International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(12): 1324-1329
www.biochemjournal.com
Received: 02-09-2025
Accepted: 05-10-2025

Syed Berjes Zehra
Division of Vegetable Science, Faculty of Horticulture, SKUAST-K, Srinagar, Jammu and Kashmir, India

Gazala Nazir
Division of Vegetable Science, Faculty of Horticulture, SKUAST-K, Srinagar, Jammu and Kashmir, India

Asima Amin
Division of Vegetable Science, Faculty of Horticulture, SKUAST-K, Srinagar, Jammu and Kashmir, India

Ummyiah Masoodi
Division of Vegetable Science, Faculty of Horticulture, SKUAST-K, Srinagar, Jammu and Kashmir, India

Ishfaq Abidi
Division of Vegetable Science, Faculty of Horticulture, SKUAST-K, Srinagar, Jammu and Kashmir, India

Faheema Mushtaq
Division of Vegetable Science, Faculty of Horticulture, SKUAST-K, Srinagar, Jammu and Kashmir, India

K Hussain
Division of Vegetable Science, Faculty of Horticulture, SKUAST-K, Srinagar, Jammu and Kashmir, India

Aamina Farooq
Division of Vegetable Science, Faculty of Horticulture, SKUAST-K, Srinagar, Jammu and Kashmir, India

Corresponding Author:
Syed Berjes Zehra
Division of Vegetable Science, Faculty of Horticulture, SKUAST-K, Srinagar, Jammu and Kashmir, India

Genetic analysis and heterotic performance of bitter gourd hybrids under the temperate Himalayan Region

Syed Berjes Zehra, Gazala Nazir, Asima Amin, Ummyiah Masoodi, Ishfaq Abidi, Faheema Mushtaq, K Hussain and Aamina Farooq

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i12Sp.6704

Abstract
The present investigation was carried out at Vegetable Experimental Farm, Division of Vegetable Science Sher-e-Kashmir University of Agricultural Science and Technology of Kashmir to generate information about magnitude of heterosis of thirty crosses for earliness and quality traits. Thirty crosses were developed by crossing ten diverse lines with three testers using Line X Tester mating design (LXT) (Kempthorne, 1957) [9]. The set of thirty crosses along with their parents were evaluated in a RCBD design with three replications at three different locations. The observations were recorded on twelve traits viz., node to first male flower appearance, node to first female flower appearance, days to anthesis of first male flower, days to anthesis of first female flower, days to first fruit harvest, total carotenoids (mg $100g^{-1}$), total phenols (mg$100g^{-1}$), total chlorophyll (mg $100g^{-1}$), iron content (mg $100g^{-1}$), vitamin-C content (mg $100g^{-1}$), dry matter (%) and dietary fibre content (%). Analysis of variance revealed significant differences among the parents and crosses for almost all the traits in individual as well as pooled environments indicating that the materials selected for present investigation were diverse. The mean squares due to parents vs crosses were significant for all the traits (except total carotenoids) which indicated the possibility of sufficient amount of heterosis exploitation for these traits. The extent of heterosis exhibited by crosses were estimated over standard parent Arka Harit. For Earliness traits, crosses NDBG-17 × Jounpuri, NDBG-17 × LBG, NDBG-12 × Local bitter gourd, and NDBG-12 × Arka Harit possessed desirable negative significant standard heterosis along with good per se performance. Crosses viz: NDBG-4 × Arka Harit and NDBG-1 x Arka Harit showed desirable significant positive heterosis for maximum quality traits.

Keywords: Bitter gourd, heterosis, earliness, quality traits, LxT

Introduction
Bitter gourd **(***Momordica charantia* L.) is an important vegetable belonging to family cucurbitaceae. The fruits are bitter in taste owing to the presence of an alkaloid 'momordicine' which is different from cucurbitacin present in other cucurbits. It has high nutritive value an is used in herbal medicine systems because of its disease preventing and health promoting phyto-chemical compounds like dietary fiber, vitamins, flavonoids and antioxidants. Together, these compounds help act as protective scavengers against oxygen-derived free radicals and reactive oxygen species (ROS) that play a role in aging, cancers and degenerative disease. Bitter gourd has large variability and its sex expression is monoecious and as such can be profitably utilized through commercial exploitation of heterosis for the production of hybrids. There is a need to exploit the naturally endowed diversity in bitter gourd to develop hybrid varieties. Line × tester (Kempthorne, 1957) [9] biometric design is useful in preliminary screening of large number of lines and crosses for their general and specific combining ability effects, components of genetic variance and heterosis. Keeping in view the above facts the present investigation was carried out to exploit the heterosis in Bitter gourd for earliness and quality.

