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Studies on heterosis in bitter gourd (*Momordica charantia* L.)

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Abstract
Heterosis study was under taken in 21 F_1 hybrids of bitter gourd obtained from half diallel by using seven parental lines for fruit yield and its contributing characters during summer season. The complete sets of 28 genotypes were evaluated in a randomized block design (RBD) with two replications during summer season. For Twelve different characters the magnitude of heterosis noted in percentage increase or decrease over better parent and standard check. The cross combinations P_1 x P_2 (Phule Green Gold x Preethi), P_2 X P_5 (Preethi x DVBTG-7), P_1x P_3 (Phule Green Gold x Arka harit) and P_6 x P_7 (Hirkani x Konkan Tara) displayed the significant positive heterosis for most of the traits in summer season. As earliness is a desirable character in bitter gourd, the significantly negative heterosis is considered desirable for all maturity traits *viz.*, inter nodal length, days to 50% flowering and days required for first harvest.

Keywords: *Momordica charantia*, heterosis, hybrid, diallel, heterobeltosis

Introduction

Bitter gourd (*Momordica charantia* L.) is commonly known as karela, grown in tropical and subtropical parts of the world. Though, the bitter gourd is native of Indo-burma, it is a prized vegetable of India. It is the important member of Cucurbitaceae having higher chromosome number of 2n=22 and diploidy in nature. Being a cross pollinated crop, bitter gourd have monoecious sex form. The favourable characters of hybrids like production stability, suitability to high input agriculture, uniform growth and maturity shifted the focus towards heterosis breeding, leading to the release of the new potential hybrids. Most of the cucurbits including bitter gourd are usually produced in relatively small quantities for local consumption and so do not enter production statistics in a significant way. Nevertheless, they are important items in the diets of many people because one or more species are element of nearly every vegetable garden both home and commercial (Whitaker and Bemis, 1979) [10]. The existing varieties/land races have emerged mostly through selection from a wide variability available in this crop. The improvement of this crop thus, is mainly achieved through selection and perpetuation of better types. The overwhelming importance of F_1 hybrids in different crop plants for the improvement of yield has long been emphasized by the early workers. Owing to the existence of wide variability, monoecious nature, conspicuous and convenient flowers and quite a large number of seeds per fruit, the bitter gourd can serve as the most potent material for the manifestation of heterosis and its commercial exploitation. The successful exploitation of hybrid vigour is determined by two main conditions: first, the parental lines should be available, which would be capable of combining so well to produce hybrids excelling not only better parents of the good hybrids but also the best variety of the locality; second, the technique to be employed for hybrid seed production should be simple and easy enough so that the cost of seed production is reasonably low. Bitter gourd being monoecious in sex expression can profitably be used for production of F_1 hybrids at cheaper rates. The present investigation was initiated with a view to find out suitable combination which give superior F_1 hybrids with high yields and other quality attributes and good consumer's acceptability. Keeping these objective in view, light varieties of bitter gourd with diverse characters were selected to constitute diallel set (excluding reciprocals) to study the extent of heterosis and genetic architecture of yield.

Material and Methods

The experimental material for this study comprised seven genotypes which were selected based on the diversity for various traits.

From seven genotypes twenty one crosses were obtained in diallel fashion (without reciprocals). The selected parental lines such as Phule green gold (P_1), Preethi (P_2), Arka harit (P_3), Co-white long (P_4), DVBTG-7 (P_5), Hirkani (P_6) and Konkan tara (P_7). The inbred lines of seven genotypes were selected for the purpose of crossing programme and sown in crossing block at Instructional-Cum-Research Farm. Department of Horticulture, College of Agriculture, Latur. Crossing was made in diallel fashion (without reciprocals). The experiments were laid out in RBD with two replications having each experimental unit of single row with spacing of 1.5 × 0.5m. The observations were recorded on parents and F_1's for twelve quantitative traits *viz*., vine length (cm), number of branches per vine, number of nodes per vine, inter nodal length (cm), days to 50% flowering, days required for first harvest, length of fruit (cm), diameter of fruit (cm), weight of fruit (g), number of fruits per vine, fruit yield per vine (kg) and fruit yield per ha (q). The experimental data analysed by statistical method suggested by Panse and Sukhatme (1985) [4]. 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) [9, 1]. Similarly per cent superiority over standard hybrid check (SC) were calculated.

