



## Studies on combining ability in bitter gourd (*Momordica charantia* L.)

K. Sundharaiya and K. Venkatesan

Department of Vegetable Crops  
Horticultural College and Research Institute  
Tamil Nadu Agricultural University, Coimbatore-641 003, India  
E-mail: aiya\_hort@rediffmail.com

### ABSTRACT

Combining ability study in eight bitter gourd lines, to identify suitable parents and crosses for further exploitation, indicated that the lines MC 13 ( $L_1$ ) and Panruti Local ( $L_2$ ) were good general combiners for yield per vine. The lines Ayakudi Local ( $L_3$ ) and Mithipagal ( $L_5$ ) recorded negative general combining ability and lower *per se* for days to first female flowering and days to fruit maturity. This can be utilized in breeding programme to develop earliness in bitter gourd. The hybrids MC 13 x Arka Harit ( $L_1$  x  $T_3$ ), Panruti Local x VK 1 Priya ( $L_2$  x  $T_2$ ) and MC 13 x Co 1 ( $L_1$  x  $T_1$ ) registered higher *per se* and specific combining ability for fruit length, individual fruit weight and yield per vine. The study revealed that additive x additive and additive x dominance type of interactions played a major role for days to first female flowering, days to fruit maturity, number of fruits per vine, fruit length, fruit size index, cavity size index, single fruit weight and yield per vine. The lines  $L_1$ ,  $L_2$ ,  $L_3$  and  $L_5$  expressed higher *per se* and general combining ability for most of the characters can successfully be utilized for developing superior hybrids in bitter gourd hybridization programmes.

**Key words:** Line x Tester analysis, combining ability, bitter gourd

Bitter gourd (*Momordica charantia* L.) is one of the most important, nutritious vegetables known for its bitter principle. In India, it is grown throughout the country as rainy and summer season vegetable. It is a highly cross-pollinated crop and its monoecious nature has resulted in wider variation in several qualitative and quantitative characters. However, it does not suffer from inbreeding depression and it seems that the population structure is similar to that of inbreeders than outbreeders (Allard, 1960). In breeding programmes, the common approach of selecting parents on the basis of *per se* performance does not lead to fruitful results. Hence, potential parents need to be selected based on their genetic architecture and combining ability.

The experiment consisted of line x tester analysis involving five lines, viz., MC 13 ( $L_1$ ), Panruti Local ( $L_2$ ), Ayakudi Local ( $L_3$ ), Long Green ( $L_4$ ) and Mithipagal ( $L_5$ ) and three testers, viz., Co-1 ( $T_1$ ), VK-1 Priya ( $T_2$ ) and Arka Harit ( $T_3$ ). The seeds of the selected parents were selfed for five generations to obtain homozygosity. The selfed seeds were raised in a crossing block and crossing was made in line x tester mating system. In all, 15  $F_1$  hybrids and eight parental lines were raised for evaluation in a randomized block design (RBD) with three replications.

Biometrical observations, viz., days to first female flowering, days to fruit maturity, number of fruits per vine, fruit length, fruit size index, cavity size index, individual fruit weight and yield per vine were made on randomly selected plants. Data were subjected to statistical analysis, and, general and specific combining ability study for eight characters was carried out as per the model of Kempthorne (1957).

Analysis of variance (ANOVA), due to parents and hybrids, showed significant differences for all the characters studied, and further, indicated presence of sufficient diversity in the lines and testers. Parental lines recorded higher significant variance for all the characters (Table 1). Mean square due to testers recorded significant variance for most of the characters except days to fruit maturity, cavity size index, single fruit weight and yield per vine, while variance due to interaction effect (line x tester) was significant for all the characters.

Significance of parents can be judged through *per se* performance and general combining ability (*gca*) of parents to obtain a desirable recombinant. In the present investigation, among the five lines used, the line  $L_1$  recorded higher *per se* performance for the characters, namely, fruit

