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Studies on hybrid vigour in bitter gourd (*Momordica charantia* L.) for earliness, yield and quality characters

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Abstract

Evaluation of ninety hybrids of bitter gourd resulting from full diallel mating of ten genetically diverse genotypes for earliness, yield and quality characters had revealed the presence of heterotic vigour. Fifty nine hybrid combinations were found to exhibit negative significant heterobeltiosis for days to first female flower appearance and the hybrid CO-1 × GL had registered favourable values for this trait. The hybrid CO-1 × MC-105 registered negative significant relative heterosis, heterobeltiosis and standard heterosis for node at which the first female flower appears. The heterosis for sex ratio was found to be in the desired direction in UB × GL and seventy six hybrids showed significant negative heterobeltiosis for sex ratio. The highest significant relative heterosis (KR × UB) and heterobeltiosis (MC-10 × KR) for fruit length was also observed. The highest positive and significant standard heterosis was observed in the hybrid Priyanka × GL for fruit length. The estimate of heterobeltiosis for fruit weight had shown positively significant value for fifteen hybrids, and it was the highest in KR × USL. Among the ninety hybrids, sixteen hybrids had registered positive and significant heterobeltiosis values for number of fruits per vine, and the hybrid Preethi × MC-30 had the highest value for this trait. The highest positive heterobeltiosis for yield of fruits per vine was recorded in KR × USL followed by Preethi × MC-30. However, the estimates of standard heterosis for fruit yield revealed that the hybrid Preethi × MC-30 had the highest positive significant value followed by the hybrid KR × USL. In order of merit the hybrids *viz.*, Preethi × MC-30, KR × USL and MC-105 × MC-10 were noted to be the top performing hybrids with respect to yield and quality parameters since they had showed significant heterotic values.

Key words: *Momordica charantia* L., diallel mating, diverse parents, relative heterosis, heterobeltiosis, standard heterosis, earliness, yield and quality

Introduction

Bitter gourd is an important commercial cucurbit belonging to the family cucurbitaceae, genus *Momordica*. It is a large genus with many species of annual and perennial climbers of which *Momordica charantia* L. is widely cultivated. 'Karela' as commonly known in Hindi is an important vegetable crop grown for its fleshy fruits in tropical and subtropical regions (Morton, 1967). As the name signifies, the fruits are bitter in taste. Bitter gourd has several uses, the fruits are used as vegetables, pickled, canned and dehydrated. The fruits has cooling, digestive, laxative, antipyretic properties and its administration reduces blood diseases, rheumatism and asthama. In Ayurveda, the juice of fresh leaves is prescribed for diabetes. Fruits have good nutritional value with 2.1 g of protein, 4.2 g of carbohydrates 1.8 mg iron, 20 mg of calcium, 55 mg of phosphorus, 210 IU of vitamin A and 88 mg of vitamin C per 100 gram of edible portion (Mohan, 2005).

Hybridisation to exploit heterosis on commercial basis or for selection of promising recombinants in subsequent generations is the prime objective of heterosis breeding programme. Heterosis in cross pollinated crop has been known to offer potentialities for increased yield. Further, superior recombinants identified in subsequent generations could also be explored for commercial exploitation, as cucurbits do not show inbreeding depression. In our country, a wide range of variability in vegetative and fruit characters is available in bitter gourd. A speedy improvement approach through the use of genetically variable parents and exploitation of hybrid vigour has been neglected so for in this crop. Owing to the existence of wide variability, monoecious nature, conspicuous and convenient flowers and large number of seeds per fruit, bitter gourd can serve as the most potent material for the exploitation of heterosis on commercial scale. And the hybrid vigour is substantially increased on crossing genetically diverse inbreds and thus heterosis is mostly obtained from genetic diversity among the parents involved.

The first report regarding heterosis in bitter gourd for growth and yield parameters was reported by Pal and Singh (1946). Though heterosis for yield and yield contributing characters has been reported earlier in bitter gourd by Lal *et al.* (1976), Singh and Joshi (1980), Munshi and Sirohi (1993) and Singh *et al.* (2000), hardly any commercially high yielding and early fruiting leading hybrid is available from public sector organization so far. With this view the present study was taken up on bitter gourd to get hybrids with high yield, earliness and quality characters through heterosis studies by diallel analysis (Griffing, 1956).

Materials and methods

In the present investigation, ten genetically diverse inbred lines of bitter gourd were chosen from the germplsam available at the College Orchard, Horticultural College and Research Institute, Tamil Nadu and used as parents in the crossing programme. The parents *viz.*, 'CO-1' and 'Green Long' (long fruited type and native of Coimbatore), 'Priyanka' and 'Preethi' (white fruited types from Kerala); 'Karala Rakshuse' (KR), 'Uchha Small Long' (USL) (medium fruited type) and 'Uchha Bolder' (UB) (small fruited type from West Bengal); 'MC-30', 'MC-105' and 'MC-10' (medium bold fruited type from Palur, Tamil Nadu) were subjected to crossing in a full diallel mating design (Method I, Model 1 Griffing,1956) in all possible combinations. Among the various breeding methods, diallel analysis helps to answer the questions concerning the importance of specific combining ability and the predictability of hybrid performance (Baker, 1978). Thus the resultant 90 F_1 hybrids along with their parents were raised in a Randomized Block Design with three replications during August – November, 2007 and evaluated for various quantitative and qualitative traits.

Observations on earliness, yield and quality traits *viz.*, days to first female flower appearance, node of first female flower appearance, number of male flowers per vine, number of female flowers per vine, sex ratio (male/female), fruit length, fruit girth, fruit weight, number of fruits per vine, yield of fruits per vine, ascorbic acid and iron content were recorded on three randomly selected single plants in each replication. The mean values were utilized for estimating the percent increase or decrease of F_1 hybrids over mid parent (di), better parent (dii) and standard variety (diii) for the above mentioned parameters according to Gowen (1952) and Fonseca and Patterson (1968). Thus the heterosis of ninety direct and reciprocal cross combinations derived from the ten genetically diverse parents was estimated. The standard error values for testing significance of heterosis were calculated as suggested by Snedecor and Cochran (1967). The productive hybrids are weighed not merely by the expression of heterosis over the parents but also in relation to the standard check variety. As the TNAU released variety CO-1 is popular and commercially grown in Tamil Nadu, it was used as the standard check to estimate the standard heterosis. The 't' value was worked out as the deviation of F_1 from the mid parent (MP) or better parent (BP) or the standard parent (SP) by standard error and tested against the table 't' value at error degrees of freedom for 5 and 1 percent levels of probability.

Results and discussion

The extent of heterosis over mid parent, better parent and standard parent values were estimated for all the twelve characters in the ninety hybrids. For judging good F_1 hybrids, negative heterosis was considered as favourable for the characters *viz.*, days to first female flower appearance, node of first female flower appearance, number of male flowers per vine, sex ratio. While, positive heterosis was considered to be desirable for the traits *viz.*, number of female flowers per vine, fruit length, fruit girth, individual fruit weight, number of fruits per vine, yield of fruits per vine, ascorbic acid content and iron content.

Table 1. Heterosis (per cent) over mid parent (di), better parent (dii) and standard parent (diii) for days to first female flower appearance, node of first female flower appearance and number of male flowers per vine

