Int.J.Curr.Microbiol.App.Sci (2018) *7*(4): 3873-3881

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 04 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.704.437

Combining Ability and Heterosis Analysis for Yield and Yield-Attributing Traits in Bitter Gourd (*Momordica charantia* L.) Using a Half-Diallel Mating Design

M. Mahesh*, RVSK Reddy and P. Saidaiah

Department of Vegetable Science, College of Horticulture, Dr.YSR Horticultural University, Rajendranagar, Hyderabad-500030, Andhra Pradesh, India

**Corresponding author*

Keywords

Bitter gourd, General combining ability, Standard heterosis

Article Info

Accepted:
26 March 2018
Available Online:
10 April 2018

A B S T R A C T

An experiment was conducted to elucidate the nature of gene action, combining ability, and the magnitude of heterosis for yield and yield-contributing traits in bitter gourd (Momordica charantia L.). The study involved five parental lines and their ten F_1 hybrids generated through a half-diallel mating design and was carried out during kharif 2012 and rabi 2012–13 at the Vegetable Research Station, Rajendranagar, Hyderabad. Analysis of variance revealed that specific combining ability (SCA) variances exceeded general combining ability (GCA) variances for most of the traits studied, indicating the predominance of non-additive gene action, except for node of first pistillate flower appearance and number of fruits per vine, where additive gene effects were more influential. Among the parental lines, RNMC-55 and RNMC-52 emerged as superior general combiners for fruit yield and related attributes. The cross RNMC-51 × RNMC-53 exhibited the best specific combining ability for days to first and last fruit harvest, fruit yield per vine, number of primary branches, and vine length. The hybrid RNMC-53 × RNMC-55 was identified as the best specific combiner for average fruit weight and fruit flesh thickness, while RNMC-54 × RNMC-55 recorded the highest significant SCA effects for node of first pistillate flower appearance, fruit diameter, and number of fruits per vine. The cross RNMC-52 × RNMC-54 showed superior performance for fruit length. Notably, the hybrids RNMC-53 × RNMC-55 (31.19%) and RNMC-52 × RNMC-55 (25.90%) exhibited high standard heterosis for fruit yield per vine along with significant SCA effects. These promising hybrids warrant further evaluation through large-scale yield trials prior to recommendation for commercial cultivation.

Introduction

Bitter gourd (*Momordica charantia* L.) is an important cucurbitaceous vegetable crop, widely valued for its high nutritional content and well-recognized medicinal properties. In India, the crop occupies approximately 6.76 million hectares, with an annual production of 101.43 million tonnes (Rai & Pandey, 2007), highlighting its economic and dietary significance. Bitter gourd is predominantly cross-pollinated owing to its monoecious nature, which provides substantial opportunities for genetic improvement through heterosis breeding. The exploitation of hybrid vigour is comparatively more efficient in cross-pollinated crops, enabling the development of high-yielding and superior hybrids for commercial cultivation. However, the success of heterosis breeding largely depends on the identification of genetically diverse parents with strong general and specific combining abilities. Evaluating combining ability not only aids in the selection of suitable parental lines but also facilitates an understanding of the underlying gene action governing yield and its component traits. In this context, the present investigation was undertaken to assess the extent of heterosis and combining ability for yield and yield-contributing characters in bitter gourd using a half-diallel mating design, with the objective of identifying promising parental lines and superior cross combinations for future breeding programmes (Rai and Pandey, 2007).

Materials and Methods

The investigation was conducted during 2012–2013 at the Vegetable Research Station, Rajendranagar, Dr. Y. S. R. Horticultural University. A total of ten F_1 hybrids, developed through a half-diallel mating design involving five genetically diverse parental lines, were evaluated to assess heterosis and combining ability. The experiment was laid out in a Randomized Block Design (RBD) with three replications. Observations were recorded on twelve quantitative traits related to yield and its contributing characters. The commercially released hybrid 'Palee', developed by East–West International Seeds, was used as the standard check for estimating standard heterosis. Standard heterosis for each trait was calculated following the procedure described by Gowen (1952), while estimates of general combining ability (GCA) and specific combining ability (SCA) were computed using Griffing's (1956) Method II, Model I.