**Table 1. Analysis of variance(ANOVA)**

Source	D.F	Days to first female flowering	Days to fruit maturity	Number of fruits per vine	Fruit length (cm)	Fruit size index (cm)	Cavity size index (cm)	Individual fruit weight(g)	Yield per vine(g)
Replication	2	9.17	1.101	13.22	1.56	252.68	33.43	3.63	30812
Parent	7	97.33**	52.99**	195.9**	85.47**	14365.76**	1127.62**	2295.94**	412152.9**
Lines	4	62.56**	78.51**	315.2**	135.9**	33621.44**	281.31**	5958.55**	901694.5**
Testers	2	84.78**	3.68	34.98**	3.16*	1063.81**	26.86	39.89	36927
Line x Tester	8	28.87**	4.68*	23.46**	16.33**	3806.5**	225.83**	383.92**	208599.3**
Hybrid	14	46.49**	25.63**	108.46**	48.45	11993.24**	1231.68**	1927.52**	382101.9**
Error	44	3.95	1.04	1.95	0.53	126.79	13.67	32.13	11607.2

\*Significant at 5%,

\*\*Significant at 1%

length, fruit size index, cavity size index, individual fruit weight and yield per vine. The line L<sub>5</sub> showed lower *per se* performance for days to first female flowering, days to fruit maturity and it ranked first in the number of fruits per vine. This was followed by line L<sub>3</sub>. Higher number of fruits per vine observed in L<sub>5</sub> and L<sub>3</sub> may be due to early flowering and small size of fruits as suggested by Richard Kennedy *et al* (1995). Among the three testers, T<sub>1</sub> expressed the best *per se* performance for number of fruits per vine, individual fruit weight and yield per vine, and, lower *per se* for days to first female flowering and days to fruit maturity. The tester T<sub>2</sub> ranked first for fruit length, fruit size index and cavity size index and second for days to first female flowering, days to fruit maturity, individual fruit weight and yield per vine (Table 2).

The line L<sub>1</sub> expressed the best *gca* for fruit length, fruit size index, cavity size index, individual fruit weight and yield per vine. This was followed by the lines L<sub>4</sub> and L<sub>2</sub>. The line L<sub>5</sub> recorded negative significant *gca* for days to first female flowering and days to fruit maturity and ranked first for number of fruits per vine and was followed by the line L<sub>3</sub>. The tester T<sub>1</sub> recorded negative significant *gca* for days to first female flowering and days to fruit maturity and higher *gca* for fruit length, fruit size index, cavity size index and individual fruit weight. The results assumed that a good combiner for any economic character need not be a good combiner for all other characters (Haripriya, 1991). High general combining ability effects observed for different characters may be helpful in identifying sorting out outstanding parents with favourable

**Table 2. *Per se* performance and general combining ability effects (*gca*) of parents**

Parent	Days to first female flowering	Days to fruit maturity	Number of fruits per vine	Fruit length (cm)	Fruit size index (cm)	Cavity size index (cm)	Individual fruit weight(g)	Yield per vine(g)
L <sub>1</sub>	47.99	23.55	14.89	16.89	213.67	63.24	86.66	1286.11
	<i>0.15</i>	<i>2.40</i>	<i>-3.53</i>	<i>4.20</i>	<i>74.19</i>	<i>19.85</i>	<i>21.97</i>	<i>327.77</i>
L <sub>2</sub>	47.44	15.00	13.33	12.89	146.66	50.12	56.11	776.66
	<i>1.22</i>	<i>2.22</i>	<i>-3.97</i>	<i>1.43</i>	<i>24.83</i>	<i>8.54</i>	<i>21.97</i>	<i>269.73</i>
L <sub>3</sub>	38.11	10.55	24.33	5.42	58.01	20.83	17.22	416.66
	<i>-1.22</i>	<i>-2.99</i>	<i>4.18</i>	<i>-4.39</i>	<i>-51.19</i>	<i>-18.42</i>	<i>-26.51</i>	<i>-331.01</i>
L <sub>4</sub>	50.77	16.66	13.89	13.78	121.22	44.53	45.55	641.66
	<i>3.45</i>	<i>1.51</i>	<i>-5.01</i>	<i>2.57</i>	<i>26.37</i>	<i>15.67</i>	<i>11.64</i>	<i>61.03</i>
L <sub>5</sub>	36.66	10.00	36.44	5.02	53.08	14.89	11.55	431.99
	<i>-3.59</i>	<i>-3.45</i>	<i>8.33</i>	<i>-3.81</i>	<i>-74.19</i>	<i>-25.64</i>	<i>-29.07</i>	<i>-327.53</i>
T <sub>1</sub>	46.22	15.99	18.77	17.994	161.65	59.66	78.89	1433.33
	<i>-1.95</i>	<i>-0.19</i>	<i>1.76</i>	<i>-0.2</i>	<i>-8.43</i>	<i>-0.48</i>	<i>0.29</i>	<i>48.90</i>
T <sub>2</sub>	46.33	16.11	13.33	19.00	249.05	68.94	74.44	952.99
	<i>2.65</i>	<i>-0.37</i>	<i>-0.81</i>	<i>-0.29</i>	<i>0.01</i>	<i>-1.03</i>	<i>-1.76</i>	<i>-50.79</i>
T <sub>3</sub>	52.99	16.88	14.78	14.33	179.33	45.33	58.89	912.22
	<i>-0.70</i>	<i>0.56</i>	<i>-0.95</i>	<i>0.53</i>	<i>8.42</i>	<i>1.51</i>	<i>1.45</i>	<i>1.39</i>
SE CD ( <i>P</i> =0.05)	1.406	0.724	0.988	0.519	7.963	2.164	4.008	76.175
	0.198	0.102	0.139	0.078	1.126	0.369	0.566	10.772
SE(gi)±SE (gi-gj) ±	<i>0.662</i>	<i>0.341</i>	<i>0.460</i>	<i>0.204</i>	<i>3.750</i>	<i>1.232</i>	<i>1.880</i>	<i>35.910</i>
	<i>0.513</i>	<i>0.264</i>	<i>0.360</i>	<i>0.189</i>	<i>2.900</i>	<i>0.954</i>	<i>1.460</i>	<i>27.810</i>

