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Study of heterosis in bitter gourd (*Momordica charantia* L.)

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ABSTRACT

Abstract: The present experiment was conducted to estimate the heterosis of 21 hybrids in bitter gourd during 2024 - 2025 at AICRP on Vegetable Crops, Department of Horticulture, M.P.K.V., Rahuri. The 21 hybrids derived from half diallel crosses from seven genetically diverse bitter gourd genotypes and which were evaluated along with the seven parents and one standard check in Kharif, 2025. Among the 21 F₁s, the crosses viz., 1 x 2, 1 x 3, 1 x 6 and 5 x 6 showed significantly highest negative heterosis for the days to first female flower appearance in desirable direction over better parent, top parent and standard check indicating earliness. While for yield and yield contributing traits the crosses, 1 x 3, 2 x 3, 3 x 5 and 5 x 6 showed significantly highest positive heterosis over better parent, top parent and standard check. These hybrids showed considerable potential for exploitation of heterosis, particularly for fruit yield and other desirable traits. Therefore, they may be considered promising hybrids for further study. Moreover these crosses could serve as valuable genetic resources in future bitter gourd breeding programmes aimed at developing high-yielding cultivar with desirable agronomic traits.

Keywords: Bitter gourd, Heterosis, Hybrid, Yield

Introduction

Cucurbitaceous crops are the largest group of vegetables grown in India and throughout the world. Bitter gourd (*Momordica charantia* L.) is one of the important cultivated cucurbits originated from Indo Burma region and has a place of high value. Bitter gourd is well known for nutritional, medicinal (antidiabetic) and other curative properties and due to these properties, tender green fruits have captured a prominent position among vegetables. (Behera et al., 2008) [1].

In India, it is grown mainly in Madhya Pradesh, Maharashtra, Gujarat, Rajasthan, Punjab, Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, West Bengal, Odisha, Assam, Uttar Pradesh and Bihar. Madhya Pradesh is highest producer of bitter gourd. The total area under bitter gourd in India is 133.46 hectares with a total production of 1716.3 metric tonnes annually with productivity of 12.86 MT per ha. In Maharashtra the total area under bitter gourd is 7,100 hectares with a total production of 72,200 metric tonnes annually with productivity of 10.50 MT per ha (Anonymous, 2025) [2].

Despite the rapid expansion in the cultivation area and total production of bitter gourd, the crop has not been extensively studied or improved through traditional breeding methods. Consequently, significant opportunities exist for developing new and better cultivars. Heterosis breeding is a widely adopted and effective breeding strategy for improving yield and other economically important characteristics. However, the expression of heterosis varies among cross combinations, since only certain parental combinations produce superior hybrids. Therefore, the success of a heterosis breeding programme in bitter gourd depends on a thorough understanding of the magnitude and nature of genetic variability controlling quantitatively inherited traits, along with the systematic assessment of parental performance and their combining ability in different hybrid combinations.

Materials and Methods

The experimental material for present investigation comprised seven promising and genetically diverse parental lines of bitter gourd viz., RHRBIG -07, RHRBIG -10, RHRBIG -49, RHRBIG -24, RHRBIG -59, Phule Green Gold and Hirkani. The seeds of genotypes used as parents were sown during summer, 2025 to constitute a crossing block. The crossing among the parents was followed in half diallel fashion, to obtain self and crossed seeds to raise the F₁. In order to get enough crossed seeds, the female and male flowers, which were open during evening, were bagged separately with butter paper bag a day prior to anthesis. On the next day morning, bagged flower buds from desired male parents were plucked and the pollens were dusted on the receptive stigma of bagged female flowers to get assured good cross seed sets, the pollination was repeated by adopting same procedure. The dusted female flowers were covered with butter paper bag and labeled properly with details of the crossing and date of pollination. The covered butter paper bag re

moved after three to four days after pollination to accelerate fruit development. The seeds were extracted from fully matured and healthy fruits. The extracted seeds were dried and stored properly for raising crossing block. In this way sufficient selfed and crossed seeds were obtained at the end of summer, 2025. These collected seeds of parents and F_1 progenies were used for evaluation in last week of June, 2025. The data were analysed for five quantitative characters. Data were collected on various parameters including quantitative traits viz., days

to first female flower appearance, number of fruits per vine, sex ratio, fruit yield per vine in kg, fruit yield (q/ha).