Materials and Methods
The present investigation entitled "Heterosis studies for earliness and quality traits in Bitter Gourd (*Momordica Charantia* L.) under temperate conditions of Kashmir" was conducted at Vegetable Experimental Farm, Division of Vegetable Science, SKUAST-Kashmir, Shalimar. Ten diverse lines viz; NDBG-1, NDBG-3, NDBG-4, and NDBG-5, NDBG-6, NDBG-7,

NDBG-12, NDBG-17, Pant Karela-1 and PBTH-52 were crossed with three testers viz; Arka Harit, Jounpuri and Local Bitter gourd to generate thirty crosses following line x tester mating design (Kempthorne, 1957) [9]. The set of thirty crosses along with their parents (10 lines and 3 testers) were evaluated in RCBD with three replications at three locations viz., Vegetable Experimental Farm, Division of Vegetable Science, SKUAST-Kashmir, Shalimar, central Kashmir (E_1); Faculty of Agriculture, Wadura, North kashmir (E_2) and KVK Malangpora, South Kashmir (E_3). The observations were recorded on twelve traits viz., node to first male flower appearance, node to first female flower appearance, days to anthesis of first male flower, days to anthesis of first female flower, days to first fruit harvest, total carotenoids (mg $100g^{-1}$), total phenols (mg$100g^{-1}$), total chlorophyll (mg $100g^{-1}$), iron content (mg $100g^{-1}$), vitamin-C content (mg $100g^{-1}$), dry matter (%) and dietary fibre content (%).Five randomly plants in each treatment over the replications were selected and labelled and were used for recording the observations. The average of the five plants was taken for analysis Analysis of variance for each of the character in randomized block design was performed utilizing the technique of Fisher and Yates (1938). The magnitude of heterosis was estimated in relation standard check values. They were thus, calculated as percentage increase or decrease of F_1s over standard parent (S.P.) using the methods of Turner (1953) and Hayes *et al.* (1956) [13, 7].

Results and Discussion

Analysis of Variance

In the present study the analysis of variance (Table 1 & 2) revealed that mean squares due to lines, testers, crosses and line × tester were significant for node to first male flower appearance, node to first female flower appearance, days to anthesis of first male flower, days to anthesis of first female flower, days to first fruit harvest, total phenols (mg$100g^{-1}$), total chlorophyll (mg $100g^{-1}$), iron content (mg $100g^{-1}$), vitamin-C content (mg $100g^{-1}$), dry matter (%) and dietary fibre content (%) in pooled analysis. This depicted the presence of significant variability among parents and crosses and the diverse lines upon crossing with testers produced substantial variability among crosses. For total carotenoids (mg100 g^{-1}) mean squares due to crosses were significant while mean squares due to various other sources of variation were non-significant which indicates that less variability was found within the parents for this trait. This implied that the variability has been created by crossing programme for total carotenoids as depicted by significant mean squares due to crosses. The mean squares due to parents vs crosses were significant for all the traits under study except total carotenoids which indicated the possibility of sufficient amount of heterosis exploitation for these traits. However for total carotenoids, the non-significant mean squares due to parents vs crosses implies that there is no scope for heterosis exploitation in the present experimental material. The interactions resulting from lines x environment, tester × environment, crosses x environment and line × tester ×environment were non-significant for the traits except dietary fiber. The similar studies were carried by Kundu, B.C *et al*. 2021 [10] for earliness in bitter gourd; Acharya, S.K *et al*. 2019 [1] in bitter gourd for earliness and Vitamin C content; Mallikarjunarao et al. (2018) [11] for ealiness and quality in bitter gourd; Kaur and Dhall, 2017 [8] for various earliness and yield traits in cucumber;

