RESEARCH PAPER
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Line x tester analysis for heterosis in okra [*Abelmoschus esculentus* (L.) Moench]

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Thirteen genetically diverse parents collected from the different parts of the country and their 36 crosses generated by using line x tester mating design, was undertaken to study the heterosis and heterobeltiosis for fruits yield and its contributing characters in okra. Majority of the hybrids exhibited significant and positive heterosis over mid-parental value and over better parent for most of the traits. Seventeen hybrids showed significant and positive heterobeltiosis for fruit yield per plant. The cross combination Parbhani Kranti x D-1-87-5 exhibited the highest heterobeltiosis (184.27%) for fruit yield per plant. Manifestation of heterosis by this particular cross combination was also realized for all the characters except for days to flowering and number of nodes per plant. The heterosis over better parent for yield per plant was mainly due to longer and thicker fruits coupled with more number of fruits per plant.

Key words : Heterosis, Heterobeltiosis, Line x tester mating design, Okra

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INTRODUCTION

Among the vegetable crops, okra [*Abelmoschus esculentus* (L.) Moench] is an important annual vegetable crop grown through out the country both as summer as well as rainy season crop for its green, tender and delicious fruits. Amount of cross pollination ranges from 4 to 18 per cent (Purewal and Randhawa, 1947). Exploitation of heterosis in okra has been recognized as a practical tool in providing the breeders a means of improving fruit yield and other important traits. For developing promising varieties through hybridization, the choice of parents is a matter of great concern to the plant breeders thus, in the present study, heterosis over mid-parent and better-parent was computed.

RESEARCH METHODOLOGY

Four lines and nine testers were crossed to generate 36 crosses by following line x tester matting design. Forty nine entries including 13 genetically diverse parents collected from the different parts of the country *viz.,* GO-2, Parbhani Kranti, JOL-1, HRB-55, Pusa Sawani, TC-17, HRB-107-4, VRO-6, Pant Bhindi-1, JO (2000K)-15, NDO-10, NOL-101 and D-1-87-5 were evaluated in a Randomized Block Design with three replications during three seasons *viz.*, early summer (E_1), late summer (E_2) and *Kharif* (E_3) at Instructional Farm, Junagadh Agricultural University, Junagadh. Each entry was planted by a single-row plot of ten plants, spaced at 45 x 30 cm. Five competitive plants were selected randomly for recording the different characters like days to flowering, number of nodes per plant, inter-nodal length (cm), plant height (cm), branches per plant, fruit length (cm), fruit girth (cm), number of fruits per plant and fruits yield per plant (g). The recommended cultural practices and plant protection measures were followed uniformly in all the three environments to raised good crop. The analysis of variance was carried out for individual environments using Cochran and Cox (1963) model. The pooled analysis of variance was done as per Comstock and Robinson (1952). The estimate of heterosis over mid-parent was done as per Briggle (1963) and over better parent as per Fonseca and Patterson (1968).

RESEARCH FINDINGS AND ANALYSIS

The analysis of variance for parents and their resultant hybrids for different characters revealed that the variances due to environments, genotypes and genotypes x environments were highly significant for all the characters indicated phenotypic diversity for these characters which could be attributed to the diversity of their origin in form of different seasons and due to varied environmental conditions. The lower magnitude of g x e variance for different characters as compared to genotypes and considerably higher magnitude of environmental variances were noteworthy (Table 1).

The range of mean performance and various heterotic effects as well as promising crosses identified on the basis of their performance for fruit yield in pooled analysis are narrated in Table 2. With regard to days to flowering, eight crosses exhibited heterobeltiosis in desired direction (negative), while with respect to number of nodes per plant, twenty crosses showed significant and positive heterosis over better parent. The hybrid GO-2xJO (2000K)-15 recorded the highest heterobeltiosis for number of nodes per plant indicating predominant role of non-additive gene action for this cross. In okra only one fruit is borne at each axil. Therefore, more number of fruiting nodes on main stem with shorter internodal distance would be helpful in increasing the number of fruits per plant. It was interesting to note that all the hybrids which involved GO-2 as a female parent displayed positive heterosis for this character indicating its superiority over others for nodes per plant. For internodal length twenty-two hybrids showed significant and negative heterosis over better parent and the cross combination HRB-55 x TC-17 was superior for internodal length. Tall plant with shorter internode plays an important role in increasing the yield as fruiting takes place at each node. With respect to plant height, twenty-six crosses exhibited significant and positive heterosis over better parent suggesting predominant role of non-additive type of gene action and the hybrid HRB-55 x NDO-10 displayed maximum heterobeltiosis for this trait. It is interesting to note that all the crosses which had GO-2 as one of the parents manifested significant and positive heterobeltiosis suggesting that it had dominant genes for taller plant height. In case of branches per plant, twenty-nine crosses showed significant and positive heterobeltiotic effect and the cross combination JOL-1 x D-1-87-5 exhibited the highest heterobeltiosis followed by HRB-55 x Pant Bhindi-1.

