CHILEANJAR
CHILEAN JOURNAL of AGRICULTURAL RESEARCH

RESEARCH

HETEROSIS FOR YIELD AND YIELD COMPONENTS IN OKRA (*Abelmoschus esculentus* (L.) MOENCH)

Thirupathi Reddy Medagam[1*], Haribabu Kadiyala[2], Ganesh Mutyala[3], and Begum Hameedunnisa[1]

The study of heterosis would help in selection of heterotic crosses for commercial exploitation of F_1 hybrids in okra (*Abelmoschus esculentus* (L.) Moench). Forty five F_1s were developed by crossing 10 elite lines of okra: P_1(IC282248), P_2(IC27826-A), P_3(IC29119-B), P_4(IC31398-A), P_5(IC45732), P_6(IC89819), P_7(IC89976), P_8(IC90107), P_9(IC99716), and P_{10}(IC111443), in half diallel fashion during summer 2009. All 45 F_1s along with their 10 parents and one standard control (Mahyco Hybrid N° 10) were evaluated in a randomized complete block design with three replicates during early *kharif* (June to September) 2009 at the Vegetable Research Station, Rajendranagar, Andhra Pradesh, India, for heterosis of yield and its components of okra. Significance of mean squares due to genotypes revealed the presence of considerable genetic variability among the material studied for almost all yield and yield attributes except plant height. The overall mean heterosis over mid parent and standard control for total yield per plant was 6.92 and -15.44%, respectively, while for marketable yield per plant were 6.64 and -22.18%, respectively. Negatively heterotic crosses like C_{19} (P_3×P_5) for days to 50% flowering (-4.35%) and C_4(P_1×P_5) for first flowering and fruiting nodes (-15.22%), respectively, are important to exploit heterosis for earliness in okra. The crosses with non-significant standard heterosis in any given direction for total yield per plant C_{42}, C_{31}, C_{35}, C_{25}, and C_{36} (8.63, -0.08, -2.61, -3.26, and -4.57%, respectively) and marketable yield per plant C_{42}, C_{31}, and C_{36} (-5.87, -6.56, and -10.54%, respectively), were statistically on par with the standard control in their mean performance and are found to be as promising as that of the standard control. The F_1 hybrid C_{42}(P_7×P_{10}) with high yield potential has the potential for commercial cultivation after further evaluation for early *kharif* season.

Key words: *Abelmoschus esculentus*, F_1 hybrids, half diallel crosses, heterotic pattern, hybrid vigour, mean performance, parental lines.

Cultivated okra (*Abelmoschus esculentus* (L.) Moench) is originated in tropical Africa. It is an introduced vegetable crop in India. Although, it is a multipurpose and multifarious crop, it is extensively grown for its tender pods, which are used as a very popular, tasty and gelatinous vegetable. It is a powerhouse of valuable nutrients. It has huge socio-economic potential for enhancing livelihoods in both rural and urban areas. It offers a possible route to prosperity for small, medium, and large-scale producers alike. Okra is the most important vegetable crop in India accounting for 5.5% of the total vegetable cropped area and 3.6% total vegetable production of the country (NHB, 2010). India is one of the largest producers and consumers of okra in the world. Despite its recognized potential and significant area and consumption in the country, it is being neglected because of non-availability of high yielding open-pollinated varieties. Yield plateau seems to have been reached in open-pollinated varieties of okra.

To break the yield barriers in existing open-pollinated varieties of okra, a hybridization-based breeding strategy would be desirable. Heterosis breeding has been the most successful approach in increasing the productivity in cross-pollinated vegetable crops. Okra is one often-cross pollinated vegetable crop where the presence of heterosis was demonstrated for the first time by Vijayaraghavan and Warrier (1946). Since then, heterosis for yield and its components were extensively studied. Several research workers have reported occurrence of heterosis in considerable quantities for fruit yield and its various components (Venkataramani, 1952; Joshi *et al*., 1958; Partap and Dhankar, 1980; Elangovan *et al*., 1981; Partap *et al*., 1981; Mehta *et al*., 2007; Weerasekara *et al*., 2007; Jindal *et al*., 2009). The ease in emasculation and very high percentage of fruit setting indicates the possibilities of exploitation of hybrid vigour in okra. The presence of sufficient hybrid vigour is an important prerequisite for successful production of hybrid varieties. Therefore, the heterotic studies can provide the basis for the exploitation of valuable hybrid combinations in the future breeding programmes and their commercial utilization.

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[1] Vegetable Research Station, Agricultural Research Institute, Rajendranagar, Hyderabad-500030, Andhra Pradesh, India. *Corresponding author (medagamtr@yahoo.co.in).

[2] Andhra Pradesh Horticultural University (APHU), Venkataramannagudem, West Godavari (Dist.), Andhra Pradesh, India.

[3] Acharya N.G. Ranga Agricultural University (ANGRAU), Rajendranagar, Hyderabad-500030, Andhra Pradesh, India.

Received: 21 November 2011.
Accepted: 17 April 2012.

Variation in most of the agronomical and horticultural traits is available in the germplasm of cultivated okra (Dhall *et al*., 2003; Singh *et al*., 2006; Dakahe *et al*., 2007; Mohapatra *et al*., 2007; Reddy, 2010). The initial selection of parents to be involved in any effective hybridization programme depends upon the nature and magnitude of relative heterosis (heterosis over mid parent), heterobeltiosis (heterosis over better parent), and economic heterosis (heterosis over check) present in genetic stocks. Exploitation of heterosis is primarily dependent on the screening and selection of available germplasm that could be produced by better combinations of important agronomical and horticultural traits. Heterosis breeding based on the identification of the parents and their cross combinations is capable of producing the highest level of transgressive segregates (Falconer, 1960). The choice of the best parental matings is crucial for the development of superior hybrids and because combinations of hybrids grow exponentially with the potential number of parents to be used, this is one of the most expensive and time-consuming steps in hybrid development programmes (Agrawal, 1998). The magnitude of heterosis provides a guide for the choice of desirable parents for developing superior F_1 hybrids, so as to exploit hybrid vigour. It also helps in choosing suitable crosses to be used for commercial exploitation as well as in component breeding programme.

The present investigation aims primarily to study the direction and extent of relative heterosis, heterobeltiosis and economic heterosis for yield and its associated traits in 10 × 10 half diallel crosses for utilization of existing genetic diversity to develop heterotic F_1 hybrids in okra.

