

Line x tester analysis for combining ability in bitter gourd (*Momordica charantia* L.)

N. S. TALEKAR¹, M. A. VADDORIA², N. B. PATEL³ AND L. L. JIVANI⁴

Department of Genetics and Plant Breeding, College of Agriculture,
Junagadh Agricultural University, Junagadh - 362 001 (Gujarat)

Received : 17 September, 2013

ABSTRACT

An experiment was under taken to study the combining ability analysis using seven lines and four testers and their 28 F₁ hybrids of bitter gourd obtained from line x tester analysis for fruit yield and its contributing characters. Analysis of variance indicated that mean squares due to lines x testers were significant for all the characters except fruit girth indicating predominant role of both additive and non-additive gene effects in the inheritance of all these traits. The estimates of σ^2_{gca} were higher than the corresponding σ^2_{sca} for days to open first female flower, days to open first male flower, days to first picking, vine length, number of primary branches per vine, number of fruits per vine, fruit length, fruit girth and fruit yield per vine, while in case of remaining characters viz., number of nodes bearing first female flower, internodal length and average weight of fruit, the magnitude of σ^2_{sca} was higher than σ^2_{gca} . This indicated the preponderance of additive and non-additive component of genetic variance. The estimate of gca effects indicated that among the lines, Preethi and Ujjwala were the good general combiners for fruit yield and some of the yield contributing characters viz., internodal length, vine length, number of fruits per vine, average fruit weight and fruit length, while among testers, HABG-22, CO-4 and HABG-21 were found good general combiners for fruit yield per vine and number of primary branches per vine. These parents were expected to accumulate additive genes that can be used as one of the parents for the development of varieties/hybrids in bitter gourd. The cross combinations viz., Kalyanpur Baramasi x HABG-21, Hirkani x CO-4, Phule Green Gold x Pant Karela-1, Kalyanpur Sona x CO-4 and Priya x HABG-21 were found to be good specific cross combinations for fruit yield per vine. These findings can be further utilized to develop and enhance the best yield potential of bitter gourd cultivars.

Key words : Line x tester, combining ability, yield, bitter gourd

Bitter gourd is an important crop of India. It is a rich source of nutrients and ranks first among all cucurbits for its nutritive value and the plant extracts have been traditionally used to cure diabetic (Dey *et al.*, 2010). Bitter gourd offers much scope of improvement through heterosis breeding among genetically diverse genotypes. Information on combining ability facilitates the choice of suitable parents for hybridization programme to develop promising F₁ hybrids. The line x tester cross help in determining both general and specific combining abilities of parents and hybrid

combinations, respectively. Further, it helps in formulating the breeding methodology for crop improvement. The present investigation was thus, conducted to identify the productive parents and its component traits in bitter gourd through combining ability analysis.

MATERIALS AND METHODS

The experimental material comprised of 28 F₁ hybrids developed by crossing of seven lines viz., Phule Green Gold, Hirkani, Kalyanpur Sona, Ujjwala, Kalyanpur Baramasi, Priya, Preethi and four testers viz., CO-4, Pant Karela-1, HABG-21 and HABG-22. Twenty eight hybrids along with 11 parents and a check variety,

¹ P.G. Student, ² Research Scientist (Garlic-Onion), Vegetable Research Station, ³ Assistant Professor, ⁴ Associate Research Scientist, Vegetable Research Station

Priya were evaluated during *kharif* 2012 in a randomized block design with three replications at Instructional farm, Department of Agronomy Junagadh Agricultural University, Junagadh. Each genotype consisting a single row of ten plants. The plants were spaced at a distance of 2.0 m between rows and 1.0 m within a row. Three seeds were dibbled in each hill, which were kept single plant per hill when the crop was 20 days old. Thus, the perfect population of ten plants of each genotype was obtained. All need based agronomic practices were followed during the crop growth period to raise a good crop. Observations were recorded on randomly selected five plants in each entry for 12 quantitative traits viz., days to open first female flower, days to open first male flower, number of nodes bearing first female flower, days to first picking, internodal length (cm), vine length (cm), number of primary branches per vine, number of fruits per vine, average weight of fruit (g), fruit length (cm), fruit girth (cm) and fruit yield per vine (kg). The mean values were used for the analysis of variance for experimental design. The combining ability analysis for different traits was worked out as per method suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