Estimation of heterosis

The values of F_1 averaged over replications were used for estimating heterosis. The magnitude of heterosis was calculated as percentage increase or decrease of F_1 mean over the mean of better parent (BP) (Turner, 1953 and Hays *et al.* 1955) [3]. Similarly per cent superiority over the top parent (Top) and standard hybrid check (SC) were calculated.

$$\text{Per cent heterosis over better parent (BP)} = \frac{F_1 - BP}{BP} \times 100$$

$$\text{Per cent heterosis over top parent (TP)} = \frac{F_1 - TP}{TP} \times 100$$

$$\text{Per cent heterosis over standard check (SC)} = \frac{F_1 - SC}{SC} \times 100$$

Heterobeltiosis and standard heterosis were estimated for all the characters by calculating the average heterotic effect across all hybrid combinations. The experimental data were subjected to statistical analysis following the procedure outlined by Panse *et al.* (1985) [4]. Heterosis (%) over the better parent, top parent and standard check was estimated following the methods described by Turner (1953) [3] and Hayes *et al.* (1955) [5].

Result and Discussion

The analysis of variance was carried out to assess the significance of character-wise variation among replications, parents, and other sources contributing to the total variation. The results presented in Table 1 indicated that significant differences was existed among the parents as well as in the cross combinations for all the characters studied.

In the present study, heterosis was estimated for yield and its components in 21 cross combinations and expressed as a percentage of heterosis increase or decrease over the better parent, top parent and the standard check. The results are presented and discussed in Table 2.

Days to first female flower appearance

All cross combinations over better parent, top parent and standard check showed highly significant negative heterosis for days to first female flowering in positive direction. The range of heterosis ranged from (-10.27) to (-16.05), (-12.51) to (-10.93) and (-10.93) to (-14.53) over better parent, top parent and standard check respectively. Among the 21 F_1 s, the cross, 1 x 2 (-15.25, -16.00, -14.48), 1 x 3 (-15.58, -16.32, -14.81) and 5 x 6 (-16.05, -16.05, -14.53) showed highest percentage of negative heterosis in positive direction over better parent, top parent and standard check respectively.

The negative heterosis for this trait indicated earliness, which is a desirable trait in bitter gourd. The F_1 hybrids exhibited variation in flowering time due to differences in vegetative phases. The results are in the present investigation are in line with the Maurya *et al.* (2009) [6], Thangamani *et al.* (2011a) [7], Kushwaha *et al.* (2011) [8], Dey *et al.* (2012) [9], Laxuman *et al.* (2012) [10], Talekar *et al.* (2013) [11], Verma *et al.* (2014) [12], Bhatt *et al.* (2017) [13], Adarsh *et al.* (2018) [14] and Malve *et al.* (2021) [15] in bitter gourd.

B. Sex ratio

As regards to sex ratio, the range of heterobeltiosis varied from -41.91 to 34.50 while the percentage of heterosis varied from -41.91 to 15.41 and -25.09 to 48.83 over top parent and standard check respectively. Among the 21 F_1 hybrids evaluated, the crosses 3 x 5 (-30.79, -31.88, -12.15), 5 x 6 (-41.91, -41.91, -25.09) and 6 x 7 (-38.31, 38.31, -20.45) showed highest percentage of negative heterosis over better

parent, top parent and standard check respectively. The negative heterosis for sex ratio is directly correlated to yield per vine as it is the ratio of total number of male flower to number of female flower. The findings of the present study are in accordance with those reported by Maurya *et al.* (2009) [6], Yadav *et al.* (2009) [16], Thangamani *et al.* (2011a) [7], Dey *et al.* (2012) [9], Verma *et al.* (2014) [12], Bhatt *et al.* (2017) [13], Adarsh *et al.* (2018) [14] and Malve *et al.* (2021) [15] in bitter gourd.