\*General combining ability values are in italics

Combining ability in bitter

**Table 3. *Per se* performance and specific combining ability effects (*sca*)**

Hybrid	Days to first female flowering	Days to fruit maturity	Number of fruits per vine	Fruit length (cm)	Fruit size index (cm)	Cavity size index (cm)	Individual fruit weight(g)	Yield per vine(g)
L <sub>1</sub> xT <sub>1</sub>	49.44 2.87*	18.11 1.64*	15.66 -2.32*	19.22 1.27*	257.44 23.94*	66.88 -1.07	71.11 1.77	1125.55 75.45*
L <sub>1</sub> xT <sub>2</sub>	50.33 -0.83	15.55 -0.74*	14.99 -0.41	15.55 -2.34*	194.88 -47.10*	59.33 -8.07*	48.77 -18.50*	756.89 -344.92*
L <sub>1</sub> xT <sub>3</sub>	45.33 -2.04*	16.33 -0.89*	17.99 2.73*	19.77 1.06*	273.49 23.16*	79.09 9.14*	87.22 16.72*	1573.89 420.38*
L <sub>2</sub> xT <sub>1</sub>	44.44 -3.20*	15.99 -0.29*	16.66 -0.88	14.55 -0.67*	176.16 -7.98*	58.79 2.15*	61.11 -8.21*	1014.99 -127.97*
L <sub>2</sub> xT <sub>2</sub>	57.44 5.20*	17.11 0.99*	17.44 2.48*	15.66 0.55*	195.37 2.80	51.90 -4.19*	82.21 14.94*	1418.33 374.55*
L <sub>2</sub> xT <sub>3</sub>	46.89 -2.00*	16.33 -0.71*	13.22 -1.61*	15.99 0.06	206.15 5.17	60.68 2.04	63.78 -6.72*	848.88 -246.57*
L <sub>3</sub> xT <sub>1</sub>	45.33 0.14	9.89 -1.81*	25.11 -0.56	6.22 -3.13*	67.11 -41.00*	20.68 -8.99*	24.44 3.59*	611.11 68.87*
L <sub>3</sub> xT <sub>2</sub>	46.98 -2.31*	9.99 -0.88*	22.99x 0.69	10.88 1.59*	128.51 11.96*	35.08 5.95*	18.33 -0.46	426.11 -16.92
L <sub>3</sub> xT <sub>3</sub>	49.11 2.67*	13.89 2.07*	23.66 0.69	11.66 1.55*	153.99 29.04*	34.72 3.05*	18.89 -3.13	442.78 -51.94
L <sub>4</sub> xT <sub>1</sub>	50.99 1.13*	15.89 0.01	15.32 -1.18*	15.66 -0.65*	197.55 11.87*	63.41 -0.35	61.11 2.12	950.55 16.28
L <sub>4</sub> xT <sub>2</sub>	53.89 -0.56	16.11 0.41	14.11 0.19	18.11 1.85*	230.44 36.32*	73.33 10.11*	57.77 0.83	817.77 -17.29
L <sub>4</sub> xT <sub>3</sub>	50.55 -0.56	16.22 -0.41	14.78 0.99*	15.88 -1.19*	154.33 -48.19*	55.99 -9.76*	57.22 -2.95	887.77 1.01
L <sub>5</sub> xT <sub>1</sub>	41.88 -0.94	10.44 -0.18	34.78 4.94*	13.05 -3.13*	98.27 13.17*	30.72 8.26*	18.99 0.71	663.99 18.28*
L <sub>5</sub> xT <sub>2</sub>	46.44 -0.98	10.66 0.22	25.11 -2.15*	8.22 -1.65*	89.55 -3.99	18.11 -3.79*	19.44 3.20	451.11 4.59
L <sub>5</sub> xT <sub>3</sub>	45.99 1.03*	11.33 -0.04	24.33 -2.79*	9.22 -1.47*	92.77 -9.18*	19.98 -4.47*	15.55 -3.91*	375.33 -128.87*
SE (L x T)	1.406	0.723	0.988	0.519	7.960	2.610	4.008	76.175
CD(P=0.05)	0.198	0.102	0.139	0.078	1.126	0.360	0.566	10.772
SE ( <i>sca</i> )	1.148	0.591	0.807	0.424	6.501	2.134	3.272	62.200

