Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(2): 486-490
Received: 04-01-2020
Accepted: 08-02-2020

Bajrang Kumar
Research Scholar, Department of Horticulture, Institute of Agricultural Science, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Anand Kumar Singh
Professor, Department of Horticulture, Institute of Agricultural Science, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Prachi Pattnaik
Research Scholar, Department of Horticulture, Institute of Agricultural Science, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Diksha Mishra
Research Scholar, Department of Horticulture, Institute of Agricultural Science, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Akhilesh Kumar Pal
Associate Professor, Department of Horticulture, Institute of Agricultural Science, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Binod Kumar Singh
Professor, Department of Horticulture, Institute of Agricultural Science, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Corresponding Author:
Bajrang Kumar
Research Scholar, Department of Horticulture, Institute of Agricultural Science, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Line × Tester analysis for estimation of heterosis in bitter gourd (*Momordica charantia* L.)

Bajrang Kumar, Anand Kumar Singh, Prachi Pattnaik, Diksha Mishra, Akhilesh Kumar Pal and Binod Kumar Singh

Abstract
Bitter gourd is one of the most popular cucurbitaceous vegetable. The present investigation for the estimation of heterosis in bittergourd was carried out involving 28 cross combinations developed out of seven lines and four testers. The experiment was laid out in Randomized Complete Block Design with three replications and evaluated using a standard check. For all the characters under study, highly significant differences were observed among the genotypes. Highly significant differences due to lines were observed for all traits under study except node at which first pistillate flower appears and number of primary branches per plant. Among the hybrids, the crosses Jaunpuri Green × Shaktigopal Local, IC-085611 × OBGCS-1, Preethi × OBGCS-2 and Katheri × Shaktigopal Local exhibited high *per se* performance as well as high economic heterosis for earliness in flowering with first female at lowest node. The cross combinations Katheri × BGCV-2, Katheri × OBGCS-1 and Katheri × OBGCS-2 were found best which expressed significant positive heterosis over mid parent (50.52, 31.62 and 27.06%), over better parent (37.99, 18.03 and 15.86%) and over standard parent (47.98, 26.57 and 24.24%) respectively for total fruit yield.

Keywords: Heterosis, significant, yield, lines, earliness

Introduction
Bitter gourd (*Momordica charantia* L.; 2n=2x=22) is one of the highly nutritive crop among cucurbits especially iron and vitamin c content. It has it's origin in the Indo-Burman region. Fruits of bitter gourd consist of anti-diabetic, anti-microbial and anti-oxidant property. It has been used as traditional medicine of India, Africa, China and Latin America as its extract contains antioxidant, antiviral, antimicrobial, anti- hepatotoxic and also have capacity to reduce blood sugar level (Raman and Lau, 1996) [8]. It is also helpful for reduction of blood sugar levels for the treatment of type-2 diabetes. Bittergourd is a highly cross pollinated plant and exhibit high levels of heterozygosity. (Singh *et al*. 2013) [11] Heterosis determines the increase or decrease in vigour of the F_1 over the parents. Heterosis breeding recognised as a practical tool providing the breeder a means of increasing yield and other economic traits. The superiority of F_1 hybrid over parents can be manifested in terms of earliness, improved quality, uniformity, high yield, wider adaptability and also helps in development of dominant gene for resistance to pest and diseases (Riggs, 1988) [10]. Being a monoecious crop, bitter gourd can be profitably utilised for F_1 hybrid seed production at cheaper rate. Hence, to increase the productivity along with production there is great scope of exploitation of hybrid vigour at commercial scale. Thus, the present study was done to investigate the magnitude of heterosis of F_1 hybrids for various yield and yield related traits.

Materials and Methods
The experiment was carried out at the Vegetables Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during *Kharif* season of 2017 and 2018. Seven promising lines of bitter gourd and four testers with improved earliness, more number of fruit per plant, increased fruit size and higher yield and their 28 hybrids were evaluated for quantification of desired traits such as early and profuse female flowering and improved fruit set. The lines used were PN-4, IC-085612, IC-085611, Jaunpuri Green, Katheri, Preethi, Meghna and four testers were BGCV-2, OBGCS-2, Shaktigopal local and OBGCS-1. Crossing was done in Line × Tester mating designs to produce 28 F_1 hybrids. Individual plants of parents were selfed to maintain pure seed. Seed from the mature ripe fruit of F_1 were collected for next generation sowing. All 28 F_1 hybrids along with 11 parents and a standard check (Pusa Do Mausami) were sown in separate plots for evaluation. Observations were recorded from five randomly choosen plants in all genotypes in each replication. The mean of five plants was taken for analysis.

