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HETEROSIS AND COMBINING ABILITY ANALYSIS IN BITTERGOURD (*MOMORDICA CHARANTIA* L.)

A. K. SINGH, R. S. PAN AND P. BHAVANA*
ICAR Research Complex for Eastern Region, Research Centre, Ranchi - 834 010, Jharkhand
e-mail: bhavanaraj2311@yahoo.co.in

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***Corresponding author**

ABSTRACT
Twenty one crosses along with their parents were studied for combining ability, heterosis and gene action for eight yield and yield components in bittergourd. Except days to 50% flowering significant differences were observed for all the characters under study. All the traits were found under the control of non additive gene action except for fruit length and fruit breadth which showed significant differences due to both gca and sca with preponderance to additive gene action. HABG-30 was found to be good general combiner for most of the characters (yield/plant, yield t/ha, fruit weight, fruit length, fruit breadth and vine length). HABG-24XHABG-30 exhibited significant sca effect for all characters except days to 50% flowering and HABG-23XHABG-34 showed significant sca effect for number of fruits/plant, yield/plant, yield t/ha and vine length. These crosses were also found to show significant heterosis in the desired direction for most of the yield characters. Hence they can be exploited as desirable hybrids.

INTRODUCTION

Momordica charantia often called bitter gourd is a tropical and subtropical important commercial vegetable crop of the family Cucurbitaceae. Bitter gourd has been used in various herbal medicine systems for a long time because of its disease preventing and health promoting phyto chemical compounds like dietary fiber, minerals, vitamins, flavonoids and anti-oxidants. It is also used for reduction of blood sugar levels in the treatment of type-2 diabetes. It is highly cross pollinated and has high levels of heterozygosity. Due to efforts of vegetable breeders, improved varieties and hybrids have been developed. Crop improvement involves strategies for enhancing yield potentiality and quality components. Selection of parents based on *per se* performance does not yield the desired results. Selection of parents for hybridization has to be based on the complete genetic information and prepotency of the potential parents. With these points in view, heterosis and combining ability studies are prerequisite in any plant breeding programme, which provides the desired information regarding the varietal improvement or exploiting heterosis for commercial purposes. Though many reports on combining ability and heterosis breeding are available in bitter gourd (Sirohi and Choudhury, 1977; Abdul Vahab, 1989; Lawande and Patil, 1990a/b; Choudhari and Kale, 1991a/b), information on identification of better parents for F_1 production is lacking. Therefore this study was conducted to generate information about general and specific combining ability and heterosis for different yield characters.

MATERIALS AND METHODS

Seven diverse bittergourd lines *viz*., HABG-23, HABG-24, HABG-28, HABG-29, HABG-30, HABG-31 and HABG-34 were selected and crossed with all possible combinations (21F_1s) excluding reciprocals. The F_1s and parents were evaluated under complete randomized block design at Experimental farm of ICAR RCER Research Centre, Ranchi during 2012. Seeds were sown in protrays and seedlings were transplanted after one month keeping row to row and plant to plant spacing 4mx2m respectively under trellis system. Observations were recorded on all the plants in each parent and F_1s for each treatment in each replication for days to 50% flowering, fruit breadth (cm), fruit length (cm), number of fruits per plant, fruit weight (g), vine length (m), yield per plant (kg) and yield (t/ha). Means of observations were subjected to combining ability analysis according to Griffing (1956) using SPAR3.0.