Heterosis for Earliness

Earliness is an important trait in bitter gourd to realize the potential economic yield in less time which is an important consideration for a vegetable grower. The earliness was measured as node to first male and female flower appearance, days to anthesis of first male and female flower and days to first fruit harvest. The results from table 3 depicts the heterosis over standard check, Arka Harit for earliness. For node to first male flower appearance the significant desirable negative heterosis over standard parent was observed in NDBG-1 × Arka Harit (-5.37%), NDBG-3 × Jounpuri (-3.73%) and NDBG-7 × LBG (-2.98). For node to first female flower appearance the crosses NDBG-17 × Jounpuri (7.25%) NDBG-7 × Arka Harit (-4.62%), NDBG-7 × LBG (-4.45%), NDBG-3 × Jounpuri (4.04%), NDBG-5 × Jounpuri (-3.23%) and NDBG-1 × Arka Harit (-2.89%) showed desirable negative significant heterosis over standard parent. For days to anthesis of first male flower, twenty three crosses showed desirable negative heterosis over standard parent. The maximum desirable negative standard heterosis was reported in NDBG-17 × Jounpuri (-14.20%), NDBG-7 × Arka Harit (-8.53%), NDBG-6 × LBG (6.98%), NDBG-4 × LBG (6.92%), NDBG-12 × LBG (-6.89%), NDBG-5 × Jounpuri (-6.65%), NDBG-5 × Arka Harit (-6.30%), NDBG-12 × Arka Harit (-6.21%) and NDBG-17 × LBG (-6.18%). For days to anthesis of first female flower nineteen crosses showed desirable negative heterosis over standard parent with maximum in NDBG-17 × Jounpuri (-15.53%), NDBG-17 × LBG (-8.92%), NDBG-12 × LBG (-5.94%), NDBG-7 × Arka Harit (-5.91%), NDBG-4 × Arka Harit (-5.83%), NDBG-12 × Arka Harit (-5.60%) and NDBG-12 × Jounpuri (-5.16%). For days to first fruit harvest the desirable negative significant heterosis over standard parent was observed in eleven crosses. The maximum standard heterosis was observed in NDBG-17 × Jounpuri (-14.36%), NDBG-17 × LBG (-4.70%), NDBG-12 × LBG (-3.43%), NDBG-12 × Arka Harit (-2.95%), NDBG-1 × LBG (-1.86%) and NDBG-4 × Arka Harit (-1.75%). The similar studies on earliness traits were conducted by Amrita Kumari et al. 2020; Acharya S.K *et al*. 2019; Bhatt et al., 2017; Dey et al. (2012); Adarsh et al. (2018); Mallikarjunarao et al. (2018) [3, 1, 11, 5, 6, 2].

Heterosis for Quality traits

Perusal of the results (Table 4) revealed that for total carotenoids the maximum desirable standard heterosis over check Arka Harit was reported in NDBG-4 × Arka Harit (65.67%), NDBG-4 × LBG (50.00%), NDBG-3 × Arka Harit (44.03%), NDBG-4 × Jounpuri (41.79%) and NDBG-1 × Arka Harit (36.57%). For total phenols the desirable heterosis over standard parent was observed in NDBG-6 × Jounpuri (6.60%) and NDBG-4 × Jounpuri (4.59%). For total chlorophyll content, thirteen crosses showed significant desirable standard heterosis with maximum in NDBG-1 × Arka Harit (35.33%), NDBG-1xJounpuri (30.89%), NDBG-6 × Jounpuri (23.82%), PBTH-52 × Jounpuri (22.22%), NDBG-7 × LBG (21.42%) and NDBG-12 × Arka Harit (17.96%). For iron content the desirable maximum significant standard heterosis was observed in NDBG-7 × Arka Harit (39.58%) followed by NDBG-12 × Arka Harit (6.25%) and NDBG-4 × Arka Harit (4.17%). For Vitamin-C none of the crosses showed desirable significant heterosis over standard parent. For dry matter content seven crosses showed desirable significant heterosis over standard parent

with maximum in NDBG-4 × Arka Harit (31.85%), NDBG-4 × Local bitter gourd (20.38%), NDBG-1 × Local bitter gourd (109.91%), Pant Karela-1 × LBG (7.87%), NDBG-7 × Jounpuri (4.74%). For dietary fibre content the desirable significant heterosis over standard parent was observed in only one cross i.e NDBG-1 × Arka Harit with heterosis per cent of 21.93%. Similar studies on different biochemical traits in bitter gourd were carried by various scientists viz; Amrita Kumari *et al*. 2020; Adarsh *et al*. (2018); Mallikarjunarao *et al*. (2018); Mamuna *et al*., (2015); Behera et al., (2010) [3, 11, 2, 12].