Data was recorded for estimation of heterosis on days to 50% staminate flowering, days to 50% pistillate flowering, node at which first staminate and pistillate flower appears, vine length (m), number of primary branches per plant, internodal length (cm) and yield (q/ha). The statistical analysis of various parameters was done according to Panse and Sukhatme (1967) [7].

Result and Discussion

The analysis of variance indicated that significant differences were observed for all traits except node at which first pistillate flower appears and number of primary branches per plant in case of lines. It was observed that the mean sum of squares due to genotypes was significant for all the traits. The mean sum of square due to tester were also significantly different for all the traits except node at which first pistillate flower, vine length (m) and internodal length (cm). Analysis of variance for all the traits recorded significant difference among parents vs. crosses.

With respect to agriculturally useful traits, heterosis is an expression of the superiority of hybrids over the mid parents, better parents, or the standard check (Hayes *et al*., 1956). To achieve significant increase in crop yield and quality is the main objective of heterosis breeding. As far as flowering trait is concerned, heterosis in negative direction is desirable. The observations on heterosis over mid parent, better parent and standard check for different parameters are presented in table.no.1, 2, 3 and 4.

For Days to 50% staminate flower anthesis, heterosis in F_1 ranged from -20.85 (PN-4 × OBGCS-2) to 4.39% (Preethi × BGCV-2) over mid parent and was from -15.42 (IC-085611× OBGCS-1) to 8.01% (Preethi × BGCV-2) over better parent whereas from -12.61 Jaunpuri Green × BGCV-2) to 2.79% (Preethi × BGCV-2) over standard check. The best cross combination were PN-4 × OBGCS-2, IC-085612 × OBGCS-2 and Katheri × OBGCS-2 which showed -20.85, -18.92 and -18.62 per cent relative heterosis respectively while the crosses IC-085611 × OBGCS-1, Jaunpuri Green × OBGCS-1 and Katheri × OBGCS-1 showed significant negative heterosis -15.42, -14.65 and -14.29 per cent over better parent and Jaunpuri Green × BGCV-2, IC-085611× OBGCS-1 and Jaunpuri Green × OBGCS-1, Katheri × BGCV-2 showed -12.61, -12.32 and -12.02 per cent significant negative heterosis respectively over standard parent. For Days to 50% pistillate flower anthesis, the top three performing F_1 hybrids were Jaunpuri Green × Shaktigopal Local, Katheri × OBGCS-1 and Meghna × OBGCS-1 that showed -25.77, -18.47 and -18.36 per cent significant negative heterosis respectively over mid parent whereas the best crosses for heterobeltosis were Jaunpuri Green × Shaktigopal Local, Meghna × OBGCS-1 and IC-085611 × OBGCS-1 which expressed significant negative heterosis -21.7, -18.08 and -17.97 per cent respectively while in case of economic heterosis, the best crosses were Jaunpuri Green × Shaktigopal Local (-20.53%), Katheri × BGCV-2 (-15.64%) and IC-085612 × OBGCS-2 (-12.39%) significant heterosis over standard parent. Such negative significant heterosis for early flowering was also reported by Singh *et al.* (2000) [12]; and Thangamani and Pugalendhi (2013) [11]; and Kumar *et al.* (2016) [5].

