Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(3): 05-09
Received: 03-03-2018
Accepted: 07-04-2018

K Mallikarjunarao
Department of Vegetable, Science, O.U.A.T. Bhubaneswar, Odisha, India

AK Das
Department of Vegetable, Science, O.U.A.T. Bhubaneswar, Odisha, India

A Nandi
Department of Vegetable, Science, O.U.A.T. Bhubaneswar, Odisha, India

B Baisakh
Dean, PGF-CUM-DRI, O.U.A.T. Bhubaneswar, Odisha, India

P Tripathy
Department of Vegetable, Science, O.U.A.T. Bhubaneswar, Odisha, India

GS Sahu
Department of Vegetable, Science, O.U.A.T. Bhubaneswar, Odisha, India

Correspondence
K Mallikarjunarao
Department of Vegetable, Science, O.U.A.T. Bhubaneswar, Odisha, India

Heterosis and combining ability of quality and yield of bitter gourd (*Momordica charantia* L.)

K Mallikarjunarao, AK Das, A Nandi, B Baisakh, P Tripathy and GS Sahu

Abstract
Eight genetically divergent parental lines were crossed in a diallel pattern to investigate general and specific combining ability along with extent of heterosis for quality traits and fruit yield per vine in bitter gourd. The combining ability analysis revealed that mean squares due to GCA and SCA were significant for all the characters studied. Non-additive gene action played a major role in controlling the characters like flesh thickness, TSS, vitamin C, iron content and fruit yield per vine. On the basis of *gca* effects, parent Preethi for flesh thickness, Pusa Do Mausami for TSS and Phule Green Gold for vitamin C, iron content and fruit yield per vine showed highest g*ca* effects. Specific combining ability analysis revealed that cross Improved Katahi x Preethi for flesh thickness; Preethi x Pusa Do Mausami for TSS; Thusi x Pusa Do Mausami for vitamin C; Phule Green Gold x Pusa Do Mausami for iron content and fruit yield per vine showed highest *sca* effects. The best crosses based on heterobeltiosis and *sca* effects for fruit yield per vine and quality traits were Phule Green Gold x Pusa Do Mausami, Phule Green Gold x Preethi and Preethi x Pusa Do Mausami.

Keywords: bitter gourd, combining ability, diallel analysis, heterosis, quality

Introduction
Bitter gourd (*Momordica charantia* L.) is one of the major cucurbitaceous vegetables grown throughout India. It has been identified as one of the promising vegetables for export by Agricultural Processed products for Export and Development Authority (APEDA) (Thangamani*et al.*, 2011) [11]. The green fruits are superior with regard to nutritive value and can very well be compared with any other vegetable. Among the cucurbits, it is considered a prized vegetable because of its pharmaceutical and high nutritive value especially ascorbic acid and iron (Behera, 2004)[2]. Bitter gourd has been used for centuries in the ancient traditional medicine of India, China, Africa, and Latin America as its extract possess antioxidant, antimicrobial, antiviral, antihepatotoxic, antiulcerogenic properties and also has the ability to lower blood sugar (Raman and Lau, 1996) [7].
Bitter gourd shows a lot of variability in yield and yield contributing components. For developing a suitable and efficient breeding programme, information regarding the nature and magnitude of genetic variation that exists in the breeding population is necessary. Although, bitter gourd is becoming a commercial crop but relatively less attention has been paid towards the improvement of existing germplasm available in different parts of the country. Information about combining ability of experimental breeding materials is imperative to a breeding program aiming to develop hybrids and composite varieties having high yield and quality. Combining ability studies aiming to identify inbred lines with good *gca* and *sca* effects rely on the availability of genetic diversity among groups of genotypes involved in a breeding program. Significant values for general combing ability (*gca*) and specific combining ability (*sca*) may be interpreted as indicating the involvement of additive and non-additive gene action, respectively. GCA enabled breeders to exploit the existing variability in the breeding materials, to identify individual genotypes conferring desirable attributes and to distinguish relatedness among genotypes. While *sca* is serving to determine heterotic patterns among populations or inbred lines, to identify promising single crosses and to assign inbred lines into heterotic groups. Knowledge of general combining ability (*gca*) and specific combining ability (*sca*) helps to make choice of the parents of for hybridization and to know the nature of gene action. The present investigation therefore was undertaken to identify potential parental combinations in order to develop superior crosses.