Analysis of variance (Table 1) indicated that mean squares due to lines and testers were significant for all the traits, while mean square due to lines x testers was also significant for all the characters except fruit girth indicating predominant role of both additive and non-additive gene effects in the inheritance of all these traits. Similar findings in bitter gourd were also reported by Khattra *et al.* (2000), Sundharaiya and Vekatesan (2007), Yadav *et al.* (2008), Jadhav *et al.* (2010), Dey *et al.* (2010), Kumara *et al.* (2011), Laxuman *et al.* (2012) and Thangamani *et al.* (2012).

The magnitude of gca and sca variances revealed that the gca variances were higher than the corresponding sca variances for days to open first female flower, days to opening of first male flower, days to first picking, vine length, number of primary branches per vine, number of fruits per vine, fruit length, fruit girth and fruit yield per vine, while in case of remaining characters viz., number of nodes bearing first female flower, internodal length and average weight of fruit, the magnitude of sca variances was higher than gca variances. This indicated the importance of non-additive gene action. Similar findings were also reported by Khattra *et al.* (2000) and Thangamani *et al.* (2012) in this crop.

The perusal of the data on general combining ability effects of the lines and testers (Table 2) indicated that among lines, Preethi and Ujjwala were found to be good general combiners for fruit yield per vine, internodal length, vine length, number of fruits per vine, average fruit weight and fruit length, while among testers, HABG-22 was the best general combiner for all the traits studied whereas, CO-4 was good general combiner for fruit yield per vine, vine length, number of primary branches per vine and number of fruits per vine. Either good or average general combining ability effect was also depicted by Phule Green Gold for days to open first female flower, days to open first male flower and days to first picking; Hirkani for number of fruits per vine; Kalyanpur Sona for average weight of fruit and Kalyanpur Baramasi for vine length and fruit length. This would help in construction of a suitable selection index for breeding productive genotypes. High general combining ability effects mostly contribute additive gene effects or additive x additive interaction effects and represent fixable portion of genetic variation. In view of this, HABG-22, HABG-21, CO-4, Preethi and Ujjwala offers the best possibilities of the development of improved lines with enhanced fruit yielding ability in bitter gourd and these lines turned out to be good general combiners and can be used as one of the parents in hybridization programme for fruit yield improvement programme.

The estimate of sca effects revealed (Table 3) that none of the crosses was consistently superior for all the characters. The crosses Kalyanpur Baramasi x HABG-21, Hirkani x CO-4, Phule Green Gold x Pant Karela-1 and Kalyanpur Sona x CO-4 had high sca for fruit yield per vine involved average x good, poor x poor and average good general combiner parents, respectively. This indicated the presence of epistatic gene action and such deviation could be attributed to the genetic diversity in the form of heterozygous loci. This could also be an indication of gene dispersion and genetic interaction between favorable alleles contributed by both the parents. Such combination could be utilized for intermating segregants in F_2 or F_3 generation and simultaneous selection for desirable plant type.

In contrast to general combining ability effects, the specific combining ability effects represent dominance and epistatic components of variation which are non fixable in nature. But if the crosses showing high sca effects involving either both or one good general combiner parents, they could be successfully exploited for varietal improvement and expected to

Table 1 Analysis of variance for combining ability and variance components for different characters in bitter gourd

