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Short communication

Combining ability analysis in bitter gourd

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Bitter gourd or balsam pear (*Momordica charantia* L.) is one of the most important cucurbitaceous vegetable crops grown throughout the country. Bitter gourd is a rich source of nutrients (Xiang *et al.*, 7) and ranks first among cucurbits for its nutritive value (Miniraj *et al.*, 5). Traditionally, plant extract of bitter gourd have been used in the treatment of diabetes (Grover *et al.*, 4). In spite of wide range of diversity very little work has been undertaken to exploit this naturally endowed diversity to breed hybrid varieties. Heterosis breeding offers a unique opportunity to develop more productive varieties with early production. To make the heterosis breeding a successful endeavour identification of good combiners with substantial diversity is the prerequisite. In this study an effort was made to identify productive parents with early fruitfulness.

Nine genetically diverse lines/cultivars of bitter gourd namely, DBGY-201, Pusa Do Mausami, Pusa Vishesh, PBIG-44-3, NDBT-12, Priya, DVBTG-5-5, Nakhara and Arka Harit were selected from different parts of India. The parent DBGY-201 is a gynoecious line with all the characteristics contributing early fruiting in bitter gourd. The nine parents were crossed in all possible combinations (excluding reciprocals) to generate diallel set. Nine parents and their 36 F_1 hybrids were evaluated for 5 earliness and growth related traits in RBD with three replications during 2006-2007. The seeds were sown on both sides of the channel with a spacing of 2 m between channel and 45 cm between plants with 90 cm irrigation channels. The recommended NPK fertilizer doses and cultural practices along with plant protection measures were followed to raise an ideal crop. The fruits were harvested at marketable stage. Ten plants were selected, after discarding the border plants at both ends, and were examined for 5 quantitative traits (Table 1). Analyses of general (GCA) and specific (SCA) combining ability were done following Griffing's Method II of Model I (Griffing 3, fixed effect) diallel analysis using SPAR1 (Statistical Package for Agricultural Research Data Analysis) software of Indian Agricultural Statistical Research Institute, New Delhi.

Among the nine parents P_1 (DBGY-201) showed maximum GCA effect in desirable direction for vine length, node to first female flower, days to open first female flower, days to first harvest. The parent P_5 (NDBT-12) had the highest desirable GCA effect for

Table 1. Estimates of general combining ability (GCA) effects of parent genotypes.

Parent	Node number of first female flower	Days to open first female flower	Days to fruit set to maturity	Days to sowing to first harvest	Vine length (cm)
P_1	-2.12**	-11.15**	-0.25**	-11.40**	-32.84**
P_2	-0.49**	-3.61*	-0.54**	-4.16*	3.14
P_3	-1.06**	-2.37*	0.73**	-1.64	-27.76**
P_4	1.19**	8.13**	-0.15**	7.79**	32.82**
P_5	-1.50**	0.07	-0.96**	0.89	-0.90
P_6	0.10	5.06**	0.83**	5.89**	53.58**
P_7	1.89**	6.45**	-0.13**	6.32**	-19.69**
P_8	2.12**	-1.90	0.16**	-1.74	-12.67
P_9	-0.14	-0.67	0.31**	0.36	4.33
SE (g_i)	0.04	0.70	0.01	0.72	3.22
SE (g_i-g_j)	0.09	1.59	0.02	1.63	7.26
CD at 5%	0.18	3.18	0.04	3.26	14.52

*5 per cent level of significance **1 per cent level of significance

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Table 2. Estimates of specific combining ability effects in cross combinations for five quantitative traits.

Cross	Node number to first female flower	Days to open first female flower	Days to fruit set to maturity	Days to sowing to first harvest	Vine length (cm)
$P_1 \times P_2$	-1.93**	-3.96	-0.31**	-4.28	-13.48
$P_1 \times P_3$	-1.73**	-7.61	-0.34**	-7.95	-7.91
$P_1 \times P_4$	1.35**	-0.74	-0.23*	-0.97	-2.48
$P_1 \times P_5$	0.54	-2.39	-0.10	-2.49	2.73
$P_1 \times P_6$	1.84**	4.66	0.43**	5.10	-18.13
$P_1 \times P_7$	3.07**	15.77*	0.20*	15.97*	-9.91
$P_1 \times P_8$	1.10*	-0.90	0.24**	-0.66	-1.14
$P_1 \times P_9$	0.04	-7.54	0.40**	-7.13	5.06
$P_2 \times P_3$	-0.36	-3.06	-0.02	-3.09	-20.39
$P_2 \times P_4$	2.18**	0.77	-0.09	0.68	6.60
$P_2 \times P_5$	1.57**	7.39	-0.26**	7.12	0.14
$P_2 \times P_6$	-2.21**	-13.99	0.70**	-13.29*	-12.66
$P_2 \times P_7$	0.73	-6.62	0.06	-6.56	-14.21
$P_2 \times P_8$	-3.46**	-2.13	0.42**	-1.71	-4.50
$P_2 \times P_9$	-0.02	-2.03	0.11	-1.92	-3.92
$P_3 \times P_4$	1.87**	5.64	-0.04	5.60	3.17
$P_3 \times P_5$	-3.40**	-9.08	0.53**	-8.55	-5.49
$P_3 \times P_6$	-1.82**	-6.78	0.67**	-6.10	-1.83
$P_3 \times P_7$	-3.66**	-7.75	0.58**	-7.17	31.70*
$P_3 \times P_8$	1.95**	3.85	-0.23*	3.62	27.60*
$P_3 \times P_9$	2.90**	12.23	-0.24**	11.99	23.71
$P_4 \times P_5$	3.76**	7.06	1.03**	8.09	-11.99
$P_4 \times P_6$	-3.99**	-5.06	0.34**	-4.72	-8.12
$P_4 \times P_7$	-0.59	2.69	1.91**	4.60	8.28
$P_4 \times P_8$	-4.49**	-8.70	-1.47**	-10.16	-4.22
$P_4 \times P_9$	0.64	0.44	-1.45**	-1.01	5.12
$P_5 \times P_6$	0.62	3.90	-2.78**	1.12	3.17
$P_5 \times P_7$	-1.39**	-1.75	-1.18**	-2.93	19.82
$P_5 \times P_8$	1.16*	-2.83	1.71**	-1.12	6.13
$P_5 \times P_9$	-0.29	0.32	1.41**	1.73	3.17
$P_6 \times P_7$	3.67**	7.83	1.07**	8.90	29.95*
$P_6 \times P_8$	0.97*	2.98	0.42**	3.40	45.27**
$P_6 \times P_9$	-0.17	-1.79	-0.04	-1.83	19.66
$P_7 \times P_8$	0.91*	1.54	-2.34**	-0.79	-7.72
$P_7 \times P_9$	-1.91**	-6.45	-0.30**	-6.75	-12.03
$P_8 \times P_9$	-2.38**	-4.49	-0.01	-4.50	-24.09
SE (S_{ii})	0.33	5.74	0.07	5.86	12.13
SE (S_{ii}-S_{jj})	0.65	11.17	0.14	11.41	20.82
SE (S_{ij})	0.43	7.34	0.09	7.49	13.06
SE (S_{ij}-S_{ik})	0.93	15.95	0.20	16.30	32.60
SE (S_{ij}-S_{kl})	0.84	14.36	0.18	14.73	25.34

