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Research Article

Estimation of combining ability and heterosis for yield and quality characters in bitter gourd (*Momordica charantia* L.)

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Abstract:
Full diallel analysis was carried out during Aug- Nov, 2007 with 10 diversified parents at Department of Vegetable Crops, Horticultural College and Research Institute, TNAU, Coimbatore to study the combining ability and heterosis for yield and quality characters. Evaluation of parents based on *per se* and gca effects revealed that the parents Preethi, CO-1, MC-30, Uchha Bolder, Green Long, MC-105 were identified as the best genotypes for improvement of yield combined with quality characters. The hybrids viz., Preethi x MC-30, KR x USL, MC-105 x MC-10 and Priyanka x CO-1 had registered favourable values of mean, significant *sca* and standard heterosis for yield and quality parameters. Hence these hybrids are recommended for commercial exploitation of heterosis. A comparison of the parental *gca* and *sca* of hybrids revealed that hybridization between good x good and medium x poor or medium x medium combiners had given rise to hybrids with significant *sca* effects.Considering the *per se* performance, *sca* and the standard heterosis, the hybrids Preethi x MC-30 had registered favourable values for the most important characters like earliness, number of fruits, yield of fruits and quality parameters. Further the top performing F_1 hybrids can be tested in different seasons over different locations for assessing their stability for high yield and quality.

Key words: *Momordica charantia* L., *per se* performance, Combining ability, standard heterosis
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Introduction

Among the cultivated cucurbits, bitter gourd (*Momordica charantia* L.) has been identified as one of the potent vegetables for export by Agricultural Processed Food Products and Export Development Authority (APEDA). It is also known for its therapeutic and hypoglycemic properties. In India, bitter gourd occupies 6.76 million hectare area with the annual production of 101.43 million tonnes (Rai and Pandey, 2007). But there is a wide gap between demand and supply and projected demand is likely to rise to 193 MT by 2030. One of the possible approaches for achieving the targeted production is to identify and develop suitable hybrids with high yield and good quality.

The exploitation of heterosis is much easier in cross pollinated crops and bitter gourd being monoecious, provides ample scope for the utilization of hybrid vigour on commercial scale. Further, the diversified parents from different locations with high yield and quality would also pave way for the development and release of hybrids through heterosis breeding. The hybrid vigour is substantially increased on crossing genetically diverse inbreds and thus heterosis mostly obtained from genetic diversity among the parents involved (Sharma, 1994).

Diallel analysis provides reliable information on the components of variance, general combining ability (GCA), specific combining ability (SCA) variances and their effects (Singh and Narayanan,1993).The concept of combining ability helps the breeder to determine the nature of gene action involved in the expression of quantitative traits of economic importance.

Material and methods

A total of ten parents CO-1, Green Long, Priyanka , Preethi, Karala Rakshuse (KR), Uchha Small Long (USL), Uchha Bolder (UB), MC-30, MC-105 and MC-10 were chosen from germplasm maintained by continuous selfing at Department of Vegetable Crops, Horticultural College and Research Institute, Coimbatore. Diallel cross (Method I, Model 1 Griffing (1956)) among the ten parents were attempted in all possible combinations. Thus a total number of ninety crosses and their ten parents were evaluated in August – November 2007 (*Aadi pattam*) for various quantitative and qualitative traits.

Observations on yield and quality traits viz., days to first female flower appearance, node of first female flower appearance, 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 recorded on three randomly selected single plants in each replication. The mean values were utilized for statistical analysis. Estimation of general and specific combining ability was done as per the procedures outlined by Griffing (1956). Heterosis in F_1 hybrids was estimated for each trait based on all the criteria using the three mean values (Gowen, 1952).

Results and discussion

In any crop breeding programme, it is essential to eliminate the undesirable types, which can be achieved by studying the *per se* performance of parents and hybrids. The *per se* performance and *gca* effects were related to each other in parents. As evaluation based on mean and combining ability effects separately did not show parallelism, it is therefore necessary to consider both *per se* and combining ability effects together for further isolation of desirable parental genotypes and hybrids.