Source	df	Days to open first female flower	Days to open first male flower	Number of nodes bearing first female flower	Days to first picking	Internodal length	Vine length
Replications	2	0.57	0.15	4.23 **	0.86	0.19 *	570.28 **
Lines	6	59.42 **++	27.59 **++	3.77 **++	68.09 **++	0.54 **++	13274.40 **++
Testers	3	30.74 **+	29.82 **+	2.88 **++	48.89 **++	0.38 **++	34203.33 **++
Lines x Testers	18	6.74 *	7.96 *	1.45 **	6.42 **	0.23 **	3277.69 **
Error	54	3.33	3.59	0.59	2.33	0.04	62.588
Variance components							
σ^2_l		4.67 **	1.99 *	0.26	5.48 **	0.04	1100.98 **
σ^2_t		1.30 *	1.24 *	0.10	2.21 **	0.01	1625.74 **
σ^2_{lt}		1.13 *	1.45 *	0.28 **	1.36 **	0.06 **	1071.70 **
σ^2_{gca}		2.53 **	1.52 **	0.16 **	3.40 **	0.02 **	1434.92 **
σ^2_{sca}		1.13	1.45	0.28	1.36	0.06	1071.70
$\sigma^2_{sca}/\sigma^2_{gca}$		0.44	0.95	1.72	0.40	2.52	0.74

Source	df	Number of primary branches per vine	Number of fruits per vine	Average weight of fruit	Fruit length	Fruit girth	Fruit yield per vine
Replications	2	1.21	5.65 *	12.45	5.92 **	0.61	0.28 **
Lines	6	2.32 **++	52.69 **+	198.35 **+	41.74 **++	3.99 **++	0.69 **++
Testers	3	25.07 **++	264.79 **++	729.84 **++	53.71 **++	14.86 **++	4.63 **++
Lines x Testers	18	1.64 **	18.84 **	52.84 **	4.81 **	0.78	0.39 **
Error	54	0.44	1.13	9.29	1.04	1.12	0.01
Variance components							
σ^2_l		0.15	4.29 *	15.75 *	3.39 **	0.23 **	0.05
σ^2_t		1.17 **	12.55 **	34.31 **	2.50 **	0.65 **	0.21 **
σ^2_{lt}		0.39 **	5.90 **	14.51 **	1.25 **	-0.11	0.12 **
σ^2_{gca}		0.80 **	9.55 **	27.56 **	2.82 **	0.50 **	0.16 **
σ^2_{sca}		0.39	5.90	55.12 **	1.25	-0.11	0.12
$\sigma^2_{sca}/\sigma^2_{gca}$		0.49	0.61	2.00	0.44	-0.22	0.75

*, ** Significant at 5 and 1 per cent levels, respectively

+, ++ Significant at 5 and 1 per cent levels, respectively against lines x testers interaction

Table 2 Estimate of gca effects of parents for quantitative traits in bitter gourd

Parents	Days to open first female flower	Days to open first male flower	Number of nodes bearing first female flower	Days to first picking	Internodal length (cm)	Vine length (cm)	Number of primary branches per vine	Number of fruits per vine	Average weight of fruit (g)	Fruit length (cm)	Fruit girth (cm)	Fruit yield per vine (kg)
Lines												
Phule Green Gold	-1.07*	-1.34*	0.67**	-1.25**	0.42**	-2.77	-0.21	-1.05**	-6.51**	-2.20**	-0.29	-0.20**
Hirkani	0.17	0.57	-0.16	-0.01	-0.02	0.24	-0.11	0.82**	0.47	-1.06**	-0.08	0.04
Kalyanpur Sona	0.01	-0.26	-0.27	0.55	-0.01	-15.44**	-0.79**	-0.33	2.13*	-0.66*	0.20	-0.05
Ujjwala	-0.48	-0.01	-0.17	0.18	-0.11*	25.63**	0.62**	2.34**	4.61**	1.81**	0.55	0.28**
Kalyanpur Baramasi	1.17*	-0.34	-0.38	0.73	-0.02	17.80**	0.16	-0.39	-1.11	2.16**	0.29	-0.01
Priya	3.76**	2.98**	0.90**	3.87**	0.02	-63.19**	0.12	-3.67**	-3.62**	-1.81**	-1.12**	-0.35**
Preethi	-3.57**	-1.59**	-0.58**	-4.07**	-0.27**	37.72**	0.20	2.29**	4.02**	1.77**	0.44	0.29**
Testers												
CO-4	0.07	0.51	0.23	-0.45	0.06	25.24**	0.39**	1.51**	0.77	0.23	0.38	0.12**
Pant Karela-1	1.26**	1.08**	0.30	1.95**	-0.03	-54.93**	-1.59**	-4.87**	-7.67**	-2.31**	-1.19**	-0.65**
HABG-21	0.31	0.08	-0.02	0.20	0.14*	-5.03**	0.32*	-0.06	0.20	0.81**	0.06	0.07*
HABG-22	-1.64**	-1.67**	-0.51*	-1.70**	-0.16**	34.72**	0.88**	3.42**	6.68**	1.26**	0.74**	0.46**