Hybrid	Days to first female flower appearance			Node of first female flower appearance			Number of male flowers per vine		
	di	dii	diii	di	dii	diii	di	dii	diii
CO -1 x GL	-12.75**	-22.69**	0.14	-9.43**	-12.40**	-6.25**	1.39*	-15.76**	27.30**
CO -1 x Priyanka	7.06**	-5.30**	23.12**	-0.33	-14.62**	-14.62**	46.63**	41.94**	51.64**
CO -1 x Preethi	11.62**	4.88**	19.29**	1.76**	-12.70**	-12.70**	18.00**	11.47**	11.47**
CO -1 x KR	13.78**	10.46**	17.32**	-4.56**	-16.39**	-16.39**	-0.21	-16.17**	23.24**
CO -1 x USL	5.72**	-6.35**	21.35**	-14.23**	-17.25**	-17.25**	-6.62**	-7.21**	-6.02**
CO -1 x UB	17.17**	13.32**	21.28**	-4.96**	-28.53**	-28.53**	4.76**	-6.93**	-6.93**
CO -1 x MC-30	-1.86*	-12.38**	11.51**	17.32**	6.96**	6.96**	18.55**	15.65**	15.65**
CO -1 x MC-105	4.71**	-1.59*	11.88**	-55.06**	-60.33**	-60.33**	17.35**	4.07**	34.51**
CO -1 x MC-10	1.07	-5.38**	8.45**	-8.78**	-24.98**	-24.98**	22.35**	7.51**	41.93**
GL x CO -1	-4.18**	-15.10**	9.97**	-17.18**	-19.89**	-14.27**	-19.90**	-33.45**	0.57
GL x Priyanka	-6.66**	-6.83**	21.12**	-11.82**	-26.53**	-21.36**	-8.85**	-22.20**	17.56**
GL x Preethi	5.13**	-1.28	27.88**	-21.32**	-34.35**	-29.74**	-1.83*	-22.03**	17.82**
GL x KR	-3.51**	-12.20**	13.74**	-3.49**	-17.84**	-12.07**	-10.20**	-11.42**	33.86**
GL x USL	-12.25**	-12.26**	13.69**	-11.78**	-17.57**	-11.78**	-4.71**	-20.42**	20.25**
GL x UB	-9.67**	-17.52**	6.84**	-20.47**	-41.51**	-37.40**	-12.50**	-33.76**	0.09
GL x MC-30	-17.49**	-18.22**	5.94**	-16.57**	-26.19**	-21.01**	7.05**	-12.79**	31.79**
GL x MC-105	-5.62**	-11.39**	14.78**	-4.81**	-18.37**	-12.63**	-16.66**	-22.69**	16.82**
GL x MC-10	-7.50**	-12.83**	12.92**	0.06	-19.83**	-14.19**	-7.16**	-13.02**	31.43**
Priyanka x CO -1	-3.19**	-14.37**	11.33**	15.16**	-1.35*	-1.35*	12.64**	9.03**	16.49**
Priyanka x GL	-5.37**	-5.54**	22.80**	-1.07	-17.57**	-11.78**	-1.12	-15.60**	27.53**
Priyanka x Preethi	9.76**	2.89**	33.77**	39.86**	39.61**	-0.07	11.69**	2.34**	9.33**
Priyanka x KR	0.10	-9.07**	18.22**	47.64**	43.84**	8.16**	-8.89**	-21.34**	15.63**
Priyanka x USL	-8.88**	-9.03**	18.27**	19.14**	5.27**	-2.13**	-2.43**	-4.96**	1.53
Priyanka x UB	-2.73**	-11.33**	15.28**	19.65**	2.09**	-27.18**	39.80**	20.73**	28.98**
Priyanka x MC-30	-1.93**	-2.96**	26.16**	11.41**	3.97**	-14.41**	5.36**	-0.43	6.38**
Priyanka x MC-105	-4.52**	-10.51**	16.34**	17.01**	13.03**	-13.48**	-13.95**	-21.41**	1.58
Priyanka x MC-10	-8.87**	-14.26**	11.47**	26.37**	20.30**	-14.19**	-4.97**	-14.03**	13.49**
Preethi x CO -1	8.59**	2.03**	16.05**	-32.00**	-41.66**	-41.66**	-5.86**	-11.06**	-11.06**
Preethi x GL	1.59*	-4.60**	23.57**	-29.27**	-40.98**	-36.83**	-18.27**	-35.09**	-1.91*
Preethi x Priyanka	-13.19**	-18.62**	5.80**	-19.25**	-19.39**	-42.30**	18.79**	8.84**	16.27**

Preethi x KR	7.96**	4.38**	18.72**	-11.61**	-13.73**	-35.13**	-6.36**	-24.85**	10.47**
Preethi x USL	-0.03	-6.14**	21.62**	-29.09**	-37.25**	-41.66**	8.67**	2.05*	3.35**
Preethi x UB	1.11	-1.87*	11.60**	-17.14**	-29.40**	-49.47**	35.32**	26.76**	12.74**
Preethi x MC-30	-5.50**	-10.53**	13.87**	-11.46**	-17.24**	-31.87**	30.41**	26.18**	20.00**
Preethi x MC-105	-1.81*	-1.83*	11.65**	-30.23**	-32.50**	-48.33**	6.98**	-9.70**	16.71**
Preethi x MC-10	3.70**	3.30**	18.40**	-4.85**	-9.57**	-35.27**	15.59**	-3.27**	27.70**
KR x CO -1	23.72**	20.10**	27.56**	-21.73**	-31.44**	-31.44**	16.00**	-2.55**	43.27**
KR x GL	8.30**	-1.45*	27.65**	-19.84**	-31.76**	-26.97**	-17.93**	-19.05**	22.33**
KR x Priyanka	-2.17**	-11.12**	15.55**	14.70**	11.75**	-15.97**	-8.06**	-20.62**	16.69**
KR x Preethi	-4.53**	-7.69**	4.99**	3.87**	1.37	-23.78**	-5.40**	-24.08**	11.60**
KR x USL	-3.34**	-12.05**	13.96**	-17.54**	-25.42**	-30.66**	-7.70**	-22.05**	14.59**
KR x UB	-3.10**	-3.47**	3.31**	28.17**	7.03**	-19.52**	2.33**	-21.80**	14.96**
KR x MC-30	-10.14**	-17.58**	4.90**	12.46**	7.59**	-11.43**	-2.78**	-19.95**	17.69**
KR x MC-105	-6.49**	-9.57**	2.81**	0.37	-0.51	-23.85**	-7.54**	-13.13**	27.71**
KR x MC-10	8.39**	4.41**	19.67**	20.93**	12.32**	-15.54**	-14.78**	-19.13**	18.89**
USL x CO -1	7.14**	-5.09**	22.98**	-39.83**	-41.94**	-41.94**	6.22**	5.54**	6.90**
USL x GL	3.81**	3.80**	34.50**	-23.56**	-28.58**	-23.56**	-22.41**	-35.20**	-2.08*
USL x Priyanka	-3.54**	-3.70**	25.20**	1.86**	-10.00**	-16.32**	5.10**	2.37**	9.37**
USL x Preethi	-6.44**	-12.16**	13.83**	-12.79**	-22.82**	-28.25**	17.35**	10.19**	11.61**
USL x KR	8.12**	-1.63*	27.47**	-5.72**	-14.73**	-20.72**	-18.25**	-30.96**	1.5
USL x UB	11.77**	2.05**	32.23**	21.29**	-6.49**	-13.06**	24.71**	10.18**	11.60**
USL x MC-30	-11.58**	-12.37**	13.55**	-4.37**	-9.85**	-16.18**	14.84**	11.34**	12.77**
USL x MC-105	-7.72**	-13.38**	12.24**	-9.06**	-17.10**	-22.92**	1.25	-9.71**	16.70**
USL x MC-10	-10.34**	-15.52**	9.47**	-12.64**	-26.03**	-31.23**	4.63**	-7.55**	22.06**
UB x CO -1	1.82*	-1.52	5.39**	-4.29**	-28.03**	-28.03**	-12.56**	-22.32**	-22.32**
UB x GL	-7.56**	-15.59**	9.34**	-26.78**	-46.15**	-42.37**	-30.24**	-47.19**	-20.20**
UB x Priyanka	0.13	-8.72**	18.68**	-9.39**	-22.69**	-44.85**	-8.25**	-20.77**	-15.35**
UB x Preethi	10.23**	6.97**	21.67**	23.25**	5.01**	-24.84**	9.03**	2.14*	-9.16**
UB x KR	13.18**	12.75**	20.67**	16.64**	-2.60**	-26.76**	-17.44**	-36.91**	-7.25**
UB x USL	-2.37**	-10.86**	15.50**	1.88*	-21.45**	-26.97**	4.96**	-7.27**	-6.08**
UB x MC-30	-4.69**	-12.27**	11.65**	19.47**	-3.71**	-20.72**	11.12**	0.95	-3.99**
UB x MC-105	8.54**	5.36**	19.79**	12.83**	-6.44**	-28.39**	-5.74**	-24.54**	-2.47**
UB x MC-10	2.73**	-0.67	13.85**	21.59**	8.31**	-30.16**	-5.00**	-24.55**	-0.39
MC-30 x CO -1	-3.50**	-13.84**	9.66**	-0.35	-9.16**	-9.16**	-2.51**	-4.89**	-4.89**
MC-30 x GL	-12.41**	-13.18**	12.47**	-24.51**	-33.22**	-28.53**	-20.72**	-35.41**	-2.40**
MC-30 x Priyanka	-12.15**	-13.08**	13.01**	21.20**	13.10**	-6.88**	-2.45**	-7.81**	-1.5
MC-30 x Preethi	-7.80**	-12.70**	11.11**	3.57**	-3.19**	-20.30**	8.80**	5.28**	0.12
MC-30 x KR	-11.62**	-18.93**	3.17**	-17.64**	-21.21**	-35.13**	-14.61**	-29.68**	3.38**
MC-30 x USL	-7.82**	-8.64**	18.38**	-19.84**	-24.43**	-29.74**	11.35**	7.96**	9.34**
MC-30 x UB	3.09**	-5.11**	20.76**	25.99**	1.55*	-16.39**	29.18**	17.35**	11.60**
MC-30 x MC-105	18.86**	12.52**	43.20**	-5.12**	-8.45**	-24.63**	2.19**	-11.30**	14.64**
MC-30 x MC-10	18.55**	12.66**	43.38**	-6.41**	-16.55**	-31.30**	3.05**	-11.36**	17.02**
MC-105 x CO -1	6.58**	0.16	13.87**	-10.19**	-20.72**	-20.72**	14.39**	1.45*	31.12**
MC-105 x GL	-6.33**	-12.06**	13.92**	-21.98**	-33.09**	-28.39**	-12.11**	-18.46**	23.21**
MC-105 x Priyanka	-10.04**	-15.69**	9.61**	-3.34**	-6.63**	-28.53**	9.91**	0.38	29.74**
MC-105 x Preethi	4.41**	4.38**	18.72**	-7.14**	-10.15**	-31.23**	6.57**	-10.05**	16.26**
MC-105 x KR	14.04**	10.29**	25.39**	0.75	-0.14	-23.56**	-13.89**	-19.09**	18.94**
MC-105 x USL	17.92**	10.69**	43.43**	-6.72**	-14.96**	-20.94**	1.36	-9.60**	16.83**
MC-105 x UB	13.60**	10.27**	25.36**	13.28**	-6.07**	-28.11**	13.09**	-9.47**	17.01**
MC-105 x MC-30	-3.53**	-8.67**	16.23**	5.61**	1.90**	-16.11**	14.32**	-0.77	28.25**
MC-105 x MC-10	15.44**	14.97**	31.78**	3.07**	-5.05**	-27.32**	-7.97**	-8.94**	20.22**
MC-10 x CO -1	10.97**	3.90**	19.08**	-13.10**	-28.53**	-28.53**	5.57**	-7.24**	22.47**
MC-10 x GL	-6.87**	-12.23**	13.69**	-16.16**	-32.82**	-28.11**	-4.08**	-10.14**	35.79**
MC-10 x Priyanka	-7.94**	-13.39**	12.60**	10.69**	5.37**	-24.84**	19.04**	7.69**	42.17**
MC-10 x Preethi	0.37	-0.02	14.60**	16.64**	10.86**	-20.65**	27.45**	6.66**	40.81**
MC-10 x KR	13.48**	9.31**	25.29**	20.33**	11.75**	-15.97**	5.39**	0.02	47.04**
MC-10 x USL	-4.84**	-10.34**	16.18**	-11.56**	-25.11**	-30.38**	14.32**	1.02	33.36**
MC-10 x UB	27.58**	23.35**	41.39**	24.68**	11.06**	-28.39**	25.03**	-0.7	31.10**
MC-10 x MC-30	14.84**	9.14**	38.89**	4.33**	-6.98**	-23.42**	17.38**	0.97	33.31**
MC-10 x MC-105	15.64**	15.17**	32.00**	18.37**	9.04**	-16.54**	4.49**	3.39**	36.50**