Materials and Methods
Eight promising and diverse inbredsof bitter gourd namely, Phule Green Gold (P_1),Improved Katahi (P_2), Hirkani (P_3), CO-1 (P_4), Nakhara Local (P_5), Thusi (P_6), Preethi (P_7) and Pusa Do Mausami (P_8) were taken for the present study.

All the lines were hand-pollinated with each other to produce all possible combinations of F_1crosses in half diallel fashion. Pollen for crossing was obtained from freshly dehisced anther.The seeds of 28 F_1crosses and 8 parents (total of 36 genotypes) were sown at All India Co-ordinated Research Project on Vegetable Crops, Orissa University of Agriculture and Technology, Bhubaneswar during Summer 2016 in randomized block design with three replications to assess the performance of 28 F_1 hybrids and their 8 parental lines. The crop was planted in rows spaced at 1.5 meters with plant to plant spacing of 1.0 meter. The observations were recorded on randomly selected four plants for quality traits flesh thickness (mm), TSS (^{0}Brix), vitamin C (mg/100g), Iron content (mg/100g). Iron content was expressed as per 100g dry weight basis. Combining ability variance and effects were worked out according to method 2 and model 1 of Griffing (1956) [3]and heterosis was worked out over mid parent and better parent.

Results and Discussion

The analysis of variance for combining ability for allcharacters showed that (Table 1) mean squares due to general combining ability (*gca*) and specific combining ability (*sca*) effects were significant for all characters. On the basis of *gca* effects (Table 2), parent Preethi for flesh thickness, Pus Do Mausami for total soluble solids and Phule Green Gold for vitamin C and iron content and fruit yield per vine were the best general combiners. The genotypic difference of *gca* effects for these traits have also been reported earlier in bitter gourd by Thangamani and Pugalendhi (2013) [10], Sridhar and Mulge (2015) [9] and Khan *et al.* (2017) [5].

The three best performing crosses showing highest specific combining ability effect in order of merit were Improved Katahi x Preethi, Preethi x Pusa Do Mausami, Phule Green Gold x Pusa Do Mausami for flesh thickness; Preethi x Pusa Do Mausami, CO-1 x Thusi and Hirkani x Nakhara Local for total soluble solids; Thusi x Pusa Do Mausami, Phule Green Gold x Nakhara Local and Phule Green Gold x Pusa Do Mausami for vitamin C; Phule Green Gold x Pusa Do Mausami, Thusi x Pusa Do Mausami and Phule Green Gold x Preethi for iron content in fruits and Phule Green Gold x Pusa Do Mausami, Hirkani x Preethi and Preethi x Pusa Do Mausami for fruit yield per vine. These results were similar to the findings of Thangamani *et al.* (2011) [11] and Rani *et al.* (2013) [8].

Table 1: Analysis of variance due to general and specific combining ability effects for quality traits and yield in bitter gourd

Source	d.f	Flesh thickness (mm)	TSS (ºBrix)	Vitamin C (mg/100g)	Iron content (mg/100g)	Fruit yield per vine (kg)
GCA	7	10.37**	1.13**	874.49**	31.70**	1.00**
SCA	28	1.49**	0.20**	132.66**	5.46**	0.32**
Error	70	0.02	0.02	20.46	0.09	0.01
σ^2gca		1.04	0.11	85.40	3.16	0.10
σ^2sca		1.48	0.18	112.20	5.37	0.31
σ^2gca: σ^2sca		0.70	0.61	0.76	0.59	0.32

*, ** significant at 5% and 1% level, respectively

Table 2: General combining ability (*gca*) effects of parents for different quality traits and yield in bitter gourd

Parents	Flesh thickness (mm)	TSS (ºBrix)	Vitamin C (mg/100g)	Iron content (mg/100g)	Fruit yield per vine (kg)
Phule Green Gold	0.43**	0.16**	14.01**	2.48**	0.49**
Improved Katahi	0.47**	-0.39**	2.92	0.38**	0.17**
Hirkani	-0.73**	-0.15**	-6.57**	-1.94**	-0.26**
CO-1	-0.15**	0.16**	-8.64**	-2.52**	-0.19**
Nakhara Local	-1.14**	0.18**	-11.20**	-1.06**	-0.37**
Thusi	-1.12**	-0.49**	-6.26**	0.02	-0.28**
Preethi	1.91**	0.01	7.14**	0.53**	0.30**
Pusa Do Mausami	0.34**	0.54**	8.59**	2.09**	0.14**
SE (gi)	0.04	0.04	1.34	0.09	0.02
CD at 5%	0.09	0.10	3.16	0.21	0.06
CDat 1%	0.13	0.15	4.68	0.31	0.08

