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Evaluation of F_1 hybrids in bitter gourd (*Momordica charantia* L.) for yield and quality

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ABSTRACT

To study the combining ability and heterosis for yield and quality characters, full diallel analysis was carried out in bitter gourd during January – April 2008 (Thai pattam), with 10 diversified parents, at Research Farm, Horticultural College and Research Institute, TNAU, Coimbatore. Parental mean and *gca* effects revealed that the parents Preethi, CO-1, MC-30, Uchha Bolder, Green Long and MC-105 were the best genotypes for improvement of yield, combined with quality characters. Hybrids, viz., Preethi x MC-30, KR x USL, MC-105 x MC-10 and Priyanka x CO-1 registered favourable values for mean, significant *sca* and standard heterosis for yield and quality parameters. Hence, these hybrids are recommended for commercial exploitation of heterosis. Comparison of parental *gca* and *sca* of hybrids revealed that hybridization between good x good, good x poor, medium x poor and poor x good combiners gave rise to hybrids with significant *sca* effects. Considering the mean performance, *sca* and standard heterosis, hybrid 'Preethi x MC-30' registered favourable values for the most important characters like earliness, number of fruits, fruit yield and quality. Top performing F_1 hybrids can be tested over seasons and locations for assessing stability for high yield and quality.

Key words: Bitter gourd, *Momordica charantia*, mean performance, combining ability, standard heterosis

INTRODUCTION

Bitter gourd (*Momordica charantia* L.) has been identified as one of the promising vegetables for export by Agricultural Processed Food Products and Export Development Authority (APEDA). The crop occupies 6.76 million hectare area with annual production of 101.43 million tonnes (Rai and Pandey, 2007). But, the demand is likely to rise to 193MT by the year 2030. Though several high-yielding varieties have been developed to augment production and productivity of this high-value vegetable, its potential can only be realized by developing high-yielding hybrids with earliness. In our country, a wide range of variability exists in vegetative and fruit characters in this crop. Exploitation of heterosis is far easier in cross-pollinated crops and bitter gourd, being monoecious, provides ample scope for utilization of hybrid vigour on a commercial scale. Hence, the present investigation was initiated to study combining ability and heterosis in bitter gourd by diallel analysis.

Diverse parents from different locations having high yield and quality pave way for development and release of hybrids, through heterosis breeding. Hybrid vigour can be substantially improved by crossing genetically diverse inbreds and, thus, heterosis is mostly accomplished from genetic diversity among parents (Sharma, 1994). Diallel analysis also provides reliable information on components of the variance, general combining ability (GCA), specific combining ability (SCA) variances and their effects (Singh and Narayanan, 1993).

MATERIAL AND METHODS

Ten parents, viz., CO-1 and Green Long, from Coimbatore, Tamil Nadu; Priyanka and Preethi from Kerala; Karala Rakshuse (KR), Uchha Small Long (USL) and Uchha Bolder (UB) from West Bangal; MC-30, MC-105 and MC-10 from Palur, Tamil Nadu, were chosen from the germplasm maintained at Research Farm, Department of Vegetable Crops, Horticultural College and Research Institute, Coimbatore. Diallel crosses [Method I, Model 1 Griffing (1956)] among the ten parents were effected in all possible combinations. Thus, a total of ninety crosses and their ten parents were evaluated in January – April, 2008 (Thai pattam) for various quantitative and qualitative traits.

Observations on yield and quality traits, viz., days to first female flower appearance, node number at which first female flower appearned, sex ratio, days to first harvest,

fruit length, fruit girth, fruit weight, number of fruits per vine, yield of fruits per vine, ascorbic acid and iron content, were all recorded on three randomly selected single-plants in each replication. Mean values were taken for statistical analysis using GenRes Statistical Package for Genetical Researchers, Version 7.01, 1994 from Pascal Intl. Software Solutions. Estimation of general and specific combining abilities was done as per Griffing (1956). Heterosis in F_1 hybrids was estimated for each trait by using the three mean values. Variety CO-1 was used as the standard parent to estimate standard heterosis.

RESULTS AND DISCUSSION

Removal of undesirable genotypes is essential in any crop breeding program. This can be achieved by studying the mean performance of parents and hybrids. Mean performance and *gca* effects were seen to be related in the parents (Table 2). Mean and combining ability effects, separately, did not show parallelism. Therefore, it is necessary to consider mean and combining ability effects together for further isolation of desirable parental genotypes and hybrids.