In the present investigation, the combining ability for each character was analysed. The study clearly revealed that variances due to GCA and SCA were significant for all the characters, as suggested by Griffing (1956), indicating the presence of both additive and dominance gene action. The variance due to reciprocal effects was also significant for all the characters studied. The reciprocal variation might be due to cytoplasmic inheritance and its interaction with nuclear genes. A comparison of the parental *gca* and *sca* of hybrids revealed that hybridization between good x good and medium x poor or medium x medium combiners had given rise to hybrids with significant *sca* effects.

Among the ten parents evaluated, the parent Preethi was found to out perform others by having favourable mean performance and *gca* effect together for the characters *viz*., node of first female flower appearance, sex ratio, fruit weight, fruit yield, ascorbic acid and iron content and it 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 1). Five parents *viz.*, Preethi, Uchha Bolder, Uchha Small Long, MC-30, MC-105 possessed lower values for the character sex ratio. In majority of the cases, parents with high mean performance were found to show significant *gca* effect and this was in conformity to the report 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 hybridising parents. A close observation of the top performing hybrids with superior *sca* for most traits had also revealed similar trend. The significance of *sca* registered for number of fruits, yield of fruits per vine and quality parameters in the cross combinations Preethi x MC-30, KR x USL and MC-105 x MC-10. These cross combinations with high *sc*a could be well utilised in heterosis breeding as reported by Sirohi and Choudhury (1977) and Sundaram (2006) in bitter gourd.

The evaluation of hybrids based on the three criteria *viz.*, mean, *sca* and standard heterosis would lead to the identification of different sets of cross combinations for each of these criteria. However, the scope for exploitation of hybrid vigour in a heterosis breeding programme depends not only on the extent of heterosis for individual traits but also on the mean performance and *sca* effects of hybrids. Hence, it would be more appropriate to evaluate the hybrids based on all these criteria. Such an evaluation had revealed that none of the hybrid was found to exhibit superiority for all the three criterions for all the characters under study.

The hybrid Preethi x MC-30 had registered favourable values of mean, significant *sca* and standard heterosis for the most important characters like earliness, number of fruits, yield of fruits and quality parameters. The other top performing hybrids with respect to yield and quality parameters are KR x USL, MC-105 x MC-10 and Priyanka x CO-1 (Table 2).

Proper choice of male and female parents is necessary in any hybridisation programme to get a superior cross combination and this is in fact revealed by the significance of *sca* among the reciprocal crosses. The reciprocal effects may be due to cytoplasmic inheritance and maternal effect. Significant reciprocal effects were reported earlier in bitter gourd by Gopalakrishnan (1986), Devadas (1993) and Sundaram (2006).

Among the reciprocal crosses, the hybrid combinations identified as superior based on the *sca* effect for yield contributing characters coupled with quality parameters were Priyanka x CO-1 (number of fruits, fruit yield and ascorbic acid content), Preethi x CO-1(number of fruits, fruit yield and ascorbic acid content) and MC-105 x Green Long (number of fruits, fruit yield and ascorbic acid content) revealed the importance of parental choice, since they exhibited reciprocal effects. In the top yielding hybrids *viz.,* Preethi x MC-30, KR x USL and MC-105 x MC-10 the reciprocal effects were negative and significant. They performed badly in their reciprocal combinations for fruit yield. This may be due to the maternal effect such significant reciprocal effects were reported earlier in bitter gourd by Devadas, 1993.

The hybrids Preethi x MC-30, KR x USL, MC-105 x MC-10 and Priyanka x CO-1 can be well exploited through heterosis breeding to obtain higher yield with quality fruits. Moreover, these hybrids could be better utilized for the improvement of the characters concerned and intermating among superior segregants resulting from these heterotic hybrids, is likely to throw desirable progenies in the subsequent later generations.

