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Heterosis studies in bitter gourd (*Momordica charantia* L.) for yield and yield attributes

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Abstract
The experiment was conducted at Bagusala Instructional Farm, M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralekhemundi, Odisha to study the performance of 10 F_1 crosses of bitter gourd obtained from half diallel were studied to investigate the extent of heterosis for yield and its contributing characters. The analysis of variance showing all treatments are significant except days to opening of first female flower. The negative heterosis which is desirable for days to opening of first male flower, number of node bearing first male flower, number of node bearing first female flower in most of the crosses. Significant heterosis was recorded over better parent. The F_1 crosses Galaxy (Selection 9) x Special Bolder Uccha had identified most important parameter like number of fruits per vine and yield per vine. The crosses Shivam (Selection 12) x Special Bolder Uccha, Galaxy (Selection 9) x Meghdut Korola and Galaxy (Selection 9) x Special Bolder Uccha were noted to be the top performing crosses with respect to earliness and yield parameter.

Keywords: Bitter gourd, heterosis, half diallel

Introduction
Bitter gourd (*Momordica charantia* L.) is one of the important vegetable crop which belongs to family Cucurbitaceae. Bitterness in bitter gourd is due to the presence of a compound called momordicin. It is highly cross pollinated crop and monoecious in nature. It has several uses, the fruits are used as vegetables in many ways and commonly used in cooked, fried and stuffed form. The fruits are also pickled, canned and dehydrated. The fruits are used as digestive, laxative, antipyretic and reduces blood diseases, rheumatism and asthma (Thangamani and Pugalendhi 2013) [9]. It is a rich source of vitamins (A and C) and minerals (iron, calcium and phosphorus). Consumption of fruit juice is very useful for diabetic patients due to its potent oxygen free radical scavenging activity (Sreejayan and Rao 1991). Due to efforts of vegetable breeders, improved varieties and crosses have been developed. The success of any breeding procedure is determined by useful gene combination organized in the form of high heterosis in their crosses. Heterosis in cross pollinated crop has been to offer potentialities for increased yield. Hybrid vigour is substantially increased on crossing genetically diverse inbreds. Though heterosis for yield and yield contributing characters has been reported earlier in bitter gourd by (Singh *et al.* (2000) [6]. Heterosis was calculated as percentage of F_1 performance in the favourable direction over mid parent and better parent for each trait. The present investigation was therefore, undertaken to obtain information regarding heterosis.

Materials and Methods
The present investigation entitled "Heterosis studies in bitter gourd (*Momordica charantia* L.) for yield and yield attributes" was carried out during late *kharif* season of the year 2019 at Bagusala Instructional Farm, Department of Horticulture, M. S. Swaminathan School of Agriculture, Centurion University, Paralakhemundi, Odisha. The details of experimental techniques, materials and methods adopted for the study are presented in this chapter.
The experimental material comprised of five genetically diverse parents *viz*., Shivam (Selection 12), Galaxy (Selection 9), West Godavari (short), Special Bolder Uccha and MeghdutKorola were crossed in half diallel design without reciprocals to develop 10 F_1 crosses.

The 10 F_1 crosses, 5 parents comprised the material for heterosis and combining studies in bitter gourd which were evaluated in randomized block design with three replication. Observations were recorded in five randomly chosen plants in each replication for vine length (m), days to opening of first female flower, number of node bearing first female flower, fruit length (cm), fruit diameter (cm), fruit weight (g), number of fruits per vine and fruit yield per vine (kg). Heterosis over mid parent and better parent, were calculated following standard statistical procedures by using griffings Model-I and Method-II (Griffings 1956) [2].

Results and Discussion

The analysis of variance for various yield and yield attributing characters are presented in Table 1. Analysis of variance showed significant differences among the parents for all the traits except days to opening of first female flower under study. This showed the presence of variability in the experimental material for the thirteen characters. The heterosis over mid parent (MP) and better parent (BP) values were estimated for all the thirteen characters among ten crosses are presented in Table 2. For mediating the desirable F_1 crosses, negative heterosis values were considered as favourable for traits *viz.*, days to opening of first male flower, days to opening of first female flower, number of node bearing first male flower, number of node bearing first female flower and days to first fruit harvest. While positive heterosis was considered to be desirable for the traits *viz.*, vine length, number of primary branches per vine, fruit diameter (cm), fruit length (cm), fruit weight (g), number of fruits per vine and number of seeds per fruit.