Combining ability for each trait was analyzed in the present investigation. The study clearly revealed that variances due to GCA and SCA were significant for all the characters studied, indicating presence of both additive and dominance gene actions. Variance due to reciprocal effects was also significant for all the characters studied (Table 1). Reciprocal variation is perhaps due to cytoplasmic inheritance and its interaction with nuclear genes. A comparison of parental *gca* and *sca* of hybrids revealed that hybridization between good x good (Preethi x MC-30, GL x Preethi), good x poor (MC-105 x MC-10), medium x poor (KR x USL), poor x good (Priyanka x CO-1) combiners gave rise to hybrids with significant *sca* effects in the favourable direction (Table 2 and 3).

Table 1. Analysis of Variance for combining ability

S.No.	Trait	Mean squares of		
		GCA	SCA	RCA
1	Days to first female-flower appearance	24.42**	19.35**	14.89**
2	Node-number first female flower appeared	36.39**	10.02**	9.67**
3	Sex ratio	170.78 **	16.44 **	14.80 **
4	Days to first harvest	148.37**	40.27**	52.69**
5	Fruit length	158.03**	14.38**	16.80**
6	Fruit girth	12.01**	4.69**	6.47**
7	Fruit weight	3022.75**	135.62**	195.01**
8	Number of fruits per vine	1511.91**	60.48**	41.43**
9	Yield of fruits per vine	0.320**	0.356**	0.308**
10	Ascorbic acid content	74.28**	286.65**	323.25**
11	Iron content	0.112**	0.203**	0.145**

** Significant at 1% level

Table 2. Mean performance and *gca* of parents for yield and quality traits

Parent	Days to first female-flower appearance	Node-number at which first female flower appeared	Sex ratio	Days to first harvest	Fruit length	Fruit girth	Fruit weight	Number of fruits per vine s	Yield of fruits per vine	Ascorbic acid	Iron content
CO -1	55.82	29.12	17.23	64.78	27.82	14.81	78.99	23.64	2.01	98.41	2.18
	*-0.34***	*0.66***	*2.33***	*-3.11***	*3.92***	*0.32***	*1.91***	*-2.55***	*0.09***	*2.51***	*0.00***
Green Long	66.14	30.23	34.68	62.45	25.89	15.51	107.53	18.59	1.71	95.61	2.14
	*0.43***	*0.90***	*3.23***	*-3.22***	*2.38***	*-0.15***	*5.27***	*-3.82***	*-0.07***	*0.07***	*-0.07***
Priyanka	61.97	20.98	26.23	65.91	20.56	14.98	114.30	18.76	1.78	96.18	2.12
	*0.28***	*1.69***	*2.37***	*-0.17***	*0.53***	*0.37***	*6.36***	*-4.08***	*-0.12***	*-4.17***	*-0.06***
Preethi	55.20	21.12	19.34	58.67	16.43	14.39	106.73	21.92	2.27	98.51	2.73
	*-2.55***	*-2.09***	*-0.47***	*1.74***	*-2.09***	*1.12***	*7.73***	*-1.34***	*0.12***	*1.96***	*0.14***
Karala Rakshuse	58.86	22.93	33.65	60.34	16.76	15.51	81.35	17.45	1.61	80.91	2.64
(KR)	*-0.19***	*0.75***	*2.45***	*-0.04***	*-0.03*	*0.27***	*4.49***	*-3.72***	*-0.08***	*0.74***	*0.04***
Uchha Small	57.18	26.84	19.42	61.82	14.89	12.56	63.67	24.72	1.48	86.28	1.72
Long(USL)	*1.04***	*0.53***	*-0.64***	*2.77***	*-1.22***	*-1.17***	*-7.55***	*-2.45***	*-0.10***	*-1.46***	*0.06***
Uchha	56.65	14.89	4.02	55.45	6.12	8.46	16.83	94.28	1.34	67.24	2.26
Bolder (UB)	*-0.29***	*-2.16***	*1.16***	*-3.47***	*-5.93***	*-1.01***	*-33.10***	*23.44***	*0.17***	*1.01***	*-0.03***
MC - 30	59.15	23.98	18.23	59.72	32.87	11.39	95.40	21.45	1.78	90.17	2.11
	*-0.59***	*1.04***	*-1.38***	*1.07***	*2.60***	*-0.66***	*10.81***	*-2.67***	*0.10***	*0.64***	*-0.07***
MC - 105	61.18	22.81	20.23	62.34	20.45	16.56	90.94	20.94	1.82	94.38	1.82
	*1.80***	*-0.76***	*-0.18***	*2.16***	*-0.51***	*0.69***	*2.88***	*-0.32***	*-0.10***	*1.77***	*-0.03***
MC-10	59.77	19.92	23.34	70.71	16.98	14.14	98.66	24.84	1.71	93.61	1.70
	*0.40***	*-0.57***	*-8.86***	*2.27***	*0.35***	*0.20***	*1.21***	*-2.51***	*-0.01***	*-3.07***	*0.03***