The results from table 5 depicts the best cross combinations for various traits with respect to desirable heterosis and good *per se* performance. Crosses NDBG-17 × Jounpuri, NDBG-17 × LBG, NDBG-12 × LBG and NDBG-12 × Arka Harit reported desirable significant negative standard heterosis along with good per se performance for maximum earliness traits. NDBG-4 x Arka Harit and NDBG-4 x Arka Harit showed high desirable standard heterosis along with good per se performance for maximum quality traits.

Conclusion

Analysis of variance revealed significant differences among the parents and crosses for almost all the traits under study indicating that the materials selected for present investigation were diverse. The mean squares due to parents vs crosses were significant for all the traits (except total carotenoids) which indicated the possibility of sufficient amount of heterosis exploitation for these traits.The extent of heterosis exhibited by crosses were estimated over standard parent Arka Harit. For Earliness traits, crosses NDBG-17 × Jounpuri, NDBG-17 × LBG, NDBG-12 × Local bitter gourd, and NDBG-12 × Arka Harit possessed desirable negative significant standard heterosis along with good per se performance. Crosses viz: NDBG-4 × Arka Harit and NDBG-1 x Arka Harit showed desirable significant positive heterosis for maximum quality traits. The best crosses in terms of standard heterosis with good per se performance especially for earliness could be considered for commercial exploitation in bitter gourd.

Table 1: Analysis of Variance for different earliness traits ((Pooled data over Locations)

Source of variation	d.f	Node to first male flower appearance	Node to first female flower appearance	Days to anthesis of first male flower	Days to anthesis of first female flower	Days to first fruit harvest
Replications	2	0.21*	0.74**	43.69**	2.09	1.51
Environments	2	23.32**	23.63**	310.68**	276.81**	395.17**
Parents + crosses	42	5.19**	11.31**	138.93**	91.45**	107.87**
Parents vs crosses	1	15.28**	36.95**	92.46**	363.92**	374.00**
Replications x Environments	4	$1xe^{-4}$	$1xe^{-5}$	$1xe^{-3}$	$1xe^{-4}$	$2xe^{-3}$
Crosses	29	4.50**	8.24**	37.60**	71.35**	72.69**
Lines	9	3.98**	15.87**	378.07**	98.22**	182.38**
Testers	2	17.87**	22.14**	140.21**	102.49**	134.62**
Lines x testers	1	0.521**	11.97**	967.28**	318.82**	137.84**
Crosses x Environments	58	$1xe^{-3}$	$1xe^{-4}$	$1xe^{-5}$	$1xe^{-3}$	$1xe^{-3}$
Lines x Environments	18	2 x e^{-3}	$1xe^{-3}$	$2xe^{-3}$	$3xe^{-3}$	$2xe^{-3}$
Testers x Environments	4	$1xe^{-6}$	$1xe^{-3}$	$1xe^{-3}$	$1xe^{-3}$	$1xe^{-5}$
Lines x Testers x Environments	24	$1xe^{-5}$	$2xe^{-3}$	$2xe^{-3}$	$2xe^{-3}$	$1xe^{-3}$
Pooled Error	252	0.05	0.05	7.10	1.71	1.12

*, ** significant at 5 &1 per cent level

Table 2: Analysis of Variance for different quality traits (Pooled data over Locations)