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Table 1. *Per se* performance and gca of parents for yield and quality traits

Parents	Days to first female flower appearance	Node of first female flower appearance	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
CO -1	44.12	28.18	16.52	65.27	28.92	14.80	80.47	25.60	2.03	100.52	2.22
	*-1.91***	*1.04***	*1.86***	*-3.38***	*4.06***	*0.29***	*1.99***	*-2.42***	*0.11***	*2.20***	*0.06***
Green Long	57.15	30.16	31.27	64.15	26.89	15.57	110.57	15.92	1.75	97.26	2.17
	*-0.28***	*1.01***	*2.81***	*-3.13***	*2.36***	-0.29**	5.68**	-4.46**	-0.11**	0.73**	0.00
Priyanka	57.36	20.11	28.86	67.65	21.35	14.83	116.20	15.60	1.80	98.82	2.11
	0.48**	1.63**	2.68**	*-0.08*	*0.66***	*0.50***	*5.74***	*-4.21***	*-0.09***	*-3.98***	*-0.07***
Preethi	50.18	20.17	20.21	60.27	17.92	14.39	110.66	20.90	2.31	101.50	2.89
	*-0.49***	*-2.05***	*-0.37***	*1.95***	*-2.07***	*1.25***	*7.60***	*-1.57***	*0.13***	*1.46***	*0.14***
Karala Rakshuse	46.86	21.19	31.12	62.54	17.75	15.51	85.76	16.26	1.68	83.94	2.78
	*-1.19***	*0.55***	*1.80***	*-0.04*	*0.03*	*0.26***	*3.76***	*-3.90***	*-0.10***	*0.91***	*0.05***
Uchha Small Long	57.17	26.20	16.56	63.58	15.14	12.56	68.28	25.78	1.56	87.20	1.75
	*1.68***	*0.36***	*-1.02***	*3.00***	*-1.09***	*-1.10***	*-6.79***	*-1.85***	*-0.12***	*-1.89***	*0.04***
Uchha Bolder	47.22	14.19	3.12	57.26	5.87	8.78	15.37	96.80	1.44	68.42	2.37
	*-0.62***	*-2.19***	*-7.10***	*-4.41***	*-6.05***	*-1.12***	*-32.44***	*24.52***	*0.20***	*0.70***	*-0.02***
MC - 30	56.15	23.21	18.13	60.51	33.85	11.39	95.28	22.38	1.86	92.61	2.25
	*0.35***	*1.12***	*-1.47***	*1.27***	*2.49***	*-0.68***	*10.61***	*-2.43***	*0.14***	*-0.3*	*-0.07***
MC - 105	50.16	21.57	19.48	64.61	19.14	16.92	90.28	20.64	1.59	96.83	1.92
	*0.74***	*-0.81***	*-0.31***	*2.36***	*-0.56***	*0.56***	*2.57***	*-2.86***	*-0.03***	*-1.50***	*-0.04***
MC-10	50.52	18.17	22.24	68.61	17.32	14.14	98.56	25.27	1.75	95.16	1.85
	*1.23***	*-0.66***	*1.13***	*2.47***	*0.17***	*0.32***	*1.27***	*-0.81***	*-0.13***	*1.68***	*-0.10***

per se values are in bold and *gca* values are in italics
* and ** Significantly superior at 5 % and 1% level respectively

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Table 2. *Per se* performance, sca and standard heterosis of important hybrids for yield and quality traits

