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Extent and magnitude of heterosis for fruit yield and it's contributing traits in okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract

The investigation comprised of a half-diallel set of eight parents including standard check GAO 5 and their 28 crosses in okra. The experiment was laid out in randomized block design with three replications at Main Vegetable Research Station, Anand Agricultural University, Anand during *kharif*-2014. The estimates of heterosis, cross combinations GO 2 x GPOK 123, AOL 10-22 x GPOK 578 and GAO 5 x GO 2 were found the most promising for fruit yield and other desirable traits; hence, could be evaluated further to exploit the heterosis or utilized in future breeding programme to obtain desirable segregants for the development of superior genotypes.

Keywords: Half-diallel, heterosis, randomized block design, standard check

Introduction

Okra is an important annual vegetable crop grown for its immature, green and non-fibrous edible fruits in the tropical and sub-tropical regions of the world. It provides an important source ofvitamins, calcium, potassium and other minerals, whichare often lacking in the diet of developing countries.Its fruits are rich source of vitamin A and C, whereas seeds are good source of protein (20%) and hasgained much interest as a new source of vegetable oil (14%). The average nutritive value (ANV) of okra is 3.21%, which is higher than Tomato, Brinjal and Cucurbitaceous vegetables (Sharma and Arora, 1993). The nutritionalvalue of 100g of edible okra is characterized by 1.9 g protein,0.2 g fat, 6.4 g carbohydrate, 0.7 g minerals and 1.2 gfibres. In India, it is cultivated in an area of about 5.31 lakh hectares with annual production of 63.50 lakh tonnes with productivity of 12.00 tonnes per ha during the year 2012-13 (Anon., 2013).

Exploitation of hybrid vigor has been recognized as an important tool for increasing genetic yield ceiling. In okra, hand emasculation and hand pollination processes are easier due to its large flower andmonoadelphous stamens. This has facilitated to the breeders for exploitation of hybrid vigour through manual hybridization.In this context, the present investigation was undertaken to elucidate information on heterosis over mid-parent, better-parents and standard-check for fruit yield and related traits in okra.

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Materials and Methods

Eight diverse okra genotypes were received from *Research Science* (Veg.), Main Vegetable Research Station, Anand and evaluated at the Vegetable Research Farm, Anand Agricultural University, Anand during 2014. Crosses were made in 'diallel' mating design excluding reciprocal, using 8 lines as parents (Gujarat Anand Okra 5, Gujarat Okra 2, PusaSawani, AOL 10-22, GPOK 123, GPOK 349, GPOK 573 and GPOK 578). A total twenty-eight okra F_1 hybrids were made to study heterosis. These 36 genotypes (28 F_1's + 8 parents) were grown in the Vegetable Research field of MVRS, AAU, Anand during *kharif*-2014.

The experiments were laid out in randomized complete block design (RCBD) with three replications at row-to-row and plant-to-plant spacing of 60 cm and 30 cm, respectively. All the observations were recorded in open field conditions such as rainfall, humidity, temperature and sunshine till last picking. Observations were recorded for twelve characters on 5 randomly selected plants, *viz.* fruit yield per plant, first fruiting node, days to first picking, fruit length, fruit girth, fruit weight, number of fruits per plant, plant height, number of nodes per plant, number of primary branches per plant and moisture content except days to 50% flowering, which was recorded on plot basis. The heterosis of F_1s over the mid parent Relative heterosis (RH), better parent (HB) and standard heterosis (SH) were calculated by following formula:

a) Relative heterosis (RH) % = $\frac{\overline{F_1} - \overline{MP}}{\overline{MP}} \times 100$

b) Heterobeltiosis (HB) % = $\frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$

c) Standard heterosis (SH) % = $\frac{\overline{F_1} - \overline{SC}}{\overline{SC}} \times 100$

Where,

$\overline{MP}$ = Mean value of the parents for respective hybrid [= (P1+P2)/2]

P1= Parent-1, P2= Parent-2

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

$\overline{SC}$ = Mean value of standard check

$\overline{F_1}$ = Mean value of the hybrid (F_1)

Results and Discussion

The results of analysis of variance of parents and their hybrids for various traits are given in Table 1. Mean squares due to genotypic differences found significant for all the traits studied. This indicated that the experimental material under study had sufficient genetic diversity for different traits. Further, partitioning of sum of squares due to genotypes indicated that the differences among parents were significant for all the characters under study.In case of hybrids, significant differences obtained for all the traits studied. While, mean squares due to parents vs. hybrids were significant for fruit yield per plant, days to 50% flowering, first fruiting node, fruit-length, fruit-girth, number of nodes per plant, number of primary branches per plant and moisture-content. The mean squares due to check vs. hybrids were significant for fruit yield per plant, first fruiting node, fruit weight, number of fruits per plant and ash content.

