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ESTIMATE OF HETEROSIS IN BITTER GOURD

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ABSTRACT

Heterotic performance of bitter gourd hybrids was studied in a set of 5 x 5 diallel cross excluding reciprocals. Analysis of variance indicated highly significant differences for all the characters suggesting the presence of genetic variability among the studied materials. The degree of heterosis was higher for days to first male flower opening, days to first female flower opening, nodes to first female flower, days to first harvest, fruit length, seeds per fruit, branches per vine, fruits per plant and while relatively lower for remaining traits. The hybrids $P_1 \times P_3$, $P_1 \times P_4$ and $P_1 \times P_5$ performed earlier compared to mid and better parents. Hybrids $P_2 \times P_4$, $P_3 \times P_5$, $P_4 \times P_5$ manifested the higher heterosis over mid parent and better parent for fruits per plant while $P_1 \times P_2$, $P_2 \times P_3$ for fruit weight. The highest significant positive mid parent heterosis for yield per plant was obtained from the cross $P_2 \times P_4$ (113.01 percent) followed by $P_3 \times P_5$ (78.65 percent), $P_4 \times P_5$ (59.30 percent) and $P_2 \times P_3$ (50.59 percent) while the highest positive better parent heterosis was obtained for yield per plant in $P_2 \times P_4$ (94.25 percent) followed by $P_2 \times P_3$ (49.20 percent).

Key words: Heterosis, Bitter gourd, Mid parent and better parent

INTRODUCTION

The bitter gourd (*Momordica charantia*) is a valuable vegetable because of its high nutritive value and medicinal properties. It ranks first among the cucurbits in respect of Iron and Vit-C having 2 mg and 96 mg per 100 g of edible portion respectively (Bose and Som, 1986). Now- a -days bitter gourd is becoming popular throughout the world and the demand of this crop is increasing day by day in our country due to its medicinal properties and nutritive values as well, the crop has huge export potentiality and it carries economic importance.

Bitter gourd being a monoecious crop, exists bright scope for exploitation of heterosis. The heterozygous nature of bitter gourd and virtually the obligatory out crossing breeding system of bitter gourd opens the scope of development of open-pollinated as well as hybrid variety. Exploitation of hybrid vigour is considered to be an outstanding achievement of plant breeding. The scope of exploitation of hybrid vigour will depend upon the available pollination mechanism. The literature available in plant breeding reveals that the exploitation of hybrid vigour is more feasible to cross-pollinated crops (Shukla and Gautam, 1990). Both positive and negative heterosis for different characters of the F_1 hybrids and reciprocal F_1s was reported by Banik (2003) and Kundu (2008). Bitter gourd being a cross-pollinated crop has considerable scope for commercial exploitation of heterosis.

Present harvestable yield of bitter gourd is very low due to unavailability of high yielding hybrid varieties. Bitter gourd is monoecious and highly cross-pollinated in nature. Such pollination mechanism can be exploited for hybrid seed production commercially. As a minor vegetable, bitter gourd did not get proper attention for its genetic improvement in the past. BARI has developed one bitter gourd (OP) variety (BARI Karola-1) and some variety introduced by private seed company. Identification of potential single cross combination having high heterosis is one of the important aims in hybrid development program of bitter gourd. Therefore the present study has been undertaken to study the heterosis in bitter gourd.