RESULTS AND DISCUSSION

Analysis of variance (Table 1) showed significant difference due to treatments for all the characters except for days to 50%flowering. This indicates presence of sufficient amount of variation for all the traits and selection will be effective in improving them. ANOVA for combining ability analysis (Table 2) revealed highly significant variances for specific combining ability for all the characters except for days to 50 % flowering. Hence these characters may be improved through hybridization (heterosis) indicating predominance of non additive gene effects. Singh *et al*. (2006), Sundharaiya and Shakila (2011), Kumara *et al*. (2011) and Laxuman *et al*. (2012) also reported significant sca variances. Fruit length and fruit breadth showed significant differences due to both gca and sca. And also gca variances were higher than sca variances indicating population improvement through recurrent

Table 1: ANOVA for yield and yield components in half diallel crosses of Bittergourd

Source of Variation	df	No. of fruits per Plant	Yield per Plant (kg)	Yield (t/ha)	Fruit weight (g)	Fruit Length(cm)	Fruit Breadth(cm)	Days to 50 % flowering	Vine length (m)
Replication	1	3.67	0.006	2.01	1712.19	0.21	0.12	0.29	0.02
Treatment	27	11.52**	0.061**	21.35**	775.32**	8.89**	0.24**	8.70	0.27**
Error	27	6.24	0.018	5.71	205.81	1.62	0.07	8.84	0.03

*P = 0.05, **P = 0.01

Table 2: ANOVA for combining ability analysis

Source of Variation	df	No. of fruits per Plant	Yield per Plant (kg)	Yield (t/ha)	Fruit weight(g)	Fruit Length (cm)	Fruit Breadth(cm)	Days to 50 % flowering	Vine length (m)
GCA	6	3.99	0.03	11.35	650.38	9.65*	0.25*	4.45	0.22
SCA	21	6.27*	0.03**	10.48**	312.59**	2.96**	0.08*	4.32	0.11**
Error	27	3.12	0.01	2.86	102.91	0.81	0.04	4.42	0.02

P = 0.05, **P = 0.01

Table 3: Mean performance of parents for yield and yield components

Parents	Characters No. of fruits per Plant	Yield per Plant (kg)	Yield (t/ha)	Fruit weight(g)	Fruit Length(cm)	Fruit Breadth(cm)	Days to 50 % flowering	Vine Length (m)
HABG-23	12.69	0.42	8.34	46.88	13.60	3.35	89.00	2.99
HABG-24	13.50	0.41	8.31	43.75	14.75	2.91	92.00	2.40
HABG-28	13.03	0.56	11.19	44.63	12.94	3.37	94.00	2.40
HABG-29	12.28	0.48	9.69	50.00	12.79	3.55	94.50	2.43
HABG-30	13.22	0.71	14.31	87.50	16.40	3.74	92.50	2.67
HABG-31	15.40	0.56	11.28	31.25	11.40	3.61	90.00	2.37
HABG-34	15.12	0.52	10.38	40.63	14.01	2.95	88.50	2.06
Mean	13.60	0.52	10.50	49.23	13.70	3.35	91.50	2.47

Table 4: General combining ability effects of parents for yield and yield components

Parents	No. of fruits per Plant	Yield per Plant (kg)	Yield (t/ha)	Fruit weight(g)	Fruit Length (cm)	Fruit Breadth(cm)	Days to 50 % flowering	Vine length (m)
HABG-23	-0.07	-0.03	-0.27	-0.18	-0.27	0.01	-0.69	0.24**
HABG-24	-0.14	-0.001	-0.36	2.07	1.39**	-0.20**	0.14	-0.004
HABG-28	0.13	0.008	0.19	-1.72	-0.10	0.06	1.14	0.03
HABG-29	-1.12*	-0.09**	-1.66**	-4.69	-0.80**	-0.08	0.42	-0.16**
HABG-30	-0.37	0.11**	2.13**	17.73**	1.33**	0.32**	0.31	0.16**
HABG-31	0.79	-0.005	-0.07	-7.76*	-1.41**	0.04	-0.75	-0.12**
HABG-34	0.78	0.001	0.04	-5.44	-0.14	-0.14*	-0.58	-0.14**
SE	0.55	0.03	0.52	3.13	0.28	0.06	0.65	0.04

selection should be adopted for improving fruit breadth. Both additive and non additive gene action were involved in the expression of fruits/plant, fruit length, breadth, weight and yield by Mishra *et al.* (1994) and Kushwaha and Karnwal (2011). Similar results were reported by Matoria and Khandelwal (1999) but with predominant non additive gene action. The difference in the results might be due difference in the genetic material studied.