MATERIALS AND METHODS

Ten elite and nearly homozygous lines of okra namely P_1(IC282248), P_2(IC27826-A), P_3(IC29119-B), P_4(IC31398-A), P_5(IC45732), P_6(IC89819), P_7(IC89976), P_8(IC90107), P_9(IC99716), and P_{10}(IC111443) selected from the germplasm were crossed in n(n - 1)/2 possible combinations during summer 2009 to generate the breeding material. The resulting 45 one way crosses along with their 10 counterpart parental lines and one standard control (Mahyco Hybrid N° 10) were evaluated in a randomized complete block design with three replicates. The experiment was conducted at the Experimental Farm, Vegetable Research Station, Rajendranagar, Hyderabad, Andhra Pradesh, India. The experiment was conducted during early *kharif* (June-September) 2009. The Experimental Farm is situated at 17.19° N, 79.23° E, 542.6 m a.s.l. The soils are sandy loams. Each entry was raised in a double row plot. The individual plot was of 3 m length and 1.2 m width. A row-to-row spacing of 60 cm and plant-to-plant spacing of 30 cm was adopted. Ten plants per row and 20 plants per plot and entry were maintained. Standard agronomic practices were followed from sowing till harvest. Since lines were grown on ridges, furrow irrigation was given at weekly interval. Recommended doses of manure (farm yard manure 25 t ha^{-1}) and fertilizers (150 kg N ha^{-1}, 150 kg P ha^{-1} and 150 kg K ha^{-1}) were applied in the experimental field. Regular plant protection measures were carried out to safeguard the crop from major insect pests and diseases. Biometric data were recorded for 17 quantitative characters. Observations on the characters like plant height (cm), number of branches per plant, internodal length (cm), first flowering node, first fruiting node, fruit length (cm), fruit width (cm), and fruit weight (g) were recorded on five randomly selected competitive plants, while the observations on the characters like days to 50% flowering, total number of fruits per plant, number of marketable fruits per plant, total yield per plant (g) and marketable yield per plant (g), fruit and shoot borer (FSB) infestation on fruits and shoots (%), and *Yellow vein mosaic virus* (YVMV) infestation on fruits and plants (%) were recorded on whole plot basis in each entry in each replicate. The replicate mean values of FSB infestation on fruits and shoots (%) and YVMV infestation on fruits (%) were subjected to square root transformation, while YVMV infestation on plants (%) were subjected to arc sin transformation to restore distribution to normality. Relative heterosis, heterobeltiosis and standard heterosis were determined as percent increase (+) or decrease (-) of F_1 over mid parent (MP), better parent (BP) and standard control (SC) using the formulae (F_1-MP/MP × 100), (F_1-BP/BP × 100) and (F_1-SC/SC × 100), respectively (Singh, 1973). The statistical significance of heterosis, heterobeltiosis and standard heterosis was assessed by t-test (Wynne *et al*., 1970).

RESULTS AND DISCUSSION

The attainment of maximum crop yield is an important objective in most breeding programmes and the major emphasis in vegetable breeding is on the development of improved varieties. The utilization of the effect of heterosis is very rightly considered to be as one of the most outstanding achievements of the vegetable breeders in the 20th century. Vegetable breeders have widely exploited and used heterosis in boosting up yield of many crops. The goal of okra hybrid breeding is to identify and then reliably reproduce superior hybrid genotypes. Virtually all commercial okra hybrids are made from crosses of inbred lines. Knowledge of heterotic groups from which to draw parental germplasm for hybrid combinations is limited. Improvement of complex characters such as pod yield may be accomplished through the component approach of breeding. This method, in general, assumes strong associations of yield with a number of characters making up yield and simpler inheritance for these component characters.

Analysis of variance

ANOVA (Table 1) indicated significance of mean squares due to genotypes for almost all characters under study except plant height. This can be attributed to the fact that there were clear cut genotypic differences among the parents and their hybrids, which were phenotypically expressed. The mean squares due to parents were highly significant for almost all characters except plant height under study. The mean squares due to crosses were highly significant for almost all characters under study except plant height. The mean squares due to parents versus crosses, which are a measure of the importance of average heterosis, were highly significant for majority of the characters except plant height, number of branches per plant and internodal length, FSB infestation on fruits and shoots and YVMV infestation on fruits and plants.

Mean performance

From the mean performance of the genotypes, it is evident that, in general, the mean values of crosses were desirably higher than those of the parents (Table 2) for number of branches per plant, fruit length, fruit weight, total number of fruits per plant and number of marketable fruits per plant, total yield per plant and marketable yield per plant. On other hand, the mean values of crosses were desirably lower than those of the parents for internodal length, fruit width and FSB infestation on fruits and plants. In general, the range of mean values of parents as a whole was highest for total yield per plant (248.84 to 359.06 g) followed by marketable yield per plant (203.26 to 300.50 g) and plant height (155.13 to 187.40 cm). Similarly, the range of mean values of crosses as a group was highest for total yield per plant (240.53 to 409.65 g) followed by marketable yield per plant (204.32 to 325.25 g) and plant height (149.60 to 195.67 cm).

Table 1. Analysis of variance for heterosis in okra.

	Mean sum of squares				
	Genotypes (54)	Parents (9)	Hybrids (44)	Parents × Hybrids (1)	Error (108)
Plant height, cm	335.9536	304.6467	349.9821	0.4659	241.3010
Number of branches per plant	0.7365**	0.9080**	0.7151**	0.1374	0.1554
Internodal length, cm	1.0893**	1.6857**	0.9853**	0.2986	0.5392
Days to 50% flowering	1.5809**	1.5000*	1.4589**	7.6771**	0.6870
First flowering node	0.3883**	0.4163**	0.3635**	1.2243**	0.0098
First fruiting node	0.3883**	0.4163**	0.3635**	1.2243**	0.0098
Fruit length, cm	3.0653**	5.2016**	2.5428**	6.8275**	0.0502
Fruit width, cm	0.0161**	0.0362**	0.0123**	0.0008*	0.0002
Fruit weight, g	4.0296**	7.4493**	3.3125**	4.8066**	0.1264
Total number of fruits per plant	10.138**	6.608**	10.771**	14.045*	2.492
Number of marketable fruits per plant	7.6354**	4.4968*	8.2630**	8.2697*	1.9316
Total yield per plant, g	4201.9111**	4442.6660**	4009.3926**	10505.9307**	588.7220
Marketable yield per plant, g	2845.0928**	2786.9846**	2765.3733**	6875.7256**	461.4470
FSB infestation on fruits, %	0.0997**	0.1409**	0.0915**	0.0889	0.0321
FSB infestation on shoots, %	0.0972**	0.1311**	0.0905**	0.0860	0.0280
YVMV infestation on fruits, %	0.2583**	0.1989**	0.2701**	0.2719	0.0746
YVMV infestation on plants, %	99.6495**	68.9943**	105.8968**	100.6642	26.4939

*,**Significant at $P \leq 0.05$ and $P \leq 0.01$ levels, respectively. Values in parentheses denote degrees of freedom.
FSB: fruit and shoot borer; YVMV: *Yellow vein mosaic virus*.