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MATERIALS AND METHODS

The experiment was conducted at the experimental farm of Olericulture Division, HRC, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during the month of May to September 2008. A diallel cross of 5 x 5 excluding reciprocals were developed from the five parental lines viz., MC 0022, MC 0026, MC 0027, MC 0028 and MC 0030 designated as P_1, P_2, P_3, P_4 and P_5 respectively. The basic seeds of the 5 x 5 half-diallel mating were produced during December 2007 to May 2008 to obtain 10 F_1s. Seeds of the five selfed parents and their ten F_1 hybrids were sown in polybag on 10 May 2008. Then at the age of 24 days, seedlings were transplanted in the main experimental plots. The experiment was set up in a randomized complete block design (RCBD) with three replications. Fifteen genotypes (10 F_1 s + 5 parents) of bitter gourd were considered as the 15 treatments of the experiment. The unit plot size was 7.0 x 1.2m and the plants were spaced 1m on row. Each unit plot contained single row accommodating 5 plants where data were collected from selected 3 plants leaving 2 border plants. The recommended dosage and method of application of manure and fertilizers were used. Weeding and mulching was done followed by top-dressing and irrigation was applied at 15 days interval. Data on days to first male flower opening, days to first female flower opening, nodes to first male flower, nodes to first female flower, days to first harvest, fruit length (cm), fruit diameter (cm), fruit weight (kg), rind thickness (cm), seeds per fruit, vine length (m), branches per vine, inter node length (cm), fruits per plant and yield/plant (kg) were recorded. The significance of increase or decrease in F_1 hybrids over their corresponding mid parent and better parent were tested by comparing their means with the help of appropriate standard error values in percentage.

RESULTS AND DISCUSSION

The estimates of percent heterosis observed in F_1 generation over better parent are presented through Table 1. The heterotic responses over mid parent and better parent of different characters among the F_1 generation were estimated and are presented in Table 1-5

Days to first male flower opening

Out of 10 cross combinations, 6 hybrids showed significant negative mid parent heterosis for this trait indicating lower days to first male flower opening (Table 1). The highest significant negative heterotic response for days to first male flower opening was observed in the hybrid $P_1 \times P_4$ (-27.22) followed by $P_2 \times P_3$ (-23.28**) and $P_1 \times P_2$ (-17.22**). In case of better parent heterosis, 6 hybrids also performed significant negative better parent heterosis. The highest negative heterotic effect was also observed in the hybrid $P_1 \times P_4$ (-29.79) followed by $P_2 \times P_3$ (-27.27**)

Days to first female flower opening

Four and six hybrids showed significant negative mid parent and better parent heterosis, respectively (Table 1). In both the cases highest significant negative heterotic response for days to first female flower opening was observed in the hybrid $P_1 \times P_4$ (–18.46**, –23.89**) followed by $P_1 \times P_3$(-13.27**, -17.02**) for mid parent and better parent heterosis, respectively. Comparable results were recorded by Banik (2003) in snake gourd, Singh and Joshi (1979) in bitter gourd.

Nodes to first male flower

Same trend was seen in case of nodes to first male flower opening, while 4 hybrids showed significant negative mid parent heterosis with ranged from –13.11 to -6.06 percent. The highest significant negative heterotic response for nodes to first male flower was observed in the hybrid $P_1 \times P_4$ followed by $P_2 \times P_3$ (-11.69**) and $P_3 \times P_5$ (-7.56**). Whereas 6 hybrids performed significant negative better parent heterosis with highest effect was observed in the hybrid $P_1 \times P_4$ (-19.22**) followed by $P_2 \times P_3$ (-18.30**). More or less similar types of results were recorded by Banik (2003) in snake gourd, Singh and Joshi (1979) in bitter gourd and Solanki *et al.* (1982) in cucumber.

Table 1. Percent heterosis over mid and better parent for different characters of 10 crosses in bitter gourd

Crosses	Days to first male flower opening		Days to first female flower opening		Nodes to first male flower	
	Mid parent	Better parent	Mid parent	Better parent	Mid parent	Better parent
$P_1 \times P_2$	-17.22**	-17.59**	10.77**	3.94	7.20**	6.91**
$P_1 \times P_3$	-9.90**	-14.95**	-13.27**	-17.02**	-6.06**	-13.33**
$P_1 \times P_4$	-27.22**	-29.79**	-18.46**	-23.89**	-13.11**	-19.22**
$P_1 \times P_5$	-12.88**	-16.05**	-8.69**	-16.77**	-0.64	-7.63**
$P_2 \times P_3$	-23.28**	-27.27**	-7.68*	-9.55**	-11.69**	-18.30**
$P_2 \times P_4$	-9.61*	-12.41**	-5.96	-6.50*	3.67*	-3.36*
$P_2 \times P_5$	1.95	-1.33	2.18	-0.95	10.90**	3.38**
$P_3 \times P_4$	9.80**	7.33*	-4.71	-7.16**	0.00	-0.83
$P_3 \times P_5$	-2.91	-4.98	0.19	-4.78	-7.56**	-8.33**
$P_4 \times P_5$	-2.02	-2.13	0.19	-2.33	2.54	2.54*
SE	3.48	3.01	2.97	2.57	1.41	1.22
CD (5%)	7.13	6.17	6.09	5.27	2.89	2.51
CD (1%)	9.62	8.33	8.21	7.11	3.90	3.38