Results and Discussion

The components of heritable variation, namely general combining ability (GCA) variance (σ^2GCA), specific combining ability (SCA) variance (σ^2SCA), and their ratios for all twelve characters are presented in Table 2. The analysis of combining ability revealed that the estimates of σ^2SCA were higher than those of σ^2GCA for most of the traits studied. Consequently, the ratio of σ^2GCA to σ^2SCA was less than unity (<1) for all characters except node of first pistillate flower appearance and number of fruits per vine. This clearly indicates the predominance of non-additive gene action in the inheritance of most yield and yield-contributing traits. Similar predominance of non-additive gene action for yield and related characters in bitter gourd has also been reported earlier by Kumara et al. (2011), Gupta et al. (2006), and Bhave et al. (2004).

The analysis of variance for combining ability (Table 3) revealed highly significant differences among genotypes for all the characters studied, indicating the presence of substantial genetic variability among parents and crosses. Replication effects were non-significant, while treatment effects were significant for all traits, thereby justifying the partitioning of treatments into parents, crosses, and parents vs. crosses. The mean sum of squares due to parents was significant for all characters, indicating significant differences among parents in their ability to transmit traits to the progenies. Similarly, the mean sum of squares due to crosses was highly significant for all characters, reflecting considerable variation in the performance of different hybrids. The significant variance due to parents vs. crosses further indicated the presence of appreciable average heterosis contributed by the parents.

Among the parental lines, RNMC-55 recorded the highest positive GCA effects for days to last fruit harvest, fruit diameter, fruit flesh thickness, number of fruits per vine, fruit yield per vine, number of primary branches per vine, and vine length. RNMC-52 exhibited the highest positive GCA effect for fruit length. Desirable negative GCA effects for days to first pistillate flower appearance, node of first pistillate flower appearance, and days to first fruit harvest were observed in RNMC-53, indicating its usefulness for earliness. A comprehensive assessment of parents based on GCA effects across twelve characters identified RNMC-55 and RNMC-52 as superior general combiners for yield and yield-contributing traits. These parents can therefore be effectively utilized as donors in commercial breeding programmes. Notably, parents with high GCA effects also exhibited superior per se performance, corroborating earlier findings reported in bitter gourd and other cucurbits.

The evaluation of specific combining ability revealed that different cross combinations were superior for different traits. The hybrid RNMC-51 × RNMC-53 was the best specific combiner for days to first fruit harvest, days to last fruit harvest, fruit yield per vine, number of primary branches per vine, and vine length. The cross RNMC-52 × RNMC-53 exhibited the highest desirable SCA effects for days to first pistillate flower appearance, indicating its suitability for early flowering. The hybrid RNMC-53 × RNMC-55 was identified as the best specific combiner for average fruit weight and fruit flesh thickness. The cross RNMC-54 × RNMC-55 recorded the highest significant SCA effects for node of first pistillate flower appearance, fruit diameter, and number of fruits per vine, while RNMC-52 × RNMC-54 was the best specific combiner for fruit length. Significant SCA effects for yield and related traits have also been reported earlier by Singh et al. (2004), Bhave et al. (2004), and Gupta et al. (2006).

Standard heterosis was estimated for ten F_1 hybrids developed through half-diallel mating of five genetically diverse parents, using the commercial hybrid Palee (East-West International Seeds) as the standard check. The mean performance of parents and hybrids is presented in Table 1. Standard heterosis was considered a critical criterion for identifying productive hybrids. Negative heterosis was desirable for days to first pistillate flower appearance, node of first pistillate flower appearance, and days to first fruit harvest, as these traits contribute to earliness. In contrast, positive heterosis was desirable for days to last fruit harvest, fruit length, fruit diameter, fruit flesh thickness, average fruit weight, number of fruits per vine, fruit yield per vine, number of primary branches per vine, and vine length.