Source of variation	d.f	Total Carotenoids (mg $100g^{-1}$)	Total Phenols (mg $100g^{-1}$)	Total Chlorophyll (mg $100g^{-1}$)	Iron content (mg $100g^{-1}$)	Vitamin C (mg $100g^{-1}$)	Dry matter (%)	Dietary fibre (%)
Replications	2	9.27	0.563	225.06**	0.0001	1.69**	1.34**	0.01**
Environments	2	0.06	279.57**	364.53**	0.05**	392.46**	53.73**	0.187**
Parents + crosses	42	15.17*	185.90**	14440.13**	0.028**	671.75**	29.99**	0.387**
Parents vs crosses	1	2.08	264.09**	8875.93**	0.027**	768.70**	9.24**	8.88**
Replications x Environments	4	$1xe^{-3}$	$1xe^{-4}$	$1xe^{-3}$	$1xe^{-4}$	$1xe^{-3}$	$1xe^{-3}$	$1xe^{-4}$
Crosses	29	21.77**	165.32**	12032.53**	0.03**	541.05**	23.77**	0.184**
Lines	9	0.336	266.82**	22236.27**	0.02**	360.69**	51.54**	0.095**
Testers	2	0.081	169.02**	23440.46**	0.038**	826.70**	22.29**	0.100**
Lines x testers	1	0.595	9.91**	1658.54**	0.23**	6854.75**	52.72**	0.768**
Crosses x Environments	58	$1xe^{-4}$	$1xe^{-3}$	$1xe^{-5}$	$1xe^{-4}$	$1xe^{-3}$	$1xe^{-4}$	0.01**
Lines x Environments	18	$1xe^{-3}$	$1xe^{-3}$	$1xe^{-3}$	$1xe^{-3}$	$1xe^{-3}$	$1xe^{-3}$	0.001**
Testers x Environments	4	$2xe^{-3}$	$1xe^{-4}$	$2xe^{-4}$	$1xe^{-4}$	$2xe^{-3}$	$1xe^{-3}$	0.002**
Lines x Testers x Environments	24	$1xe^{-4}$	0.24	$1xe^{-4}$	$1xe^{-5}$	0.174	0.013	$1xe^{-3}$**
Pooled Error	252	5.13	0.48	12.03	$1xe^{-3}$	0.52	0.11	$1xe^{-4}$

*, ** significant at 5 &1 per cent level

Table 3: Estimates of standard heterosis over check Arka Harit for different Earliness traits in bitter gourd (*Momordica charantia* L.) (Pooled data over Locations)

Crosses	Node to first male flower appearance	Node to first female flower appearance	Days to anthesis of first male flower	Days to anthesis of first female flower	Days to first fruit harvest
NDBG-1 × Arka Harit	-5.37**	-2.89*	-5.35**	-0.41	2.15**
NDBG-1 × Jounpuri	1.09	33.42**	-0.40	3.63**	-0.16
NDBG-1 × Local Bitter gourd	15.67**	24.77**	-5.88**	-5.46**	-1.86**
NDBG-3 × Arka Harit	19.90**	40.27**	-1.89**	-3.17**	-0.46
NDBG-3 × Jounpuri	-3.73**	-4.04**	4.90**	5.96**	4.46**
NDBG-3 ×Local Bitter gourd	27.36**	23.12**	-4.13**	0.47	7.45**
NDBG-4 × Arka Harit	15.62**	20.57**	-7.37**	-5.83**	-1.75**
NDBG-4 × Jounpuri	29.60**	22.54**	0.11	0.44	0.82
NDBG-4 × Local Bitter gourd	26.12**	18.49**	-6.92**	-2.25**	-1.45**
NDBG-5 × Arka Harit	11.44**	15.37**	-6.30**	-3.06**	0.25
NDBG-5 × Jounpuri	3.73*	-3.23**	-6.65**	-4.73**	1.36**
NDBG-5 × Local Bitter gourd	11.94**	1.38	0.03	-3.37**	1.14**
NDBG-6 × Arka Harit	22.64**	17.34**	-0.68	-1.19*	-1.14**
NDBG-6 × Jounpuri	30.60**	21.97**	-4.72**	1.17*	3.47**
NDBG-6 × Local Bitter gourd	11.19**	10.98**	-6.98**	-3.50**	1.39**
NDBG-7 × Arka Harit	9.95**	-4.62**	-8.53**	-5.91**	-1.34**
NDBG-7 × Jounpuri	21.89**	18.84**	-0.68	0.54	2.45**
NDBG-7 × Local Bitter gourd	-2.98*	-4.45**	-3.06**	-2.23*	-1.32**
NDBG-12 × Arka Harit	21.39**	17.57**	-6.21**	-5.60**	-2.95**
NDBG-12 × Jounpuri	31.34**	19.07**	-4.40**	-5.16**	1.66**
NDBG-12 × Local Bitter gourd	22.39**	25.43**	-6.89**	-5.94**	-3.43**
NDBG-17 × Arka Harit	29.60**	25.66**	-4.60**	-4.43**	0.73
NDBG-17 × Jounpuri	10.95**	19.42**	-14.20**	-15.53**	-14.36**
NDBG-17 × Local Bitter gourd	-2.24	-7.28**	-6.18**	-8.92**	-4.70**
Pant Karela-1 × Arka Harit	18.66**	20.46**	-4.43**	0.41	-0.39
Pant Karela-1 × Jounpuri	4.73**	9.24**	-2.55**	-2.85**	-2.05**
Pant Karela-1 × Local Bitter gourd	20.90**	20.80**	-4.25**	-5.13**	-0.61
PBTH- 52 × Arka Harit	24.13**	31.79**	-3.12**	2.98**	1.70**
PBTH- 52 × Jounpuri	13.18**	37.91**	-1.34*	3.50**	3.59**
PBTH-52 × Local Bitter gourd	6.97**	43.65**	1.66**	5.70**	6.73**
No. of crosses showing desirable heterosis	3	6	23	19	11