An examination of performance of hybrids for fruit length revealed that twenty-five hybrids over better parent and fourteen over mid-parental value exhibited significant and positive heterotic effects and the cross combination JOL-1 x D-1-87-5 exhibited the highest heterobeltiosis followed by the hybrid JOL-1 x HRB-107-4 for this trait. The parent JOL-1 was considered as the best as it had favourable alleles for fruit length and transmitted its in desirable performance into its progeny because all the crosses which involved JOL-1 as one of the parent showed significant and positive heterobeltiosis for fruit length. Conspicuous heterosis was recorded by number of crosses for fruit girth in the present study. Twenty-six hybrids exhibited significant and positive heterosis over better parent for fruit girth and the hybrid JOL-1x Pant Bhindi-1 registered the highest heterobeltiosis. Number of fruits per plant is a major yield contributing character and the hybrid GO-2 x D-1-87-5 showed significant and the highest heterosis over better parent followed by GO-2 x NOL-101 for this trait. The female parents either GO-2 or Parbhani Kranti involving in the hybrid exhibited significant and positive heterobeltiosis for most of the combinations indicating its superiority for number of fruits per plant. The results further revealed that both these parents exhibited high *per se* performance for number of fruits per plant.

Fruit yield is the character of economic importance for which considerable magnitude of heterosis was registered in number of crosses in the present investigation. Majority of the hybrids exhibited significant and positive heterosis over mid-parental value and over better parent. In all, sixteen crosses showed significant and positive heterosis over mid-parental value and seventeen hybrids showed significant and positive heterobeltiosis for fruit yield per plant. The highest values of heterobeltiosis was observed in the hybrid Parbhani Kranti x D-1-87-5 (35.42%) followed by GO-2 x D-1-87-5 (32.07%) and GO-2 x NOL-101 but ranked second, third and forth respectively in *per se* performance for yield per plant. The cross combination Parbhani Kranti x D-1-87-5 also exhibited the highest heterobeltiosis for fruits yield per plant and also realized high heterosis for all the characters except for days to flowering and number of nodes per plant. It was found that the heterosis for fruit yield per plant was mainly due to longer and thicker fruits coupled with more number of fruits per plant. The study of best heterotic crosses (Table 3) indicated that crosses which prove its superiority in terms of number of

Table 1: Pooled analysis of variances (over environment) for the experimental design for various characters in okra

Source	d.f.	Mean squares								
		Days to flowering	Number of nodes per plant	Internodal length	Plant height	Branches per plant	Fruit length	Fruit girth	Fruits per plant	Fruit yield per plant
Environments	2	518.996**	4870.969**	378.318**	200256.500**	20.171**	39.168**	0.808**	58.279**	17634.340**
Genotypes	48	36.600**	15.824**	2.301**	1132.124**	0.326**	4.192**	0.739**	36.323**	4435.262**
Genotypes x environments	96	12.866**	5.099**	1.162**	353.101**	0.069**	1.095**	0.058**	2.132**	506.314**
Error	288	5.545	1.147	0.013	2.491	0.014	0.030	0.007	0.108	21.904

*and** indicates significance of value at P=0.05 and P=0.01 level, respectively

Table 2: Range of per se performance, range of heterosis over mid parent and better parent and most heterotic crosses for yield and yield attributing characters in okra