* Significant at 5% level & ** Significant at 1% level

Nodes to first female flower

Seven and eight hybrids showed significant negative mid parent and better parent heterosis for this trait indicating lower nodes to first female flower, respectively. The estimates of mid parent heterosis ranged from –13.74 to 10.78 percent. The highest response was observed in the hybrid $P_1 \times P_3$(–13.74**) closely followed by $P_4 \times P_5$ (-12.53**) and $P_1 \times P_4$ (-12.43**). While highest better parent heterosis was observed in the hybrid $P_1 \times P_5$ (–20.94**) followed by $P_4 \times P_5$ (-18.84**). Negative heterosis provides female flower in lower node than their respective better parents. Banik (2003) recorded the similar trend in snake gourd.

Days to first harvest

Only four hybrids showed significant negative heterosis i.e early harvest for this trait (Table 2). The highest negative mid parent heterosis for this trait was observed in the hybrid $P_1 \times P_3$ (-11.91**) closely followed by $P_1 \times P_4$ (-9.73**) and $P_1 \times P_5$ (-8.22**). While seven crosses exhibited significant negative heterosis in case of better parent heterosis. The highest negative heterosis was also observed from $P_1 \times P_4$ (-16.42**) followed by $P_1 \times P_5$ (-15.15**) and $P_1 \times P_3$ (-14.86**). Similar types of findings were also reported by Banik (2003) in snake gourd, Chaudhary (1987) and Pal *et al.* (1983) in bitter gourd.

Fruit length

Four and three hybrids showed significant positive mid parent and better parent heterosis, respectively (Table 2). In both the cases highest significant negative heterotic response for fruit length was observed in the hybrid $P_1 \times P_3$ (15.01**, 12.38**) followed by $P_2 \times P_4$ (11.92**, 11.32**) for mid parent and better parent heterosis, respectively. While positive significant mid parent and better parent heterosis ranged from 7.22 to 15.01 percent and 8.59 to 12.38 percent, respectively. The present findings agreed with the finding of Banik (2003) in snake gourd.

Fruit diameter

Six and three hybrids showed significant positive mid parent and better parent heterosis for this trait indicating wider fruits, respectively (Table 3). Significant positive mid parent heterosis ranged from 1.00 to 7.09 and highest response was obtained by the hybrids $P_2 \times P_3$ followed by $P_1 \times P_2$ and $P_2 \times P_5$ respectively. In case of better parent heterosis positive significant effect ranged from 0.49 to 4.95 percent. The highest value of significant positive effect was observed from the hybrid $P_2 \times P_3$ followed by $P_3 \times P_5$ (1.23 **). The result coincided with the findings of Banik (2003) in snake gourd, Chaudhary (1987) in bitter gourd, Shukla and Goutam (1990) in okra.

Table 2. Percent heterosis over mid and better parent for different characters of 10 crosses in bitter gourd

Crosses	Nodes to first female flower		Days to first harvest		Fruit length (cm)	
	Mid parent	Better parent	Mid parent	Better parent	Mid parent	Better parent
$P_1 \times P_2$	5.26	-7.12**	4.66*	-0.14	-18.17**	-20.24**
$P_1 \times P_3$	-13.74**	-17.26**	-11.91**	-14.86**	15.01**	12.38**
$P_1 \times P_4$	-12.43**	-15.54**	-9.73**	-16.42**	-6.11**	-8.98**
$P_1 \times P_5$	-11.92**	-20.94**	-8.22**	-15.15**	-3.79*	-8.36**
$P_2 \times P_3$	-6.05*	-13.88**	-7.54**	-8.78**	8.85**	8.59**
$P_2 \times P_4$	-2.05	-10.70**	-2.04	-5.09*	11.92**	11.32**
$P_2 \times P_5$	10.78**	8.66**	2.92	-0.43	-1.77	-8.66**
$P_3 \times P_4$	-8.79**	-9.32**	-0.93	-5.25*	-3.12	-3.88**
$P_3 \times P_5$	-7.19*	-13.40**	-1.31	-5.76**	-0.65	-7.40**
$P_4 \times P_5$	-12.53**	-18.84**	-0.04	-0.20	7.22**	-0.82
SE	2.93	2.54	2.23	1.93	1.77	1.53
CD (5%)	6.00	5.20	4.57	3.96	3.62	3.13
CD (1%)	8.10	7.01	6.17	5.34	4.88	4.23