Table 4: Estimates of standard heterosis over check Arka Harit for quality traits in bitter gourd (*Momordica charantia* L.) (Pooled data over Locations)

Crosses	Total Carotenoids (mg 100g^{-1})	Total Phenols (mg 100g^{-1})	Total Chlorophyll (mg 100g^{-1})	Iron Content (mg 100g^{-1})	Dry matter (%)	Dietary fibre (%)
NDBG-1 × Arka Harit	36.57**	-0.79	35.33**	-22.92**	3.55**	21.93**
NDBG-1 x Jounpuri	20.90**	-13.42**	30.89**	-16.67**	-1.97	-13.90**
NDBG-1 × Local bitter gourd	-13.43**	-24.74**	-7.55*	-8.33**	10.91**	-34.22**
NDBG-3 × Arka Harit	44.03**	-28.67**	4.60	-19.79**	-0.92	-50.80**
NDBG-3 × Jounpuri	32.09**	-11.15**	-3.61	-30.21**	-38.56**	-40.64**
NDBG-3 × Local bitter gourd	-20.15**	-40.35**	-15.84**	-40.63**	-32.81**	-50.80**
NDBG-4 × Arka Harit	65.67**	-14.80**	12.03**	4.17*	31.85**	-2.14*
NDBG-4 × Jounpuri	41.79**	4.59**	22.39**	3.13	4.02**	-18.72**
NDBG-4 × Local bitter gourd	50.0**	-4.32**	12.98**	-7.29**	20.38**	-36.36**
NDBG-5 × Arka Harit	-38.63**	-18.01**	3.19	-40.63**	-13.29**	-71.12**
NDBG-5 × Jounpuri	-33.58**	-9.01**	-13.53**	-33.33**	-17.76**	-68.45**
NDBG-5 × Local bitter gourd	-37.51**	-10.09**	-6.77*	-25.00**	-18.06**	-65.24**
NDBG-6 × Arka Harit	-51.49**	-18.03**	9.55**	-34.38**	-24.91**	-66.84**
NDBG-6 × Jounpuri	-44.03**	6.60**	23.82**	-20.83**	-7.63**	-68.45**
NDBG-6 × Local bitter gourd	-47.01**	-23.32**	12.54**	3.13	-11.05**	-61.50**
NDBG-7 × Arka Harit	-24.63**	-9.85**	3.24	39.58**	-5.99**	-47.59**
NDBG-7 × Jounpuri	-55.22**	-21.00**	1.69	-17.71**	4.74**	-68.45**
NDBG-7 × Local bitter gourd	-60.45**	-16.36**	21.42**	-34.38**	-6.44**	-37.97**
NDBG-12 × Arka Harit	-40.30**	-10.03**	17.96**	6.25**	-9.71**	-57.75**
NDBG-12 × Jounpuri	-38.06**	-37.90**	-16.78**	-18.75**	-10.01**	-53.48**
NDBG-12 × Local bitter gourd	-20.41**	-16.09**	-21.22**	-40.63**	-22.23**	-66.84**
NDBG-17 × Arka Harit	-40.51**	-34.86**	-23.24**	-43.75**	-17.31**	-71.66**
NDBG-17 × Jounpuri	-37.83**	-13.68**	-13.94**	-12.50**	-12.40**	-68.45**
NDBG-17 × Local bitter gourd	-1.88	-4.64**	14.14**	-25.00**	-13.59**	-66.31**
Pant Karela-1 × Arka Harit	16.48**	-2.76**	11.43**	-12.50**	-7.48**	-18.72**
Pant Karela-1 × Jounpuri	18.84**	-8.47**	5.63	-12.50**	-14.27**	-37.97**
Pant Karela-1 × Local bitter gourd	-3.45**	-14.09**	-0.99	0.00	7.87**	-48.13**
PBTH- 52 × Arka Harit	-28.54**	-21.85**	-8.39**	-9.38**	-14.18**	-41.18**
PBTH- 52 × Jounpuri	39.72**	-7.62**	22.22**	-18.75**	-0.03	-33.16**
PBTH-52 × Local bitter gourd	-29.98**	-27.06**	-16.50**	-33.33**	-13.59**	-59.80**
No. of crosses showin desirable heterosis	10	2	13	3	7	1