For node at which first staminate flower appears, the estimated heterosis of F_1 ranged from -34.61 (Katheri × OBGCS-1) to 6.65% (Jaunpuri Green × BGCV-2) over mid parent, from -30.79 (Katheri × OBGCS-1) to 12.45% (Preethi × Shaktigopal Local) over better parent while economic heterosis varied from -32.71 (Katheri × OBGCS-1) to 13.62% (Meghna × Shaktigopal Local) over standard variety. In order of merit, the maximum significant negative heterosis was observed for the crosses Katheri × OBGCS-1 (-34.61%) followed by IC-085611 × BGCV-2 (-29.26%) and Jaunpuri Green × OBGCS-1 (-26.52%) over mid parent whereas the crosses Katheri × OBGCS-1 (-30.79%) followed by IC-085611 × BGCV-2 (-28.13%) and Jaunpuri Green × OBGCS-1 (-25.66%) showed significant negative heterosis over better parent while cross Katheri × OBGCS-1 (-32.71%) followed by PN-4 × OBGCS-2 (-29.76%) and Jaunpuri Green × OBGCS-1 (-29.37%). The estimate heterosis of F_1 for node at which first pistilate flower appears ranged -39.32 (Preethi × OBGCS-2) to 43.91% (Meghna × Shaktigopal Local) over relative parent, -35.85 (Preethi × OBGCS-2) to 54.15% (Meghna × Shaktigopal Local) over better parent whereas from -45.12 (Preethi × OBGCS-2) to 38.49% (Meghna × Shaktigopal Local) over standard check. For node at which first pistillate flower appears, per cent negative heterosis considered desirable in bitter gourd. In order of their merit the cross combinations Preethi × OBGCS-2, Katheri × Shaktigopal Local and Meghna× OBGCS-2 showed -39.32, -35.12 and -30.22 per cent significant negative heterosis respectively over relative parent, while the crosses Preethi × OBGCS-2, Katheri × Shaktigopal Local and Meghna × OBGCS-2 showed significant negative heterosis -35.85, -32.74 and -23.25 per cent respectively over better parent whereas the cross combinations Preethi × OBGCS-2, Katheri × Shaktigopal Local and IC-085611 × BGCV-2 exhibited -45.12, -39.57, -34.67 per cent significant negative heterosis respectively over standard parent. Similar results were also found by Sundaram (2007) [13]; Thangmani and Pugalendhi (2013) [11]; Kumar *et al.* (2016) [5]; and Rao *et al.* (2017) [9] in bitter gourd. Based on the data it was observed that for vine length, the best crosses were Jaunpuri Green × OBGCS-2, Katheri × BGCV-2 and Preethi × BGCV-2 which depicted 56.53, 44.87 and 37.63 per cent respectively significant positive relative heterosis, while the crosses Jaunpuri Green × OBGCS-2 (48.96%) followed by Katheri × BGCV-2 (41.46%) and Jaunpuri Green × OBGCS-1 (30.35%) recorded significant positive heterosis over better parent whereas over standard parent the crosses Katheri × BGCV-2, Jaunpuri Green × OBGCS-2 and Preethi × BGCV-2 recorded 87.17, 70.94 and 58.57 per cent respectively positive significant heterosis which is desirable for the trait under study. The estimated relative heterosis of F_1 for vine length ranged from -30.19 (Preethi × OBGCS-1) to 56.53% (Jaunpuri Green × OBGCS-2) while heterobeltiosis varied from -33.39 (Preethi × OBGCS-1) to 48.96% (Jaunpuri Green × OBGCS-2) and the range of variation for economic heterosis were -25.21 (Preethi × OBGCS-1) to 87.17% (Katheri × BGCV-2). Similar result were also reported by Singh *et al*. (2013) [11]; and Tiwari *et al*. (2016) [15].

For the trait number of primary branches per plant, positive significant heterosis is considered desirable. Out of all the cross combinations, in order of their merit the cross combinations Jaunpuri Green × Shaktigopal Local, IC-085611× Shaktigopal Local and Katheri × OBGCS-1 exhibited 28.76, 21.77 and 15.90 per cent respectively significant relative heterosis while the crosses Jaunpuri Green × Shaktigopal Local, Katheri × OBGCS-2 and IC-085611 × Shaktigopal Local showed significant heterosis of 19.08, 13.36 and 12.98 per cent over better parent while the crosses Katheri × OBGCS-1, Katheri × OBGCS-2 and Jaunpuri Green × Shaktigopal Local expressed 44.54, 36.37, 32.02 per cent respectively significant positive heterosis over standard parent for this trait. The work done by Lawande and Patil (1990) [6]; Ram *et al*. (1997); Jadhav *et al*. (2009) [3]; and Behera *et al*. (2009) [1] also observed heterobeltiosis for the same trait. Internodal length is an important parameter because shorter internodal length is desirable for higher yield for which per cent negative heterosis considered desirable in bitter gourd. In order of their performance, the cross combinations IC-085612 × OBGCS-1, Katheri × BGCV-2 and IC-085612 × Shaktigopal Local depicted -29.20, -13.28 and -10.26 per cent respectively significant negative heterosis over mid parent while the crosses IC-085612 × OBGCS-1, Katheri × BGCV-2 and IC-085612 × Shaktigopal Local showed significant negative heterosis -25.7, -9.30 and -7.70 per cent over better parent and the crosses IC-085612 × OBGCS-1 followed by Katheri × BGCV-2 showed -14.11 and -1.33 per cent significant negative heterosis over standard parent. Similar result was observed by Singh *et al*. (2013) [11]; and Tiwari *et al*. (2016) [15].