G = Good; A = Average; P = Poor

throw better transgressive segregants carrying favourable gene effects. The most of the cross combinations which were either due to good x poor, poor x good or average x average crosses besides exhibiting favourable and high additive effect of parents and manifest the complementary interaction effects and thus leads to higher sca effects.

In the present study, such cross combinations for fruit yield per vine were Kalyanpur Baramasi x HABG-21 (average x good), Hirkani x CO-4 (average x good), Phule Green Gold x Pant Karela-1 (poor x poor), Kalyanpur Sona x CO-4 (average x good) and Priya x HABG-21 (poor x good). This indicated the presence of both additive and non-additive gene action involved in the expression of fruit yield per vine. Further, some parents with positive and significant general combining ability produced hybrids with negative and significant specific combining ability indicating the role of complementary gene action. The combining ability of parents could not always be judged by the *per se* performance accurately. Therefore, both general combining ability and *per se* performance of breeding lines should be considered together for assessing their breeding potentiality. In the present investigation, none of the cross combination showed simultaneous significant specific combining ability effect favorably for all the characters. This may be due to complementation of favourable genes. The good combiners when crossed did not produce good hybrid. These findings are akin to the findings of Singh *et al.* (2004), Sundharaiya and Vekatesan (2007), Yadav *et al.* (2008), Dey *et al.* (2010) and Jadhav *et al.* (2010).

On the basis of general combining ability effects and specific combining ability effects, a few crosses were identified. These F_1 hybrids were Kalyanpur Baramasi x HABG-21, Hirkani x CO-4, Phule Green Gold x Pant Karela-1 and Kalyanpur Sona x CO-4. These are the potential source for the development of F_1 hybrid varieties in bitter gourd.

From the present study, it was formed that the parents viz., Preethi, Ujjwala, HABG-21, HABG-22 and CO-4 were good general combiners for fruit yield and its attributing characters and could be utilized in future breeding programmes. Among hybrids, Kalyanpur Baramasi x HABG-21, Hirkani x CO-4, Phule Green Gold x Pant Karela-1 and Kalyanpur Sona x CO-4 were the promising hybrid combinations for most of the desirable characters including fruit yield per vine in bitter gourd.

Table 3 Specific combining ability effects for different characters in bitter gourd