*,** 5 and 1% levels of significance

days from fruit set to maturity. The parent P_2 (Pusa Do Mousami) showed negative significant GCA effect for characters like node to first female flower, days to first female flower opening, days from fruit setting to maturity and days to first harvest (Table 1). High GCA effect for attributes like vine length, node to first female flower and maturity period was also found in P_3 (Pusa Vishesh). These parents (Pusa Do Mausami and Pusa Vishesh) were involved in the crosses which showed highest superiority over standard check. Dey *et al.* (2) observed the high GCA effects for earliness when Pusa Do Mausami was used in the hybrid development. Munshi and Sirohi (6) noticed that when either or two parental lines having high GCA effects for different characters were involved in crosses, the F_1 hybrids showed promising result.

Out of the thirty six hybrids, significant SCA effect in favourable direction were exhibited by none of the combinations for vine length, twelve combinations for node to first female flower, none for days to first female flower appearance, 13 crosses for days from fruit setting to maturity, two combinations for days to first harvest and 18 combinations for numbers of fruits per plant. Three F_1 combinations showing highest significant desirable SCA effect for various characters in order of merit were, $P_4 \times P_8$ (PBIG-44-3 × Nakhara), $P_4 \times P_6$ (PBIG-44-3 × Priya) and $P_4 \times P_7$ (PBIG-44-3 × DVBTG-5-5) for node to first female flower, $P_5 \times P_6$ (NDBT-12 × Priya), $P_7 \times P_8$ (DVBTG-5-5 × Nakhara) and $P_4 \times P_8$ (PBIG-44-3 × Nakhara)for days from fruit set to maturity and $P_2 \times P_6$ (Pusa Do Mausami × Priya) for days to first harvest (Table 2). Moreover, the gynoecious line, DBGY-201 (P_1) was proved to be good combiner. Similar observations were also recorded by Behera *et al.* (1) and Dey *et al.* (2) in different experiments. It exhibited highest significant GCA effect and high significant SCA effect with all the parents except with P_4 (PBIG-44-3) and P_8 (DVBTG-5-5). Majority of F_1 crosses which exhibited significant SCA effect, showed high amount of heterosis for all characters studied. The above discussion revealed that in almost all the F_1 hybrids which showed best SCA effect, the parental lines involved were at least one of the most outstanding parental lines, namely, P_1 (DBGY-201), P_2 (Pusa Do Mausami), P_3 (Pusa Vishesh) and P_6 (Priya).

In the present study, mean square due to GCA and SCA were highly significant for all the characters studied which revealed that both additive and non-additive gene actions were important in the inheritance of studied characters. Hence, for the improvement of these traits, both selection and heterosis breeding methods could be adopted. The response to selection is expected to be best in the crosses involving parents having high GCA effects. The selected parental lines having better performance can be crossed in suitable combination to exploit heterosis. The crosses which showed high specific combining ability (SCA) can be best utilized in heterosis breeding. The gynoecious line taken in the present study could be utilized for heterosis breeding for development of predominantly gynoecious hybrids. Besides, as this line showed high general combining ability (GCA), development of predominantly gynoecious cultivars by using this line as female parent in bitter gourd improvement programme could be future course of breeding (Behera *et al.*, 1). The highest SCA effects were observed in $P_4 \times P_8$ (PBIG-44-3 × Nakhara) for node to first female flower, $P_5 \times P_6$ (NDBT-12 × Priya) for days from fruit set to maturity and $P_2 \times P_6$ (Pusa Do Mausami × Priya) for days to first harvest and these hybrids can be tested in multilocation trials.

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