Table 2. Range and average performance of parents, crosses and control and average and standard heterosis in okra.

	Parents		Crosses		Control mean	Heterosis (%)	
	Range	Mean	Range	Mean		AH	SH
Plant height, cm	155.13-187.40	174.30	149.60-195.67	174.16	195.93	-0.08	-11.11
Number of branches per plant	1.47-3.07	2.01	1.20-3.60	2.08	2.20	3.48	-5.45
Internodal length, cm	5.52-7.89	6.93	5.55-7.95	6.82	7.16	-1.59	-4.75
Days to 50% flowering	36.33-38.67	37.50	36.67-39.33	38.06	38.33	1.49	-0.70
First flowering node	4.00-5.10	4.49	3.90-5.30	4.71	4.60	4.90	2.39
First fruiting node	4.00-5.10	4.49	3.90-5.30	4.71	4.60	4.90	2.39
Fruit length, cm	11.47-15.72	13.89	12.20-16.33	14.41	13.93	3.74	3.45
Fruit width, cm	1.70-2.07	1.90	1.70-2.03	1.89	1.85	-0.53	2.16
Fruit weight, g	12.75-17.35	14.89	13.78-17.80	15.33	16.40	2.96	-6.52
Total number of fruits per plant	18.13-22.07	20.37	15.60-24.87	21.12	23.27	3.68	-9.24
Number of marketable fruits per plant	14.94-18.82	17.23	13.29-21.36	17.86	21.37	3.66	-16.42
Total yield per plant, g	248.84-359.06	298.23	240.53-409.65	318.87	377.11	6.92	-15.44
Marketable yield per plant, g	203.26-300.50	251.97	204.32-325.25	268.70	345.30	6.64	-22.18
FSB infestation on fruits, %	2.42-3.08	2.79	2.29-3.08	2.73	2.43	-2.15	12.35
FSB infestation on shoots, %	1.95-2.63	2.27	1.94-2.62	2.21	1.98	-57.50	11.62
YVMV infestation on fruits, %	2.31-3.15	2.68	2.11-3.41	2.79	1.53	4.10	82.35
YVMV infestation on plants, %	34.15-49.80	40.90	30.78-60.07	42.93	27.52	4.96	56.00

AH: Average heterosis; SH: standard heterosis; FSB: fruit and shoot borer; YVMV: *Yellow vein mosaic virus*.

The range of mean performance of 10 parental lines and their 45 cross combinations are presented in Table 2. Plant height among the parents and crosses varied from 155.13 to 187.40 and 149.60 to 195.67 cm, respectively. Number of branches per plant varied from 1.47 to 3.07 and 1.20 to 3.60 among the parents and crosses, respectively. Internodal length among the parents and crosses varied from 5.52 to 7.89 and 5.55 to 7.95 cm, respectively. The number of days taken to 50% flowering among the parents and crosses varied from 36.33 to 38.67 and 36.67 to 39.33, respectively. The first flowering and fruiting node varied from 4.00 to 5.10 among parents and 3.90 to 5.30 among hybrids. Fruit length among the parents and crosses varied from 11.47 to 15.72 and 12.20 to16.33, respectively. Fruit width varied from 1.70 to 2.07 among parents and 1.70 to 2.03 among hybrids. Fruit weight varied from 12.75 to 17.35 among parents and 13.78 to 17.80 among hybrids. Total number of fruits per plant among the parents and crosses varied from 18.13 to 22.07 and 15.60-24.87, respectively. Number of marketable fruits per plant varied from 14.94 to18.82 and 13.29 to 21.36 among the parents and crosses, respectively. Total yield per plant among the parents and crosses varied from 248.84 to 359.06 and 240.53 to 409.65 g, respectively. Marketable yield per plant varied from 203.26 to 300.50 and 204.32 to 325.25 g among the parents and crosses, respectively. FSB infestation on fruits among the parents and crosses varied from 2.42 to 3.08 and 2.29 to 3.08%, respectively. Similarly, FSB infestation on shoots among the parents and crosses varied from 1.95 to 2.63 and 1.94 to 2.62%, respectively. YVMV infestation on fruits among the parents and crosses varied from 2.31 to 3.15 and 2.11 to 3.41%, respectively. Similarly, YVMV infestation on plants among the parents and crosses varied from 34.15 to 49.80 and 30.78 to 60.07%, respectively.

Heterosis

Overall average heterosis and standard heterosis of hybrids as a group were estimated and presented in Table 2. The hybrids, in general, manifested highest average heterosis in desirable positive direction for total yield per plant (6.92%), followed by marketable yield per plant (6.64%), total number of fruits per plant (3.68%) and number of marketable fruits per plant (3.66%). Similarly, the hybrids, in general, exhibited highest standard heterosis in desirable negative direction for internodal length (-4.75%) followed by days to 50% flowering (-0.70%).

The range of heterosis and the number of crosses displaying significantly positive and negative heterosis over the mid parent, better parent and standard control (Mahyco Hybrid N°10) are presented in Table 3. There was huge amount of variation in heterotic effects as they varied differently for different characters. For plant height, heterosis over mid parent, better parent and standard control ranged from -18.56 to 13.94, -20.17 to 8.70 and -23.65 to -0.14%, respectively. For this trait, only one cross over mid parent manifested significantly positive heterosis. For number of branches per plant, average heterosis, heterobeltiosis and standard heterosis ranged from -25.00 to 37.85, -41.46 to 25.00 and -45.45 to 63.64%, respectively. For this trait, nine crosses over better parent and five crosses over standard control manifested significantly positive heterosis. Heterosis over mid parent, better parent and standard control varied from -27.80 to 28.09, -29.63 to 28.09 and -22.49 to 11.03%, respectively for internodal length. For internodal length, four crosses over mid parent, six crosses over better parent and four crosses over standard control manifested significantly negative heterosis.

For days to 50% flowering, relative heterosis, heterobeltiosis, and standard heterosis ranged from -1.79 to 5.83, -2.65 to 5.36 and -4.35 to 2.61%, respectively (Table 3). Only one cross over standard control manifested significantly negative standard heterosis. Heterosis over mid parent, better parent and standard control ranged from -12.36 to 20.93, -13.73 to 16.67 and -15.22 to 15.22%, respectively for first flowering and fruiting nodes. For these traits, five crosses over mid parent, fifteen crosses over better parent and 13 crosses over commercial control manifested significant heterosis in desirable direction (negative).