C. Number of fruits per vine

With respect of number of fruits per vine, the percentage of heterosis range from (-24.77) to (60.64), (-31.90) to (-50.60) and (-42.80) to (26.49) over better parent, top parent and standard check respectively. Among the 21 F_1 hybrids, the crosses 1 x 4 (50.60, 50.60, 26.49) and 5 x 6 (60.64, 41.74, 19.05) displayed highest percentage of positive heterosis over better parent, top parent and standard check respectively. The number of fruits per vine is an important component of yield and is positively associated with overall fruit production. In the present study, the F_1 hybrids showed considerable variation in both heterobeltiosis and standard heterosis, with values expressed in positive as well as negative directions. The occurrence of contrasting heterotic effects among the crosses could be due to the different combinations and interactions of favourable and unfavourable alleles inherited from the respective parents. The present results support the earlier findings of Jadhav *et al.* (2009) [17], Maurya *et al.* (2009) [6], Thangamani *et al.* (2011a) [7], Kushwaha *et al.* (2011) [8], Dey *et al.* (2012) [9], Laxuman *et al.* (2012) [10], Talekar *et al.* (2013) [11], Verma *et al.* (2014) [12], Bhatt *et al.* (2017) [13], Adarsh *et al.* (2018) [14] and Malve *et al.* (2021) [15] in bitter gourd.

D. Fruit yield (kg / Vine)

The range of heterobeltiosis varied from 21.65 to 55.07 while the percentage of heterosis over top parent and standard check varied from 21.65 to 55.07 and -27.96 to 42.58 respectively for fruit yield (kg / Vine). Among the 21 F_1 hybrids, 13 cross combinations over better parent, 12 cross combinations over top parent and 11 cross combinations over standard hybrid check showed positive heterosis during kharif season. Among them the cross combinations, 3 x 5 (44.64, 33.42, 22.67) and 5 x 6 (55.07, 55.07, 42.58) displayed statistically highly significant positive heterosis over better parent, top parent and standard check respectively. Yield is a complex quantitative trait governed by the combined influence of several yield-contributing characters like fruit length, fruit diameter, weight of fruits, etc. Therefore, the positive heterosis is considered desirable for this character. A similar trend was observed earlier by Jadhav *et al.* (2009) [17], Maurya *et al.* (2009) [6], Thangamani *et al.* (2011a) [7], Kushwaha *et al.* (2011) [8], Dey *et al.* (2012) [9], Laxuman *et al.* (2012) [10], Talekar *et al.*

al. (2013) [11], Verma *et al.* (2014) [12], Bhatt *et al.* (2017) [13] and Adarsh *et al.* (2018) [14] in bitter gourd.

E. Fruit yield (q/ha)

Among the 21 F₁ hybrids, 15 cross combinations over better parent, 11 cross combinations over top parent and 10 cross combinations over standard hybrid check showed positive heterosis for fruit yield during *kharif* season. The percentage of heterosis ranged between -21.69 to 55.08, -21.69 to 55.08 and -27.96 to 42.65 over better parent, top parent and standard check respectively. The crosses are 2 x 3, 2 x 4, 2 x 5, 2 x 6, 2 x 7, 3 x 5, 5 x 6, 5 x 7 and 6 x 7 showed significant positive heterosis over better parent, top parent and standard check. Out of these 3 x 5 (44.57, 33.42, 22.73) and 5 x 6 (55.08, 55.08, 42.65) crosses displayed statistically highly significant positive heterosis over better parent, top parent and standard check respectively. In the present study, several F₁ hybrids exhibited significant and desirable positive heterobeltiosis and standard heterosis, indicating their superior performance over the better parent and standard check, respectively. The present investigation revealed findings similar to those re-

ported by Yadav *et al.* (2009) [16], Thangamani *et al.* (2011a) [7], Kushwaha *et al.* (2011) [8], Dey *et al.* (2012) [9], Laxuman *et al.* (2012) [10], Talekar *et al.* (2013) [11], Bhatt *et al.* (2017) [13] and Malve *et al.* (2021) [15] in bitter gourd.