* Significant at *P*=0.05   ** Significant at *P*=0.01

Heterosis for earliness: In cucurbits, the flowering time measured as the days to opening of first female flower and nodal position of first female flower are considered as the indices of earliness. Earliness indicated by negative heterosis is a prime objective of heterosis breeding in bitter gourd. Negative and significant relative heterosis was observed by 46 hybrids and the hybrid GL × MC-30 (-17.49 %) had the lowest value for days to first female flower appearance. Negative and significant heterobeltiosis was also noticed for days to first female flower appearance in 59 hybrids (-22.69 % in CO-1× GL to 23.35% in MC-10 × UB). The heterosis over standard parent (CO-1) for this character was found positively significant for 89 hybrids and none of the hybrids exhibited negative significant values (Table 1).

The relative heterosis for node of first female flower appearance ranged from -55.06 % (CO-1 × MC-105) to 47.64 % (Priyanka × KR). Among the ninety hybrids, forty nine hybrids registered significant heterosis on desirable direction. The heterobeltiosis ranged from -60.33 % (CO-1 × MC-105) to 43.84 % (Priyanka × KR) and sixty five hybrids showed negatively significant heterosis for this character. The heterosis over the standard parent CO-1 was found negatively significant for eighty seven hybrids (-60.33 % in CO-1 × MC-105 to -1.35 % in Priyanka × CO-1) (Table 1). Hybrid vigour on bitter gourd for node of first female flower appearance had been earlier reported by Kennedy *et al.* (1995).

Heterosis for sex ratio: Number of male and female flowers per vine in bitter gourd is an important criterion as they decide the sex ratio, which in turn influences the yield. The relative heterosis for number of male flowers per vine was found to vary from -30.24 % (UB × GL) to 46.63% (CO-1 × Priyanka). Of the ninety hybrids studied, significant relative heterosis on negative direction was recorded in thirty nine hybrids. The lowest negative and significant heterobeltiosis was recorded in UB × GL (-47.19 %). The standard heterosis for number of male flowers per vine was significant in eighty two hybrids of which, fifteen hybrids recorded negative significant values which was the lowest in UB × CO-1 (-22.32 %) (Table 1). Number of female flowers per vine ranged from -33.55 % (UB × CO-1) to 81.26 % (Preethi × MC-30) and fifty two cross combinations had shown significantly positive relative heterosis. The heterobeltiosis for number of female flowers per vine was also high for Preethi × MC-30 (65.51%) and it was positive in thirty eight hybrids. The range of standard heterosis was -15.03 % (GL× MC-30) to 97.26 % (Preethi × UB). Significant standard heterosis on desired positive direction was observed in forty nine hybrids (Table 2).

The estimates of relative heterosis in respect of sex ratio ranged from -61.03 % (UB × GL) to 55.81 % (CO-1 × Preethi). The heterobeltiosis on desired negative direction was recorded for seventy six hybrids and it ranged from -72.34 % (UB × GL) to -4.36 % (MC-30 × MC-105). Heterosis over standard parent ranged from -46.83 % (UB × GL) to 87.83 % (CO-1 × Priyanka). The result with regard to hybrid vigour of sex ratio is in line with the earlier findings of Sundaram (2006).

Table 2. Heterosis (per cent) over mid parent (di), better parent (dii) and standard parent (diii) for number of female flowers per vine, sex ratio and fruit length

Hybrid	Number of female flowers per vine			Sex ratio (M/F)			Fruit length		
	di	dii	diii	di	dii	diii	di	dii	diii
CO-1 x GL	23.03**	22.78**	-5.71**	1.43	-22.90**	48.19**	5.00**	1.31*	1.31*
CO-1 x Priyanka	13.99**	3.40**	-2.46*	35.43**	5.89**	87.83**	12.23**	-2.46**	-2.46**
CO-1 x Preethi	-3.01**	-40.21**	97.26**	55.81**	40.62**	74.68**	-18.45**	-33.96**	-33.96**
CO-1 x KR	81.26**	65.51**	53.85**	9.39**	-16.71**	59.31**	9.28**	-11.83**	-11.83**
CO-1 x USL	-7.40**	-20.82**	-14.37**	12.21**	11.23**	13.21**	9.40**	-16.67**	-16.67**
CO-1 x UB	4.67**	-6.76**	-8.39**	-26.91**	-33.99**	-33.99**	-33.89**	-60.24**	-60.24**
CO-1 x MC-30	4.35**	-7.92**	-7.92**	34.30**	27.41**	41.98**	-12.38**	-18.76**	-4.91**
CO-1 x MC-105	24.72**	22.04**	-2.46*	41.15**	29.52**	55.07**	43.57**	19.29**	19.29**
CO-1 x MC-10	63.40**	46.68**	12.19**	26.82**	9.80**	50.09**	23.27**	-1.45*	-1.45*
GL x CO-1	27.10**	26.84**	-2.59*	-7.95**	-30.03**	34.48**	-9.98**	-13.14**	-13.14**
GL x Priyanka	46.91**	33.02**	25.48**	-1.68**	-5.47**	81.68**	-7.96**	-17.45**	-23.24**
GL x Preethi	-17.72**	-49.32**	67.20**	-40.40**	-50.94**	-5.72**	13.81**	-5.18**	-11.83**
GL x KR	12.27**	2.33*	-4.88**	-17.81**	-18.00**	57.59**	13.79**	-5.55**	-12.17**
GL x USL	21.33**	3.58**	12.00**	17.58**	-10.07**	72.83**	15.15**	-10.01**	-16.32**
GL x UB	15.92**	3.08**	1.28	-49.90**	-64.44**	-31.65**	-34.07**	-59.84**	-62.66**
GL x MC-30	-12.55**	-15.03**	-15.03**	3.77**	-18.04**	57.53**	-25.92**	-33.53**	-22.20**
GL x MC-105	6.16**	-1.95	-7.51**	-20.71**	-35.66**	23.66**	-20.53**	-31.99**	-36.76**
GL x MC-10	21.54**	-0.03	-5.71**	-13.59**	-26.06**	42.10**	-8.62**	-24.88**	-30.15**
Priyanka x CO-1	33.16**	20.79**	13.94**	-23.95**	-40.54**	5.47**	-3.72**	-16.32**	-16.32**
Priyanka x GL	29.83**	17.55**	10.88**	-20.64**	-23.70**	46.65**	2.40**	-8.15**	-14.59**
Priyanka x Preethi	-20.45**	-48.85**	68.76**	4.34**	-11.30**	57.34**	19.68**	10.07**	-18.74**
Priyanka x KR	-1.37	-2.08	-7.64**	-7.84**	-11.18**	69.88**	20.20**	10.07**	-18.74**
Priyanka x USL	-0.02	-6.40**	1.22	-11.84**	-30.63**	23.05**	-15.05**	-27.40**	-46.40**
Priyanka x UB	1.3	-0.73	-2.46*	-38.59**	-55.34**	-20.77**	6.54**	-32.08**	-49.86**
Priyanka x MC-30	-33.55**	-56.71**	42.84**	-22.83**	-37.18**	11.43**	-28.62**	-41.80**	-31.88**
Priyanka x MC-105	-14.15**	-46.68**	75.93**	-26.07**	-38.08**	9.83**	0.47	-4.73**	-29.67**
Priyanka x MC-10	-19.47**	-52.31**	57.34**	-16.91**	-26.44**	30.49**	23.61**	11.94**	-17.36**
Preethi x CO-1	-10.21**	-44.66**	82.60**	-29.44**	-36.32**	-20.90**	-7.77**	-25.31**	-25.31**
Preethi x GL	-17.20**	-49.00**	68.26**	-28.40**	-41.06**	13.28**	-29.04**	-40.87**	-45.02**