The findings of heterosis over mid parent, better parent and standard check (GAO 5) are presented in Table 2. While interpreting the results of heterosis, the positive effects considered favourable for all the characters except days to 50% flowering, first fruiting node, days to first picking and moisture content for which negative effects were considered favourable.The aim of estimation of heterosis in the investigation was to identify the superior crosses with high degree of useful heterosis and characterization of parents for their prospects for future uses in breeding programme.

The successful heterosis-breeding programme involved two important strategies *viz.*, presence of significant heterotic effect in hybrids that can be exploited easily and the feasibility of hybrid seed production on commercial basis. Okra being an often-cross pollinated crop, hand emasculation and hand pollination found feasible with higher success rate of fruit setting and good number of seeds per fruit. The cost of hybrid seed production at a commercial scale may also be lower due to simple floral biology, more number of seeds per cross and higher percentage of successful crosses. In the present study, heterosis over mid parent, better parent and standard check (GAO 5) were estimated for fruit yield and its attributing traits in 28 hybrids derived from the 8 x 8 diallel mating design.

The results of relative heterosis in thirteen cross combinations exhibited significantly higher fruit yield, among those GPOK 123 x GPOK 349, AOL 10-22 x GPOK 578 and GO 2 x GPOK 123 were the best hybrids. In case of heterobeltiosis, four crosses exhibited significant and positive value for fruit yield than their respective better parent. A comparative study of three most heterobeltiotic crosses *viz.,* GPOK 123 x GPOK

Table 1. Analysis of variance (mean squares) for parents and hybrids for 12 characters in okra.

Sources of variation	Replications	Genotypes	Parents	Hybrids	Parents vs hybrids	Check vs hybrids	Error
d. f.	2	36	7	27	1	1	72
Fruit yield per plant (g)	1550.11	6737.44**	11463.04**	5865.95*	3924.66*	5439.08*	1121.66
Days to 50% flowering	2.06	24.74**	36.23**	23.40**	5.23*	12.71	1.53
First fruiting node	0.59	2.75*	4.38*	2.07*	12.23**	4.96**	1.01
Days to first picking	2	22.58**	33.52**	21.39**	0.68	9.48	2.45
Fruit length (cm)	0.58	10.38**	20.93**	8.22**	5.01*	0.17	0.88
Fruit girth (cm)	0.31*	0.43*	0.81**	0.33*	0.84**	0.051	0.73
Fruit weight (g)	2.06	6.05**	8.74**	5.79*	0.21	8.57**	1.29
Number of fruits per plant	4.17	37.58**	46.75**	37.94**	1.19	90.60**	2.27
Plant height (cm)	581.48*	600.68**	800.27**	592.23*	32.3	161.89	130.47
Number of nodes per plant	0.25	6.55**	3.04*	7.11*	22.14**	0.39	1.3
Number of primary branches per plant	0.37	0.85**	0.59**	0.90**	2.04**	0.075	0.59
Moisture content %	7.89*	8.72**	26.47**	4.29*	12.44**	1.06	1.25

*, ** Significant at 5 and 1% probability levels, respectively

Table 2. Heterosis of 'half-diallel' for twelve characters of best three crosses in okra.