Table 5: Best crosses identified on the basis Standard heterosis and *per se* performance for different Earliness and quality traits in bitter gourd (*Momordica charantia* L.) (Pooled over locations)

Trait	Cross combinations	*Per se* performance	Cross combinations	Standard Heterosis (%)
Node to first male flower appearance	NDBG-1 x Arka Harit NDBG-3 x Jounpuri NDBG-7 x Local bitter gourd NDBG-17 x Local bitter gourd NDBG-5 x Jounpuri	6.34 6.45 6.50 6.55 6.95	NDBG-1 x Arka Harit NDBG-3 x Jounpuri NDBG-7x Local bitter gourd	-5.37 -3.75 -2.98
Node to first female flower appearance	NDBG-17 x Local bitter gourd NDBG-7 x Local bitter gourd NDBG-7x Arka Harit NDBG-3 x Jounpuri NDBG-5 x Jounpuri	8.02 8.15 8.25 8.30 8.37	NDBG-17 x Arka Harit NDBG-7 x Arka Harit NDBG-7 x Local bitter gourd NDBG-3 x Jounpuri NDBG-5x Jounpuri	-7.28 -4.62 -4.45 -4.04 -3.23
Days to anthesis of first male flower	NDBG-17 x Jounpuri NDBG-7x Arka Harit NDBG-4 x Arka Harit NDBG-6 x Local bitter gourd NDBG-4 x Local bitter gourd	48.13 51.32 51.97 52.18 52.22	NDBG-17 x Jounpuri NDBG-7 x Arka Harit NDBG-6x Local bitter gourd NDBG-4 x Local bitter gourd NDBG-12 x Local bitter gourd	-14.20 -8.53 -6.98 -6.92 -6.89
Days to anthesis of first female flower	NDBG-17 x Jounpuri NDBG-17x Local bitter gourd NDBG-12 x Local bitter gourd NDBG-7 x Arka Harit NDBG-4 x Arka Harit	54.30 58.55 60.47 60.48 60.53	NDBG-17 x Jounpuri NDBG-17 x Local bitter gourd NDBG-12 x Local bitter gourd NDBG-7 x Arka Harit NDBG-4 x Arka Harit	-15.53 -8.92 -5.94 -5.91 -5.83
Days to first fruit harvest	NDBG-17 x Jounpuri NDBG-17 x Local bitter gourd NDBG-12 x Local bitter gourd NDBG-12 x Arka Harit Pant karela-1 x Jounpuri	62.80 69.88 70.82 71.17 71.83	NDBG-17 x Jounpuri NDBG-17 x Local bitter gourd NDBG-12 x Local bitter gourd NDBG-12 x Arka Harit NDBG-1 x Local bitter gourd	-14.36 -4.70 -3.43 -2.95 -1.86
Total carotenoids (mg $100g^{-1}$)	NDBG-4 x Arka Harit NDBG-4 x Local bitter gourd NDBG-3 x Arka Harit NDBG-4 x Jounpuri NDBG-1x Arka Harit	0.74 0.67 0.64 0.63 0.61	NDBG-4 x Arka Harit NDBG-4 x Local bitter gourd NDBG-3 x Arka Harit NDBG-4 x Jounpuri NDBG-1x Arka Harit	65.67 50.0 44.03 41.79 36.57
Total phenols (mg $100g^{-1}$)	NDBG-6 x Jounpuri NDBG-4 x Jounpuri NDBG-1x Arka Harit Pant Karela-1 x Arka Harit NDBG-4 x Local bitter gourd	39.85 39.10 37.09 36.35 35.77	NDBG-6 x Jounpuri NDBG-4 x Jounpuri	6.60 4.59
Total chlorophyll (mg $100g^{-1}$)	NDBG-1x Arka Harit NDBG-1 x Jounpuri NDBG-6 x Jounpuri NDBG-4 x Jounpuri PBTH-52 x Jounpuri	309.35 299.18 283.03 279.77 279.30	NDBG-1x Arka Harit NDBG-1 x Jounpuri NDBG-6 x Jounpuri PBTH- 52 x Jounpuri NDBG-7x Local bitter gourd	35.33 30.89 23.82 22.22 21.42
Iron content (mg $100g^{-1}$)	NDBG-7 x Arka Harit NDBG-12 x Arka Harit NDBG-6 x Local bitter gourd NDBG-4 x Arka Harit Pant Karela-1 x Local bitter gourd	0.45 0.34 0.33 0.33 0.32	NDBG-7 x Arka Harit NDBG-12 x Arka Harit NDBG-4 x Arka Harit	39.58 6.25 4.17
Dry matter (%)	NDBG-4 x Arka Harit NDBG-4 x Local bitter gourd NDBG-1 x Local bitter gourd Pant karela-1 x Local bitter gourd NDBG-7 x Jounpuri	14.75 13.47 12.41 12.07 11.72	NDBG-4 x Arka Harit NDBG-4 x Local bitter gourd NDBG-1 x Local bitter gourd Pant Karela-1 x Local bitter gourd NDBG-7 x Jounpuri	31.85 20.38 10.91 7.87 4.74
Dietary fibre (%)	NDBG-1x Arka Harit NDBG-4 x Arka Harit NDBG-1 x Jounpuri NDBG-4 x Jounpuri Pant Karela-1 x Arka Harit	0.76 0.61 0.54 0.51 0.50	NDBG-1 x Arka Harit	21.93