The relationship between per se performance and SCA effects revealed that only a few hybrids showed concordance in ranking based on both criteria. This indicates that high SCA effects do not always translate into superior per se performance. The enhanced expression of yield and yield-contributing traits in certain hybrids may be attributed to genetic complementation, wherein one parent compensates for the deficiencies of the other, resulting in improved hybrid performance (Saidaiah et al., 2009).

Table.1 Mean performance of parents and hybrids for twelve quantitative characters in bitter gourd

Parent / hybrid	Days to first pistillate flower	Node of first pistillate flower	Days to first fruit harvest	Days to last fruit harvest	Fruit length (cm)	Fruit diameter (cm)	Fruit flesh thickness (mm)	Average fruit weight (gm)	No. of fruits per vine	Fruit yield per vine	No. of primary branches	Vine length (m)
Parents												
RNMC-51	60.55	17.00	80.48	108.60	13.19	3.26	4.93	66.07	14.30	0.94	4.60	**2.82**
RNMC-52	55.66	11.37	74.40	103.12	16.37	2.63	4.16	70.27	15.75	1.11	5.97	**3.32**
RNMC-53	48.72	10.39	67.43	96.40	11.29	2.90	4.33	57.33	15.72	0.90	4.44	**2.78**
RNMC-54	53.25	12.66	72.40	98.93	13.18	2.66	4.87	66.80	12.72	0.87	4.74	**2.98**
RNMC-55	55.44	13.11	73.48	107.51	10.83	2.97	5.05	51.20	26.77	1.35	6.50	**3.36**
Hybrids												
RNMC-51 X 52	55.57	13.08	1.57	104.65	15.18	3.42	5.17	69.73	16.17	1.13	6.32	**3.02**
RNMC-51 X 53	53.58	13.94	68.33	109.65	13.29	3.23	5.53	66.90	20.17	1.35	6.44	**3.43**
RNMC-51 X 54	54.39	16.72	71.50	105.30	13.79	2.90	4.98	69.37	14.60	1.01	4.76	**3.35**
RNMC-51 X 55	54.80	14.80	73.25	107.13	11.90	3.47	6.15	65.43	19.60	1.28	6.90	**3.50**
RNMC-52 X 53	49.29	9.85	68.32	105.11	15.20	2.59	4.37	60.45	20.45	1.24	6.40	**3.26**
RNMC-52 X 54	54.34	12.61	72.23	100.60	19.40	2.67	4.26	77.10	12.47	0.96	5.65	**2.86**
RNMC-52 X 55	52.17	14.72	69.41	112.03	13.73	3.27	5.28	70.90	21.80	1.54	6.88	**3.74**
RNMC-53 X 54	53.84	11.11	71.33	102.84	12.70	2.94	5.09	64.59	17.10	1.10	5.32	**3.16**
RNMC-53 X 55	53.65	11.41	70.69	109.16	12.72	3.50	6.10	64.99	24.77	1.60	6.57	**3.25**
RNMC-54 X 55	51.08	10.28	69.68	110.50	16.16	3.79	6.02	61.49	23.77	1.46	6.24	**3.40**
Check Palee	**53.17**	**11.72**	**72.93**	**104.64**	**18.62**	**3.65**	**6.14**	**84.87**	**14.50**	**1.23**	**6.65**	**3.44**

Table.2 Components of heritable variation and their ratios for twelve quantitative characters in bitter gourd