* Significant at 5% level & ** Significant at 1% level

Fruit weight

Out of 10 crosses, eight and five crosses showed significant positive mid parent and better parent heterosis for fruit weight (Table 3). The highest positive significant mid parent heterosis was obtained by the cross $P_1 \times P_2$ (29.97**) followed by $P_2 \times P_3$ (21.88**) while it was same for better parent heterosis which was $P_1 \times P_2$ (28.67**) followed by $P_2 \times P_3$ (18.18**). Similar trend of results was reported by Banik (2003). Highest heterosis of 35.22 % observed in the cross $P_6 \times P_1$ in snake gourd. Solanki *et al.* (1982) noted that maximum average fruit weight was in cross H × BL (33.24 %) in cucumber. Rajput *et al.* (1984) observed 56% heterosis over the better parent for mean fruit weight. Better parent heterosis for fruit weight was also reported by Dahiya *et al.* (1984) and Patil and Shinde (1984).

Table 3. Percent heterosis over mid and better parent for different characters of 10 crosses in Percent bitter gourd

Crosses	Fruit diameter (cm)		Fruit weight (kg)		Rind thickness (cm)	
	Mid parent	Better parent	Mid parent	Better parent	Mid parent	Better parent
$P_1 \times P_2$	5.53**	0.55*	29.97**	28.67**	66.97**	39.97**
$P_1 \times P_3$	-1.69**	-4.59**	11.36**	6.97**	38.19**	13.10**
$P_1 \times P_4$	-5.28**	-8.37**	-10.41**	-29.17**	37.93**	5.26**
$P_1 \times P_5$	-5.58**	-7.24**	11.62**	10.50**	6.30**	-14.43**
$P_2 \times P_3$	7.09**	4.95**	21.88**	18.18**	15.09**	11.61**
$P_2 \times P_4$	1.00**	-6.67**	4.58**	-16.67**	8.02**	-4.07**
$P_2 \times P_5$	3.79**	0.49	10.00**	10.00**	4.83**	-0.41
$P_3 \times P_4$	3.41**	-2.74**	-3.11**	-18.75**	6.24**	-3.09**
$P_3 \times P_5$	2.62**	1.23**	3.13**	0.00	4.07**	1.79**
$P_4 \times P_5$	-5.43**	-10.00**	5.88**	-15.63**	4.70**	-2.63**
SE	0.28	0.25	0.02	0.02	0.44	0.38
CD (5%)	0.58	0.50	0.04	0.03	0.89	0.77
CD (1%)	0.78	0.68	0.05	0.04	1.21	1.04

* Significant at 5% level & ** Significant at 1% level

Rind thickness

All of 10 cross combinations showed significant positive mid parent heterosis while for better parent heterosis fifty percent was obtained for this trait (Table 3). The estimates of mid parent heterosis ranged from 4.07 to 66.97 percent with highest significant heterotic response was observed in the hybrid $P_1 \times P_2$ (66.97**) followed by $P_1 \times P_3$ (38.19**) and $P_1 \times P_4$ (37.93**). Meanwhile, five hybrids showed significant positive better parent heterosis. The estimates of better parent heterosis ranged from 1.79 to 39.97 percent. The highest positive heterotic effect was observed same in the hybrid $P_1 \times P_2$ (39.97**) followed by $P_1 \times P_3$ (13.10**).