Mean values are shown in bold and *gca* values in italics; * and ** Significantly superior at 5% and 1% levels, respectively

Table 3. Mean performance, *sca* and standard heterosis in important bitter gourd hybrids for yield and quality traits

Parent	Days to first female-flower appearance	Node-number at which first female flower appeared	Sex ratio	Days to first harvest	Fruit length	Fruit girth	Fruit weight	Number of fruits per vine	Yield of fruits per vine	Ascorbic acid	Iron content
Preethi x	52.18	20.20	11.90	57.62	11.84	13.65	105.79	37.02	3.42	104.81	2.53
MC-30	-4.97**	0.35**	2.82**	-4.91**	-2.84**	0.43**	-5.39**	8.66**	0.70**	10.05**	0.46**
	-4.04	-29.58**	-29.90**	-9.70**	-56.80**	-6.44**	35.96**	58.99**	72.73**	8.01**	17.67**
KR x USL	59.47	20.88	17.47	58.39	18.45	14.99	110.75	36.98	3.24	104.12	2.74
	1.39**	-2.10**	-4.66**	-1.00**	0.85**	0.81**	24.66**	7.32**	0.93**	8.73**	0.42**
	9.37**	-27.21**	2.92**	-8.49**	-32.68**	2.74**	42.33**	58.81**	63.64**	7.30**	27.44**
MC 105 x	59.76	19.98	16.87	61.56	20.68	18.43	78.65	40.24	2.65	100.18	2.61
MC 10	0.24	1.02**	-3.96	-3.53**	0.07**	3.00**	-3.35	13.11**	1.07**	5.27**	0.49**
	9.90**	-30.35**	**-0.62	-3.53**	-24.54**	26.32**	**1.03	72.82**	33.84**	3.24**	21.40**
Green Long x	60.76	20.61	16.02	59.29	26.54	15.51	90.72	32.92	2.65	97.18	2.73
Preethi	1.68**	-2.27**	-4.19**	-2.55**	1.27**	0.37**	-9.87**	4.84**	0.22**	0.06*	0.16**
	11.74**	-28.15**	-5.63**	-7.08**	-3.16	6.31**	16.59**	41.38**	38.84**	0.15**	26.98**
Priyanka x	55.62	27.96	19.92	58.22	23.66	14.86	100.51	31.03	2.56	108.11	2.01
CO -1	-0.67**	1.47**	-7.32**	-6.05**	-1.94**	0.62**	5.42**	6.34**	0.67**	11.42**	0.40**
	2.29**	-2.53**	17.35**	-8.76**	-13.67**	1.85*	29.17**	33.26**	29.29**	11.41**	6.51**
Preethi x	56.86	18.23	15.92	60.21	20.11-	17.23	99.46	29.56	2.31	91.12	2.03
CO -1	2.00**	-3.24**	-6.71**	-8.10**	0.35**	1.70**	1.54*	3.37**	0.16**	9.01**	0.33**
	10.09**	-36.45**	-6.622**	-5.64**	-26.62**	18.09**	27.82**	26.95**	16.67**	6.10**	5.58**
MC 105 x	65.96	21.92	17.88	70.36	21.98	17.54	98.14	19.49	2.28	95.41	1.81
Green Long	-0.35	-0.99**	-0.97**	1.04**	2.16**	0.09	-0.66	3.76**	0.13**	23.00**	-0.05**
	21.31**	-23.58**	5.33**	10.26**	-19.80**	-11.31**	26.13**	-16.30**	-38.89**	-1.67*	-15.81**
Preethi x UB	54.89	14.78	11.92	63.77	10.99	12.63	62.28	55.92	2.21	90.14	1.84
	-1.48**	-0.72**	-0.79**	-0.51	0.87**	0.37**	0.7	7.01**	0.19**	0.21	-0.15**
	0.95**	-48.47**	-29.78**	-0.06	-59.90**	-13.43**	-19.96**	140.15**	11.62**	-7.11**	-14.42**
KR x MC-30	57.86	26.81	23.84	67.29	23.66	13.91	102.76	18.89	1.77	90.21	1.44
	-3.25**	-1.23**	0.66**	1.24**	-1.23**	2.22**	-2.38**	3.03**	0.22**	0.48	-0.13**
	6.41**	-6.54**	40.44**	5.45**	-13.67**	-4.66**	32.07**	-18.87**	-10.61**	-7.03**	-33.02**