*, ** significant at 5% and 1% level, respectively

Table 3: Specific combining ability (*sca*) effects for F_1 crosses for different quality traits and yield in bitter gourd

Hybrid	Flesh thickness (mm)	TSS (ºBrix)	Vitamin C (mg/100g)	Iron content (mg/100g)	Fruit yield per vine (kg)
Phule Green Gold x Improved Katahi	0.33**	0.44**	0.52	0.51	0.02
Phule Green Gold x Hirkani	-0.99**	-0.18	-11.04*	-2.47**	-0.74**
Phule Green Gold x CO-1	0.54**	0.43**	4.47	1.68**	0.46**
Phule Green Gold x Nakhara Local	0.67**	0.13	16.65**	2.74**	0.44**
Phule Green Gold x Thusi	0.32*	-0.46**	6.98	0.16	0.09
Phule Green Gold x Preethi	1.14**	0.39**	11.26*	2.75**	0.48**
Phule Green Gold x Pusa Do Mausami	1.22**	-0.03	13.04**	3.13**	0.83**
Improved Katahi x Hirkani	-1.79**	0.40**	-11.56**	-3.25**	-0.65**
Improved Katahi x CO-1	0.58**	-0.87**	2.24	2.26**	0.43**
Improved Katahi x Nakhara Local	-0.64**	0.28*	-4.34	-1.49**	-0.24**
Improved Katahi x Thusi	-0.01	-0.38**	7.85	1.19**	0.14
Improved Katahi x Preethi	2.10**	-0.04	10.03*	1.86**	0.48**
Improved Katahi x Pusa Do Mausami	0.95**	0.39**	7.85	1.45**	0.56**
Hirkani x CO-1	0.72**	0.12	-5.40	2.09**	0.10

Hirkani x Nakhara Local	0.62**	0.49**	9.16*	2.60**	0.16*
Hirkani x Thusi	0.75**	-0.08	7.19	1.65**	0.58**
Hirkani x Preethi	0.71**	-0.87**	10.79*	2.67**	0.68**
Hirkani x Pusa Do Mausami	-1.31**	-0.15	-10.25*	-2.75**	-0.54**
CO-1 x Nakhara Local	-0.66**	0.45**	-6.73	-1.21**	-0.37**
CO-1 x Thusi	0.52**	0.56**	-10.34*	-2.48**	-0.06
CO-1 x Preethi	1.08**	-0.37*	12.29**	1.07**	0.31**
CO-1 x Pusa Do Mausami	-1.28**	-0.01	-8.42*	-2.02**	-0.68**
Nakhara Local x Thusi	0.84**	0.15	-1.83	0.11	0.13
Nakhara Local x Preethi	-1.95**	-0.40**	-7.53	-2.21**	-0.49**
Nakhara Local x Pusa Do Mausami	0.69**	0.35*	-7.60	-1.54**	0.36**
Thusi x Preethi	-1.29**	0.38**	-14.52**	-1.38**	-0.67**
Thusi x Pusa Do Mausami	0.43**	-0.07	18.82**	2.91**	0.59**
Preethi x Pusa Do Mausami	1.95**	0.67**	11.18**	1.44**	0.64**
SE (Sij)	0.12	0.13	4.10	0.27	0.07
CD at 5%	0.24	0.27	8.42	0.56	0.15
CDat 1%	0.33	0.37	11.36	0.76	0.20

*, ** significant at 5% and 1% level, respectively

The magnitude of heterosis over the MP (mid parent) and BP (better parent) for different characters was estimated and given in (Table 4). For flesh thickness, the extent of heterosis varied from -17.11 to 32.00 per cent over mid parent and -25.19 to 26.87 per cent over better parent. Out of twenty eight crosses, nineteen crosses had exhibited positive heterosis over mid parent and fourteen crosses over better parent. The cross combinations Phule Green Gold x Pusa Do Mausami, Improved Katahi x Preethi and Preethi x Pusa Do Mausami exhibited maximum significant heterosis over better parent.