Results and Discussion

For twelve different characters the magnitude of heterosis noted in percentage increase or decrease over better parent and standard check which was presented in Table 1. Developed varieties which matures early in all seasons is the always desirable traits for realizing the highest economic yield as soon as possible in less time which is helpful and important ultimate goal for vegetable growers. As earliness is a desirable character in bitter gourd, the significantly negative heterosis is considered desirable for all maturity traits *viz*., internodal length, days to 50% flowering and days required for first harvest. While positive heterosis considered desirable for rest of the other characters. With respect to length of vine, the cross combinations P_1 x P_4 and P_2 x P_4 exhibited highest percentage of magnitude of positive significant heterosis over better parent and superiority over standard hybrid check, which can be attributed by better per se performance. Similarly, results were obtained by Ranpise (1985) [6] and Lawande (1987) [2]. For number of branches per vine, 14 and 16 hybrids exhibited significant positive heterosis over better parent and standard hybrid check respectively. The cross combination P_1 x P_2 exhibited significant positive heterosis over better parent. While P_4 x P_7 showed significant positive heterosis over standard check. Similarly, results were obtained by Lawande (1987) [2] and Ram *et al.* (1999) [5]. The highest significant positive heterosis for number of nodes per vine over better parent and standard check was obtained in the cross combinations P_2 x P_3 and P_1 x P_4. For inter nodal length of vine, 10 and 6 hybrids exhibited significant negative heterosis over better parent and standard hybrid check respectively. The cross combinations P_2 x P_3 and P_3 X P_4 exhibited significant negative heterosis over better parent and standard check. Similar, results were obtained by Ranpise (1985) [6]. For, days to 50 percent flowering 9 hybrids exhibited significant negative heterosis both over better parent and standard hybrid check respectively. The cross combinations P_2 x P_6 and P_1 x P_3 exhibited significant negative heterosis over better parent. While P_1 x P_3 and P_1 x P_6 showed significant negative heterosis over standard check. Similar, results were obtained by Tewari *et al.* (2001) [8]. For, Days required for first harvest 8 and 6 hybrids exhibited significant negative heterosis over better parent and standard hybrid check respectively. The crosses P_6 x P_7 and P_3 x P_4 exhibited significant negative heterosis over better parent and standard check. Similar, results were obtained by Ram *et al.* (1999) [5]. With respect to length of fruit, 8 and 7 crosses exhibited highest significant positive magnitude of heterosis over better parent and superiority over standard hybrid check respectively. The cross combinations P_2 x P_3 and P_3 x P_7 exhibited highest magnitude of positive significant heterosis over better. These results are in agreement with the finding reported by Tewari *et al.* (2001) [8]. With respect to diameter of fruit, 10 and 7 cross combinations exhibited highest significant positive magnitude of heterosis over better parent and superiority over standard hybrid check respectively. The crosses P_4 x P_5 and P_2 x P_6 exhibited highest magnitude of positive significant heterosis over better. These results are in agreement with the finding reported by Ranpise *et al.* (2001) and Tewari *et al.* (2001) [8]. As many as, 3 hybrids out of 21 hybrids, showed significant heterosis over better parent and non significant heterosis over standard hybrid check respectively for fruit weight. The hybrids P_2 x P_5 and P_3 x P_5 were most promising crosses were recorded maximum heterosis percentage over better parent and standard hybrid check. Similar results have been reported by Ranpise *et al.* (2001) and Tewari *et al.* (2001) [8]. For the character, number of fruits per vine 13 and 5 hybrids exhibited significant positive heterosis over better parent and standard check respectively. The best five hybrids P_1 X P_2, P_1 X P_6, P_1 x P_3 and P_1 x P_4 gave more number of fruit per vine over better parent and the best hybrids P_1 X P_2 and P_1 x P_3 standard hybrid check. These results were in conformity with Laxuman *et al.* (2012) [3] and Singh *et al.* (2013) [7]. With respect to fruit yield per vine, 16 and 9 cross combinations exhibit significant heterosis over better parent and standard hybrid check respectively. The best five hybrids P_1 x P_2, P_2 x P_5, P_1 x P_5, P_1 x P_3 and P_2 x P_7 were most promising crosses and recorded maximum heterosis percentage over better parent and standard hybrid check. Similarly, results have been reported by Laxuman *et al.* (2012) [3] and Singh *et al.* (2013) [7]. The high magnitude of heterosis was exhibited for the character fruit yield per hectare, as many as, 16 and 10 hybrids, exhibited positive and highly significant heterosis over better parent and standard hybrid check respectively. The best five hybrids P_2 x P_5, P_1 X P_2, P_1 X P_3, P_2 X P_4 and P_4 x P_5 were most promising since these crosses recorded maximum heterosis percentage over better parent and standard hybrid check.

