit yield per plant was dependent on its attributing traits. The results are matching with the results of Kumar and Pathania (2011); Kumar and Singh (2012); Hazem *et al.,* (2013); Pathak and Prabhat (2014) and Katagi *et al.,* (2015).

Significant and positive heterosis for fruit yield per plant and its related traits followed by significant inbreeding depression indicated major role of non-additive gene actions in the inheritance of fruit yield per plant and its attributes. These findings are similar to those of Kumar *et al*., (2004).

Conclusion

Inbreeding depression was high in good performing hybrids. Highest yielding F_1 hybrids yielded lesser in the subsequent generation due to over dominance and inbreeding depression, whereas moderate yielding F_1 hybrids were found to be more stable even passing through process of segregation due to additive gene action. It also suggested that combined performance of F_1 and F_2 hybrids could be a good indicator to identify the most promising populations to be utilized either as F_2 hybrids or as a resource population for further selection in advanced generations. F_2 hybrids having extraordinary performance could also be used to improve the yield.

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