Characters	σ2 gca	σ2 sca	σ2 sca
Days to 1st pistillate flower appearance	2.55	3.76	**0.68**
Node of 1st pistillate flower appearance	1.79	1.67	**1.07**
Days to first fruit harvest	2.57	6.47	**0.39**
Days to first fruit harvest	5.07	13.06	**0.39**
Fruit length (cm)	1.51	2.57	**0.58**
Fruit diameter (cm)	0.03	0.1	**0.29**
Fruit flesh thickness (mm)	0.11	0.28	**0.39**
Average fruit weight (g)	11.02	22.06	**0.5**
Number of fruits per vine	8.07	5.08	**1.59**
Fruit yield per vine (kg)	0.16	0.33	**0.47**
Number of primary branches per vine	0.21	0.42	**0.50**
Vine length (m)	**0.012**	**0.062**	**0.20**

Table.3 Analysis of variance for combining ability for twelve quantitative characters in bitter gourd

Source of variation	d.f	Days to first pistillate flower appearance	Node of first pistillate flower appearance	Days to first fruit harvest	Days to last fruit harvest	Fruit length (cm)	Fruit diameter (cm)	Fruit flesh thickness (mm)	Average fruit weight (g)	No. of fruits per vine	Fruit yield per vine (kg)	No. of primary branches per vine	Vine length (m)
Replications	2	0.91	0.79	0.17	1.17	0.45	0.03	0.05	0.54	0.83	0.00	0.10	0.04
Treatments	14	24.23**	14.98**	30.45**	59.61**	14.84**	0.41**	1.28**	115.10**	59.85**	0.17**	2.24**	0.23**
Parents	4	55.20**	19.18**	65.55**	83.82**	14.27**	0.20**	0.47**	184.33**	93.16**	0.12**	2.56**	0.23**
Hybrids	9	10.82**	14.77**	8.19**	39.55**	14.44**	0.46**	1.35**	71.92**	47.08**	0.15**	1.44**	0.19**
Parents vs Hybrids	1	21.12**	0.03	90.36**	143.36**	20.69**	0.84**	3.91**	226.83**	41.53**	0.54**	8.09**	0.60**
Error	28	0.86	0.66	1.15	1.18	0.29	0.01	0.02	1.68	0.52	0.00	0.05	0.02
Total	44	8.30	5.22	10.43	19.77	4.92	0.14	0.43	37.71	19.41	0.05	0.75	0.09
GCA	4	18.16**	12.74**	18.38**	35.91**	10.64**	0.21**	0.77**	77.74**	56.68**	0.11**	1.51	0.09
SCA	10	4.05**	1.89**	6.86**	13.45**	2.67**	0.11**	0.29**	22.62**	5.26**	0.03**	0.44	0.07
Error (GCA/SCA)	28	0.29	0.22	0.38	0.39	0.10	0.00	0.01	0.56	0.17	0.00	0.02	0.01

* Significant at 5% level ** Significant at 1% level

Table.4 Estimates of general combining ability effects of parents for twelve quantitative characters in bitter gourd

Parent	Days to first pistillate flower appearance	Node of first pistillate flower appearance	Days to first fruit harvest	Days to last fruit harvest	Fruit length (cm)	Fruit diameter (cm)	Fruit flesh thickness (mm)	Average fruit weight (g)	No. of fruits per vine	Fruit yield per vine (kg)	No. of primary branches per vine	Vine length (m)
RNMC-51	2.42**	2.19**	2.26**	−1.62**	−0.43**	0.15**	0.17**	1.50**	−1.62**	−0.07**	−0.21**	−0.05
RNMC-52	0.02	−0.60**	0.08	−0.57*	1.81**	−0.18**	−0.44**	3.67**	−1.15**	−0.01	0.30**	0.03
RNMC-53	−2.10**	−1.45**	−2.32**	−1.86**	−1.01**	−0.06**	−0.11**	−3.07**	0.49**	−0.01	−0.21**	−0.09**
RNMC-54	−0.34	−0.17	−0.04	−2.22**	0.69**	−0.12**	−0.06	1.87**	−2.44**	−0.12**	−0.52**	−0.08**
RNMC-55	0.01	0.03	0.03	3.03**	−1.06**	0.21**	0.45**	−3.98**	4.72**	0.21**	0.64**	0.19**
S.E.	0.18	0.16	0.21	0.21	0.10	0.02	0.03	0.25	0.14	0.01	0.04	0.03