\*Significant at 5%

\*\*Specific combining ability values are in italics

alleles for different components of yield. Therefore, high general combining ability of the parents seems to be a reliable criterion for prediction of specific combining ability (Brar and Sidhu, 1977). The negative estimates of *gca* for days to first female flowering and days to fruit maturity registered by lines L<sub>5</sub>, L<sub>3</sub> and T<sub>1</sub> indicate that these can be utilized in hybridization programmes for developing earliness in bitter gourd it being monoecious with earliness as an important trait (Pal *et al*, 1983). The lines L<sub>1</sub> and L<sub>2</sub> expressing higher *per se* and *gca* for most of the yield attributing characters can be successfully utilized for developing superior hybrids where heterosis in the cross involving low x high combiners may be due to dominant x additive type of interaction, which is partially fixable and crosses involving both poor combining parents showing high *sca* might be due to intra - and inter- allelic interactions.

Among the 15 F<sub>1</sub> hybrids, L<sub>1</sub> x T<sub>3</sub>, L<sub>2</sub> x T<sub>2</sub> and L<sub>1</sub> x T<sub>1</sub> recorded higher *per se* performance for fruit length, fruit size index, cavity size index, individual fruit weight and yield per vine. The cross L<sub>5</sub> x T<sub>1</sub> proved to be the best *per se* performer for days to first female flowering and number of fruits per vine. Results indicated the crosses L<sub>1</sub> x T<sub>3</sub> and L<sub>2</sub> x T<sub>2</sub> to be products of high x low combination, and, L<sub>1</sub> x T<sub>1</sub> and L<sub>5</sub> x T<sub>1</sub> to be products of high x high combination, suggesting the role of additive x dominance and additive x additive type of interactions, respectively. It is evident that the best performance of hybrids for specific characters may be due to either one or both parents having high *gca* for the respective character (Choudhury, 1987). The same hybrids also exhibited higher specific combining ability effects for individual fruit weight and yield per vine. L<sub>1</sub> x T<sub>3</sub> was a product of good x good combiner for individual fruit weight.

This mean that *per se* performance was reflected in their respective *sca* effects (Munshi, and Sirohi, 1991). The hybrid  $L_3 \times T_1$  was the best specific combiner for number of fruits per vine, days to fruit maturity and days to first female flower. The cross was a product of good x good combiner for the respective traits. Higher *gca* effect of the parent involved in a cross also confirms superiority of the cross. The above results suggest that crosses with high *sca* effects for particular traits generally involved one of the parents which had either good or medium combining ability. Similar result was also reported by Arora *et al* (1996) in summer squash. Perusal of the data on *sca* effects shows that no specific hybrid combination had significant *sca* effect for all the characters studied. Of the 15  $F_1$  hybrid combinations, four hybrids recorded significant positive *sca* for yield per vine. Highest *sca* for yield per vine showed by the crosses  $L_1 \times T_3$  and  $L_2 \times T_2$  could be exploited for hybrid vigour in bitter gourd. However, this needs further testing before these combinations can be recommended for large scale commercial exploitation.

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