Preethi x Priyanka	-22.71**	-50.31**	63.95**	-16.57**	-29.07**	25.81**	-25.13**	-31.15**	-49.17**
Preethi x KR	23.03**	22.78**	-5.71**	-27.37**	-40.10**	14.57**	-9.17**	-9.60**	-43.98**
Preethi x USL	13.99**	3.40**	-2.46*	-6.88**	-15.29**	5.22**	-8.05**	-15.18**	-47.44**
Preethi x UB	-3.01**	-40.21**	97.26**	-34.95**	-46.36**	-33.37**	-16.77**	-44.75**	-65.77**
Preethi x MC-30	81.26**	65.51**	53.85**	-41.73**	-44.73**	-31.35**	-59.44**	-68.98**	-63.69**
Preethi x MC-105	-7.40**	-20.82**	-14.37**	12.27**	10.24**	36.94**	-34.16**	-36.26**	-57.81**
Preethi x MC-10	4.67**	-6.76**	-8.39**	14.58**	9.35**	49.48**	6.70**	4.91**	-34.99**
KR x CO-1	4.35**	-7.92**	-7.92**	7.87**	-17.87**	57.10**	-3.58**	-22.20**	-22.20**
KR x GL	24.72**	22.04**	-2.46*	-36.34**	-36.49**	22.07**	-8.16**	-23.77**	-29.11**
KR x Priyanka	63.40**	46.68**	12.19**	-44.25**	-46.27**	2.77*	-32.48**	-38.17**	-54.36**
KR x Preethi	27.10**	26.84**	-2.59*	-27.22**	-39.97**	14.81**	-9.17**	-9.60**	-43.98**
KR x USL	46.91**	33.02**	25.48**	-36.07**	-51.03**	-6.33**	18.58**	9.86**	-32.57**
KR x UB	-17.72**	-49.32**	67.20**	-49.73**	-64.27**	-31.65**	83.74**	22.25**	-24.97**
KR x MC-30	12.27**	2.33*	-4.88**	-17.40**	-34.64**	25.02**	-5.04**	-27.62**	-15.28**
KR x MC-105	21.33**	3.58**	12.00**	-32.33**	-44.99**	5.22**	-26.81**	-29.47**	-53.32**
KR x MC-10	15.92**	3.08**	1.28	-28.94**	-39.07**	16.53**	11.21**	9.86**	-32.57**
USL x CO-1	-12.55**	-15.03**	-15.03**	16.54**	15.52**	17.58**	-21.47**	-40.18**	-40.18**
USL x GL	6.16**	-1.95	-7.51**	-31.67**	-47.75**	0.43	-6.26**	-26.74**	-31.88**
USL x Priyanka	21.54**	-0.03	-5.71**	-19.07**	-36.31**	12.97**	-8.47**	-21.78**	-42.25**
USL x Preethi	33.16**	20.79**	13.94**	-13.90**	-21.67**	-2.70*	4.66**	-3.46**	-40.18**
USL x KR	29.83**	17.55**	10.88**	-35.65**	-50.71**	-5.72**	19.79**	10.99**	-31.88**
USL x UB	-20.45**	-48.85**	68.76**	-28.37**	-35.81**	-34.67**	58.97**	10.30**	-42.25**
USL x MC-30	-1.37	-2.08	-7.64**	14.33**	9.38**	21.88**	11.04**	-19.65**	-5.95**
USL x MC-105	-0.02	-6.40**	1.22	7.10**	-0.92	18.62**	31.27**	17.55**	-22.20**
USL x MC-10	1.3	-0.73	-2.46*	5.10**	-8.32**	25.32**	20.15**	12.59**	-32.57**
UB x CO-1	-33.55**	-56.71**	42.84**	-37.94**	-43.95**	-43.95**	-45.39**	-67.15**	-67.15**
UB x GL	-14.15**	-46.68**	75.93**	-61.03**	-72.34**	-46.83**	-12.70**	-46.82**	-50.55**
UB x Priyanka	-19.47**	-52.31**	57.34**	-50.50**	-64.00**	-36.14**	-22.85**	-50.82**	-63.69**
UB x Preethi	-10.21**	-44.66**	82.60**	-42.81**	-52.85**	-41.43**	10.97**	-26.34**	-54.36**
UB x KR	-17.20**	-49.00**	68.26**	-52.98**	-66.58**	-36.08**	32.09**	-12.11**	-46.06**
UB x USL	-22.71**	-50.31**	63.95**	-23.85**	-31.76**	-30.55**	13.28**	-21.40**	-58.85**
UB x MC-30	-27.53**	-53.56**	53.23**	-30.69**	-40.26**	-33.44**	-14.90**	-50.07**	-41.56**
UB x MC-105	-28.19**	-52.33**	57.28**	-30.67**	-41.99**	-30.55**	16.75**	-23.72**	-49.52**
UB x MC-10	-29.27**	-54.11**	51.42**	-30.32**	-44.60**	-24.28**	-0.82	-33.60**	-60.24**
MC-30 x CO-1	22.20**	17.90**	17.90**	-22.44**	-26.42**	-18.01**	-29.58**	-34.71**	-23.58**
MC-30 x GL	26.62**	17.75**	9.45**	-42.06**	-54.24**	-12.05**	-46.00**	-51.55**	-43.29**
MC-30 x Priyanka	68.45**	39.35**	29.53**	-49.22**	-58.66**	-26.67**	-16.30**	-31.76**	-20.12**
MC-30 x Preethi	32.99**	21.44**	12.88**	-26.08**	-29.89**	-12.91**	-20.80**	-39.44**	-29.11**
MC-30 x KR	28.52**	17.14**	8.89**	-37.79**	-50.77**	-5.84**	-31.01**	-47.42**	-38.45**
MC-30 x USL	33.87**	32.89**	25.35**	-17.04**	-20.63**	-11.56**	-37.95**	-55.10**	-47.44**
MC-30 x UB	-25.82**	-52.46**	56.84**	-27.04**	-37.12**	-29.93**	-2.82**	-42.98**	-33.26**
MC-30 x MC-105	-0.08	-7.09**	0.47	-0.93	-4.36**	14.51**	-18.85**	-36.48**	-25.66**
MC-30 x MC-10	15.79**	12.66**	10.70**	-8.89**	-17.31**	13.03**	-9.32**	-31.46**	-19.78**
MC-105 x CO-1	3.91**	0.00	8.14**	8.48**	-0.46	19.18**	-15.52**	-29.81**	-29.81**
MC-105 x GL	31.39**	14.24**	23.54**	-35.68**	-47.81**	0.31	-0.94	-15.22**	-21.16**
MC-105 x Priyanka	18.77**	-7.21**	0.34	-11.50**	-25.88**	31.47**	-18.50**	-22.72**	-42.95**
MC-105 x Preethi	13.57**	-2.88**	5.02**	-7.33**	-9.01**	13.03**	-5.13**	-8.15**	-39.21**
MC-105 x KR	15.72**	-1.21	6.83**	-27.67**	-41.20**	12.48**	-32.99**	-35.42**	-57.26**
MC-105 x USL	30.05**	21.74**	31.65**	-22.64**	-28.44**	-14.32**	-36.99**	-43.57**	-62.66**
MC-105 x UB	-26.60**	-51.27**	60.77**	-24.51**	-36.83**	-24.37**	39.94**	-8.57**	-39.49**
MC-105 x MC-30	2.96**	-4.27**	3.52**	8.96**	5.18**	25.94**	-22.63**	-39.44**	-29.11**
MC-105 x MC-10	38.45**	32.12**	42.87**	-30.87**	-35.16**	-11.37**	19.03**	13.38**	-24.97**
MC-10 x CO-1	5.16**	4.24**	4.24**	17.22**	1.48	38.72**	-26.04**	-40.87**	-40.87**
MC-10 x GL	33.92**	21.42**	19.30**	-30.93**	-40.90**	13.58**	-8.58**	-24.85**	-30.12**
MC-10 x Priyanka	41.91**	14.88**	12.88**	-24.11**	-32.81**	19.18**	4.06**	-5.76**	-30.43**
MC-10 x Preethi	54.04**	37.23**	34.83**	-18.49**	-22.21**	6.33**	10.67**	8.82**	-32.57**
MC-10 x KR	39.90**	24.40**	22.23**	-24.14**	-34.96**	24.40**	28.31**	26.76**	-22.20**
MC-10 x USL	13.86**	11.58**	9.64**	3.71**	-9.53**	23.66**	20.15**	12.59**	-32.57**
MC-10 x UB	-30.96**	-55.20**	47.80**	-19.68**	-36.15**	-12.72**	2.63	-31.29**	-58.85**
MC-10 x MC-30	14.94**	11.84**	9.88**	-0.02	-9.26**	24.03**	-28.86**	-46.23**	-37.07**
MC-10 x MC-105	39.36**	32.99**	43.81**	-26.75**	-31.29**	-6.08**	-3.89**	-8.46**	-39.42**