Heterosis for growth parameters

The cross Special Bolder Uccha x MeghdutKorola (12.83%) showed the higher significance heterobeltiosis for vine length and the cross West Godavari (Short) x MeghdutKorola (11.83%) showed higher significance heterobeltiosis for number of primary branches per vine among the ten crosses. Similar results were reported by Rani *et al.* (2014) [5] and Singh *et al.* (2018) [7]. Earliness is an important trait for realizing the potential economic yield in as less time as possible which is an important consideration for a vegetable grower in bitter gourd. The flowering time for bitter gourd is measured as the days to opening of first male flower, days to opening of first female flower, number of node bearing first male flower, number of node bearing first female flower. Earliness is a primary goal to indicate the negative heterosis in bitter gourd breeding. In days to opening of first male flower, the cross Shivam (Selection 12) x Special Bolder Uccha (-9.53%) showed the negative and significant heterobeltiosis. Negative and significant heterobeltiosis was also noticed for days to opening of first female flower for Shivam (Selection 12) x West Godavari (Short) (-6.76%) appearance in seven crosses.

The cross West Godavari (Short) x Special Bolder Uccha (-30.46%) had favourable heterotic values in desirable direction for number of node bearing first male flower. Among the ten crosses, five crosses had significant negative heterosis and number of node bearing first female flower the cross West Godavari (Short) x MeghdutKorola (-26.39) have shown negative and significant heterobeltiosis.

The cross Shivam (Selection 12) x West Godavari (Short) (-5.30%) had negative and significant heterobeltiosis values for the days to first fruit harvest for this trait. Similar results were reported by Yadav *et al.* (2009) [12] and Thangamani *et al.* (2013) [9].

Heterosis for yield parameters *viz.*, fruit diameter (cm), fruit length (cm), fruit weight (g), number of fruits per vine and fruit yield per vine (kg) are the important towards total yield. The cross West Goavari (Short) x MeghdutKorola had shown the positive and significant heterobeltiosis for fruit diameter. Positive and significant heterobeltiosis has shown in the cross West Godavari (Short) x MeghdutKorola (17.20%) for fruit length. The cross Galaxy (Selection 9) x MeghdutKorola (22.42%) showed higher positive and significant heterobeltiosis for fruit weight. This is in accordance with the earlier reports of Tiwari *et al.* (2016) [11], Laxuman *et al.* (2012) [3] and Robindro *et al.* (2018).

In number of seeds per fruit, the cross Galaxy (Selection 9) x Special Bolder Uccha (17.51%) has shown positive and significant heterobeltiosis for this trait. Similar results was reported by Rani *et al.* (2014) [5].

In number of fruits per vine, the cross Galaxy (Selection 9) x Special Bolder Uccha (24.63%) had shown the positive and significant heterosis for this trait. Higher estimates of heterobeltiosis were recorded in Galaxy (Selection 9) x Special Bolder Uccha (44.47%) had registered positive and significant heterosis. This conformity to the earlier findings of Bhatt *et al.* (2017) [1], Laxuman *et al.* (2012) [3] and Mallikarjunarao *et al.* (2018) [4].

Table 1: Analysis of variance for fruit yield and yield contributing characters

Source of variation	D.f.	Vine length (m)	Number of primary branches	Days to opening of first male flower	Days to opening of first female flower	Number of node bearing first male flower	Number of node bearing first female flower	Days to first fruit harvest	Fruit diameter (cm)	Fruit length (cm)	Fruit weight (g)	Number of fruits per vine	Fruit yield per vine (kg)	Number of seeds per fruit
Replication	2	0.62**	10.72	3.9	5.77	6.78*	10.53	31.41**	0.12	6.52**	144.48**	30.08**	28981.34*	16.67
Treatments	14	0.13**	10.69**	7.87**	5.05	4.05*	9.05*	10.44**	0.26**	2.78**	32.91**	11.79*	34002.738**	16.26**
Error	28	0.04	3.45	1.36	2.56	1.55	3.47	1.58	0.038	0.26	8.57	4.35	5961.21	5.34
Total	44	0.09	6.08	3.55	3.5	2.58	5.57	5.75	0.11	1.35	22.49	7.89	15929.88	9.33

*, ** Significant at 5% and 1% level, respectively

Table 2: Estimation of heterosis over mid parent and better parent for yield and yield attributing characters

Crosses	Vine length (m)		Number of primary branches per vine		Days to opening of first male flower		Days to opening of first female flower		Number of node bearing first male flower		Number of node bearing first female flower	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
Shivam (Selection 12) x Galaxy (Selection 9)	3.24	2.42	1.54	-2.65	-8.28	-8.63**	1.79	1.44	-22.89	-27.27**	10.86*	8.98
Shivam (Selection 12) x West Godavari (Short)	-3.60	-4.16	13.44**	10.01**	3.54	1.33	-4.98	-6.76**	7.45*	3.79	-15.69	-19.17*