* Significant at 5% level ** Significant at 1% level

Table.5 Estimates of specific combining ability (sca) effects for twelve quantitative characters in bitter gourd

Cross	Days to 1st pistillate flower appearance	Node of 1st pistillate flower appearance	Days to first fruit harvest	Days to last fruit harvest	Fruit length (cm)	Fruit diameter (cm)	Fruit flesh thickness (mm)	Average fruit weight (g)	No. of fruits per vine	Fruit yield per vine (kg)	No. of primary branches per vine	Vine length (m)
RNMC-51 × RNMC-52	−0.63	−1.37**	−2.40**	−1.83**	−0.13	0.37**	0.36**	−0.95	0.53	0.01	0.38**	−0.18*
RNMC-51 × RNMC-53	−0.49	0.33	−3.23**	4.46**	0.81*	0.06	0.38**	2.95**	2.88**	0.23**	1.02**	0.36**
RNMC-51 × RNMC-54	−1.44*	1.83**	−2.36**	0.46	−0.39	−0.21**	−0.22*	0.49	0.25	0.02	−0.36**	0.26**
RNMC-51 × RNMC-55	−1.38*	−0.29	−0.67	−2.96**	−0.54	0.02	0.45**	2.40**	−1.91**	−0.05*	0.62**	0.14
RNMC-52 × RNMC-53	−2.39**	−0.97*	−1.07	2.11**	0.47	−0.25**	−0.17	−5.66**	2.70**	0.06**	0.46**	0.11
RNMC-52 × RNMC-54	0.91	0.51	0.56	−2.05**	2.97**	−0.11*	−0.32**	6.05**	−2.35**	−0.10**	0.02	−0.31**
RNMC-52 × RNMC-55	−1.61**	2.42**	−2.32**	4.13**	−0.95**	0.16**	0.19*	5.70**	−0.17	0.15**	0.09	0.30**
RNMC-53 × RNMC-54	2.53**	−0.14	2.06**	1.49*	−0.91**	0.04	0.18	0.27	0.64	0.04*	0.20	0.12
RNMC-53 × RNMC-55	2.00**	−0.04	1.35*	2.56**	0.86**	0.27**	0.68**	6.52**	1.15*	0.22**	0.29*	−0.07
RNMC-54 × RNMC-55	−2.34**	5.00**	−1.94**	4.25**	2.60**	0.62**	0.55**	−1.91*	3.08**	0.19**	0.27*	0.08
S.E. (Mean)	0.47	0.41	0.54	0.55	0.27	0.04	0.08	0.65	0.36	0.02	0.11	0.07
CD @ 5%	1.05	0.92	1.22	1.24	0.61	0.10	0.18	1.47	0.82	0.04	0.25	0.16
CD @ 1%	1.52	1.33	1.76	1.78	0.87	0.15	0.26	2.12	1.18	0.06	0.36	0.22

* Significant at 5% level ** Significant at 1% level

Table.6 Heterosis (percent) over standard check for twelve quantitative traits in bitter gourd