* Significant at *P*=0.05   ** Significant at *P*=0.01

Heterosis for fruit characters: Heterosis for fruit characters *viz.*, length of fruit, girth of fruit and individual fruit weight are important as they contribute towards total yield. The highest heterosis over mid parent and better parent for fruit length was recorded in KR × UB (83.74%) and MC-10 × KR (26.76%) respectively (Table 2). Positive and significant relative heterosis was observed for fruit girth in forty five hybrids (Table 3). The heterosis over better parent for fruit girth ranged between -43.85 % (MC-105 × UB) and 56.85% (USL × UB) and the estimate of standard heterosis varied from -37.84 % (MC-30 × GL) to 38.51% (Priyanka × GL). For individual fruit weight significant positive relative heterosis was observed for forty three hybrids which ranged from 1.70 % (MC 105× GL) to 49.46 % (UB × USL). The estimate of heterobeltiosis had shown positively significant value for fifteen hybrids which ranged from 2.05% (MC-30 × MC-105) to 28.44 % (KR × USL). The study also revealed that sixty four hybrids had registered positively significant standard heterosis for this trait which ranged from -59.13 % (GL × UB) to 51.71 % (USL × MC-30) (Table 3). This is in accordance with the earlier reports of Rajeswari and Natarajan (1999).

Heterosis for yield characters: Twenty five hybrids had shown positively significant relative heterosis for number of fruits per vine. Higher estimates of relative heterosis were recorded in KR × USL (78.43 %), Preethi × MC-30 (75.69 %) and MC-105 × MC-10 (75.30 %). Heterosis over better parent ranged from -77.55 % (UB × CO-1) to 69.88 % (Preethi × MC-30) and sixteen hybrids had registered positive and significant values for this trait. Maximum standard heterosis of 129.07 % was observed in Preethi × UB followed by UB × Preethi (113.64 %) and KR × UB (95.12 %) for number of fruits per vine (Table 3). Similar results of heterosis for this trait had been reported earlier by Sirohi and Choudhury (1978) and Tewari and Ram (1999).

The relative heterosis for yield ranged from -59.61 % (Preethi

Table 3. Heterosis (per cent) over mid parent (di), better parent (dii) and standard parent (diii) for fruit length, fruit girth and individual fruit weight and number of fruits per vine

Hybrid	Fruit girth			Individual fruit weight			Number of fruits per vine		
	di	dii	diii	di	dii	diii	di	dii	diii
CO-1 x GL	-1.68*	-3.93**	0.68	5.99**	-9.01**	26.92**	-30.96**	-43.68**	-43.68**
CO-1 x Priyanka	-7.97**	-7.97**	-7.97**	-7.50**	-22.20**	14.04**	-20.23**	-35.44**	-35.44**
CO-1 x Preethi	-5.45**	-6.76**	-6.76**	0.25	-13.97**	20.10**	5.82**	-3.23**	-3.23**
CO-1 x KR	2.28**	-0.06	4.73**	3.81**	-0.12	8.06**	-26.32**	-39.40**	-39.40**
CO-1 x USL	-1.32	-8.78**	-8.78**	-27.17**	-32.22**	-32.22**	-16.85**	-17.77**	-15.92**
CO-1 x UB	20.44**	-4.05**	-4.05**	32.84**	-20.70**	-20.70**	-20.83**	-50.10**	91.55**
CO-1 x MC-30	4.62**	-7.43**	-7.43**	14.81**	5.16**	26.40**	-13.84**	-18.68**	-18.68**
CO-1 x MC-105	27.36**	19.39**	36.49**	8.68**	2.05*	16.22**	-36.23**	-42.02**	-42.02**
CO-1 x MC-10	-15.27**	-17.16**	-17.16**	-7.37**	-16.44**	3.90**	25.50**	25.37**	25.64**
GL x CO-1	-10.92**	-12.96**	-8.78**	6.09**	-8.93**	27.03**	-10.49**	-26.99**	-26.99**
GL x Priyanka	-24.78**	-26.50**	-22.97**	-20.17**	-22.10**	14.19**	40.86**	39.45**	-11.96**
GL x Preethi	3.68**	-0.06	4.73**	-15.39**	-15.43**	18.06**	85.99**	63.83**	35.79**
GL x KR	12.19**	12.19**	17.57**	-12.16**	-22.01**	8.78**	-3.64*	-4.64**	-38.51**
GL x USL	-25.90**	-32.95**	-29.73**	1.08	-18.25**	14.03**	3.31*	-16.45**	-14.57**
GL x UB	-13.54**	-32.30**	-29.05**	-48.55**	-70.70**	-59.13**	-17.93**	-52.22**	83.44**
GL x MC-30	10.78**	-3.93**	0.68	4.21**	-2.99**	35.31**	-31.07**	-41.02**	-47.65**
GL x MC-105	-18.29**	-21.69**	-10.47**	0.00	-9.18**	26.68**	-43.00**	-49.52**	-58.68**
GL x MC-10	-18.38**	-21.99**	-18.24**	-13.66**	-18.35**	13.89**	-40.28**	-51.33**	-51.22**
Priyanka x CO-1	2.03**	2.03**	2.03**	5.63**	-11.15**	30.24**	65.72**	34.13**	34.13**
Priyanka x GL	35.27**	32.17**	38.51**	-2.73**	-5.09**	39.13**	-2.28	-3.27	-38.93**
Priyanka x Preethi	26.76**	25.00**	25.00**	-11.56**	-13.67**	26.55**	-8.16**	-19.81**	-33.53**
Priyanka x KR	-19.50**	-21.34**	-17.57**	3.49**	-10.06**	31.83**	14.25**	11.93**	-27.82**
Priyanka x USL	-8.63**	-15.54**	-15.54**	3.21**	-18.07**	20.10**	-36.20**	-48.80**	-47.65**
Priyanka x UB	18.74**	-5.41**	-5.41**	-3.93**	-45.61**	-20.27**	-20.78**	-54.01**	76.56**
Priyanka x MC-30	26.00**	11.49**	11.49**	-17.00**	-24.48**	10.71**	-4.16**	-18.68**	-27.82**
Priyanka x MC-105	-4.16**	-10.17**	2.70**	-21.97**	-30.67**	1.63	-25.47**	-34.57**	-46.44**
Priyanka x MC-10	17.48**	14.86**	14.86**	-8.20**	-15.17**	24.35**	-26.74**	-40.76**	-40.63**
Preethi x CO-1	18.53**	16.89**	16.89**	5.80**	-9.21**	26.74**	30.20**	19.06**	19.06**
Preethi x GL	-1.00	-4.58**	0.00	-24.11**	-24.14**	5.90**	-12.98**	-23.35**	-36.47**
Preethi x Priyanka	8.94**	7.43**	7.43**	-7.21**	-9.42**	32.78**	-4.49**	-16.60**	-30.87**
Preethi x KR	5.69**	1.87**	6.76**	7.22**	-4.84**	32.84**	-28.96**	-36.84**	-47.65**
Preethi x USL	-10.20**	-15.91**	-18.24**	2.20*	-17.37**	15.35**	-26.18**	-33.17**	-31.67**
Preethi x UB	17.39**	-5.49**	-8.11**	3.32**	-41.16**	-17.86**	-1.85**	-40.33**	129.07**
Preethi x MC-30	5.51**	-5.49**	-8.11**	5.73**	-1.62*	37.34**	75.69**	69.88**	50.78**
Preethi x MC-105	4.12**	-3.66**	10.14**	0.2	-9.03**	27.00**	-45.11**	-45.45**	-54.79**
Preethi x MC-10	8.66**	7.71**	4.73**	-0.56	-6.00**	31.22**	-45.20**	-49.94**	-49.83**
KR x CO-1	-30.06**	-31.66**	-28.38**	12.13**	7.88**	16.72**	-2.59	-19.89**	-19.89**
KR x GL	-25.85**	-25.85**	-22.30**	-7.95**	-18.28**	13.99**	10.25**	9.10**	-29.65**
KR x Priyanka	-17.52**	-19.41**	-15.54**	-20.20**	-30.65**	1.65	18.77**	16.36**	-24.97**