Shivam (Selection 12) x Special Bolder Uccha	15.30*	11.07*	12.61**	11.09**	-8.12	-9.53**	2.92	1.23	-23.84	-25.00**	14.69*	13.87*
Shivam (Selection 12) x MeghdutKorola	-4.26	-8.41	16.65**	3.39	-6.87	-7.971**	-3.48	-5.51**	-6.90	-10.48	-17.54*	-22.31**
Galaxy (Selection 9) x West Godavari (Short)	3.44	3.66	9.78*	2.19	3.92	1.33	-4.17	-6.28**	12.91*	10.16*	-17.01*	-19.10*
Galaxy (Selection 9) x Special Bolder Uccha	13.65*	10.32**	3.25	0.31	-6.41	-8.18**	-3.51	-5.40**	-9.38	-13.28	-17.89	-19.85*
Galaxy (Selection 9) x MeghdutKorola	14.67*	10.53**	13.10**	-3.37	-1.01	-2.54	-1.58	-3.98**	13.08*	14.84*	-15.50	-21.67**
West Godavari (Short) x Special Bolder Uccha	4.09	0.83	15.00**	10.06**	-5.72	-6.31*	5.06*	5.32*	-29.08	-30.46**	16.33*	10.76*
West Godavari (Short) x MeghdutKorola	9.36*	5.20	22.73**	11.83**	-3.77	-4.71	-3.82	-4.06**	-5.26	-11.88	-18.72*	-26.39**
Special Bolder Uccha x MeghdutKorola	13.65*	12.83**	18.37**	3.68	-3.52	-3.87	-1.96	-2.44	1.11	-4.20	-14.93	-19.31

*, ** Significant at 5% and 1% level, respectively.MP = Mid parent and BP = Better parent

Table 2: Cont.,

Crosses	Day to first fruit harvest		Fruit diameter (cm)		Fruit length (cm)		Fruit weight (g)		Number of fruits per vine		Fruit yield per vine (kg)		Number of seeds per fruit	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
Shivam (Selection 12) x Galaxy (Selection 9)	4.46*	2.06	-4.58	-6.05	-2.25	-2.19	10.60*	8.75*	17.86*	15.61*	17.89*	14.78*	3.77	-3.70
Shivam (Selection 12) x West Godavari (Short)	-3.77	-5.30*	18.01**	15.71**	19.38**	16.44**	19.81**	17.26**	17.60*	12.89*	4.84	-4.27	-22.33	-28.18
Shivam (Selection 12) x Special Bolder Uccha	4.92*	2.89	-4.47	-4.47	6.27*	4.83*	8.97*	7.98*	17.23*	14.88*	22.74*	16.79*	-14.07	-19.07
Shivam (Selection 12) x MeghdutKorola	-1.17	-1.46	6.06*	5.59*	1.42	-3.12	1.22	-4.09	15.93	14.11*	-1.25	-5.09	-11.21	-12.38
Galaxy (Selection 9) x West Godavari (Short)	-3.62	-4.31	19.93**	15.82**	18.60**	15.61**	24.03**	19.42**	20.74**	18.12*	38.45**	29.60**	-4.07	-4.44
Galaxy (Selection 9) x Special Bolder Uccha	-4.85	-5.20	-2.90	-4.39	-2.05	-3.44	17.66**	16.76**	29.61**	24.63**	47.93**	44.47**	19.36*	17.51**
Galaxy (Selection 9) x MeghdutKorola	-1.92	-4.44	15.81*	14.53*	18.07**	12.72**	27.13**	22.42**	19.49*	19.06*	42.99**	41.10**	17.80*	10.70**
West Godavari (Short) x Special Bolder Uccha	-1.10	-1.46	-1.85	-3.77	15.81**	14.50*	1.88	-1.18	17.21*	10.35*	21.68*	16.50*	1.18	-0.77
West Godavari (Short) x MeghdutKorola	-1.37	-3.22	19.67*	16.82**	19.75**	17.20**	23.13**	14.32**	24.52**	21.38**	48.19**	40.46**	24.32**	16.41**
Special Bolder Uccha x MeghdutKorola	-1.32	-3.51	7.39*	6.92*	-3.50	-6.59	9.76*	4.91	13.51*	9.53	27.47*	26.13*	3.58	-1.20

*, ** Significant at 5% and 1% level, respectively. MP = Mid parent and BP = Better parent

Conclusion

From the present study suggest that the crosses like earliness and higher yield parameters to accomplish higher gains in the F_1 crosses through heterosis breeding. The cross Galaxy (Selection 9) x Special Bolder Uccha had identified the most important parameter like number of fruits per vine and yield per vine. The crosses Shivam (Selection 12) x Special Bolder Uccha, Galaxy (Selection 9) x MeghdutKorola and Galaxy (Selection 9) x Special Bolder Uccha were noted to be the top performing crosses for earliness and yield parameters since they has shown significant heterosis values. These crosses could be better utilized for the improvement of the characters concerned and intermating among superior segregant resulting from these heterotic crosses, is likely to throw desirable progenies in the subsequent later generations.

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