Characters	Best three crosses	RH	HB	SH
Fruit yield per plant (g)	GPOK 123 x GPOK 349	47.09**	47.09**	1.47**
	GO 2 x GPOK 123	34.46**	11.48**	16.84**
	GAO 5 x GO 2	7.83**	5.36**	10.43**
Days to 50% flowering	GPOK 349 x GPOK 573	-7.83**	-14.04**	2.68**
	PusaSawani x GPOK 578	-7.32**	-14.61**	2.01*
	AOL 10-22 x GPOK 578	-7.32**	-14.61**	2.01*
First fruiting node	GO 2 x GPOK 573	-11.11**	-15.15**	12.00*
	AOL 10-22 x GPOK 573	-1.82	-18.18**	8.00
	GPOK 123 x GPOK 578	-8.20*	-15.15**	12.00*
Days to first picking	AOL 10-22 x GPOK 578	-6.59**	-13.33**	0.00
	AOL 10-22 x GPOK 573	-5.52**	-10.47**	-1.28
	GPOK 349 x GPOK 573	-5.26**	-10.00**	3.85**
Fruit length (cm)	GO 2 x GPOK 123	21.52**	19.22**	22.91**
	GO 2 x PusaSawani	11.61**	9.85**	16.95**
	GO 2 x GPOK 349	9.31**	8.04**	11.38**
Fruit girth (cm)	GPOK 349 x GPOK 573	11.83**	6.21	14.45**
	GO 2 x GPOK 578	6.09	1.77	9.67
	GPOK 123 x GPOK 349	9.92	9.92	6.53
Fruit weight (g)	GPOK 123 x GPOK 578	33.33**	29.93**	54.34**
	GO 2 x GPOK 578	16.09**	3.43	21.97**
	GAO 5 x GO 2	11.41**	2.94	21.39**
Number of fruits per plant	GPOK 123 x GPOK 349	62.73**	62.73**	-19.38**
	GO 2 x GPOK 123	58.81**	25.72**	6.77**
	GPOK 349 x GPOK 573	20.63**	18.01**	-41.54**
Plant height (cm)	GO 2 x GPOK 578	35.09**	3.49**	18.10**
	GPOK 123 x GPOK 573	21.65**	16.09**	12.88**
	GAO 5 x PusaSawani	11.61**	6.13**	6.13**
Number of nodes per plant	GPOK 123 x GPOK 349	25.00**	25.00**	5.77*
	GAO 5 x GPOK 349	17.17**	11.54**	11.54**
	PusaSawani x GPOK 578	16.13**	8.00**	3.85
Number of primary branches per plant	AOL 10-22 x GPOK 578	113.70**	65.96*	30.00
	GO 2 x AOL 10-22	95.12**	70.21**	33.33
	GO 2 x GPOK 123	83.53**	56.00**	30.00
Moisture content %	GO 2 x PusaSawani	-6.05**	-8.66**	-1.20*
	PusaSawani x GPOK 578	-5.20**	-6.22**	-2.09**
	GO 2 x GPOK 123	-4.88**	-7.45**	0.11

*, ** Significant at 5 and 1% probability levels, respectively

349, GO 2 x GPOK 123 and AOL 10-22 x GPOK 578 for fruit yield corresponding to other attributes. In the most of cases, former two crosses also exhibited significant and desirable heterosis for fruit length, number of fruits per plant and moisture content.

In case of standard heterosis, the trait fruit yield per plant was observed significant in four hybrids *viz.,* GO 2 x GPOK 123, GAO 5 x GO 2, GO 2 x PusaSawani and GPOK 123 x GPOK 578. The crosses also exhibited significant and desirable heterosis for first fruiting node, days to first picking, fruit length, fruit weight and plant height. These studies thus substantiate the finding of Grafius (1956) who indicated that heterosis in yield was reflected through heterosis in individual yield components.

The high heterotic effect for fruit yield and its components in okra was also reported by Kumbhani *et* al., (1993), Poshiya and Vashi (1995), Dhankhar *et* al., (1996), Panda and Singh (1999), Dhaduk*et* al. (2003), Rawale*et* al. (2003), Ahlawat (2004), Bhalekar*et* al., (2004), Borgaonkar*et* al., (2006), Singh and Shyamal (2006), Desai *et* al., (2007), Khanpara *et* al., (2009), Dabandata*et* al., (2010), Ramya and Senthil (2010), Wammanda*et* al., (2010), Solankey *et* al., (2013), Medagam *et* al., (2013) and Ashwani *et* al., (2013).

It was interesting to note that the expression of heterosis for fruit yield per plant in various hybrids of present study was associated with heterotic manifestation in some other yield contributing traits. However, none of the hybrid showed heterotic effects for all the traits studied. This was because the components compete for sum total of metabolic substances produced by the plant and the conditions favouring development of one component may adversely affect other components. Therefore, to obtain maximum yield, desired levels of each component should be known in any selection programme.