KR x Preethi	13.04**	8.96**	14.19**	6.41**	-5.56**	31.83**	-45.10**	-51.20**	-59.55**
KR x USL	11.15**	0.58	5.41**	43.01**	28.44**	38.96**	78.43**	45.48**	48.74**
KR x UB	3.75**	-18.76**	-14.86**	-22.95**	-54.57**	-50.85**	-12.97**	-49.17**	95.12**
KR x MC-30	7.81**	-6.51**	-2.03**	13.28**	7.62**	29.36**	7.66**	-7.06**	-17.51**
KR x MC-105	-4.41**	-8.39**	4.73**	6.82**	4.14**	18.61**	-0.27	-10.85**	-27.03**
KR x MC-10	-10.29**	-14.25**	-10.14**	-2.04*	-8.40**	13.89**	-13.85**	-29.20**	-29.05**
USL x CO-1	1.61*	-6.08**	-6.08**	17.00**	8.89**	8.89**	-48.23**	-48.80**	-47.65**
USL x GL	-32.31**	-38.75**	-35.81**	-11.81**	-28.68**	-0.52	-31.89**	-44.92**	-43.68**
USL x Priyanka	-23.25**	-29.05**	-29.05**	-43.08**	-54.82**	-33.77**	8.84**	-12.65**	-10.69**
USL x Preethi	12.80**	5.63**	2.70**	-30.12**	-43.50**	-21.13**	-19.54**	-27.15**	-25.52**
USL x KR	-18.77**	-26.50**	-22.97**	35.58**	21.76**	31.73**	-22.93**	-37.16**	-35.75**
USL x UB	84.63**	56.85**	33.11**	6.75**	-34.61**	-43.67**	-20.44**	-49.63**	93.38**
USL x MC-30	-20.67**	-24.36**	-35.81**	47.05**	26.22**	51.71**	-32.23**	-36.70**	-35.28**
USL x MC-105	-15.20**	-26.12**	-15.54**	41.73**	24.46**	41.74**	-26.37**	-33.71**	-32.22**
USL x MC-10	-15.36**	-20.08**	-23.65**	-42.87**	-51.64**	-39.88**	-20.86**	-21.64**	-19.89**
UB x CO-1	-5.00**	-24.32**	-24.32**	19.02**	-28.95**	-28.95**	-64.38**	-77.55**	-13.82**
UB x GL	-0.37	-21.99**	-18.24**	-1.38	-43.84**	-21.66**	-21.58**	-54.34**	75.29**
UB x Priyanka	14.50**	-8.78**	-8.78**	-38.71**	-65.30**	-49.14**	-25.93**	-56.99**	65.10**
UB x Preethi	39.84**	12.58**	9.46**	-8.69**	-48.00**	-27.41**	-8.46**	-44.35**	113.64**
UB x KR	13.63**	-11.03**	-6.76**	19.25**	-29.69**	-23.93**	-14.74**	-50.21**	91.16**
UB x USL	32.15**	12.26**	-4.73**	49.46**	-8.45**	-21.14**	-21.49**	-50.29**	90.84**
UB x MC-30	4.12**	-7.81**	-29.05**	26.62**	-26.48**	-11.63**	-29.12**	-56.36**	67.52**
UB x MC-105	5.06**	-20.21**	-8.78**	21.82**	-28.72**	-18.82**	-20.21**	-51.60**	85.80**
UB x MC-10	0.35	-18.67**	-22.30**	26.74**	-26.75**	-8.92**	-32.92**	-57.71**	62.36**
MC-30 x CO-1	12.26**	-0.68	-0.68	31.14**	20.12**	44.38**	-7.13**	-12.35**	-12.35**
MC-30 x GL	-31.60**	-40.68**	-37.84**	-1.68*	-8.47**	27.66**	5.48**	-9.74**	-19.89**
MC-30 x Priyanka	-3.78**	-14.86**	-14.86**	6.11**	-3.44**	41.54**	25.91**	6.84**	-5.18**
MC-30 x Preethi	28.01**	14.66**	11.49**	-13.70**	-19.70**	12.10**	3.14*	-0.27	-11.48**
MC-30 x KR	30.11**	12.83**	18.24**	1.16	-3.89**	15.52**	26.92**	9.56**	-2.76*
MC-30 x USL	-6.47**	-10.83**	-24.32**	12.81**	-3.17**	16.39**	-20.10**	-25.37**	-23.70**
MC-30 x UB	58.65**	40.47**	8.11**	40.06**	-18.67**	-2.25*	-31.11**	-57.59**	62.80**
MC-30 x MC-105	15.15**	-3.66**	10.14**	4.80**	2.05*	22.66**	-21.85**	-24.89**	-33.33**
MC-30 x MC-10	-2.08*	-11.60**	-15.54**	5.05**	3.30**	28.43**	-16.39**	-21.17**	-21.00**
MC-105 x CO-1	-33.80**	-37.94**	-29.05**	8.90**	2.26**	16.46**	-11.90**	-19.89**	-19.89**
MC-105 x GL	-18.35**	-21.75**	-10.54**	1.70*	-7.63**	28.84**	5.03**	-6.98**	-23.85**
MC-105 x Priyanka	-13.62**	-19.03**	-7.43**	-8.70**	-18.88**	18.91**	16.56**	2.33	-16.24**
MC-105 x Preethi	-19.77**	-25.77**	-15.14**	-9.11**	-17.48**	15.20**	-7.37**	-7.94**	-23.70**
MC-105 x KR	-22.66**	-25.89**	-15.27**	11.68**	8.88**	24.01**	-5.69**	-15.70**	-30.99**
MC-105 x USL	-9.77**	-21.39**	-10.14**	-37.02**	-44.69**	-37.01**	32.31**	19.12**	21.79**
MC-105 x UB	-26.07**	-43.85**	-35.81**	23.43**	-27.78**	-17.75**	-22.51**	-52.99**	80.47**
MC-105 x MC-30	-11.69**	-26.12**	-15.54**	-10.90**	-13.23**	4.29**	-13.97**	-17.31**	-26.61**
MC-105 x MC-10	19.12**	9.34**	25.00**	-12.84**	-16.50**	3.82**	75.30**	59.24**	59.59**
MC-10 x CO-1	14.72**	12.16**	12.16**	5.40**	-4.91**	18.23**	-2.70*	-2.81*	-2.60*
MC-10 x GL	18.04**	12.83**	18.24**	-11.04**	-15.87**	17.35**	61.40**	31.54**	31.83**
MC-10 x Priyanka	-1.87*	-4.05**	-4.05**	-11.98**	-18.66**	19.24**	5.21**	-14.92**	-14.73**
MC-10 x Preethi	6.55**	5.63**	2.70**	-10.53**	-15.43**	18.06**	-1.32	-9.85**	-9.66**
MC-10 x KR	-6.24**	-10.38**	-6.08**	-7.49**	-13.49**	7.56**	-5.13**	-22.04**	-21.87**
MC-10 x USL	17.60**	11.03**	6.08**	13.14**	-4.24**	19.06**	-2.37*	-3.34**	-1.17
MC-10 x UB	9.08**	-11.60**	-15.54**	-17.84**	-52.52**	-40.96**	-39.18**	-61.65**	47.21**
MC-10 x MC-30	-19.31**	-27.16**	-30.41**	-10.34**	-11.83**	9.63**	-23.27**	-27.66**	-27.50**
MC-10 x MC-105	11.40**	2.25**	16.89**	-2.01*	-6.13**	16.72**	30.08**	18.16**	18.42**