References

1. Acharya SK, Kaushik RA, Ameta K, Dubey RB, Upadhyay B. Heterosis and combining ability in bitter gourd (*Momordica charantia* L.). International Journal of Bioassays. 2019;8(1):5692-5711.
2. Adarsh A, Kumar R, Singh HK, Bhardwaj A. Heterosis study in bitter gourd for earliness and qualitative traits. International Journal of Current Microbiology and Applied Sciences. 2018;7:4239-4245.
3. Kumari A, Shree S, Kumar R, Kishore C, Singh VK, Haque M. Estimation of heterosis for yield and quality traits in bitter gourd (*Momordica charantia* L.). International Journal of Current Microbiology and Applied Sciences. 2020;9(2):1614-1623.
4. Behera TK, Behera S, Bharath LK. Bitter gourd: botany, horticulture, breeding. In: Janick J, editor. Horticultural Reviews. Vol. 37. Wiley-Blackwell; 2010. p. 102-136.
5. Bhatt L, Singh SP, Soni AK, Samota MK. Combining ability studies in bitter gourd (*Momordica charantia* L.) for quantitative characters. International Journal of Current Microbiology and Applied Sciences. 2017;6(7):4471-4478.
6. Dey SS, Behera TK, Munshi AD, Rakshit S, Bhatia R. Utility of gynoecious sex form in heterosis breeding of bitter gourd and genetics of associated vegetative and flowering traits. Indian Journal of Horticulture. 2012;69(4):523-529.
7. Hayes HK, Immer FF, Smith DC. Methods of plant breeding. New Delhi: McGraw Hill Book Publishing Company; 1956.
8. Kaur K, Dhall RK. Heterosis and combining ability for yield and yield attributes in cucumber (*Cucumis sativus* L.). Journal of Breeding and Genetics. 2017;49(1):94-103.
9. Kempthorne O. An introduction to genetic statistics. New York: John Wiley and Sons; 1957. p. 468-472.
10. Kundu BC, Mohsin GM, Rahman MS, Ahamed F, Mahato AK, Hossain KM, Jalloh MB, Alam MA. Combining ability analysis in bitter gourd (*Momordica charantia* L.) for potential quality improvement. Brazilian Journal of Biology. 2021;81:e255605.
11. Mallikarjunara K, Das AK, Nandi A, Baisakh B, Tripathy P, Sahu G. Heterosis and combining ability of quality and yield of bitter gourd (*Momordica charantia* L.). Journal of Pharmacognosy and Phytochemistry. 2018;7(3):5-9.
12. Mamuna MHA, Rashid MH, Uddin N, Islam MR, Asaduzzaman M. Heterosis studies in bitter gourd (*Momordica charantia* L.). International Journal of Vegetable Science. 2016;22(5):442-450.
13. Turner JM. A study of heterosis in upland cotton. II. Combining ability and inbreeding effects. Agronomy Journal. 1953;45:484-490.