Information regarding gca effect of the parent is of prime importance as it helps in successful prediction of genetic potentiality of crosses. HABG-30 was the best general combiner for most of the characters under study (Table-4). HABG 30 had highest mean values for yield/plant, yield (t/ha), fruit weight, fruit length and fruit breadth (Table-3). Hence HABG-30 can be used in bittergourd breeding programme. The parent with good gca for a character also exhibits good *per se* performance. Similar results for some characters were reported by Laxuman *et al.* (2012) for the parent Gadag Local. However the parents HABG-31 and HABG-34 had high *per se* performance for number of fruits per plant and days to 50 % flowering but low gca. Hence it can be concluded that combining ability of parents can't always be judged by their *per se* performance. Similar results obtained by Ingale and Patil (1997), Bavage (2002) in brinjal and Maurya *et al.* (1993) in bottle gourd.

Estimates of specific combining ability effects are given in Table-5. HABG-24 x HABG-30 and HABG-23XHABG-34 were showing significant sca effects for almost all the important yield contributing characters.

HABG-29 was the best general combiner for number of fruits per plant. Best crosses showing positive significant sca effects were HABG-23X HABG-34, HABG-24X HABG-30, HABG-28X HABG-31 and HABG-28X HABG-34. Significant gca effects for HABG-30 and significant sca effects for crosses HABG-23X HABG-34 and HABG-24X HABG-30 were reported for yield per plant. HABG-30 was the best general combiner for yield (t/

Table 5: Specific combining ability effects of crosses for yield and yield components

Crosses	No. of fruits per Plant	Yield per Plant (kg)	Yield (t/ha)	Fruit weight(g)	Fruit Length(cm)	Fruit Breadth(cm)	Days to 50% flowering	Vine length (m)
HABG-23X HABG-24	-0.56	-0.09	-1.66	-2.48	-0.22	-0.10	0.08	0.16
HABG-23X HABG-28	2.98	0.07	1.15	-4.94	-1.74*	-0.07	-0.92	0.10
HABG-23X HABG-29	-0.68	-0.05	-1.22	13.65	-0.44	-0.27	-1.69	-0.12
HABG-23X HABG-30	0.89	0.14	5.04**	3.10	1.43	0.26	0.92	0.10
HABG-23X HABG-31	0.42	0.06	1.01	7.97	1.18	-0.06	-0.53	-0.05
HABG-23X HABG-34	3.95*	0.25**	4.83**	-4.35	-0.24	0.19	0.31	0.48**
HABG-24X HABG-28	0.67	-0.02	0.003	-16.56	-0.84	0.01	-1.25	-0.08
HABG-24X HABG-29	2.23	0.10	2.22	-10.46	-0.38	0.05	-0.53	0.09
HABG-24X HABG-30	3.20*	0.50**	7.09**	49.06**	4.49*	0.22	-3.92*	0.70**
HABG-24X HABG-31	1.04	0.12	2.82	11.35	-0.28	0.20	0.64	-0.20
HABG-24X HABG-34	-1.47	-0.09	-1.65	-2.71	1.52	-0.41*	0.47	0.20
HABG-28X HABG-29	-1.51	0.08	1.49	33.95**	3.61*	0.42*	-0.03	0.26*
HABG-28X HABG-30	-1.48	-0.07	-1.56	-0.98	0.31	0.11	1.08	0.21
HABG-28X HABG-31	3.43*	0.14	2.71	-0.48	0.60	-0.19	-3.36	0.39**
HABG-28X HABG-34	3.06*	0.08	1.48	0.32	0.04	-0.20	-0.03	0.15
HABG-29X HABG-30	1.59	-0.11	-2.05	-29.26**	-1.64*	-0.39*	-3.69*	-0.07
HABG-29X HABG-31	0.96	-0.01	-0.28	-10.01	-0.96	-0.57**	-1.14	0.09
HABG-29X HABG-34	1.04	0.03	0.73	-9.21	-0.70	-0.05	-1.31	-0.05
HABG-30X HABG-31	0.39	-0.13	-2.41	-16.94	-1.79*	-0.14	0.47	0.04
HABG-30X HABG-34	0.19	0.03	0.71	-1.63	-2.03*	0.34*	0.31	0.01
HABG-31X HABG-34	-1.22	0.01	0.23	21.99*	1.05	0.29	-0.14	0.19
SE	1.59	0.08	1.52	9.10	0.81	0.17	1.89	0.11