* Significant at *P*=0.05 ** Significant at *P*=0.01

× CO-1) to 119.75 % (KR × USL). Among the ninety hybrids, twenty five were found to express mid parental heterosis in the positive direction. The relative heterosis was also high for the hybrids Preethi x MC-30 (81.29 %), MC-105 × MC-10 (51.17%) and Priyanka × CO-1 (42.56%). The heterobeltiosis was positive and significant in seventeen hybrids. It was the highest in KR × USL (111.9%), followed by Preethi × MC-30 (63.64%). The estimates of standard heterosis revealed that twelve hybrids had shown positive and significant estimates, which ranged between 1.48 % (CO-1 × UB) and 86.21 % (Preethi × MC-30). The standard heterosis was also high for KR × USL (75.37 per cent) (Table 4). This is in conformity to the earlier findings of Tewari *et al.* (2001) and Chaubey and Ram (2004).

Heterosis for quality: Quality parameters are also an important factor in hybrid development. In bitter gourd iron and ascorbic acid are the major quality factors. For ascorbic acid content,

Table 4. Heterosis (%) over mid parent (di), better parent (dii) and standard parent (diii) for yield of fruits per vine, ascorbic acid content and iron content

Hybrid	Yield of fruits per vine			Ascorbic acid content			Iron content		
	di	dii	diii	di	dii	di	dii	dii	diii
CO-1 x GL	-46.56**	-50.25**	-50.25**	-17.57**	-18.30**	-17.57**	-18.30**	-17.57**	-18.30**
CO-1 x Priyanka	-32.64**	-36.45**	-36.45**	-11.85**	-11.93**	-11.85**	-11.93**	-11.85**	-11.93**
CO-1 x Preethi	-3.23**	-9.09**	3.45**	-25.09**	-26.01**	-25.09**	-26.01**	-25.09**	-26.01**
CO-1 x KR	-32.08**	-37.93**	-37.93**	-15.61**	-22.03**	-15.61**	-22.03**	-15.61**	-22.03**
CO-1 x USL	-33.15**	-40.89**	-40.89**	-26.54**	-30.92**	-26.54**	-30.92**	-26.54**	-30.92**
CO-1 x UB	18.73**	1.48*	1.48*	-2.53**	-17.59**	-2.53**	-17.59**	-2.53**	-17.59**
CO-1 x MC-30	-16.71**	-20.20**	-20.20**	-49.49**	-51.12**	-49.49**	-51.12**	-49.49**	-51.12**
CO-1 x MC-105	-51.02**	-52.71**	-52.71**	-33.52**	-34.25**	-33.52**	-34.25**	-33.52**	-34.25**
CO-1 x MC-10	24.70**	16.26**	16.26**	-3.93**	-5.80**	-3.93**	-5.80**	-3.93**	-5.80**
GL x CO-1	-38.62**	-42.86**	-42.86**	-18.38**	-19.11**	-18.38**	-19.11**	-18.38**	-19.11**
GL x Priyanka	-6.48**	-7.78**	-18.23**	-36.96**	-37.46**	-36.96**	-37.46**	-36.96**	-37.46**
GL x Preethi	35.96**	19.48**	35.96**	-0.29	-2.37**	-0.29	-2.37**	-0.29	-2.37**
GL x KR	-46.94**	-48.00**	-55.17**	-46.25**	-49.93**	-46.25**	-49.93**	-46.25**	-49.93**
GL x USL	1.51	-4.00**	-17.24**	-43.73**	-46.64**	-43.73**	-46.64**	-43.73**	-46.64**
GL x UB	-14.73**	-22.29**	-33.00**	-1.74*	-16.31**	-1.74*	-16.31**	-1.74*	-16.31**
GL x MC-30	-47.37**	-48.92**	-53.20**	-24.47**	-26.28**	-24.47**	-26.28**	-24.47**	-26.28**
GL x MC-105	-54.95**	-56.61**	-59.61**	-46.62**	-46.74**	-46.62**	-46.74**	-46.62**	-46.74**
GL x MC-10	-44.08**	-44.16**	-51.72**	-21.83**	-22.67**	-21.83**	-22.67**	-21.83**	-22.67**
Priyanka x CO-1	42.56**	34.48**	34.48**	11.71**	11.60**	11.71**	11.60**	11.71**	11.60**
Priyanka x GL	-27.89**	-28.89**	-36.95**	-10.04**	-10.75**	-10.04**	-10.75**	-10.04**	-10.75**
Priyanka x Preethi	-26.03**	-34.20**	-25.12**	-50.28**	-50.94**	-50.28**	-50.94**	-50.28**	-50.94**
Priyanka x KR	-38.51**	-40.56**	-47.29**	-50.86**	-54.56**	-50.86**	-54.56**	-50.86**	-54.56**
Priyanka x USL	-51.19**	-54.44**	-59.61**	-3.99**	-9.63**	-3.99**	-9.63**	-3.99**	-9.63**
Priyanka x UB	9.88**	-1.11	-12.32**	14.81**	-2.85**	14.81**	-2.85**	13.92**	-3.57**
Priyanka x MC-30	-25.68**	-26.88**	-33.00**	-24.15**	-26.53**	-24.15**	-26.53**	-24.15**	-26.53**
Priyanka x MC-105	-51.76**	-52.91**	-56.16**	-33.45**	-34.12**	-33.45**	-34.12**	-33.45**	-34.12**
Priyanka x MC-10	-48.24**	-48.89**	-54.68**	-5.76**	-7.51**	-5.76**	-7.51**	-5.76**	-7.51**
Preethi x CO-1	11.52**	4.76**	19.21**	-7.04**	-8.18**	-7.04**	-8.18**	-7.04**	-8.18**
Preethi x GL	-59.61**	-64.50**	-59.61**	-35.59**	-36.94**	-35.59**	-36.94**	-35.59**	-36.94**
Preethi x Priyanka	-50.85**	-56.28**	-50.25**	-34.96**	-35.82**	-34.96**	-35.82**	-34.96**	-35.82**
Preethi x KR	-50.88**	-57.58**	-51.72**	-22.02**	-28.77**	-26.98**	-56.61**	-57.44**	-43.75**
Preethi x USL	-38.50**	-48.48**	-41.38**	-28.67**	-33.69**	-32.03**	-32.76**	-46.02**	-28.66**
Preethi x UB	21.60**	-1.30*	12.32**	8.40**	-9.26**	-6.99**	-25.48**	-32.18**	-10.37**
Preethi x MC-30	81.29**	63.64**	86.21**	7.46**	2.76**	5.33**	4.67**	-6.92**	23.01**
Preethi x MC-105	-54.76**	-58.87**	-53.20**	-9.84**	-11.91**	-9.70**	-31.81**	-43.25**	-25.00**
Preethi x MC-10	-58.18**	-63.20**	-58.13**	-15.29**	-17.93**	-15.87**	-21.10**	-35.29**	-14.49**
KR x CO-1	-25.07**	-31.53**	-31.53**	6.14**	-1.94**	-1.94**	-26.71**	-34.53**	-16.77**
KR x GL	-43.44**	-44.57**	-52.22**	2.87**	-4.17**	-5.88**	-40.61**	-47.12**	-32.78**
KR x Priyanka	-47.70**	-49.44**	-55.17**	-35.41**	-40.28**	-40.39**	-37.83**	-45.32**	-30.49**
KR x Preethi	-51.88**	-58.44**	-52.71**	-4.34**	-12.61**	-10.42**	-47.80**	-48.79**	-32.32**
KR x USL	119.75**	111.90**	75.37**	24.12**	21.80**	7.26**	26.71**	3.24**	31.24**
KR x UB	12.50**	4.46**	-13.55**	23.13**	11.75**	-5.27**	-41.75**	-46.04**	-31.41**
KR x MC-30	2.82**	-2.15**	-10.34**	4.33**	-0.55	-6.99**	-36.78**	-42.81**	-27.29**
KR x MC-105	-30.53**	-34.39**	-38.92**	11.63**	4.20**	1.90**	-31.91**	-42.45**	-26.83**
KR x MC-10	-42.94**	-44.16**	-51.72**	-19.26**	-24.02**	-26.98**	-36.93**	-47.48**	-33.24**
USL x CO-1	-43.73**	-50.25**	-50.25**	-2.59**	-8.40**	-8.40**	-19.73**	-27.75**	-27.75**
USL x GL	-51.06**	-53.71**	-60.10**	-11.53**	-16.10**	-17.59**	-11.22**	-19.82**	-20.43**
USL x Priyanka	-45.24**	-48.89**	-54.68**	-54.63**	-57.30**	-57.38**	-7.77**	-15.64**	-18.60**
USL x Preethi	-52.45**	-60.17**	-54.68**	-10.02**	-16.35**	-14.26**	-40.09**	-51.90**	-36.44**
USL x KR	-28.40**	-30.95**	-42.86**	-18.78**	-20.30**	-29.81**	-38.19**	-49.64**	-35.98**
USL x UB	10.00**	5.77**	-18.72**	17.34**	4.70**	-7.79**	-12.14**	-23.63**	-17.23**
USL x MC-30	-26.32**	-32.26**	-37.93**	-25.37**	-27.55**	-32.23**	-15.50**	-24.89**	-22.72**
USL x MC-105	-29.86**	-35.98**	-40.39**	-36.74**	-39.88**	-41.21**	-30.79**	-33.85**	-41.92**
USL x MC-10	-40.87**	-44.16**	-51.72**	-14.24**	-17.82**	-21.02**	6.11**	3.24**	-12.66**
UB x CO-1	-44.67**	-52.71**	-52.71**	-1.46	-16.68**	-16.68**	-20.56**	-23.63**	-17.23**
UB x GL	22.26**	11.43**	-3.94**	18.90**	1.27	-0.52	-16.74**	-20.25**	-13.57**
UB x Priyanka	-12.35**	-21.11**	-30.05**	0.93	-14.59**	-14.76**	-47.77**	-50.63**	-46.50**