Seeds per fruit

Two and six hybrids showed significant negative mid parent and better parent heterosis, respectively for this trait indicating less seeds per fruit (Table 4). The highest significant negative heterotic response for seeds per fruit was observed in the hybrid $P_1 \times P_5$ (–18.75**) followed by $P_1 \times P_2$ (-12.40**). In case of better parent heterosis, the highest negative heterotic effect was also observed in the hybrid $P_1 \times P_5$ (–22.00**) followed by $P_1 \times P_2$ (-16.52**). These combinations may be desirable for consumer preference for less seeded fruit. The highest positive mid parent and better parent heterotic effect i.e. more seeded was observed from $P_2 \times P_3$ (20.46**,15.38**). The findings of the present study coincide with the findings of Banik (2003) in snake gourd.

Vine length

Among the 10 cross combinations 5 crosses showed significant positive mid parent heterosis for vine length but 5 hybrids showed significant negative heterosis for this trait (Table 4). The highest percentage of positive and negative heterosis was observed from the cross $P_1 \times P_2$ (111.74**) and $P_2 \times P_4$ (-42.56**), respectively for this trait. In case of better parent heterosis, 3 crosses showed significant positive better parent heterosis. For better parent heterosis, the highest percentage of positive and negative heterosis was observed from the cross $P_1 \times P_2$ (49.08**) and $P_3 \times P_5$ (-45.10**), respectively. Considering the trait, both positive and negative heterosis are desirable depending on breeder prefix objectives, dwarf vine length may increase the total yield per unit area by increasing population per unit area. Banik (2003) also observed similar results in snake gourd. Agrawal *et al.* (1957) and Vahab (1989) also observed heterosis for this trait in bitter gourd.

Branches per vine

Three and two crosses showed positive significant heterotic effect over mid parent and better parent for branches per vine at last harvest (Table 4). Percent positive mid parent heterosis ranged from 5.88 to 182.35 with highest heterosis was observed in $P_1 \times P_5$ followed by $P_3 \times P_5$ (16.67**). While for better parent heterosis, the range was 3.70 to 140.00 percent with the maximum positive heterotic effect in hybrid $P_1 \times P_5$ followed by $P_3 \times P_5$ (3.70**).

Table 4. Percent heterosis over mid and better parent for different characters of 10 crosses in bitter gourd

Crosses	seeds per fruit		Vine length (m)		Branches per vine	
	Mid parent	Better parent	Mid parent	Better parent	Mid parent	Better parent
$P_1 \times P_2$	-12.40**	-16.52**	111.74**	49.08**	-33.33**	-40.00**
$P_1 \times P_3$	5.28*	4.71*	-19.54**	-20.84**	-47.37**	-50.00**
$P_1 \times P_4$	-0.39	-8.91**	52.91**	10.82**	-33.33**	-40.00**
$P_1 \times P_5$	-18.75**	-22.00**	-34.06**	-41.07**	182.35**	140.00**
$P_2 \times P_3$	20.46**	15.38**	-21.99**	-44.60**	-29.41**	-33.33**
$P_2 \times P_4$	6.95**	-6.38**	-42.56**	-45.10**	-25.00**	-25.00**
$P_2 \times P_5$	-0.12	-8.44**	22.15**	-7.16**	-20.00**	-25.00**
$P_3 \times P_4$	20.13**	9.31**	21.66**	-10.99**	5.88**	0.00
$P_3 \times P_5$	-2.14	-6.55*	12.28**	1.73**	16.67**	3.70**
$P_4 \times P_5$	9.95**	4.50*	-17.50**	-34.46**	-20.00**	-25.00**
SE	2.47	2.14	0.56	0.48	0.78	0.68
CD (5%)	5.05	4.38	1.14	0.99	1.60	1.39
CD (1%)	6.82	5.90	1.54	1.33	2.16	1.87

* Significant at 5% level & ** Significant at 1% level

Inter node length

Five and seven hybrids showed significant negative mid parent and better parent heterosis for this trait indicating lower inter node length (Table 5). The highest significant negative mid parent heterotic response was observed in the hybrid $P_2 \times P_4$ (-39.31**) followed by $P_1 \times P_2$ (-14.42**). While the highest negative heterotic effect for better parent heterosis was observed in the hybrid $P_2 \times P_4$(–42.53**) followed by $P_1 \times P_2$ (-16.85**).