Table 1: Per cent Heterosis over better parent and standard check for different characters in 7 x 7 half diallel of bitter gourd

Sr. No.	Crosses	Length of vine (cm)		Number of branches per vine		Number of nodes per vine		Inter nodal length (cm)	
		BP	SH	BP	SH	BP	SH	BP	SH
1.	P_1 x P_2	14.92*	25.44**	60.12**	65.33**	6.36	8.84	-5.62	11.51
2.	P_1 x P_3	8.98	18.95*	17.04	23.84*	19.06*	6.05	-10.06	7.95
3.	P_1 x P_4	27.36**	39.01**	39.53**	54.93**	19.22**	28.37**	-11.35*	4.74
4.	P_1 x P_5	-2.08	6.88	-3.27	16.69	2.70	6.05	-24.39**	-10.67
5.	P_1 x P_6	-0.45	14.93*	32.42**	34.19**	4.31	-3.26	-10.01	6.32
6.	P_1 x P_7	8.41	18.33*	-4.58	8.80	12.50*	29.77**	-8.84	7.70
7.	P_2 x P_3	-5.67	2.28	23.49*	30.67**	30.00**	33.02**	-38.18**	-25.80**
8.	P_2 x P_4	22.73**	23.58**	36.22**	51.25**	7.13	15.35*	-2.66	-3.14
9.	P_2 x P_5	8.29	7.24	21.31*	46.35**	-6.31	-3.26	-7.65	1.04
10.	P_2 x P_6	8.28	25.01**	41.27**	45.87**	10.00	12.56	-15.90**	-7.41
11.	P_2 x P_7	6.67	12.99	15.11	31.25**	-8.87	5.12	-10.13	4.07
12.	P_3 x P_4	-6.11	1.80	39.00**	54.35**	12.31	20.93**	-36.60**	-23.90**
13.	P_3 x P_5	7.55	16.61*	18.97*	43.52**	11.26	14.88*	-18.39**	-2.05
14.	P_3 x P_6	-3.20	11.75	6.75	12.96	6.82	-0.93	-9.36	8.79
15.	P_3 x P_7	10.65	19.97**	23.76**	41.12**	10.48	27.44**	-33.47**	-20.15**
16.	P_4 x P_5	10.17	10.93	35.23**	63.15**	4.54	12.56	-32.09**	-25.70**
17.	P_4 x P_6	-3.80	11.06	40.73**	56.27**	-16.20*	-9.77	-2.31	7.56
18.	P_4 x P_7	0.73	6.70	54.44**	76.11**	-4.44	10.23	-27.55**	-16.10*
19.	P_5 x P_6	9.48	26.40**	-12.02	6.13	18.02**	21.86**	-20.88**	-12.89*
20.	P_5 x P_7	21.50**	28.70**	-8.66	10.19	-0.42	14.86*	-10.06	4.15
21.	P_6 x P_7	0.46	15.98*	21.84*	38.93**	-17.74**	-5.12	-4.07	11.09
S.E. ±		29.46	29.46	0.89	0.89	1.39	1.39	1.25	1.25
C.D. 5%		60.45	60.45	183	1.83	2.86	2.86	2.58	2.58
C.D. 1%		81.63	81.63	2.47	2.47	3.86	3.86	3.48	3.48

Sr. No.	Crosses	Days to 50% flowering		Days required for first harvest		Length of fruit (cm)		Diameter of fruit (cm)	
		BP	SH	BP	SH	BP	SH	BP	SH
1.	P_1 x P_2	-10.16*	-8.73*	-0.64	-1.59	10.57	-0.77	16.67*	16.47*
2.	P_1 x P_3	-14.29**	-14.29**	-3.30	-1.91	-6.29	-15.90*	6.33	6.16
3.	P_1 x P_4	-1.59	-1.59	-6.69	-4.46	39.50**	32.92**	3.33	3.16
4.	P_1 x P_5	-5.56	-5.56	3.38	2.39	9.14	-2.05	8.00	7.82
5.	P_1 x P_6	-14.29**	-14.29**	-10.42*	-8.28	-10.99	-7.15	17.50*	17.30*
6.	P_1 x P_7	-11.11*	-11.11*	0.48	0.32	-5.32	-14.69*	10.00	9.82
7.	P_2 x P_3	-1.56	0.00	-0.16	1.27	61.52**	24.41**	16.49*	12.81
8.	P_2 x P_4	-3.91	-2.38	-3.11	-0.80	23.63**	17.79*	2.75	-0.50
9.	P_2 x P_5	-3.13	-1.59	3.25	1.11	9.44	-6.97	8.25	4.83
10.	P_2 x P_6	-15.63**	-14.29**	-14.77**	-12.74**	6.54	11.13	20.45**	16.64*
11.	P_2 x P_7	-1.56	0.00	1.75	1.59	23.14**	10.95	19.66**	17.47*
12.	P_3 x P_4	1.59	1.59	-14.90**	-12.87**	-9.36	-13.64	10.18	4.49
13.	P_3 x P_5	0.79	0.79	-10.52*	-9.24*	8.02	-8.18	4.21	-1.16
14.	P_3 x P_6	-13.49**	-13.49**	-9.49*	-7.32	-16.59*	-13.00	14.39*	8.49
15.	P_3 x P_7	-9.52*	-9.52*	-10.52*	-9.24*	46.04**	31.59**	8.14	6.16
16.	P_4 x P_5	-12.10**	-13.49**	-12.91**	-10.83*	27.15**	21.15**	27.78**	14.81*
17.	P_4 x P_6	3.25	0.79	-6.38	-4.14	25.86**	31.28**	14.51*	7.65
18.	P_4 x P_7	-9.68*	-11.11*	-6.22	-3.98	-18.41*	-22.26**	16.78*	14.64*
19.	P_5 x P_6	-1.61	-3.17	-6.84	-4.62	-12.76	-9.00	9.73	3.16
20.	P_5 x P_7	-1.61	-3.17	-4.23	-4.38	39.10	25.33**	7.97	5.99
21.	P_6 x P_7	-3.23	-4.76	-15.71**	-13.69**	-15.56**	-11.92	16.95*	14.81*
S.E. ±		2.57	2.57	2.56	2.56	1.35	1.35	0.19	0.19
C.D. 5%		5.27	5.27	5.25	5.25	2.78	2.78	0.40	0.40
C.D. 1%		7.12	7.12	7.09	7.09	3.75	3.75	0.54	0.54