UB x Preethi	-6.67**	-24.24**	-13.79**	-14.67**	-28.57**	-26.78**	-47.15**	-51.90**	-36.44**
UB x KR	7.69**	0	-17.24**	10.40**	0.19	-15.07**	-43.69**	-47.84**	-33.69**
UB x USL	27.33**	22.44**	-5.91**	-6.44**	-16.51**	-26.48**	-19.42**	-29.96**	-24.09**
UB x MC-30	18.79**	5.38**	-3.45**	4.45**	-9.19**	-15.07**	-24.68**	-26.58**	-20.43**
UB x MC-105	11.71**	-1.59*	-8.37**	-10.92**	-23.99**	-25.67**	-41.72**	-47.26**	-42.84**
UB x MC-10	17.06**	6.55**	-7.88**	-4.14**	-17.61**	-20.82**	-51.66**	-56.96**	-53.36**
MC-30 x CO-1	-0.77	-4.93**	-4.93**	-17.86**	-20.52**	-20.52**	-48.16**	-48.89**	-47.41**
MC-30 x GL	-3.60**	-6.45**	-14.29**	0.49	-1.91**	-3.65**	-27.15**	-28.44**	-26.38**
MC-30 x Priyanka	4.92**	3.23**	-5.42**	-15.69**	-18.34**	-18.50**	-26.61**	-28.89**	-26.83**
MC-30 x Preethi	-32.37**	-38.96**	-30.54**	-22.42**	-25.81**	-23.95**	-32.68**	-40.14**	-20.89**
MC-30 x KR	-1.69*	-6.45**	-14.29**	-20.36**	-24.09**	-29.00**	-34.39**	-40.65**	-24.55**
MC-30 x USL	-4.68**	-12.37**	-19.70**	1.55*	-1.41	-7.79**	-16.50**	-25.78**	-23.63**
MC-30 x UB	9.70**	-2.69**	-10.84**	-15.30**	-26.36**	-31.12**	-47.62**	-48.95**	-44.67**
MC-30 x MC-105	-49.33**	-49.74**	-53.20**	-21.03**	-22.75**	-24.46**	-32.37**	-37.33**	-35.52**
MC-30 x MC-10	-34.16**	-36.02**	-41.38**	-0.2	-1.53*	-5.37**	-42.44**	-47.56**	-46.04**
MC-105 x CO-1	-25.51**	-28.08**	-28.08**	-49.25**	-49.81**	-49.81**	-12.83**	-18.15**	-18.15**
MC-105 x GL	-44.51**	-46.56**	-50.25**	-0.36	-0.58	-2.34**	-2.69**	-8.29**	-9.00**
MC-105 x Priyanka	-22.49**	-24.34**	-29.56**	-16.28**	-17.12**	-17.29**	-44.91**	-47.39**	-49.24**
MC-105 x Preethi	-53.33**	-57.58**	-51.72**	-39.80**	-41.18**	-39.71**	-26.40**	-38.75**	-19.06**
MC-105 x KR	-36.69**	-40.21**	-44.33**	36.97**	27.85**	25.03**	-16.17**	-29.14**	-9.91**
MC-105 x USL	-47.25**	-51.85**	-55.17**	5.09**	-0.13	-2.34**	-41.14**	-43.75**	-50.61**
MC-105 x UB	11.11**	-2.12**	-8.87**	13.40**	-3.23**	-5.37**	-20.28**	-27.85**	-21.80**
MC-105 x MC-30	-56.27**	-56.61**	-59.61**	-7.20**	-9.22**	-11.23**	-36.21**	-40.89**	-39.18**
MC-105 x MC-10	51.17**	45.77**	35.71**	6.08**	5.16**	2.84**	28.91**	26.56**	11.12**
MC-10 x CO-1	-42.93**	-46.80**	-46.80**	-14.10**	-15.77**	-15.77**	-8.34**	-15.40**	-15.40**
MC-10 x GL	30.10**	29.91**	12.32**	0.93	-0.16	-1.94**	-39.30**	-43.78**	-44.21**
MC-10 x Priyanka	-10.55**	-11.67**	-21.67**	-48.76**	-49.71**	-49.81**	-40.40**	-44.08**	-46.04**
MC-10 x Preethi	-41.94**	-48.92**	-41.87**	-11.22**	-13.99**	-11.83**	-54.85**	-62.98**	-51.07**
MC-10 x KR	-47.02**	-48.15**	-55.17**	-40.37**	-43.88**	-46.07**	-54.64**	-62.23**	-51.98**
MC-10 x USL	-4.07**	-9.40**	-21.67**	-15.22**	-18.77**	-21.93**	-3.89**	-6.49**	-20.89**
MC-10 x UB	-31.14**	-37.32**	-45.81**	-44.49**	-52.29**	-54.15**	-28.44**	-36.29**	-30.95**
MC-10 x MC-30	-46.89**	-48.39**	-52.71**	-47.38**	-48.09**	-50.11**	-48.29**	-52.89**	-51.53**
MC-10 x MC-105	23.73**	19.31**	11.08**	-31.04**	-31.63**	-33.14**	-20.42**	-21.88**	-31.41**

* Significant at *P*=0.05 ** Significant at *P*=0.01

positive and significant relative heterosis was observed for nineteen hybrids which ranged between 1.55 % in MC-30 × USL and 36.97 % in MC-105 × KR. It was also high for the hybrids KR × USL (24.12 %) and KR × UB (23.13 %). The estimate of heterobeltiosis had shown positively significant value for eight hybrids only. Six hybrids had registered positively significant standard heterosis, which ranged from 1.9 % in KR × MC-105 to 25.03 % in MC-105 × KR (Table 4).

Only eight hybrids showed positively significant relative heterosis for iron content and it was the highest in MC-105 × MC-10 (28.91 %) followed by KR × USL (26.71 %). The highest heterobeltiosis was observed in the hybrid combination MC-105 × MC-10 (26.56 %) and only five hybrids registered significant and positive heterosis over mid parent. The estimate of standard heterosis was significant and positive for six hybrids and the highest percentage was observed in KR × USL (31.24 %) followed by Preethi × MC-30 (23.01 %). The results are in corroboration with earlier reports of Rajeswari and Natarajan (1999).

The results from the present study suggest that from economic point of view, it is useful to select hybrids having one or more important characters like earliness, higher fruit number, higher yield and quality parameters in order to achieve higher gains in the F_1 hybrids through heterosis breeding. The hybrid Preethi × MC-30 had registered favourable values of heterosis for the most important characters like number of female flowers per vine, number of fruits and yield of fruits. In order of merit the hybrids *viz.*, Preethi × MC-30, KR × USL and MC-105 × MC-10 were noted to be the top performing hybrids with respect to yield and quality parameters since they showed significant heterotic values. These three hybrids can be well exploited through heterosis breeding to obtain higher yield with quality fruits. Moreover, these hybrids could be better utilized for the improvement of the characters concerned and intermating among superior segregants resulting from these heterotic hybrids, is likely to throw desirable progenies in the subsequent later generations.

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