Conclusion

The present study on heterosis breeding in bitter gourd revealed substantial genetic variability among the parents and their F₁ hybrids for yield, yield-contributing and earliness-related traits. Significant heterosis was observed for several characters, indicating the presence of considerable genetic diversity among the parental lines and the potential for exploiting hybrid vigour in bitter gourd. Among the 21 hybrids evaluated during present investigation, the hybrids viz., 2 x 3 (RHRBIG -10 x RHRBIG -49), 2 x 5 (RHRBIG -10 x RHRBIG -59), 2 x 7 (RHRBIG -10 x Hirkani), 3 x 5 (RHRBIG -49 x RHRBIG -59) and 5 x 6 (RHRBIG -59 x Phule Green Gold) showed significant heterosis for earliness, yield and yield attributing characters. Hence they can be used in future for improving given traits.

Table 1. Analysis of variance for different characters in 7 x 7 half diallel of bitter gourd

Sources	DF	Days to 1 st female flower appearance	Sex Ratio	Number of fruits per vine	Fruit yield (kg/vine)	Fruit yield (q/ha)
Replications	2	5.150	0.01	0.06	0.02	33.94
Treatments	27	32.34**	5.45**	109.70**	0.96**	4273.22**
Parents	6	3.78**	2.27**	10.98**	0.05**	257.87**
Hybrids	20	1.59**	6.63**	134.17**	1.16**	5164.63**
P. vs Hybrid	1	818.82**	0.87**	212.64**	2.36**	10537.04**
Error	54	0.68	0.40	1.95	0.01	48.10
Total	83	11.09	1.75	36.96	0.32	1422.19

Table 2. Heterosis (%) over better parent, top parent and standard hybrid check in 7 x 7 half diallel in bitter gourd