Table 6: Estimates of heterobeltosis for yield and yield components

Crosses	No. of fruits per Plant	Yield per Plant (kg)	Yield(t/ha)	Fruit weight(g)	Fruit Length (cm)	Fruit Breadth(cm)	Days to 50 % flowering	Vine length (m)
HABG-23X HABG-24	15.30**	33.73**	33.73**	13.33	1.87	-10.01**	0.00	8.36**
HABG-23X HABG-28	48.75**	29.73**	29.85**	0.00	-11.69**	-2.23**	0.00	7.86**
HABG-23X HABG-29	14.03**	6.25**	6.40*	25.00	-7.28**	-16.62**	-1.69	-6.35**
HABG-23X HABG-30	26.98**	26.06**	42.26**	-15.00	1.28	4.02**	1.12	12.04**
HABG-23X HABG-31	13.41**	25.00**	25.22**	14.67	0.07	-9.00**	-1.69	-2.51**
HABG-23X HABG-34	38.86**	73.79**	74.04**	-6.67	-3.93**	0.75**	0.00	14.55**
HABG-24X HABG-28	25.94**	18.92**	18.68**	-15.97	-1.15	-5.93**	-2.72	16.67**
HABG-24X HABG-29	28.23**	41.67**	40.92**	-18.75	-2.78*	-13.38**	-2.72	14.43**
HABG-24X HABG-30	41.02**	79.58**	55.92**	40.09**	30.03**	-2.68**	-6.52*	38.58**
HABG-24X HABG-31	17.05**	40.18**	40.47**	35.71**	-6.34**	-7.62**	-0.56	5.21**
HABG-24X HABG-34	2.51	11.65**	10.69**	8.86	14.51**	-13.22**	1.13	20.83**
HABG-28X HABG-29	6.26**	20.72**	20.38**	62.50**	30.15**	4.37**	-3.19	22.68**
HABG-28X HABG-30	10.63**	0.70**	-0.66	-21.43	-4.51	1.34**	-0.54	21.72**
HABG-28X HABG-31	34.32**	44.64**	44.33**	-1.96	2.13	-11.08**	-3.89	31.25**
HABG-28X HABG-34	34.33**	36.04**	35.57**	5.04	-0.64	-10.39**	1.69	20.42**
HABG-29X HABG-30	24.37**	-16.90**	-17.01**	-57.14**	-20.67**	-15.66**	-6.49*	3.93**
HABG-29X HABG-31	10.16**	0.89**	1.42	-37.50**	-14.39**	-25.35**	-2.22	9.28**
HABG-29X HABG-34	12.63**	20.39**	21.05**	-31.25*	-10.96**	-14.51**	-0.56	2.68**
HABG-30X HABG-31	11.36**	-8.45**	-8.45**	-46.57**	-25.34**	-5.76**	-0.56	9.55**
HABG-30X HABG-34	12.00**	14.79**	14.18**	-26.43*	-19.09**	2.28**	1.13	7.68**
HABG-31X HABG-34	8.34**	21.43**	21.05**	53.85**	-2.86*	-3.05**	-0.56	17.09**
SE	2.74	0.14	2.69	13.66	1.20	0.31	3.12	0.16