The estimated range of heterosis for total soluble soilds was from -28.35 to 27.37 per cent over mid parent and -34.44 to 20.18 per cent over better parent. The crosses Hirkani x Nakhara Local, Preethi x Pusa Do Mausami and CO-1 x Nakhara Local recorded highest significant positive heterobeltiosis. Out of twenty eight crosses, fourteen and eight crosses exhibited significantly positive relative heterosis and heterobeltiosis, respectively.

The extent of heterosis for vitamin C ranged from -11.60 to 29.03 per cent over mid parent and -16.15 to 24.75 per cent over better parent.Thirteen and eight crosses recorded significantly positive heterosis over mid and better parent, respectively. The crosses Phule Green Gold x Pusa Do Mausami, Phule Green Gold x Preethi and Preethi x Pusa Do Mausami showed maximum positive heterosis over better parent.

The magnitude of heterosis ranged from -23.43 to 52.34 per cent over mid parent and -34.62 to 36.97 per cent over better parent for iron content in fruit. Seventeen crosses manifested positive heterosis over mid parent and fifteen crosses over better parent. Maximum heterosis over better parent was exhibited by Phule Green Gold x Preethi, Phule Green Gold x Pusa Do Mausami and Hirkani x Preethi.

Regarding fruit yield per vine, among twenty eight crosses, seventeen were found to express mid parental heterosis in a positive direction. The relative heterosis ranged from -37.79 (Improved Katahi x Hirkani) to 136.43 per cent (Thusi x Pusa Do Mausami). The heterobeltiosis was positive and significant in fifteen crosses whereas, it was negative and significant for eight cross combinations. The heterobeltiosis varied from -43.64 (Improved Katahi x Hirkani) to 98.75 per cent (Thusi x Pusa Do Mausami). The highest significant positive heterobeltiosis was recorded in Thusi x Pusa Do Mausami (98.75%) followed by Preethi x Pusa Do Mausami (75.37%), Nakhara Local x Pusa Do Mausami (68.13%), Phule Green Gold x Pusa Do Mausami (67.08%) and Phule Green Gold x Preethi (60.12%) with the yielding potentialities of 2.12, 2.75, 1.79, 3.13 and 3.00 kg fruit per vine, respectively. These above results are in conformity with the results of Jadav*et al*. (2009) [4], Muttineni (2013) [6], Thangamani and Pugalendhi (2013) [10], Rani *et al.* (2014) and Angadi (2015) [1].

Table 4: Extent of Heterosis (%) over mid parent (MP) and better parent (BP) for different quality and yield traits in bitter gourd during summer season 2016

Crosses	Flesh thickness (mm)		TSS (ºBrix)	
	MP	BP	MP	BP
Phule Green Gold x Improved Katahi	14.92**	9.87**	21.91**	7.05
Phule Green Gold x Hirkani	-5.28**	-5.60**	-1.99	-3.81
Phule Green Gold x CO-1	18.01**	16.19**	18.87**	15.56**
Phule Green Gold x Nakhara Local	15.02**	7.22**	19.86**	14.38*
Phule Green Gold x Thusi	17.68**	3.95*	-8.44	-21.52**
Phule Green Gold x Preethi	26.11**	12.43**	14.31*	11.62*
Phule Green Gold x Pusa Do Mausami	27.52**	26.87**	11.44*	3.96
Improved Katahi x Hirkani	-17.11**	-21.00**	12.69*	0.59
Improved Katahi x CO-1	13.34**	6.77**	-23.50**	-34.44**
Improved Katahi x Nakhara Local	-3.91*	-14.08**	23.57**	13.21*
Improved Katahi x Thusi	8.47**	-7.84**	-11.79	-14.23*
Improved Katahi x Preethi	29.66**	20.48**	-1.58	-15.34**
Improved Katahi x Pusa Do Mausami	19.51**	14.83**	21.57**	0.58
Hirkani x CO-1	8.06**	6.75**	3.44	-1.26
Hirkani x Nakhara Local	2.13	-4.50*	23.66**	20.18**