For fruit length, relative heterosis, heterobeltiosis, and standard heterosis ranged from -14.22 to 19.22, -15.04 to 9.81and -12.44 to 17.22%, respectively (Table 3). Twenty six crosses over mid parent, 11 crosses over better parent and 25 crosses over standard control manifested significantly positive heterosis for this trait. For fruit width, heterosis over mid parent, better parent and standard control ranged from -5.81 to 10.27, -14.15 to 4.38 and -8.09 to 9.35%, respectively. For this traits, 11 crosses over mid parent, three crosses over better parent and 30 crosses over commercial control manifested positively significant heterosis. For fruit weight, heterosis over mid parent, better parent and standard control ranged from -13.38 to 12.30, -16.37 to 9.88 and -15.98 to 8.54%, respectively. For this traits, 21 crosses over mid parent, six crosses over better parent and five crosses over commercial control manifested positively significant heterosis.

For total number of fruits per plant, heterosis over mid parent, better parent and standard control ranged from -19.59 to 36.88, -24.52 to 36.63, and -32.95 to 6.88%, respectively (Table 3). For this trait, ten crosses over mid parent and three crosses over better parent manifested positively significant heterosis. For number of marketable fruits per plant, average heterosis, heterobeltiosis, and standard heterosis ranged from -21.27 to 38.80, -25.83 to 34.81, and -37.68 to 0.16%, respectively. For this trait, nine crosses over mid parent and three crosses over better parent manifested positively significant heterosis.

For total yield per plant, heterosis over mid parent, better parent and standard control ranged from -16.40 to

Table 3. Ranges of heterosis over three bases and number of crosses with significantly positive and negative heterosis for seventeen traits in okra.

Heterosis	Range	Nº of heterotics Positive	Nº of heterotics Negative
Plant height, cm			
RH	-18.56** to 13.94*	1	3
HB	-20.17** to 8.70	-	3
SH	-23.65** to -0.14	-	13
Number of branches per plant			
RH	-25.00 to 37.85**	5	-
HB	-41.46** to 25.00	-	9
SH	-45.45** to 63.64**	2	5
Internodal length, cm			
RH	-27.80** to 28.09**	3	4
HB	-29.63** to 28.09**	1	6
SH	-22.49** to 11.03	-	4
Days to 50% flowering			
RH	-1.79 to 5.83	5	-
HB	-2.65 to 5.36**	1	-
SH	-4.35* to 2.61	-	1
First flowering node			
RH	-12.36** to 20.93**	26	5
HB	-13.73** to 16.67**	15	15
SH	-15.22** to 15.22**	25	13
First fruiting node			
RH	-12.36** to 20.93**	26	5
HB	-13.73** to 16.67**	15	15
SH	-15.22** to 15.22**	25	13
Fruit length, cm			
RH	-14.22** to 19.22**	26	5
HB	-15.04** to 9.81**	11	23
SH	-12.44** to 17.22**	25	9
Fruit width, cm			
RH	-5.81** to 10.27**	11	15
HB	-14.15** to 4.38*	3	34
SH	-8.09** to 9.35**	30	7
Fruit weight, g			
RH	-13.38** to 12.30**	21	3
HB	-16.37** to 9.88**	6	20
SH	-15.98** to 8.54**	5	32
Total number of fruits per plant			
RH	-19.59** to 36.88**	10	3
HB	-24.52** to 36.63**	3	5
SH	-32.95** to 6.88	18	-
Number of marketable fruits per plant			
RH	-21.27** to 38.80**	9	2
HB	-25.83** to 34.81**	3	4
SH	-37.68** to 0.16	33	-
Total yield per plant, g			
RH	-16.40** to 38.83**	19	3
HB	-23.77** to 35.87**	6	10
SH	-36.22** to 8.63	27	-
Marketable yield per plant, g			
RH	-18.17** to 40.90**	17	3
HB	-25.12** to 33.67**	5	8
SH	-40.83** to 5.81	42	-
FSB infestation on fruits, %			
RH	-10.18* to 4.47	-	2
HB	-14.79** to 1.33	-	12
SH	-4.82 to 28.77**	21	-
FSB infestation on shoots, %			
RH	-9.90 to 5.90	-	-
HB	-19.94** to 3.37	-	15
SH	-1.70 to 32.59**	18	-
YVMV infestation on fruits, %			
RH	-26.19** to 32.79**	9	2
HB	-28.54** to 25.74**	5	4
SH	37.95* to 133.86**	45	-
YVMV infestation on plants, %			
RH	-30.11** to 46.11**	9	2
HB	-33.06** to 32.10**	5	5
SH	11.86 to 118.28**	43	-

*,**Significant at $P \leq 0.05$ and $P \leq 0.01$ levels, respectively.

RH: Relative heterosis; HB: heterobeltiosis; SH: standard heterosis; FSB: fruit and shoot borer; YVMV: *Yellow vein mosaic virus*.

38.83, -23.77 to 35.87, and -36.22 to 8.63%, respectively (Table 3). Nineteen crosses over mid parent and six crosses over better parent manifested significantly positive heterosis for this trait. For marketable yield per plant, average heterosis, heterobeltiosis, and standard heterosis ranged from -18.17 to 40.90, -25.12 to 33.67, and -40.83 to 5.81%, respectively. Seventeen crosses over mid parent and five crosses over better parent manifested significantly positive heterosis for this trait.

For FSB infestation on fruits, heterosis over mid parent, better parent and standard control ranged from -10.18 to 4.47, -14.79 to 1.33, and -4.82 to 28.77%, respectively (Table 3). Two crosses over mid parent and 12 crosses over better parent manifested significantly negative heterosis for this trait. For FSB infestation on shoots, heterosis over mid parent, better parent and standard control ranged from -9.90 to 5.90, -19.94 to 3.37, and -1.70 to 32.59%, respectively. Fifteen crosses over better parent manifested significantly negative heterosis for this trait. For YVMV infestation on fruits, heterosis over mid parent, better parent and standard control ranged from -26.19 to 32.79, -28.54 to 25.74, and 37.95 to 133.86%, respectively. For this trait, two crosses over mid parent and four crosses over better parent manifested significantly negative heterosis. For YVMV infestation on plants, heterosis over mid parent, better parent and standard control ranged from -30.11 to 46.11, -33.06 to 32.10, and 11.86 to 118.28%, respectively. For this trait, two crosses over mid parent and five crosses over better parent manifested significantly negative heterosis.

From the results of the heterosis studies, it is evident that none of the 45 F_1 hybrids of okra showed consistency in direction and degree of heterosis over three bases for all the characters studied. Some of them manifested positive heterosis while others exhibited negative heterosis (data not shown), mainly due to varying extent of genetic diversity between parents of different cross combinations for the component characters. Significant heterosis was observed for all the growth, earliness and yield attributes. It is inferred that the magnitude of economic heterosis was higher for most of the growth and earliness characters under study. In the present study, the estimates of relative heterosis, heterobeltiosis, and standard heterosis were found to be highly variable in direction and magnitude among crosses for all the characters under study. Weerasekara *et al*. (2007) and Jindal *et al*. (2009) also reported such a variation in heterosis for different characters. The manifestation of negative heterosis observed in some of the crosses for different traits may be due to the combination of the unfavorable genes of the parents.