Total fruit yield (q/ha) varied significantly among all the genotypes under study. The magnitude of heterosis of F_1 for fruit yield (q/ha) ranged from -26.01 (IC-085612 × Shaktigopal Local) to 50.52% (Katheri × BGCV-2) over mid parent and the top three crosses showing maximum significant relative heterosis were Katheri × BGCV-2 (50.52%) followed by Katheri × OBGCS-1 (31.62%) and Katheri × OBGCS-2 (27.06%) while per cent heterobeltiosis varied from 37.99% (Katheri × BGCV-2) to -33.16% (IC-085611 × BGCV-2) and the three best crosses exhibiting significant positive heterobeltiosis were Katheri × BGCV-2 (37.99%), Katheri × OBGCS-1 (18.03%) and Katheri × OBGCS-2 (15.86%). The range of heterosis over commercial check varied between -40.59 (IC-085611 × Shaktigopal Local) to 47.98% (Katheri × BGCV-2) while the cross Katheri × BGCV-2 (47.98%) exhibited maximum significant heterosis over standard check followed by Katheri × OBGCS-1 (26.57%) and Katheri × OBGCS-2 (24.24%) for total fruit yield (q/ha) out of 28 crosses. Similar findings were also observed in the research conducted by Verma and Singh (2014) [16]; Kandasamy (2015) [4]; and Tiwari *et al*. (2016) [15].

Conclusion

Significant heterosis over better parent and over standard check in desired direction is used for selection of best hybrids. Thus from the present study, it was observed that among the hybrids, the crosses Jaunpuri Green × Shaktigopal Local, IC-085611 × OBGCS-1, Preethi × OBGCS-2 and Katheri × Shaktigopal Local exhibited high *per se* performance as well as high economic heterosis for earliness in flowering with first female at lowest node. With regards to the growth parameters like vine length, the hybrids Jaunpuri Green × OBGCS-2, Katheri × BGCV-2 and Preethi × BGCV-2 had registered favourable values of mean and standard heterosis in desirable direction. The hybrids exhibiting higher significant heterosis for total fruit yield were Katheri × BGCV-2, Katheri × OBGCS-1 and Katheri × OBGCS-2. These results clearly indicate that there is tremendous scope for the development of F_1 hybrids in bitter gourd. Hybrids with significant heterosis in desirable direction for yield and its attributing traits should be further evaluated and can be exploited for commercial cultivation.

Table 1: Estimates of heterosis over mid parent, better and standard parent for Days to 50% staminate flower anthesis and Days to 50% pistillate flower anthesis