Hirkani x Thusi	9.59**	-2.91	-4.26	-16.62**
Hirkani x Preethi	12.05**	-0.40	-28.35**	-31.31**
Hirkani x Pusa Do Mausami	-10.02**	-10.78**	1.62	-6.84
CO-1 x Nakhara Local	-4.40*	-9.57**	25.56**	16.64**
CO-1 x Thusi	15.22**	3.19	21.37**	1.62
CO-1 x Preethi	21.91**	7.21**	-9.58	-9.98
CO-1 x Pusa Do Mausami	-2.60	-4.59*	8.90	4.37
Nakhara Local x Thusi	14.16**	7.71**	18.66**	5.97
Nakhara Local x Preethi	-10.77**	-25.19**	-2.92	-9.44
Nakhara Local x Pusa Do Mausami	13.69**	5.48**	27.37**	13.77*
Thusi x Preethi	0.45	-19.62**	11.34	-6.44
Thusi x Pusa Do Mausami	17.19**	3.06	7.28	-13.19*
Preethi x Pusa Do Mausami	32.00**	18.22**	23.20**	17.56**

*, ** significant at 5% and 1% level, respectively

Table 4: contd…

Crosses	Vitamin C (mg/100g)		Iron content (mg/100g)	
	MP	BP	MP	BP
Phule Green Gold x Improved Katahi	11.48*	7.76	25.03**	19.44**
Phule Green Gold x Hirkani	-3.42	-9.90	-1.96	-19.39**
Phule Green Gold x CO-1	11.27*	1.96	39.85**	6.79*
Phule Green Gold x Nakhara Local	26.62**	10.46	36.97**	25.25**
Phule Green Gold x Thusi	20.80**	6.29	22.06**	14.16**
Phule Green Gold x Preethi	27.57**	21.90**	52.34**	36.97**
Phule Green Gold x Pusa Do Mausami	26.28**	24.75**	40.08**	30.51**
Improved Katahi x Hirkani	-11.24*	-14.46**	-23.43**	-34.62**
Improved Katahi x CO-1	2.15	-3.36	33.05**	5.04
Improved Katahi x Nakhara Local	-2.11	-12.00*	-9.28**	-13.35**
Improved Katahi x Thusi	14.89**	4.21	19.39**	16.76**
Improved Katahi x Preethi	20.39**	18.95**	34.64**	26.33**
Improved Katahi x Pusa Do Mausami	15.63**	13.12*	19.41**	6.64*
Hirkani x CO-1	-11.60*	-13.29*	32.06**	20.05**
Hirkani x Nakhara Local	6.38	-1.05	24.65**	10.78**
Hirkani x Thusi	8.64	1.99	22.40**	6.51
Hirkani x Preethi	16.28**	13.40*	44.21**	30.32**
Hirkani x Pusa Do Mausami	-6.59	-11.85*	-15.98**	-34.62**
CO-1 x Nakhara Local	-11.48*	-16.15**	-12.05**	-28.05**
CO-1 x Thusi	-10.84	-14.74*	-16.70**	-33.13**
CO-1 x Preethi	17.92**	12.85*	32.83**	10.28**
CO-1 x Pusa Do Mausami	-5.11	-12.07*	-8.87**	-33.69**
Nakhara Local x Thusi	1.36	0.36	3.46	0.98
Nakhara Local x Preethi	0.30	-8.85	-8.21**	-9.90*
Nakhara Local x Pusa Do Mausami	-2.05	-13.64*	-8.39**	-21.42**
Thusi x Preethi	-2.76	-10.83	6.23	1.82
Thusi x Pusa Do Mausami	29.03**	14.74*	29.63**	13.54**
Preethi x Pusa Do Mausami	24.07**	19.95**	27.28**	7.51**

*, ** significant at 5% and 1% level, respectively

Table 4: contd…

Crosses	Fruit yield per vine (kg)	
	MP	BP
Phule Green Gold x Improved Katahi	32.26**	24.38**
Phule Green Gold x Hirkani	-27.80**	-38.08**
Phule Green Gold x CO-1	58.27**	30.25**
Phule Green Gold x Nakhara Local	59.33**	19.22**
Phule Green Gold x Thusi	52.05**	5.52
Phule Green Gold x Preethi	74.08**	60.12**
Phule Green Gold x Pusa Do Mausami	112.93**	67.08**
Improved Katahi x Hirkani	-37.79**	-43.64**
Improved Katahi x CO-1	45.92**	26.46**
Improved Katahi x Nakhara Local	-4.91	-25.66**
Improved Katahi x Thusi	43.34**	3.23
Improved Katahi x Preethi	62.94**	58.99**
Improved Katahi x Pusa Do Mausami	86.99**	53.94**
Hirkani x CO-1	4.05	-1.00