Fruits per plant

Out of 10 crosses, six showed significant positive mid parent heterosis for fruits per plant (Table 5). The positive significant mid parent heterosis ranged from 23.15 to 90.30 percent while the highest positive significant heterosis was obtained by the cross, $P_2 \times P_4$ followed by $P_3 \times P_5$ (74.85**), $P_4 \times P_5$ (46.89**), $P_3 \times P_4$ (38.55**) and $P_1 \times P_4$ (24.29**). Meanwhile five crosses exhibited significant positive better parent heterotic effect. The significant positive better parent heterosis ranged from 16.79 to 52.05 percent with highest positive heterosis was attained by the cross, $P_3 \times P_5$ followed by $P_2 \times P_4$ (45.81**) and $P_4 \times P_5$ (32.40**). Baha-Eldin *et al.* (1968) from a study with parents, F_1, F_2 and backcross of a cross observed distinct heterosis. Lal *et al.* (1974) observed 1.57 to 23.43 percent heterosis over the better parents.

Yield per plant

Nine and six crosses for yield per plant showed significant positive mid parent and better parent heterotic effect, respectively (Table 5). Percent of mid parent positive heterosis ranged from 5.02 to 113.01 percent. More than 50% mid parent heterosis was observed from 4 crosses. The highest significant positive heterosis was obtained from the cross, $P_2 \times P_4$ (113.01**) followed by $P_3 \times P_5$ (78.65**), $P_4 \times P_5$ (59.30**) and $P_2 \times P_3$ (50.59**). While positive better parent heterosis ranged from 4.91 to 94.25 percent. The highest significant positive better parent heterosis showed by the hybrid $P_2 \times P_4$ followed by $P_2 \times P_3$ (49.20**). The other four hybrids showed less than 50% better parent heterosis.

Table 5. Percent heterosis over mid and better parent for different characters of 10 crosses in bitter gourd

Crosses	Inter node length (cm)		Fruits per plant		Yield per plant (kg)	
	Mid parent	Better parent	Mid parent	Better parent	Mid parent	Better parent
$P_1 \times P_2$	-14.42**	-16.85**	-29.61**	-40.20**	-8.35**	-21.67**
$P_1 \times P_3$	-0.93	-6.74**	7.64	-12.41**	21.89**	4.91**
$P_1 \times P_4$	22.36**	19.16**	24.29**	-14.71**	24.13**	-1.60**
$P_1 \times P_5$	-2.18**	-5.30**	-6.25	-31.37**	5.02**	-22.80**
$P_2 \times P_3$	32.84**	28.57**	23.15**	16.79**	50.59**	49.20**
$P_2 \times P_4$	-39.31**	-42.53**	90.30**	45.81**	113.01**	94.25**
$P_2 \times P_5$	-3.92**	-9.53**	7.87	-10.29**	18.66**	-1.40**
$P_3 \times P_4$	14.74**	5.36**	38.55**	10.37**	39.78**	26.53**
$P_3 \times P_5$	3.77**	-5.24**	74.85**	52.05**	78.65**	47.48**
$P_4 \times P_5$	-6.89**	-7.45**	46.89**	32.40**	59.30**	43.91**
SE	0.59	0.51	4.12	3.57	0.52	0.45
CD (5%)	1.20	1.04	8.44	7.31	1.06	0.92
CD (1%)	1.62	1.40	11.39	9.86	1.44	1.24

* Significant at 5% level & ** Significant at 1% level

Mishra (1962) and Dharmegowda (1977) concluded that the increase in yields of hybrids was mainly due to fruit number and fruit weight while Singh and Swarup (1971) and Balamohan *et al.* (1983) reported that heterosis in yield was attributed to increase in number of branches, fruit number and fruit length.

CONCLUSION

Heterosis is not responsible to only fruit length or fruit diameter, but also to individual fruit weight and number of fruits per plant. From the study the cross combinations $P_2 \times P_4$, $P_3 \times P_5$, $P_4 \times P_5$ and $P_2 \times P_3$ manifested the highest heterosis over mid parent and better parent for yield per plant as well as fruits per plant and fruit weight, these combination may be use as breeding material.

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