ha). Crosses HABG-23X HABG-30, HABG-23X HABG-34 and HABG-24X HABG-30 recorded significant positive sca effects for yield in t/ha. The best general combiner for fruit weight was HABG-30 and the best crosses were HABG-24X HABG-30, HABG-28X HABG-29 and HABG-31X HABG-34. For fruit length, the best combiners were HABG-24 and HABG-30 with significant positive gca effects. The best crosses with significant positive sca effects were HABG-24X HABG-30 and HABG-28X HABG-29. HABG-30 recorded significant positive gca for fruit breadth and HABG-28X HABG-29 and HABG-30 X HABG-34 showed positive sca effects. Significant negative sca effects were recorded for days to 50% flowering in HABG-24 x HABG-30 and HABG-29 x HABG-30. HABG-23and HABG-30 recorded positive significant gca effects for vine length. Best crosses with positive significant sca effects were HABG-23X HABG-34, HABG-24X HABG-30, HABG-28X HABG-29 and HABG-28X HABG-31. These crosses with higher specific combining ability effects are useful to derive high performing hybrids. These crosses involved parents with high x high, high x low and low x low general combining ability effects indicating presence of additive, dominance and epistatic gene actions for controlling these characters. Similar results were reported by Niyaria and Bhalala 92001) in ridge gourd and Laxuman *et al*. (2012) in bitter gourd. High x low general combining ability combinations are suitable for heterosis breeding. High x high general combining ability combinations can be considered for developing superior variants through pedigree method.

Heterosis is the superiority of F_1 over the mean of the parents or over the better parent or over the standard check (Hayes *et al*. 1956). Significant better parent heterosis in desired direction is used for selection of best hybrids. Most of the crosses were proved to be highly heterotic for all the characters except days to 50% flowering. Only two crosses *viz*., HABG-24XHABG-30 and HABG-29XHABG-30 showed significant negative heterobeltosis for days to 50 % flowering (Table 6). Laxuman *et al*. (2012) also emphasized the importance of earliness for realizing potential economic yield in less time. Number of fruits per plant, fruit length and fruit weight form the most important closely related productivity traits. The extent of percent heterosis for number of fruits of fruits per plant ranged from 48.75 (HABG-23X HABG-28) to 2.51 (HABG-24X HABG-34). Twenty crosses out of twenty one cross combinations showed significant positive heterosis. Similar results were obtained by Mishra *et al*. (1994) and Laxuman *et al*. (2012). Fruit yield per palnt is the ultimate and the most important trait. Data on heterosis for yield per plant ranged from 79.58% (HABG-24X HABG-30) to -16.90 (HABG-29X HABG-30). Only two crosses showed negative significant heterosis. The cross HABG-24xHABG-30 had highest positive heterosis of 79.58 percent over better parent followed by HABG-23xHABG-34 (73.39%). Seventeen hybrids out of the twenty one crosses showed positive significant heterobeltosis for yield in t/ha. Four crosses *viz*., HABG-24X HABG-30, HABG-24X HABG-3, HABG-28X HABG-29and HABG-31X HABG-34 exhibited positive significant heterosis for fruit weight. For fruit length, HABG-24X HABG-30, HABG-24X HABG-34 and HABG-28X HABG-29, for fruit breadth, HABG-23X HABG-30, HABG-28X HABG-29, HABG-28X HABG-30 and HABG-30X HABG-34 recorded positive significant heterobeltosis. Nineteen hybrids exhibited significant positive heterosis for vine length. These results are in agreement with those of Choudhari and Kale (1991b), Ranpise *et al*. (1992), Mishra *et al*. (1994) and Laxuman *et al*. (2012).

In terms of better general combiners and *per se* performance, HABG-30 and among crosses based on sca effects and heterobeltosis, HABG-24XHABG-30 and HABG-23XHABG-34 were found superior. It is therefore, suggested that these promising parents and crosses may be exploited for further amelioration of yield and yield components in bittergourd. The selected crosses can be directly utilized as promosing hybrids.

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