Sr. No.	Crosses	Days to open first female flower	Days to opening of first male flower	Number of nodes bearing first female flower	Days to first picking	Internodal length (cm)	Vine length (cm)
1	Phule Green Gold x CO-4	0.59	0.15	0.50	0.71	0.24*	55.25**
2	Phule Green Gold x Pant Karela-1	-0.26	-1.75	-0.60	0.02	-0.28*	7.10
3	Phule Green Gold x HABG-21	-0.30	0.25	0.29	-1.10	0.40**	-44.79**
4	Phule Green Gold x HABG-22	-0.02	1.34	-0.18	0.36	-0.36**	-17.55**
5	Hirkani x CO-4	1.34	2.57*	-1.09*	1.97*	-0.09	10.56*
6	Hirkani x Pant Karela-1	0.48	-0.66	0.10	0.64	-0.01	19.14**
7	Hirkani x HABG-21	0.77	0.66	1.33**	-0.71	-0.05	-32.45**
8	Hirkani x HABG-22	-2.60*	-2.57*	-0.34	-1.91*	0.16	2.75
9	Kalyanpur Sona x CO-4	-1.48	-0.59	-1.11*	-1.29	-0.28*	17.92**
10	Kalyanpur Sona x Pant Karela-1	-1.01	-0.16	0.44	1.48	-0.16	-1.89
11	Kalyanpur Sona x HABG-21	0.60	-0.50	-0.16	-0.36	0.25*	-26.13**
12	Kalyanpur Sona x HABG-22	1.89	1.26	0.83	0.17	0.20	10.11*
13	Ujjwala x CO-4	-1.65	-3.17**	0.65	-1.48	-0.10	-26.16**
14	Ujjwala x Pant Karela-1	-0.17	0.58	0.44	-2.32**	0.26*	-8.31
15	Ujjwala x HABG-21	0.77	0.58	-0.56	3.44**	-0.26*	17.11**
16	Ujjwala x HABG-22	1.06	2.01	-0.53	0.37	0.10	17.36**
17	Kalyanpur Baramasi x CO-4	0.01	0.48	0.49	-0.97	-0.23	-16.99**
18	Kalyanpur Baramasi x Pant Karela-1	0.48	-0.08	-0.24	0.96	0.34**	-30.14**
19	Kalyanpur Baramasi x HABG-21	-1.22	-0.75	-0.65	-0.78	-0.21	46.61**
20	Kalyanpur Baramasi x HABG-22	0.72	0.34	0.40	0.78	0.10	0.52
21	Priya x CO-4	1.76	0.15	0.27	0.25	0.21	-14.33**
22	Priya x Pant Karela-1	-2.09*	1.58	-0.43	-0.57	-0.19	45.85**
23	Priya x HABG-21	0.19	-1.41	0.03	-0.04	-0.17	-2.71
24	Priya x HABG-22	0.14	-0.32	0.12	0.36	0.15	-28.80**
25	Preethi x CO-4	-0.57	0.40	0.29	0.81	0.24*	-26.24**
26	Preethi x Pant Karela-1	2.57*	0.50	0.28	-0.23	0.05	-31.73**
27	Preethi x HABG-21	-0.81	1.16	-0.28	-0.42	0.06	42.36**
28	Preethi x HABG-22	-1.19	-2.07	-0.29	-0.15	-0.36**	15.61**
	SE (S _d)	1.05	1.09	0.44	0.88	0.12	4.56

*, ** Significant at 5 % and 1 % levels, respectively

Table 3 Contd. ...

Sr. No.	Crosses	Number of primary branches per vine	Number of fruits per vine	Average weight of fruit (g)	Fruit length (cm)	Fruit girth (cm)	Fruit yield per vine (kg)
1	Phule Green Gold x CO-4	-0.91*	-2.10**	-4.56**	-2.40**	-0.29	-0.34**
2	Phule Green Gold x Pant Karela-1	0.50	2.89**	0.07	1.88**	0.19	0.43**
3	Phule Green Gold x HABG-21	0.05	-0.98	-0.33	1.02	-0.35	-0.19*
4	Phule Green Gold x HABG-22	0.36	0.19	4.81**	-0.50	0.45	0.11
5	Hirkani x CO-4	0.82*	2.54**	5.38**	0.74	0.59	0.45**
6	Hirkani x Pant Karela-1	-1.12**	-1.58*	-0.61	-0.19	0.15	-0.13
7	Hirkani x HABG-21	-0.07	-0.93	-4.34*	-0.18	-0.99	-0.37**
8	Hirkani x HABG-22	0.37	-0.22	-0.42	-0.36	0.25	0.05
9	Kalyanpur Sona x CO-4	0.96*	2.11**	3.78*	1.11	0.43	0.41**
10	Kalyanpur Sona x Pant Karela-1	-0.91*	0.03	0.17	-0.85	0.07	0.02
11	Kalyanpur Sona x HABG-21	-0.16	-1.84**	-4.39*	-1.45*	-0.43	-0.38**
12	Kalyanpur Sona x HABG-22	0.11	-0.30	0.43	1.19*	-0.07	-0.05
13	Ujjwala x CO-4	0.18	-0.19	3.45*	0.70	0.13	0.03
14	Ujjwala x Pant Karela-1	-0.19	-0.71	-0.20	-1.33*	-0.16	-0.01
15	Ujjwala x HABG-21	0.05	-0.86	0.24	0.05	0.12	0.01
16	Ujjwala x HABG-22	-0.03	1.76**	-3.49*	0.57	-0.09	0.03
17	Kalyanpur Baramasi x CO-4	0.43	0.28	0.59	0.42	0.08	0.19*
18	Kalyanpur Baramasi x Pant Karela-1	0.09	-3.76**	-5.06**	-0.15	-0.46	-0.58
19	Kalyanpur Baramasi x HABG-21	0.24	4.55**	6.13**	0.20	0.69	0.47**
20	Kalyanpur Baramasi x HABG-22	-0.78*	-1.06	-1.67	-0.47	-0.31	-0.08
21	Priya x CO-4	-0.38	0.22	-7.98**	-1.18*	-0.79	-0.61**
22	Priya x Pant Karela-1	1.27**	3.71**	2.88	1.89**	0.39	0.34**
23	Priya x HABG-21	-0.41	-0.73	2.22	0.43	0.73	0.39**
24	Priya x HABG-22	-0.47	-3.20**	2.87	-1.15*	-0.34	-0.12
25	Preethi x CO-4	-1.10**	-2.87**	-0.67	0.59	-0.15	-0.14
26	Preethi x Pant Karela-1	0.35	-0.58	2.74	-1.23*	-0.20	-0.06
27	Preethi x HABG-21	0.30	0.81	0.46	-0.08	0.23	0.07
28	Preethi x HABG-22	0.44	2.64**	-2.53	0.72	0.12	0.13
	SE (S _y)	0.38	0.61	1.76	0.58	0.61	0.08