Hybrids	Days to first female flower appearance	Node of first female flower appearance	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 MC-30	50.24	19.20	11.17	59.36	10.48	13.61	108.87	38.02	3.78	104.30	2.69
	*-2.22***	*0.14*	*-3.85***	*-5.73***	*-4.15***	*0.53***	*-5.44***	*8.70***	*0.84***	*8.78***	*0.47***
	-4.04**	-15.76	-29.90**	-9.70**	-56.80**	-6.44**	35.96**	58.99**	72.73**	8.01**	17.67**
KR x USL	50.28	79.54	15.24	60.42	19.51	15.67	110.15	37.50	3.56	106.21	2.87
	*0.78***	*-1.59***	*-3.86***	*-0.86**	*1.43***	*0.39***	*24.22***	*7.13***	*1.09***	*8.98***	*0.38***
	9.37**	-27.21**	2.92**	-8.49**	-32.68**	2.74**	24.22**	58.81**	63.64**	7.30**	27.44**
MC 105 x MC 10	58.14	20.48	14.42	60.67	21.74	18.51	82.30	40.24	2.75	101.83	2.43
	*4.23***	*1.85***	*-4.33***	*-5.11***	*0.78***	*3.06***	*-2.53***	*13.24***	*1.17***	*3.98***	*0.44***
	9.90**	-30.35**	-0.62	-3.53**	-24.54**	26.32**	1.03	72.84**	33.84**	3.24**	21.40**
Priyanka x CO 1	49.12	27.81	17.16	60.82	24.18	15.12	103.24	33.82	2.73	110.50	2.28
	*-2.60***	*1.87***	*-6.70***	*-5.87***	*-2.00***	*0.74***	*6.42***	*8.77***	*0.72***	*11.65***	*0.50***
	2.29**	-2.53**	17.35**	-8.76**	-13.67**	1.85*	1.85*	33.26**	29.29**	11.41**	-6.51**
Green Long x Preethi	56.42	19.81	15.34	61.68	25.51	15.50	93.59	34.24	2.76	99.09	2.63
	*4.25***	*-1.79***	*-3.91***	*-2.81***	*1.18***	*0.24***	*-10.60***	*5.69***	*0.28***	*-0.50*	*0.03***
	11.74**	-28.15**	-5.63**	-7.08**	-3.16	6.31**	16.59**	41.38**	38.84**	0.15	26.98**
Preethi x CO 1	51.20	16.44	12.87	62.18	21.59	17.31	100.47	30.02	2.42	93.20	2.01
	*-0.71***	*-4.08***	*-7.78***	*-8.65***	*1.25***	*1.75***	*2.64***	*2.81***	*0.16***	*9.05***	*0.31***
	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 Green Long	50.26	20.18	16.32	75.26	22.78	17.54	93.02	33.24	2.28	96.70	1.99
	-0.19	*-2.22***	*-1.90***	*2.49***	*2.25***	*-0.01*	*0.86*	*4.39***	*0.09***	*22.45***	*0.06***
	21.31**	-23.58**	5.33**	10.26**	-19.80**	-11.31**	26.13**	-16.30**	-38.89**	-1.67*	-15.81**
KR x MC-30	46.28	24.96	20.34	69.46	24.46	14.51	102.54	20.80	1.82	92.10	1.59
	*-5.25***	*-1.67***	*-0.86***	*1.69***	*-0.59***	*2.48***	*-3.41***	*3.51***	*0.26***	*0.73*	*-0.03***
	6.41**	6.54**	40.44**	5.45**	-13.67**	-4.66**	32.07**	-10.61**	-10.61**	-7.03**	-33.02**
Preethi x UB	49.24	14.24	10.84	64.63	9.89	13.60	65.11	57.76	2.28	92.10	1.96
	*0.58**	*0.32***	*-0.71***	*-1.01***	*0.44***	*0.82***	*0.07*	*7.39***	*0.19***	*0.28*	*-0.10***
	0.98	-30.02**	-29.78**	-0.06	-59.90**	-13.43**	-19.96**	140.15**	11.62**	-7.11**	-14.42**

per se values are in bold, *sca* values are in italics and standard heterosis values are in normal font

* and ** Significantly superior at 5 % and 1% level respectively