Cross	Days to 1st pistillate flower appearance	Node of 1st pistillate flower appearance	Days to first fruit harvest	Days to last fruit harvest	Fruit length (cm)	Fruit diameter (cm)	Fruit flesh thickness (mm)	Average fruit weight (g)	No. of fruits per vine	Fruit yield per vine (kg)	No. of primary branches per vine	Vine length (m)
RNMC-51 × 52	4.50**	11.63	−1.87	0.01	−18.48**	−6.39**	−15.84**	−17.83**	11.49**	−8.18**	−5.06	−12.29**
RNMC-51 × 53	0.76	18.97**	−6.31**	4.79**	−28.59**	−11.51**	−10.04**	−21.17**	39.08**	9.92**	−3.16	−0.39
RNMC-51 × 54	2.28	42.66**	−1.97	0.63	−25.91**	−20.46**	−18.99**	−18.26**	0.69	−17.53**	−28.46**	−2.81
RNMC-51 × 55	3.05	26.31**	0.43	2.38**	−36.06**	−5.02*	0.11	−22.90**	35.17**	4.43	3.76	1.55
RNMC-52 × 53	−7.31**	−15.96**	−6.33**	0.45	−18.35**	−29.13**	−28.92**	−28.77**	41.06**	0.76	−3.81	−5.23
RNMC-52 × 54	2.20	7.59	−0.96	−3.86**	4.21	−26.85**	−30.66**	−9.15**	−14.02**	−21.74**	−15.08**	−17.04**
RNMC-52 × 55	−1.89	25.60**	−4.83**	7.06**	−26.23**	−10.41**	−14.00**	−16.46**	50.34**	25.90**	3.36	8.52*
RNMC-53 × 54	1.26	−5.20	−2.19	−1.72	−31.76**	−19.45**	−17.09**	−23.90**	17.93*	−10.33**	−20.09**	−8.13*
RNMC-53 × 55	0.90	−2.59	−3.08*	4.32**	−31.66**	−4.11	−0.65	−23.42**	70.80**	31.14**	−1.30	−5.71
RNMC-54 × 55	−3.94*	−12.32	−4.46**	5.60**	−13.18**	3.74	−1.95	−27.54**	63.91**	19.05**	−6.16*	−1.16
SE (d)	0.76	0.66	0.88	0.89	0.44	0.07	0.13	1.06	0.59	0.029	0.18	0.11

* Significant at 5% level ** Significant at 1% level

Among the ten hybrids evaluated, significant standard heterosis in the desirable direction was expressed for several traits, though none of the hybrids exhibited significant standard heterosis for all twelve characters studied. Significant desirable standard heterosis was recorded in two hybrids for days to first pistillate flower appearance, one hybrid each for node of first pistillate flower appearance and vine length, five hybrids each for days to first fruit harvest and days to last fruit harvest, eight hybrids for number of fruits per vine, and four hybrids for fruit yield per vine. However, none of the hybrids showed significant standard heterosis for fruit length, fruit diameter, fruit flesh thickness, average fruit weight, and number of primary branches per vine. Overall, the magnitude of standard heterosis over the commercial check was highest for number of fruits per vine, followed by fruit yield per vine.

The standard heterosis for days to first pistillate flower appearance ranged from −7.31% in RNMC-52 × RNMC-53 to 4.50% in RNMC-51 × RNMC-52. The cross RNMC-52 × RNMC-53 also recorded the maximum significant and desirable standard heterosis for node of first pistillate flower appearance (−15.96%), indicating its potential for earliness. For days to first fruit harvest, standard heterosis ranged from −6.33% in RNMC-52 × RNMC-53 to 0.43% in RNMC-51 × RNMC-55.

Positive and significant standard heterosis for days to last fruit harvest was highest in RNMC-52 × RNMC-55 (7.06%), followed by RNMC-54 × RNMC-55 (5.60%), indicating prolonged harvesting duration in these hybrids. The maximum standard heterosis for number of fruits per vine was observed in RNMC-54 × RNMC-55 (70.80%), followed by RNMC-53 × RNMC-55 (62.79%), RNMC-52 × RNMC-55 (49.32%), and RNMC-52 × RNMC-53 (41.06%), reflecting the strong contribution of heterosis for fruit-bearing capacity.