Crosses	Days to 50% staminate flower anthesis			Days to 50% pistilate flower anthesis		
	MPH	BPH	SH	MPH	BPH	SH
PN-4 × BGCV-2	-12.38 **	-13.48 **	-9.68 **	-6.66 **	-10.29 **	-6.13 **
PN-4 × OBGCS-2	-20.85 **	-27.15 **	-9.53 **	-11.07 **	-14.47 **	-10.51 **
PN-4 × Shaktigopal Local	-11.80 **	-13.81 **	-5.72 *	-10.63 **	-11.96 **	-7.88**
PN-4 × OBGCS-1	-9.94 **	-10.25 **	-6.30 *	-17.02 **	-19.32 **	-10.64 **
IC-085612 × BGCV-2	-8.60 **	-9.12 **	-6.45 **	-7.41 **	-7.95 **	-10.14 **
IC-085612 × OBGCS-2	-18.92 **	-25.86 **	-7.92 **	-9.79 **	-10.26 **	-12.39 **
IC-085612 × Shaktigopal Local	-12.29 **	-14.88 **	-6.89 **	-7.10 **	-8.88 **	-7.51 **
IC-085612 × OBGCS-1	-8.30 **	-8.63 **	-5.28 *	-3.06 *	-8.81 **	1
IC-085611 × BGCV-2	-3.76	-5.17 *	-0.59	-3.79 *	-10.31 **	0.13
IC-085611 × OBGCS-2	-16.26 **	-22.79 **	-4.11	0.48	-6.28 **	4.63 **
IC-085611 × Shaktigopal Local	-11.98 **	-13.81 **	-5.72 *	-6.28 **	-10.54 **	-0.13
IC-085611 × OBGCS-1	-15.89 **	-16.36 **	-12.32 **	-18.29 **	-18.61 **	-9.14 **
Jaunpuri Green × BGCV-2	-14.67 **	-15.22 **	-12.61 **	-15.14 **	-21.22 **	-11.26 **
Jaunpuri Green × OBGCS-2	-13.16 **	-20.54 **	-1.32	-7.54 **	-14.11 **	-3.25
Jaunpuri Green × Shaktigopal Local	-13.87 **	-16.35 **	-8.50 **	-25.77 **	-29.44 **	-20.53 **
Jaunpuri Green × OBGCS-1	-14.89 **	-15.13 **	-12.02 **	-17.42 **	-18.11 **	-7.76 **
katheri × BGCV-2	-14.89 **	-16.20 **	-12.02 **	-17.55 **	-21.99 **	-15.64 **
katheri × OBGCS-2	-18.62 **	-24.91 **	-6.74 **	-12.47 **	-17.13 **	-10.39 **
katheri × Shaktigopal Local	-9.58 **	-11.39 **	-3.08	-11.64 **	-14.35 **	-7.38 **
katheri × OBGCS-1	-14.83 **	-15.36 **	-11.14 **	-18.47 **	-19.44 **	-10.76 **
Preethi × BGCV-2	4.39 *	1.01	2.79	-0.53	-1.82	-5.26 **
Preethi × OBGCS-2	-12.83 **	-23.02 **	-4.4	3.22 *	1.81	-1.63
Preethi × Shaktigopal Local	-6.38 **	-12.47 **	-4.25	-4.74 **	-8.26 **	-6.88 **
Preethi × OBGCS-1	-6.93 **	-10.75 **	-7.48 **	-10.27 **	-17.06 **	-8.14 **
Meghna × BGCV-2	-8.14 **	-9.74 **	-4.84 *	-9.63 **	-15.71 **	-6.01 **
Meghna × OBGCS-2	-16.60 **	-22.90 **	-4.25	-8.12 **	-14.25 **	-4.38 *
Meghna × Shaktigopal Local	-6.08 **	-7.77 **	0.88	-15.28 **	-19.08 **	-9.76 **
Meghna × OBGCS-1	-8.13 **	-8.90 **	-3.96	-18.36 **	-18.63 **	-9.26 **
*significant at p = 0.05, ** significant at p= 0.01						

Table 2: Estimates of heterosis over mid parent, better and standard parent for node at which first staminate flower appears and node at which first pistillate flower appears