Crosses	Days to 1 st female flower appearance			Sex Ratio			Number of fruits per vine			Fruit yield (kg / vine)			Fruit yield (q/ha)	
	BP	TP	SC	BP	TP	SC	BP	TP	SC	BP	TP	SC	BP	TP
1 x 2	-15.25**	-16.00**	-14.48**	2.54**	-20.06	3.08	-2.34	-2.34	-17.97**	12.75**	4.01	-4.37	12.84**	4.02
1 x 3	-15.58**	-16.32**	-14.81**	-23.43**	-24.64**	-2.82	-15.39**	-15.39**	-28.94**	3.89	-6.51*	-14.04**	4.04	-6.43
1 x 4	-12.18**	-12.95**	-11.38**	-21.60**	-34.95**	-16.12	50.60**	50.60**	26.49**	21.89**	21.28**	11.51**	21.70**	21.27**
1 x 5	-13.44**	-13.44**	-11.88**	0.97	-7.16	19.72*	-17.13**	-17.13**	-30.39**	-8.14*	-15.27**	-22.09**	-8.12*	-5.21
1 x 6	-14.54**	-15.29**	-13.76**	-16.34*	-16.34*	7.88	-19.53**	-19.53**	-32.41**	-21.65**	-21.65**	-27.96**	-21.69**	-21.69
1 x 7	-13.93**	-14.68**	-13.14*	4.12	-12.10	13.35	-16.40**	-16.40**	-29.78**	-12.59**	-13.14**	-20.14**	12.36**	-2.99
2 x 3	-11.31**	-15.13**	-13.59**	-25.40**	-26.58**	-5.32	35.20**	15.27**	-3.18	39.21**	28.41**	18.07**	39.36**	38.47**
2 x 4	-11.60**	-12.95**	-11.38**	-0.10	-17.11**	6.89	13.03**	2.33	-14.05**	23.77**	23.15**	13.23**	23.48**	23.05**
2 x 5	-13.55**	-13.55**	-11.99**	-24.95**	-30.99**	-11.01	41.29**	20.46**	1.18	39.35**	28.54**	18.18**	39.29**	28.54**
2 x 6	-11.61**	-14.25**	-12.71**	-29.45**	-29.45**	-9.02	27.56**	12.55**	-5.46	22.03**	22.03**	12.20**	22.04**	22.04**
2 x 7	-11.22**	-13.44**	-11.88**	-11.16	-25.00**	-3.29	28.83**	13.98**	-4.27	28.46**	27.66**	17.38**	28.57**	27.63**
3 x 4	-13.81**	-15.13**	-13.59**	-4.56	-6.07	21.13*	0.79	-8.75*	-23.36**	6.04	5.51	-2.99	5.83	5.46
3 x 5	-13.33**	-13.33**	-11.76**	-30.79**	-31.88**	-12.15	51.34**	24.36**	4.46	44.64**	33.42**	22.67**	44.57**	33.42**
3 x 6	-11.22**	-13.87**	-12.32**	-0.73	-0.73	28.01**	-5.07**	-16.24	-29.65**	-17.40**	-17.40**	24.05**	17.35**	17.35**
3 x 7	-10.27**	-12.51**	-10.93**	17.06*	15.21*	48.57**	-14.88**	-24.69**	-36.75**	-12.47**	-13.02**	-20.02**	-12.32**	-2.96
4 x 5	-13.22**	-13.22**	-11.65**	25.52**	15.41*	48.83**	-24.77**	-31.90**	-42.80**	-18.62**	-19.02**	-25.55**	-18.64**	-8.92
4 x 6	-14.59**	-15.89**	-14.37**	9.10	9.10	40.69**	-14.53**	-22.63**	-35.01**	-12.77**	-12.77**	-19.79**	-12.77**	-2.77
4 x 7	-12.71**	-14.04**	-12.48**	34.50**	13.55*	46.43**	-10.83*	-19.27**	-32.20**	-12.20**	-12.64**	-19.68**	-12.45**	-2.76
5 x 6	-16.05**	-16.05**	-14.53**	-41.91**	-41.91**	-25.09**	60.64**	41.74**	19.05**	55.07**	55.07**	42.58**	55.08**	55.08**
5 x 7	-12.84**	-12.84**	-11.27**	-22.31**	-28.56**	-7.88	39.24**	23.19**	3.47	40.93**	40.05**	28.77**	41.07**	40.05**
6 x 7	-12.00**	-14.20**	-12.65**	-38.31**	-38.31**	-20.45*	10.40*	-2.33	-17.96**	29.66**	29.66**	19.22**	29.66**	29.66**
Range	(-16.05)	(-16.32)	(-14.81)	(-41.91)	(-41.91)	(-25.09)	(-24.77)	(-31.90)	(-42.80)	(-21.65)	(-21.65)	(-27.96)	(-21.69)	(-21.69)
	(-10.27)	(-12.51)	(-10.93)	-34.50	-15.41	-48.83	-60.64	-50.60	-26.49	-55.07	-55.07	-42.58	-55.08	55.08

(continued on next page)

Crosses	Days to 1 st female flower appearance			Sex Ratio			Number of fruits per vine			Fruit yield (kg / vine)			Fruit yield
S. E.m	0.67	0.67	0.67	0.51	0.51	0.51	1.14	1.14	11.35	1.14	0.08	0.08	0.08
C.D 5 %	1.35	1.35	1.35	1.04	1.04	1.04	2.28	2.28	2.28	0.17	0.17	0.17	11.35
C.D 1 %	1.79	1.79	1.79	1.38	1.38	1.38	3.04	3.04	3.04	0.22	0.22	1.16	15.11

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