Mean values are shown in bold, *sca* values in italics and standard heterosis values in normal font* and ** significantly superior at 5% and 1% levels, respectively

The parent 'Preethi' was found to outperform other parents by its favourable mean performance and *gca* effect together for the following characters: node of first female-flower appearance, sex ratio, fruit weight, fruit yield, ascorbic acid and iron content. This was followed by CO-1 for days to first female-flower appearance, days to first harvest, fruit length, fruit girth, fruit yield, ascorbic acid and iron content (Table 2). Five parents, viz., Uchha Bolder, MC-30, Preethi, Uchha Small Long and MC-105 possessed lower values for the character of sex ratio. In majority of the cases, parents with high mean performance were found to show a significant *gca* effect, and this was in conformity with reports of Lawande and Patil (1990) and Sundaram (2006) in bitter gourd.

High specific-combining ability of a particular cross-combination results mostly from dominance and interaction effects existing between the hybridizing parents (Sundaram, 2006). A close observation of top-performing hybrids with superior *sca* for most traits also revealed a similar trend. Significance of *sca* was registered for number of fruits, fruit yield and quality parameters in the cross combinations 'Preethi x MC-30', 'KR x USL', 'MC-105' x 'MC-10', 'GL x Preethi' and 'Priyanka x CO-1'. Cross combinations with high *sc*a can be well-utilized in heterosis breeding, as reported by Sirohi and Choudhury (1977) and Sundaram (2006) in bitter gourd.

Evaluation of hybrids based on three criteria, viz., mean, *sca* and standard heterosis, could lead to identification of different sets of cross-combinations for each of these criteria. However, scope for exploiting hybrid vigour in heterosis breeding depends not only on the extent of heterosis for individual traits, but also on mean performance and *sca* effects of the hybrids. Hence, it would be more appropriate to evaluate hybrids based on the above three criteria. Such evaluation revealed that none of the hybrids exhibited superiority for all the three criteria with regard to any of the characters studied.

Hybrid 'Preethi x MC-30' registered favourable values for mean, significant *sca* and standard heterosis for the most important characters like earliness, number of fruits, fruit yield and quality parameters. The other top-performing hybrids with respect to yield and quality parameters were KR x USL, MC-105 x MC-10, GL x Preethi and Priyanka x CO-1 (Table 3).

In any hybridization programme, correct choice of male and female parents becomes necessary to obtain a superior cross-combination; and this, in fact, is revealed by significance of *sca* among reciprocal crosses. Reciprocal effects may be due to cytoplasmic inheritance and the maternal effect. Among the reciprocal crosses, hybrid combinations identified as superior (based on the *sca* effect for yield contributing characters coupled with quality parameters viz., number of fruits, fruit yield, ascorbic acid and iron content) were: Priyanka x CO-1 and Preethi x CO-1. Significant reciprocal effects have been reported earlier in bitter gourd by Gopalakrishnan (1986), Devadas (1993) and Sundaram (2006).

In the top-yielding hybrids, viz., Preethi x MC-30, KR x USL and MC-105 x MC-10, reciprocal effects were negative and significant. These performed badly in their reciprocal combinations for fruit yield, which could be due to the maternal effect. Such non-significant reciprocal effects have been reported earlier too in bitter gourd by Devadas (1993).

Considering the three criteria, viz., mean, *sca* and standard heterosis, hybrids 'Preethi x MC-30', 'KR x USL', 'MC-105 x MC-10', 'GL x Preethi' and 'Priyanka x CO-1' can be well-exploited in heterosis breeding to obtain higher yield, with quality fruits. Moreover, these hybrids can be better-utilized for improvement of the characters listed above and by intermating among superior segregants resulting from these heterotic hybrids. This likely to throw up desirable progeny in subsequent generations.

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