Crosses	Node at which first staminate flower appears			Node at which first pistilate flower appears		
	MPH	BPH	SH	MPH	BPH	SH
PN-4 × BGCV-2	-13.75 *	-22.42 **	-16.05 **	8.28	-1.95	-1.36
PN-4 × OBGCS-2	-21.58 **	-24.20 **	-29.76 **	-21.04 *	-26.95 *	-26.51 *
PN-4 × Shaktigopal Local	-2.8	-10.93	-7.51	0.51	-4.87	-4.3
PN-4 × OBGCS-1	-19.14 **	-23.62 **	-25.74 **	-17.99	-25.65 *	-25.20 *
IC-085612 × BGCV-2	-4.78	-8.71	-1.21	-10.32	-21.67 *	-14.42
IC-085612 × OBGCS-2	-22.14 **	-24.73 **	-25.27 **	12.01	-0.15	9.1
IC-085612 × Shaktigopal Local	-21.04 **	-22.77 **	-19.80 **	-16.33	-23.77 *	-16.71
IC-085612 × OBGCS-1	4.27	3.18	2.45	-1.2	-13.6	-5.6
IC-085611 × BGCV-2	-29.20 **	-30.24 **	-22.22 **	-23.77 *	-27.26 *	-34.67 **
IC-085611 × OBGCS-2	-18.48 **	-25.36 **	-16.78 **	-10.22	-12.35	-21.28
IC-085611 × Shaktigopal Local	-11.21 *	-14.26 **	-4.4	-20.55	-20.56	-28.63 *
IC-085611 × OBGCS-1	-20.83 **	-25.89 **	-17.38 **	2.01	-2.53	-12.46
Jaunpuri Green × BGCV-2	6.65	0.14	8.36	3.62	-7.7	-3.64
Jaunpuri Green × OBGCS-2	-23.04 **	-23.98 **	-27.78 **	-9.54	-17.71	-14.09
Jaunpuri Green × Shaktigopal Local	-25.10 **	-28.29 **	-25.53 **	-9.53	-15.83	-12.13
Jaunpuri Green × OBGCS-1	-26.52 **	-27.36 **	-29.37 **	-3.17	-13.64	-9.85
katheri × BGCV-2	-23.17 **	-23.30 **	-16.73 **	2.39	-5.49	-8.87
katheri × OBGCS-2	-15.77 **	-21.94 **	-15.25 *	-20.66	-25.14 *	-27.81 *
katheri × Shaktigopal Local	-3.28	-5.39	2.72	-35.12 **	-37.33 **	-39.57 **
katheri × OBGCS-1	-34.61 **	-38.02 **	-32.71 **	7.75	-0.41	-3.97
Preethi × BGCV-2	-5.12	-12.18 *	-4.96	4.87	-2.67	-7.24
Preethi × OBGCS-2	1.2	0.89	-6.5	-39.32 **	-42.43 **	-45.12 **
Preethi × Shaktigopal Local	5.72	-0.26	3.58	-5.44	-8.16	-12.46
Preethi × OBGCS-1	3.45	0.73	-2.07	-3.37	-10.21	-14.42
Meghna × BGCV-2	-0.8	-2.83	9.63	9.93	-1.34	1.26
Meghna × OBGCS-2	-17.23 **	-24.62 **	-14.95 *	-30.22 **	-36.03 **	-34.35 **
Meghna × Shaktigopal Local	4.88	0.71	13.62 *	43.91 **	34.95 **	38.49 **
Meghna × OBGCS-1	-17.05 **	-22.79 **	-12.88 *	-12.17	-21.07	-18.99
*significant at p = 0.05, ** significant at p= 0.01						

Table 3: Estimates of heterosis over mid parent, better and standard parent for vine length (m) and internodal length (cm)

Crosses	Vine length (m)			Internodal length (cm)		
	MPH	BPH	SH	MPH	BPH	SH
PN-4 × BGCV-2	19.94 **	11.62	40.88 **	23.18 **	9.11	29.86 **
PN-4 × OBGCS-2	-1.17	-3.46	4.95	22.32 **	10.86	25.26 **
PN-4 × Shaktigopal Local	-15.34 *	-17.35 *	-5.68	13.33 *	-0.04	20.14 **
PN-4 × OBGCS-1	4.52	2.86	15.49	8.95	-2.26	12.99 *
IC-085612 × BGCV-2	5.01	-3.34	22.00 *	-7.33	-10.26 *	14.01 *
IC-085612 × OBGCS-2	27.39 **	25.91 **	33.64 **	3.51	-2.21	24.23 **
IC-085612 × Shaktigopal Local	-2.54	-5.94	7.33	-10.26 *	-12.68 *	10.94
IC-085612 × OBGCS-1	-4.83	-7.43	3.94	-29.20 **	-32.39 **	-14.11 *
IC-085611 × BGCV-2	-18.59 **	-21.93 **	-1.47	3.93	3.91	23.72 **
IC-085611 × OBGCS-2	-10.98	-15.66	-2.29	1.34	-1.25	17.59 **
IC-085611 × Shaktigopal Local	14.55 *	13.69	31.71 **	-2.56	-3.02	16.56 *
IC-085611 × OBGCS-1	-13.54	-14.87	-1.37	-2.83	-4.25	14.01 *
Jaunpuri Green × BGCV-2	26.13 **	20.41 **	51.97 **	-0.19	-7.65	9.92
Jaunpuri Green × OBGCS-2	56.53 **	48.96 **	70.94 **	19.33 **	13.12 *	27.81 **
Jaunpuri Green × Shaktigopal Local	10.45	10.14	26.40 **	14.52 **	5.49	26.79 **
Jaunpuri Green × OBGCS-1	31.77 **	30.35 **	49.59 **	-2.38	-8.45	5.83
katheri × BGCV-2	44.87 **	41.61 **	87.17 **	-13.38 **	-17.10 **	-1.33
katheri × OBGCS-2	20.09 **	7.14	41.61 **	6.04	4.07	17.59 **
katheri × Shaktigopal Local	-2.2	-8.88	20.44 *	-1.32	-6	12.99 *
katheri × OBGCS-1	15.49 *	6.8	41.15 **	-2.03	-4.91	9.92
Preethi × BGCV-2	37.63 **	25.64 **	58.57 **	19.98 **	10.4	31.39 **
Preethi × OBGCS-2	27.69 **	27.35 **	32.72 **	8.5	2.26	15.54 *
Preethi × Shaktigopal Local	-23.34 **	-26.67 **	-16.32	10.05	0.81	21.17 **
Preethi × OBGCS-1	-30.91 **	-33.39 **	-25.21 *	-3.25	-9.77	4.29
Meghna × BGCV-2	-11.68	-12.81	12.92	-0.13	-3.35	15.03 *
Meghna × OBGCS-2	-8.41	-17.55 *	6.78	-7.02	-7.69	4.29
Meghna × Shaktigopal Local	-3.24	-8.99	17.87	-2.85	-6.42	12.47
Meghna × OBGCS-1	-8.87	-14.93 *	10.17	-3.13	-4.91	9.92
*significant at p = 0.05, ** significant at p= 0.01						