Of the 17 characters under study, plant height, number of branches per plant, and internodal length largely determine the fruit bearing surface and thus considered as growth attributes. Okra bears pods at almost all nodes on main stem and primary branches. Higher the plant height with more number of branches on the main stem, higher is the number of fruits per plant because of accommodation of more number of nodes for a given internodal length. Shorter distance between nodes accommodates more number of nodes on main stem, which will ultimately lead to higher fruit number and higher fruit production. Hence, positive heterosis is desirable for plant height and number of branches, while negative heterosis is desirable for internodal length to accommodate more number of nodes and to get higher fruit yield in okra. Most of the crosses displayed negative standard heterosis for plant height, which is in the undesirable direction. However, appreciable amount of standard heterosis in desirable direction was observed for number of branches per plant (up to 63.64%) and internodal length (up to -22.49%). Ahmed *et al*. (1999), Dhankar and Dhankar (2001) and Rewale *et al*. (2003), Singh *et al*. (2004), Weerasekara *et al*. (2007) and Jindal *et al*. (2009) also reported the similar projections for number of branches in okra. For internodal length, similar projections were also made by Rewale *et al*. (2003), Singh *et al*. (2004), and Jindal *et al*. (2009).

Days to 50% flowering, first flowering node, and first fruiting node are the indicators of earliness in okra. Early flowering not only gives early pickings and better returns but also widens fruiting period of the plant. Flowering and fruiting at lower nodes are helpful in increasing the number of fruits per plant as well as getting early yields. Negative heterosis is highly desirable for all these three attributes of earliness. In the present study, cross C_{19} exhibiting high negative heterosis over standard control for days to 50% flowering (-4.35%) and the cross C_4 displaying high negative heterosis over standard control for first flowering and fruiting node (-15.22%) are, therefore, important to exploit heterosis for earliness in okra. Weerasekara *et al*. (2007) and Jaiprakashnarayan *et al*. (2008) also noticed heterosis in desirable direction for days to 50% flowering in okra. The negative estimates of heterobeltiosis and economic heterosis for earliness revealed the presence of genes for the development of earliness in okra. The estimates of heterosis over mid parent, better parent and standard control for both first flowering node and first fruiting node were of equal magnitude in all the crosses, indicating 100% fruit set in the early stages of flowering. Tippeswamy *et al*. (2005) and Jindal *et al*. (2009) also noticed desirable heterosis for first flowering node in okra. Mandal and Das (1991) noticed desirable heterosis for first flowering and fruiting nodes in okra.

Total number of fruits per plant and fruit length, width, and weight are considered to be associated directly with total yield per plant, for which positive heterosis is desirable. The cross C_{35} displayed highest positively significant relative heterosis (19.22%) and standard heterosis (17.22%), while the cross C_{22} exhibited highest positively significant heterobeltiosis (9.81%) for fruit length. The cross C_{22} exhibited highest positively significant relative heterosis (10.27%) and heterobeltiosis (4.38%), while the cross C_{25} exhibited highest positively significant standard heterosis (9.35%) for fruit width. For average fruit weight, highest positively significant relative heterosis (12.30%) and heterobeltiosis (9.88%) and standard heterosis (8.54%) was displayed by the cross C_{35}. Similar results were also reported by Ahmed *et al*. (1999) and Jaiprakashnarayan *et al*. (2008) in okra. Cross combinations C_{23} (36.88%), C_{24} (23.50%), C_{36} (21.31%), C_{19} (18.84%) and C_{43} (16.23%) were the top five crosses on the basis of average heterosis, while cross C_{23} (36.63%), C_{24} (16.13%), and C_{36} (13.85%) were the top three on the basis of heterobeltiosis for total number of fruits per plant. Similar results have been reported by Weerasekara *et al*. (2007) and Jaiprakashnarayan *et al*. (2008).

For number of marketable fruits per plant, the crosses C_{23}, C_{36}, C_{24}, C_{19}, and C_{31} displaying an average heterosis of 38.80, 24.28, 23.88, 15.70, and 13.88%, respectively were the top five crosses, while the crosses C_{23}, C_{36}, and C_{24} manifesting a heterobeltiosis of 34.89, 17.25, and 13.56% were the top three crosses for this trait. The cross C_{23} displayed highest positively significant heterosis over mid parent (38.83%) and better parent (35.87%) for number of marketable fruits per plant. Maximum significantly negative heterosis over better parent was displayed by the cross C_{12} (-14.79%) and C_7 (-19.94%) for FSB infestation on fruits and shoots, respectively. The cross C_{14} not only displayed highest negatively significant heterosis over mid parent (-26.15%) and better parent (-28.54%) for YVMV infestation on fruits, but also displayed highest negatively significant heterosis over mid parent (-30.11%) and better parent (-27.32%) for YVMV infestation on plants.

Griffing (1956) has suggested the possibility of working with yield components which are likely to be more simply inherited than is by itself. Grafius (1959) suggested that there is no separate gene system for yield *per se* and that the yield is an end product of the multiplication interaction between the yield components.

The contribution of components of yield is through component compensation mechanism (Adams, 1967). Since then component breeding rather than direct selection on yield has commonly been practiced. It is obvious that high heterosis for yield was built up by the yield components. Hybrid vigour of even small magnitude for individual components may result in significant hybrid vigour for yield *per se*. This was confirmed by the present investigation where none showed hybrid vigor for yield alone. The high heterosis for fruit yield observed in these crosses could probably be due to combined heterosis of their component characters, as these hybrids were not only heterotic in respect of fruit yield but were also found superior for one or the other yield components. Thus, the observed high heterosis for total yield seems to be due to increase in the total number of fruits per plant rather than increase in the size and weight of fruits, which is a desirable requirement in okra improvement. The results obtained in the present investigation were encouraging and tremendous increase in yield was obtained in most of the hybrids. Based on the overall performance of the hybrids and parental lines, some of the lines could be used as parents of hybrids of okra with high to moderate yield potential.

The major components of marketable yield are not only the total number of pods per plant, pod size, and weight but also the percent infestation of fruits and shoots by FSB and fruits and plants by YVMV. In the present investigation, in general, positively high heterosis for marketable yield per plant was associated with positively high heterosis for total number of fruits per plant, size (length and width) and weight of fruits and negatively high heterosis for FSB infestation on fruits and shoots and YVMV infestation on fruits and plants. Thus, the observed high heterosis for marketable yield seems to be due to decrease in the incidence of FSB on fruits and shoots and YVMV on fruits and shoots. Most of the hybrids showing positive heterosis for marketable yield also showed significantly negative heterosis for FSB on fruits and shoots and YVMV on fruits and plants.