A good number of hybrids significantly exceeded mid-

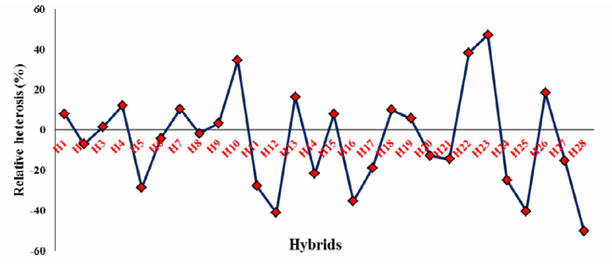

Fig. 1 Phenogram of per cent relative heterosis for fruit yield per plant

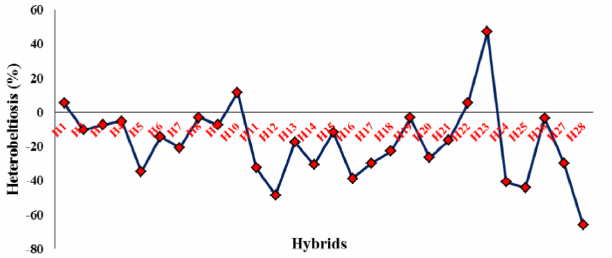

Fig. 2 Phenogram of per cent heterobeltiosis for fruit yield per plant

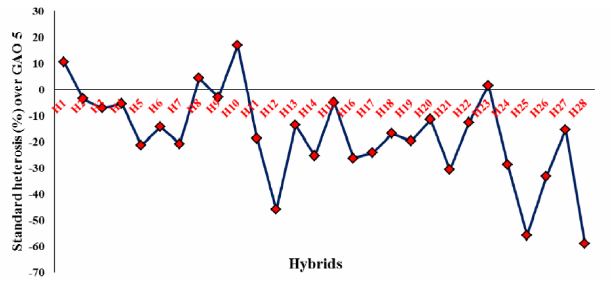

Fig. 3 Phenogram of per cent standard heterosis over GAO 5 for fruit yield per plant

parent, better-parent and standard-check heterosis for various traits. The magnitude of standard heterosis was high for fruit-yield per plant, fruit-length, fruit-weight, number of fruits per plant and number of primary branches per plant. Whereas it was medium for first fruiting-node, plant-height, number of nodes per plant and ash content; and low for days to 50% flowering, days to first picking, fruit-girth and moisture-content.

A perusal of Table 2 indicated that three best heterotic hybrids for various traits involved GO 2 and GPOK 123 as a common parent. This suggested that involvement of GO 2 and GPOK 123 as a parent resulted in expression of high heterosis for fruit yield per plant, fruit length, number of fruits per plant, number of primary branches per plant and moisture content per cent. It is clear, from above discussion that three crosses GPOK 123 x GPOK 349, AOL 10-22 x GPOK 578, GO 2 x GPOK 123 and GAO 5 x GO 2 found to be most promising for fruit yield and other desirable traits. Hence, could be further evaluated in heterosis breeding programme and simultaneously, advanced in segregating generations to obtain desirable segregates for development of superior genotypes.

सारांश

भिण्डी के आठ पित्रो जिनमें मानक नियंत्रक जी.ए.ओ.–5 को समाहित कर अर्द्ध डाइएलिल सेट से संकरण कर 28 संकरण समूह विकसित किए गये। प्रयोग याद्दक्षिक प्रखण्ड आकार विधि से तीन बार प्रतिकृति कर मुख्य सब्जी शोध केन्द्र, आनन्द कृषि विश्वविद्यालय, आनन्द (गुजरात) में वर्ष 2014 में खरीफ मौसम में किया गया। ओज आकलन संकरण मेल जी.ओ.–2 × जी.पी.ओ.के.–123, ए.ओ.एल.–10–22 × जी.पी.ओ.के.–578 तथा जी.ए.ओ.–5 × जी.ओ.–2 अधिक उपज तथा अन्य वांछित घटकों के लिए सबसे उत्तम पाये गये। इन्हीं मेल को आगामी बार मूल्यांकित कर अधिक ओज प्राप्त करने तथा प्रजनन कार्यक्रम में वांछित विसंयोजक प्राप्त कर उत्कृष्ट प्रभेद विकसित किये जा सकते है।

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