Table 4: Estimates of heterosis over mid parent, better and standard parent for number of primary branches per plant and Total fruit yield (q/ha)

Crosses	Number of primary branches per plant			Total Fruit yield (q/ha)		
	MPH	BPH	SH	MPH	BPH	SH
PN-4 × BGCV-2	-5.15	-9.32 *	13.73 *	14.00 **	13.14 **	2.68
PN-4 × OBGCS-2	-12.20 **	-13.82 **	2.36	6.39 **	4.97 *	-4.73 *
PN-4 × Shaktigopal Local	-16.20 **	-24.24 **	-13.33 *	16.18 **	11.85 **	1.51
PN-4 × OBGCS-1	-13.22 **	-18.17 **	5.67	19.34 **	15.62 **	4.93 *
IC-085612 × BGCV-2	-30.68 **	-34.34 **	-17.65 **	-0.15	-3.38	-13.63 **
IC-085612 × OBGCS-2	-1.62	-4.36	13.59 *	0.01	-2.66	-14.02 **
IC-085612 × Shaktigopal Local	1.32	-7.57	3.66	-26.01 **	-26.17 **	-38.00 **
IC-085612 × OBGCS-1	-6.44	-12.60 **	12.87 *	1.62	0.74	-14.28 **
IC-085611 × BGCV-2	-22.06 **	-27.46 **	-9.01	-18.36 **	-33.16 **	-40.25 **
IC-085611 × OBGCS-2	-7.34	-11.52 *	5.1	-9.12 **	-25.25 **	-33.97 **
IC-085611 × Shaktigopal Local	21.77 **	12.98 *	22.08 **	-15.71 **	-29.26 **	-40.59 **
IC-085611 × OBGCS-1	2.43	-5.93	21.48 **	-15.39 **	-29.37 **	-39.90 **
Jaunpuri Green × BGCV-2	-3.48	-9.87 *	13.04 *	20.57 **	13.37 **	15.10 **
Jaunpuri Green × OBGCS-2	5.82	1.38	20.41 **	15.33 **	7.84 **	9.48 **
Jaunpuri Green × Shaktigopal Local	28.76 **	19.08 **	29.57 **	22.67 **	12.07 **	13.78 **
Jaunpuri Green × OBGCS-1	10.96 **	2.23	32.02 **	26.49 **	16.25 **	18.03 **
katheri × BGCV-2	4.52	2.39	28.42 **	50.52 **	37.99 **	47.98 **
katheri × OBGCS-2	14.08 **	13.36 **	36.37 **	27.06 **	15.86 **	24.24 **
katheri × Shaktigopal Local	6.27	-6.03	13.04 *	-0.63	-11.41 **	-4.99 *
katheri × OBGCS-1	15.90 **	11.93 **	44.54 **	31.62 **	18.03 **	26.57 **
Preethi × BGCV-2	-1.48	-6.34	17.48 **	7.82 **	1.96	2.26
Preethi × OBGCS-2	-13.86 **	-15.93 **	-0.14	5.31 *	-0.97	-0.67
Preethi × Shaktigopal Local	3.11	-6.29	5.96	-6.99 **	-14.55 **	-14.30 **
Preethi × OBGCS-1	-25.58 **	-30.21 **	-9.88	10.98 **	2.57	2.87
Meghna × BGCV-2	-15.96 **	-22.41 **	-2.68	-9.21 **	-18.12 **	-26.81 **
Meghna × OBGCS-2	-26.28 **	-30.18 **	-17.07 **	-6.37 **	-15.11 **	-25.01 **
Meghna × Shaktigopal Local	-1.58	-7.94	-2.25	-8.72 **	-15.31 **	-28.88 **
Meghna × OBGCS-1	-9.95 *	-17.95 **	5.96	-0.82	-8.55 **	-22.18 **