Significantly positive heterosis has been observed mainly in terms of total yield in crosses over their mid and better parents. The crosses C_{23}, C_{43}, C_{24}, C_{42}, and C_{34} were the top five heterotic crosses, manifesting an average heterosis of 38.83, 26.44, 24.93, 21.45, and 20.59%, respectively, while the crosses C_{23}, C_{43}, C_{22}, C_{42}, and C_{31} were the top five crosses, displaying a heterobeltiosis of 35.87, 24.20, 21.06, 14.09, and 13.99%, respectively for total yield per plant (Table 4). These results are in agreement with the findings of Weerasekara *et al.* (2007) and Jaiprakashnarayan *et al.* (2008). None of the hybrids showed positively significant heterosis over standard control for this trait. However, crosses C_{42}, C_{31}, C_{35}, C_{25}, and C_{36}, displaying 8.63, -0.08, -2.61, -3.26, and -4.57% non-significant standard heterosis in any given direction are as promising as that of standard control (Table 5). It is apparent that the high heterosis for total fruit yield may probably be due to dominance nature of genes. The significantly positive heterobeltiosis for total yield per plant could be apparently due to preponderance of fixable gene effects, which is also reported by Elangovan *et al.* (1981) and Singh *et al.* (1996).

Significantly positive heterosis has been observed mainly in terms of marketable yield in crosses over their respective mid and better parents. The crosses C_{23}, C_{24}, C_{43}, C_{21}, and C_{34} were the top five heterotic hybrids, manifesting an average heterosis of 40.90, 25.28, 21.82, 19.08, and 18.95%, respectively, while the crosses C_{23}, C_{43}, C_{28}, C_{31}, and C_{22} were the top five heterotic hybrids, displaying a heterobeltiosis of 33.67, 20.20, 17.20, 16.42, and 16.41%, respectively for this trait. Similar results were also found by Tippeswamy *et al.* (2005) and Jindal *et al.* (2009). None of the hybrids showed positively significant heterosis over standard control for this trait. However, crosses C_{42}, C_{31}, and C_{31} displaying -5.81, -6.56, and -10.14% non-significant standard heterosis in negative direction are as promising as that of standard control for this trait.

In the present study, it is apparent that high heterosis for yield may probably be due to dominance nature of genes. For yield attributes, some crosses were non-heterotic which may be ascribed to cancellation of positive and negative effects exhibited by the parents involved in a cross combination and can also happen when the dominance is not unidirectional as also pointed out by Gardner and Eberhart (1966) and Mather and Jinks (1982). Heterosis is thought to result from the combined action and interaction of allelic and non allelic factors and is usually closely and positively correlated with heterozygosity (Falconer and Mackay, 1986).

According to Swaminathan *et al.* (1972) heterobeltiosis of more than 20% over better parent could offset the cost of hybrid seed. Thus, the crosses showing more than 20% of heterobeltiosis viz. may be exploited for hybrid okra production. Although the range of average heterosis and heterobeltiosis manifested by the crosses for different characters was comparatively wide, but it might not be of much significance unless it shows sufficient gain over the standard control. In the present study, the moderate extent of relative heterosis and heterobeltiosis as observed for yield and yield components could be attributed to its often-cross pollinated nature. The extent of heterosis over standard control for total yield per plant (8.63%) and marketable yield per plant (-5.81%) appears to be sufficient for exploitation of heterosis commercially (Table 5). F_1 hybrids C_{42}, C_{31}, C_{35}, C_{25}, and C_{36} with non-significant standard heterosis in any given direction for total yield per plant (8.63, -0.08, -2.61, -3.26, and -4.57%, respectively) and F_1 hybrids C_{42}, C_{31}, and C_{36} with non-significant standard heterosis in any given direction for

Table 4. Top five crosses with significant heterosis in desirable direction for 17 traits in okra.