The estimates of standard heterosis for fruit yield per vine varied from −21.74% in RNMC-52 × RNMC-54 to a maximum of 31.14% in RNMC-53 × RNMC-55. Higher and significant standard heterosis for fruit yield per vine was also observed in RNMC-52 × RNMC-55 (25.90%), RNMC-54 × RNMC-55 (19.05%), and RNMC-51 × RNMC-53 (9.92%). These findings are in agreement with earlier reports by Singh et al. (2000), Tewari et al. (2001), Sundaram (2008), Jadav et al. (2009), and Thangamani et al. (2011), who also reported substantial heterotic response for yield and yield-related traits in bitter gourd.

Among the ten cross combinations, RNMC-54 × RNMC-55 and RNMC-52 × RNMC-55 exhibited significant standard heterosis for five out of the twelve characters studied, indicating their overall superiority. Notably, the hybrids RNMC-53 × RNMC-55 (31.14%) and RNMC-52 × RNMC-55 (25.90%) recorded the highest standard heterosis for fruit yield per vine. These hybrids, owing to their superior heterotic performance, may be further evaluated through large-scale and multi-location yield trials before being recommended for commercial cultivation.

References

Bhave, S. G., Bendale, V. W., Pethe, U. B., Dhere, H. D., & Mehta, J. L. (2004). Hindu survey of Indian agriculture (pp. 112–119). Hindu Publications.

Gowen, J. W. (1952). Heterosis. Iowa State College Press.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. Australian Journal of Biological Sciences, 9, 463–493.

Gupta, V., Nanda Kishore, & Pratap, P. S. (2006). Diallel analysis for combining ability in bitter gourd (*Momordica charantia* L.). Crop Research, 32(3), 406–410.

Jadhav, K. A., Garad, B. V., Kshirsagar, D. B., Dhumal, S. S., Patil, B. T., & Shinde, K. G. (2009). Heterosis in bitter gourd (*Momordica charantia* L.). Agricultural Science Digest, 29(1), 7–11.

Kumara, B. S., Puttaraju, T. B., Shivanand, H., Prakash, K., Jainag, K., & Sudheesh, N. K. (2011). Combining ability studies in bitter gourd (*Momordica charantia* L.). Asian Journal of Horticulture, 6(1), 135–140.

Rai, M., & Pandey, A. K. (2007). Towards a rainbow revolution. Indian Horticulture, 52(1), 4–7.

Saidaiah, P., Ramesha, M. S., & Sudheer Kumar, S. (2009). Combining ability analysis for yield and yield components in rice. International Journal of Agriculture, Environment and Biotechnology, 2(2), 147–150.

Singh, A. K., Pandey, U. B., & Singh, M. (2000). Studies on heterosis in bitter gourd (*Momordica charantia* L.). Vegetable Science, 27(2), 158–161.

Singh, A. K., Ram, H. H., & Singh, J. P. (2004). Combining ability in bitter gourd (*Momordica charantia* L.). Progressive Horticulture, 36(1), 107–112.

Sundaram, V. (2008). Heterosis for yield attributing traits in bitter gourd. Mysore Journal of Agricultural Sciences, 42(2), 297–303.

Tewari, R. D., Ram, H. H., & Jaiswal, H. R. (2001). Studies on heterosis and combining ability in indigenous bitter gourd (*Momordica charantia* L.) for fruit yield. Vegetable Science, 28(2), 106–108.

Thangamani, C., Pugalendhi, L., Sumathi, T., & Kavitha, C. (2011). Evaluation of F_1 hybrids in bitter gourd (*Momordica charantia* L.) for yield and quality. Journal of Horticultural Sciences, 6(2), 105–108.

How to cite this article:

Mahesh, M., RVSK Reddy and Saidaiah, P. 2018. Combining Ability and Heterosis Analysis for Yield and Yield-Attributing Traits in Bitter Gourd (*Momordica charantia* L.) Using a Half-Diallel Mating Design. *Int.J.Curr.Microbiol.App.Sci.* 7(04): 3873-3881.
doi: https://doi.org/10.20546/ijcmas.2018.704.437