*, ** Significant at 5 % and 1 % levels, respectively

REFERENCES

- Dey, S.S., Behera, T. K., Munshi, A. D. and Pal Anand, 2010. Combining ability analysis in bitter gourd. *Indian Journal of Horticulture*, **67**(3): 399-401.
- Jadhav, K. A., Garad, B. V., Kshirsagar, D. B., Dhumal, S. S. and Patil, B. T. 2010. Combining ability studies in bitter gourd (*Momordica charantia* L.). *Journal of Maharashtra Agricultural University*, **35**(2): 203-206.
- Kempthorne, O. 1957. An Introduction to Genetical Statistics. John Wiley and Sons, New York, pp 545.
- Khattra, A. S., Singh Raghbir and Thakur, J. C. 2000. Combining ability studies in bitter gourd in relation to line x tester crossing system. *Vegetable Science*, **27**(2): 148-151.
- Kumara, B. S., Puttaraju, T. B., Hongal Shivanand, Prakash, K., Jainag, K. and Sudheesh, N. K. (2011). Combining ability studies in bitter gourd (*Momordica charantia* L.) for quantitative characters. *Asian Journal of Horticulture*, **6**(1): 135-140.
- Laxuman, Patil, S. A., Salimath, P. M., Dharmatti P. R., Byadgi, A. S. and Yenagi Nirmala, 2012. Heterosis and combining ability analysis for productivity traits in bitter gourd (*Momordica charantia* L.). *Karnataka Journal of Agricultural Science*, **25**(1): 9-13.
- Singh, S. K., Ram, H. H. and Singh, J. P. 2004. Combining ability in bitter gourd (*Momordica charantia* L.). *Haryana Journal of Horticulture Science*, **36**(1): 107-112.
- Sundharaiya, K. and Venkatesan, K. 2007. Studies on combining ability in bitter gourd (*Momordica charantia* L.). *Journal of Horticulture Science*, **2**(1): 63-66.
- Thangamani, C., Pugalandhi, L. and Sumathi, T. 2012. Studies on combining ability for characters related to yield and earliness in bitter gourd (*Momordica charantia* L.). *Vegetable Science*, **39**(1): 40-46.
- Yadav Murlee, Chaudhary Rashmi and Singh, D. B. 2008. Combining ability in bitter gourd. *Indian Journal of Horticulture*, **65**(2): 163-166.