Heterosis (%)			Heterosis (%)		
RH	HB	SH	RH	HB	SH
Plant height, cm			Total number of fruits per plant		
$C_{24}(P_3\times P_{10})$ 13.94*	-	-	$C_{23}(P_3\times P_9)$ 36.88**	$C_{23}(P_3\times P_9)$ 36.63**	-
-	-	-	$C_{24}(P_3\times P_{10})$ 23.50**	$C_{24}(P_3\times P_{10})$ 16.13**	-
-	-	-	$C_{36}(P_6\times P_7)$ 21.31**	$C_{36}(P_6\times P_7)$ 13.85**	-
-	-	-	$C_{19}(P_3\times P_5)$ 18.84**	-	-
-	-	-	$C_{43}(P_8\times P_9)$ 16.22**	-	-
Number of branches per plant			Number of marketable fruits per plant		
$C_{36}(P_6\times P_7)$ 37.84**	-	$C_{31}(P_5\times P_6)$ 63.64**	$C_{23}(P_3\times P_9)$ 38.80**	$C_{23}(P_3\times P_9)$ 34.89**	-
$C_{6}(P_1\times P_7)$ 37.25*	-	$C_{36}(P_6\times P_7)$ 54.55**	$C_{36}(P_6\times P_7)$ 24.28**	$C_{36}(P_6\times P_7)$ 17.25**	-
$C_{27}(P_4\times P_7)$ 36.00**	-	-	$C_{24}(P_3\times P_{10})$ 23.88**	$C_{24}(P_3\times P_{10})$ 13.56**	-
$C_{24}(P_3\times P_{10})$ 34.55*	-	-	$C_{19}(P_3\times P_5)$ 15.70*	-	-
$C_{31}(P_5\times P_6)$ 24.14*	-	-	$C_{31}(P_5\times P_6)$ 13.88*	-	-
Internodal length, cm			Total yield per plant, g		
$C_{44}(P_8\times P_{10})$ -27.80**	$C_{44}(P_8\times P_{10})$ -22.63**	$C_{44}(P_8\times P_{10})$ -22.49**	$C_{23}(P_3\times P_9)$ 38.83**	$C_{23}(P_3\times P_9)$ 35.87**	-
$C_{22}(P_3\times P_8)$ -16.55**	$C_{30}(P_4\times P_{10})$ -19.48*	$C_{1}(P_1\times P_2)$ -19.23*	$C_{43}(P_8\times P_9)$ 26.44**	$C_{43}(P_8\times P_9)$ 24.20**	-
$C_{30}(P_4\times P_{10})$ -15.30 *	$C_{22}(P_3\times P_8)$ -18.74*	$C_{14}(P_2\times P_7)$ -19.04*	$C_{24}(P_3\times P_{10})$ 24.93**	$C_{22}(P_3\times P_8)$ 21.06**	-
$C_{43}(P_8\times P_9)$ -14.19*	$C_{9}(P_1\times P_{10})$ -18.22*	$C_{2}(P_1\times P_3)$ -17.46*	$C_{42}(P_7\times P_{10})$ 21.45**	$C_{42}(P_7\times P_{10})$14.09*	-
-	$C_{8}(P_1\times P_9)$ -17.10*	-	$C_{34}(P_5\times P_9)$ 20.59**	$C_{31}(P_5\times P_6)$ 13.99*	-
Days to 50% flowering			Marketable yield per plant, g		
-	-	$C_{19}(P_3\times P_5)$ -4.35*	$C_{23}(P_3\times P_9)$ 40.90**	$C_{23}(P_3\times P_9)$ 33.67**	-
-	-	-	$C_{24}(P_3\times P_{10})$ 25.28**	$C_{43}(P_8\times P_9)$ 20.20*	-
-	-	-	$C_{43}(P_8\times P_9)$ 21.82**	$C_{28}(P_4\times P_8)$ 17.20*	-
-	-	-	$C_{21}(P_3\times P_7)$ 19.08**	$C_{31}(P_5\times P_6)$16.42*	-
-	-	-	$C_{34}(P_5\times P_9)$ 18.95**	$C_{22}(P_3\times P_8)$ 16.41*	-
First flowering node			FSB infestation on fruits, %		
$C_{4}(P_1\times P_5)$ -12.36**	$C_{45}(P_9\times P_{10})$ -13.73**	$C_{4}(P_1\times P_5)$ -15.22**	$C_{15}(P_2\times P_8)$ -10.81*	$C_{12}(P_2\times P_5)$ -14.79**	-
$C_{11}(P_2\times P_4)$ -5.88**	$C_{4}(P_1\times P_5)$ -13.33**	$C_{11}(P_2\times P_4)$ -13.04**	$C_{12}(P_2\times P_5)$ -10.11*	$C_{15}(P_2\times P_8)$ -14.32*	-
$C_{39}(P_6\times P_{10})$ -5.88**	$C_{9}(P_1\times P_{10})$ -9.80**	$C_{2}(P_1\times P_3)$ -8.70**	-	$C_{28}(P_4\times P_8)$ -14.19*	-
$C_{45}(P_9\times P_{10})$ -5.38**	$C_{11}(P_2\times P_4)$ -9.09**	$C_{8}(P_1\times P_9)$ -6.52**	-	$C_{7}(P_1\times P_8)$ -14.02*	-
$C_{9}(P_1\times P_{10})$ -4.17**	$C_{17}(P_2\times P_{10})$ -7.84**	$C_{16}(P_2\times P_9)$ -6.52**	-	$C_{23}(P_3\times P_9)$ -13.69*	-
First fruiting node			FSB infestation on shoots, %		
$C_{4}(P_1\times P_5)$ -12.36**	$C_{45}(P_9\times P_{10})$ -13.73**	$C_{4}(P_1\times P_5)$ -15.22**	-	$C_{7}(P_1\times P_8)$ -19.94**	-
$C_{11}(P_2\times P_4)$ -5.88**	$C_{4}(P_1\times P_5)$ -13.33**	$C_{11}(P_2\times P_4)$ -13.04**	-	$C_{22}(P_3\times P_8)$ -14.29**	-
$C_{39}(P_6\times P_{10})$ -5.88**	$C_{9}(P_1\times P_{10})$ -9.80**	$C_{2}(P_1\times P_3)$ -8.70**	-	$C_{3}(P_1\times P_4)$ -13.98*	-
$C_{45}(P_9\times P_{10})$ -5.38**	$C_{11}(P_2\times P_4)$ -9.09**	$C_{8}(P_1\times P_9)$ -6.52**	-	$C_{26}(P_4\times P_6)$ -13.93*	-
$C_{9}(P_1\times P_{10})$-4.17**	$C_{17}(P_2\times P_{10})$ -7.84**	$C_{16}(P_2\times P_9)$ -6.52**	-	$C_{13}(P_2\times P_6)$ -13.93*	-
Fruit length, cm			YVMV infestation on fruits, %		
$C_{35}(P_5\times P_{10})$ 19.22**	$C_{22}(P_3\times P_8)$ 9.81**	$C_{35}(P_5\times P_{10})$ 17.22**	$C_{14}(P_2\times P_7)$ -26.15**	$C_{14}(P_2\times P_7)$ -28.54**	-
$C_{23}(P_3\times P_9)$ 12.75**	$C_{35}(P_5\times P_{10})$ 9.38**	$C_{33}(P_5\times P_8)$ 15.55**	$C_{2}(P_1\times P_3)$ -15.08*	$C_{2}(P_1\times P_3)$ -19.00**	-
$C_{33}(P_5\times P_8)$ 11.55**	$C_{11}(P_2\times P_4)$ 8.63**	$C_{44}(P_8\times P_{10})$ 15.55**	-	$C_{5}(P_1\times P_6)$ -15.69*	-
$C_{43}(P_8\times P_9)$ 10.24**	$C_{4}(P_1\times P_5)$ 7.81**	$C_{21}(P_3\times P_7)$ 11.24**	-	$C_{36}(P_6\times P_7)$ -15.56*	-
$C_{4}(P_1\times P_5)$ 10.0**	$C_{7}(P_1\times P_8)$ 6.28**	$C_{25}(P_4\times P_5)$ 10.77**	-	-	-
Fruit width, cm			YVMV infestation on plants, %		
$C_{22}(P_3\times P_8)$ 10.27**	$C_{22}(P_3\times P_8)$ 4.38**	$C_{25}(P_4\times P_5)$ 9.35**	$C_{14}(P_2\times P_7)$ -30.11**	$C_{14}(P_2\times P_7)$ -33.06**	-
$C_{25}(P_4\times P_5)$ 4.20**	$C_{19}(P_3\times P_5)$ 2.98**	$C_{22}(P_3\times P_8)$ 7.19**	$C_{2}(P_1\times P_3)$ -18.18*	$C_{2}(P_1\times P_3)$ -23.20**	-
$C_{42}(P_7\times P_{10})$ 3.68**	$C_{25}(P_4\times P_5)$ 1.85**	$C_{28}(P_4\times P_8)$ 6.83**	-	$C_{5}(P_1\times P_6)$ -19.34*	-
$C_{28}(P_4\times P_8)$ 3.52**	-	$C_{16}(P_2\times P_9)$ 6.83**	-	$C_{36}(P_6\times P_7)$ -19.04*	-
$C_{19}(P_3\times P_5)$ 3.07**	-	$C_{41}(P_7\times P_9)$ 6.29**	-	$C_{4}(P_1\times P_5)$ -17.40*	-
Fruit weight, g					
$C_{35}(P_5\times P_{10})$ 12.30**	$C_{35}(P_5\times P_{10})$ 9.88**	$C_{35}(P_5\times P_{10})$ 8.54**			
$C_{33}(P_5\times P_8)$ 11.92**	$C_{11}(P_2\times P_4)$ 8.52**	$C_{39}(P_6\times P_{10})$ 6.95**			
$C_{22}(P_3\times P_5)$ 11.31 **	$C_{4}(P_1\times P_5)$ 7.41**	$C_{4}(P_1\times P_5)$ 6.10**			
$C_{4}(P_1\times P_5)$ 11.11**	$C_{22}(P_3\times P_8)$ 6.52**	$C_{42}(P_7\times P_{10})$ 5.30**			
$C_{11}(P_2\times P_4)$ 9.94**	$C_{15}(P_2\times P_8)$ 6.08**	$C_{31}(P_5\times P_6)$ 4.57**			