Sr. No.	Crosses	Weight of fruit (g)		Number of fruits per vine		Fruit yield per vine (kg)		Fruit yield /ha (q)	
		BP	SH	BP	SH	BP	SH	BP	SH
1.	P_1 x P_2	12.20	8.13	62.75**	26.04**	110.98**	40.44**	74.50**	40.58**
2.	P_1 x P_3	9.88	5.89	51.26**	21.97**	70.83**	33.90**	66.05**	33.77**
3.	P_1 x P_4	4.59	3.45	42.93**	10.69	45.51**	18.35	45.53**	18.36*
4.	P_1 x P_5	15.56*	11.37	25.91**	7.26	85.75**	23.64*	53.54**	23.69*
5.	P_1 x P_6	-12.53	-15.70*	51.70**	21.01**	21.39*	5.91	21.28*	5.86
6.	P_1 x P_7	4.57	0.78	12.67	-2.71	24.00*	1.24	23.91*	1.17
7.	P_2 x P_3	7.29	-4.12	12.36	-9.39	14.88	-9.95	14.90	-9.94
8.	P_2 x P_4	8.09	6.91	58.03**	21.01**	64.44**	33.75**	64.38**	33.70**
9.	P_2 x P_5	19.86**	6.88	32.80**	13.13	104.33**	24.88*	85.45**	24.88**
10.	P_2 x P_6	8.22	4.18	19.32*	-4.82	34.94**	17.73	25.39*	9.44

11.	P_2 x P_7	9.75	3.29	32.51**	14.42	49.33**	21.93*	49.34**	21.94*
12.	P_3 x P_4	-5.79	-6.81	38.06**	11.33	30.78*	6.38	30.82**	6.40
13.	P_3 x P_5	18.46*	5.86	5.45	-10.16	26.59*	-0.78	26.59*	-0.78
14.	P_3 x P_6	12.71	8.51	39.26**	12.29	43.85**	25.51**	43.67**	25.40**
15.	P_3 x P_7	6.31	0.05	-1.35	-14.81*	43.43**	17.11	29.33*	5.60
16.	P_4 x P_5	2.62	1.50	40.91**	20.04**	55.07**	26.13**	55.15**	26.19**
17.	P_4 x P_6	5.45	4.30	13.25	-9.66	11.59	-2.64	11.60	-2.59
18.	P_4 x P_7	6.58	5.41	-7.62	-20.23**	6.48	-13.06	6.50	-13.04
19.	P_5 x P_6	-7.81	-11.25	-5.09	-19.15*	-14.97	-25.82**	-14.95	-25.77**
20.	P_5 x P_7	6.32	0.06	-13.09	-24.96**	-5.14	-22.55*	-5.14	-22.55*
21.	P_6 x P_7	12.15	7.97	29.26**	11.62	43.14**	24.88*	43.06**	24.87**
S.E. ±		4.01	4.01	3.64	3.64	0.29	0.29	9.12	9.12
C.D. 5%		8.24	8.24	7.48	7.48	0.59	0.59	39.25	39.25
C.D. 1%		11.13	11.13	10.10	10.10	0.80	0.80	53.00	53.00

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