Sr. No.	Characters	Range of per se performance		Range of heterosis over		Better parents (based on mean performance)	Number of hybrids@		Best hybrid based on mean performance	
		Parents	Hybrids	MP	BP		+ve	-ve	MP	BP
1.	Days to flowering	46.22 to 50.33	43.33 to 52.78	-5.79** to 10.71**	-11.56** to 6.03**	VRO-6 Parbhani Kranti	3	8	GO-2 X VRO-6 (51.11)	Parbhani Kranti X Pant Bhindi-1 (52.78)
2.	Number of nodes per plant	13.21 to 16.74	11.6 to 18.82	-16.35** to 15.63**	-12.20** to 27.82**	Parbhani Kranti JO (2000K)-15	20	3	Parbhani Kranti X Pant Bhindi-1(18.22)	GO-2 X JO(2000K)-15 (15.98)
3.	Inter-nodal length (cm)	7.76 to 9.11	6.76 to 9.57	-15.96** to 10.03**	-18.83 to 7.09**	Parbhani Kranti	10	22	Parbhani Kranti X VRO-6 (9.57)	Parbhani Kranti X VRO-6 (9.57)
4.	Plant height (cm)	76.89 to 111.58	73.62 to 123.57	-23.14** to 29.79**	-15.00** to 34.70**	NDO-10	26	4	HRB-55 X NDO-10 (103.57)	HRB-55 X NDO-10 (103.57)
5.	Branches per plant	1.36 to 2.02	1.4 to 2.18	-9.09** to 17.99**	-6.67** to 44.26**	HRB-55 D-1-87-5	29	4	HRB-55 X Pant Bhindi-1 (1.82)	JOL-1 X D-1-87-5 (1.96)
6.	Fruit length (cm)	9.6 to 12.41	9.51 to 12.54	-10.36** to 10.76**	-10.00 to 13.53**	NDO-10	25	7	Parbhani Kranti X NDO-10 (4.90)	Parbhani Kranti X NDO-10 (4.90)
7.	Fruit girth (cm)	4.67 to 5.44	4.64 to 5.66	-11.09** to 12.66**	-10.52** to 17.80**	Parbhani Kranti NOL-101	26	7	Parbhani Kranti X TC-17 (10.53)	JOL-1 X NOL-101 (10.96)
8.	Number of fruits per plant	9.73 to 15.00	8.07 to 16.87	-24.15** to 24.22**	-18.12** to 49.12**	NOL-101	23	8	GO-2 X NOL-101 (15.13)	GO-2 X NOL-101 (15.13)
9.	Fruit yield per plant (g)	115.51 to 163.49	92.2 to 188.44	-25.75** to 27.06**	-23.17** to 35.42**	NOL-101 D-1-87-5	17	12	GO-2 X NOL-101 (171.78)	Parbhani Kranti X D-1-87-5 (184.27)

@ Having significant heterotic effects based on heterobeltiosis
*and** indicates significance of value at P=0.05 and P=0.01 level, respectively.

Table 3: Best heterotic crosses and their per se performance for fruit yield in pooled analysis

Sr. No.	Best cross	Fruit yield per plant (g)	Heterosis (%)	Hetero-beltiosis (%)	Significant heterosis in other traits in desired direction
1.	HRB-55 X D-1-87-5	188.44	18.73**	22.42**	Internodal length, plant height, branches per plant, fruit girth, fruits per plant
2.	P. Kranti x D-1-87-5	184.27	23.03**	35.42**	Internodal length, fruit girth, fruits per plant
3.	GO-2 x D-1-87-5	173.51	17.69**	32.07**	Number of nodes per plant, internodal length, plant height, branches per plant, fruit girth, fruits per plant
4.	GO-2 x NOL-101	171.78	27.06**	30.75**	Number of nodes per plant, internodal length, branches per plant, fruit girth, fruits per plant
5.	HRB-55 x JO(2000K)-15	164.33	10.50**	14.51**	Internodal length, fruit length, fruit girth, fruits per plant
6.	GO-2 x NDO-10	162.31	20.11**	23.55**	Number of nodes per plant, plant height, fruit length, fruit girth, fruits per plant
7.	JOL-1 x D-1-87-5	161.96	10.99**	26.18**	In ternodal length, branches per plant, fruit length, fruit girth, fruits per plant
8.	HRB-55 x NOL-101	157.73	7.69**	13.48**	Days to flowering, branches per plant, fruit girth, fruits per plant

fruits per plant are also found superior for characters like internodal length, plant height, fruit girth, branches per plant and number of nodes per plant showed its association with fruit yield per plant. Heterosis for fruit yield per plant was also observed by Shukla and Gautam (1990), Kumbhani *et al*. (1993), Ahmed *et al*. (1999), Panda and Singh (1999), Pawar *et al*. (1999) and Sood (1999). Heterobeltiosis was recorded by Patel (1991), Patoliya (1994), Poshiya and Vashi (1995), Wankhade *et al*. (1997) and Pathak and Shyamal (1997).

It is pertinent to note that the crosses of poor x good yielding parents also showed heterobeltiosis though their mean yields were lower as compared to good x good crosses. On the contrary, the crosses involving good x good yielding parents exhibited lower heterosis in some cases. The probable explanation for this type of behaviour seems from that fact that poor yielding parents could have different constellations of genes showing complementary interactions when brought together in hybrid combinations. It would, therefore, be desirable to select the hybrid based on *per se* performance rather than extent of heterosis and heterobeltiosis.

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