*significant at p = 0.05, ** significant at p= 0.01

References

1. Behera TK, Staub JE, Behera S, Simon PW. Bitter gourd and human health. Medicinal and Aromatic Plant Science and Biotechnology. 2008; 1:224-226.
2. Hayes HK, Immer FR, Smith DC. Methods of plant breeding. Mcgraw-Hill Book Company, Inc.; New York, 1955, 555.
3. Jadhav KA, Garad BV, Dhumal SS, Kshirsagar DB, Patil BT, Shinde KG. Heterosis in bitter gourd (*Momordica charantia* L.). Agricultural Science Digest. 2009; 29(1):7-11.
4. Kandasamy R. Heterosis in bitter gourd (*Momordica charantia* L.). Asian Journal of Horticulture. 2015; 10(1):158-160.
5. Kumar A, Singh BK, Singh AK, Anand PK. Combining ability analysis for yield and yield contributing traits in bitter gourd. Indian Journal of Agriculture and Allied Sciences. 2016; 2(1):50-54.
6. Lawande KE, Patil AV. Heterosis in bitter gourd. Haryana Journal of Horticultural Sciences. 1990; 19(3-4):342-348.
7. Panse VG, Sukhatme PV. Statistical methods for agricultural workers, Indian Council of Agricultural Research, New Delhi, 1967, 695p.
8. Raman A, Lau C. Anti-diabetic properties and phytochemistry of *Momordica charantia* L. (Cucurbitaceae). Phytomedicine. 1996; 2(4):349-362.
9. Rao PG, Behera TK, Munshi AD, Dev B. Estimation of genetic components of variation and heterosis studies in bitter gourd for horticultural traits. Indian Journal of Horticulture. 2017; 74(2):227-232.
10. Riggs TJ. Breeding of F_1 hybrid varieties of vegetables. Journal of Horticultural Science. 1988; 63(3):369-382.
11. Singh AK, Pan RS, Bhavana P. Heterosis and combining ability analysis in bitter gourd (*Momordica charantia* L.). The Bioscan. 2013; 8(4):1533-1536.
12. Singh AK, Pandey UB, Mamta S. Studies on heterosis in bitter gourd (*Momordica charantia* L.). Vegetable Science. 2000; 27(2):158-161.
13. Sundaram V. Studies on hybrid vigour in bitter gourd (*Momordica charantia* L.) under salinity. Asian Journal of Horticulture. 2007; 2(2):151-156.
14. Thangamani C, Pugalendhi L, Sumathi T, Kavitha C, Rajashree V. Estimation of combining ability and heterosis for yield and quality characters in bitter gourd (*Momordica charantia* L.). Electronic Journal of Plant Breeding. 2011; 2(1):62-66.
15. Tiwari R, Singh DK. Study of heterosis and combining ability for earliness and vegetative traits in Cucumber (*Cucumis sativus* L.). Journal of Applied and Natural Science. 2016; 8(2):999-1005.
16. Verma RS, Singh MK. Combining ability and gene action in indigenous bitter gourd (*Momordica charantia* L.). HortFlora Research Spectrum. 2014; 3(2):122-126.