*,**Significant at $P \leq 0.05$ and $P \leq 0.01$ levels, respectively.
RH: Relative heterosis; HB: heterobeltiosis; SH: standard heterosis.

marketable yield per plant (-5.87, -6.56, and -10.54%, respectively), were statistically on par with the standard control in their mean performance and are found to be as promising as that of the standard control (Mahyco Hybrid N° 10) under comparison (Table 5). For both total yield and marketable yield per plant, the crosses $C_{42}(P_7\times P_{10})$, $C_{31}(P_5\times P_6)$ and $C_{36}(P_6\times P_7)$ were found to be as promising as that of the standard control (Mahyco Hybrid N° 10), which can be exploited for commercial cultivation after further testing during early *kharif* in Andhra Pradesh.

Table 5. Top five crosses on the basis of *per se* performance and heterotic effects for total and marketable yield per plant in okra.

	Heterosis (%)			
Hybrid	Standard heterosis	Heterobeltiosis	Relative heterosis	Mean performance (g plant^{-1})
Total yield per plant				
$C_{42}(P_7 \times P_{10})$	8.63	14.09*	21.45**	409.65
$C_{31}(P_5 \times P_6)$	-0.08	13.98*	15.08**	376.82
$C_{35}(P_5 \times P_{10})$	-2.61	11.10	13.69*	367.27
$C_{25}(P_4 \times P_5)$	-3.26	10.36	19.59**	364.81
$C_{36}(P_6 \times P_7)$	-4.57	0.22	5.32	359.86
Mahyco Hybrid N° 10				377.11
				LSD (5%) = 40.28
Marketable yield per plant				
$C_{42}(P_7 \times P_{10})$	-5.81	8.24	13.45*	325.25
$C_{31}(P_5 \times P_6)$	-6.56	16.42*	16.99**	322.66
$C_{36}(P_6 \times P_7)$	-10.14	3.26	7.93	310.29
$C_{35}(P_5 \times P_{10})$	-10.75*	11.20	12.07*	308.18
$C_{25}(P_4 \times P_5)$	-11.10*	10.77	19.08**	306.98
Mahyco Hybrid N° 10				345.30
				LSD (5%) = 35.76

*,**Significant at $P \leq 0.05$ and $P \leq 0.01$ levels, respectively.
LSD: Least significant difference.

CONCLUSIONS

On an average, okra displays heterosis for yield and its component traits studied. However, for each trait important differences exist among hybrids for the individual values of heterosis. Yield components should be considered to increase the yield through selections. In the present study, cross C_{19} exhibiting high negative heterosis over standard control for days to 50% flowering (-4.35%) and the cross C_4 displaying high negative heterosis over standard control for first flowering and fruiting nodes (-15.22%) are, therefore, important to exploit heterosis for earliness in okra. For both total yield and marketable yield per plant, the crosses $C_{42}(P_7 \times P_{10})$, $C_{31}(P_5 \times P_6)$, and $C_{36}(P_6 \times P_7)$ were found to be as promising as that of the standard control (Mahyco Hybrid N° 10), which can be exploited for commercial cultivation after further testing during early *kharif* in Andhra Pradesh.

ACKNOWLEDGEMENTS

The authors are highly grateful to the NBPGR Regional Station, Thrissur, for providing the germplasm of okra from which the parents for the present study were selected.

Heterosis para producción y componentes del rendimiento en gombo (*Abelmoschus esculentus* (L.) Moench). El estudio de heterosis podría ayudar en la selección de cruzas heteróticas para la explotación comercial de híbridos F_1 de gombo (*Abelmoschus esculentus* (L.) Moench). Cuarenta y cinco F_1s fueron desarrolladas cruzando 10 líneas elite de gombo: P_1(IC282248), P_2(IC27826-A), P_3(IC29119-B), P_4(IC31398-A), P_5(IC45732), P_6(IC89819), P_7(IC89976), P_8(IC90107), P_9(IC99716) y P_{10}(IC111443), en forma de medio dialelo durante el verano 2009. Todas las 45 F_1s junto con sus 10 padres y un control estándar (Híbrido de Mahyco N° 10) fueron evaluadas en un diseño de bloques completos al azar con tres repeticiones durante *kharif* temprano (junio a septiembre) 2009 en la Estación de Investigación de Vegetales, Rajendranagar, Andhra Pradesh, India, para heterosis de la producción de gombo y sus componentes. La significancia de cuadrados medios debida a genotipos reveló la presencia de variabilidad genética considerable entre el material estudiado para casi toda la producción y atributos de producción excepto la altura de planta. La heterosis media total entre los padres y control estándar para la producción total por planta fue 6,92 y -15,44%, respectivamente, mientras para la producción comerciable por planta fue 6,64 y el -22,18%, respectivamente. Cruzas negativamente heteróticas como $C_{19}(P_3 \times P_5)$ para días a 50% floración (-4.35%) y $C_4(P_1 \times P_5)$ para primera floración y nudos fructíferos (-15,22%), respectivamente, son importantes para explotar heterosis de precocidad en quingombó. Las cruzas con heterosis estándar no significativa en cualquier dirección dada para producción total por planta C_{42}, C_{31}, C_{35}, C_{25}, y C_{36} (8,6; -0,08; -2,61; -3,26; y -4,57%, respectivamente) y producción comerciable por planta C_{42}, C_{31}, y C_{36} (-5,87; -6,56, y -10,54%, respectivamente), fueron estadísticamente iguales con el control estándar para rendimiento medio y fueron tan prometedoras como aquellas del control estándar. El híbrido F_1 $C_{42}(P_7 \times P_{10})$ con alto potencial de rendimiento tiene potencial para cultivo comercial después de evaluación adicional para la temporada *kharif* temprana.

Palabras clave: *Abelmoschus esculentus*, F_1 híbridos, cruzas medio dialelo, patrón heterótico, vigor híbrido, rendimiento medio, líneas parentales.

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