Hirkani x Nakhara Local	5.73	-10.45
Hirkani x Thusi	66.13**	28.11**
Hirkani x Preethi	64.72**	52.65**
Hirkani x Pusa Do Mausami	-16.07	-24.63**
CO-1 x Nakhara Local	-30.22**	-38.29**
CO-1 x Thusi	18.76	-4.96
CO-1 x Preethi	54.78**	37.05**
CO-1 x Pusa Do Mausami	-17.42	-22.31*
Nakhara Local x Thusi	39.24**	24.01**
Nakhara Local x Preethi	-10.40	-28.66**
Nakhara Local x Pusa Do Mausami	79.63**	68.13**
Thusi x Preethi	-10.30	-34.39**
Thusi x Pusa Do Mausami	136.43**	98.75**
Preethi x Pusa Do Mausami	108.85**	75.37**

*, ** significant at 5% and 1% level, respectively

Conclusion

The present study was attempted to identify suitable parental genotypes and to develop superior cross combinations having profuse vegetative growth. Keeping the results in mind it can be concluded that mean squares due to GCA and SCA were highly significant for all the character studied which indicated that both additive and non-additive gene actions were important in the inheritance of these characters. For improvement of these traits, both selection and heterosis methods of breeding can be adopted. The cross combinations Phule Green Gold x Pusa Do Mausami, Phule Green Gold x Preethi and Preethi x Pusa Do Mausami involving parents having good *gca* effects may be commercially exploited after assessing their stability. The genotypes Phule Green Gold, Preethi and Improved Katahi can be used as suitable parent to develop commercial hybrid with high yield and quality hybrids.

Acknowledgement

The Dept. of Science and Technology – INSPIRE Fellowship (IF 140454) awarded to me to carry out research is gratefully acknowledged here. My sincere thanks are extended to DST for the timely disbursal of the grant. Experimental facilities and assistance provided by College of Agriculture, OUAT, Bhubaneswar for conducting the research is duly acknowledged.

References

1. Angadi A. Divergence Heterosis and Genetic studies in bitter gourd (*Momordica charantia* L.). Ph.D Thesis, UHS., Bagalkot, 2015, 157-180
2. Behera TK. Heterosis in bitter gourd. In: P K Singh, S K Dasgupta, and SK Thpathi (eds.), Hybrid vegetable development Haworth Press, New York, 2004, 217-221.
3. Griffing B. Concept of generall and specific combining ability in relation to diallel crossing system. Australlian Journal of Biological Science 1956; 9:463-493.
4. Jadhav KA, Garad BV, Dahmal SS, Kashirsagar DB, PatilBT,Shinde KG. Heterosis in bitter gourd (*Momordica charantia* L.). Agricultural Science Digest.2009; 29(1):7-11.
5. Khan R, Sarolia DK, Kaushik RA, Dubey RB, Mahawer LN. Combining ability studies in bitter gourd (*Momordica charantia* L.). Electronic Journal of Plant Breeding.2017;8(1):1298-1302.
6. Muttineni M. Exploitation of Heterosis in Bitter gourd (*Momordica charantia* L.). M.Sc., Thesis, Dr. YSRHU., V.R.Gudem, 2013, 102-106.
7. Raman A, Lau C. Anti-diabetic properties and phytochemistry of *Momordica charantia* L. (Cucurbitaceae). Phytomedicine. 1996; 2:349-362.
8. Rani K, Reddy KR,RajuChS. Heterosis and combining ability for quantitative traits in bitter gourd (*Momordica charantia* L.).CurrentAdvances in Agricultural Sciences.2013; 5(2):184-188.
9. Sridhar,Mulge R. Combining Ability Studies in Bitter Gourd [*Momordica charantia* L.] in Relation to Line × Tester Crossing System. Indian Journal of Ecology. 2015; 42(2):377-381.
10. Thangamani C,Pugalendhi L. Heterosis Studies in Bitter Gourd for Yield and Related Characters. International Journal of Vegetable Science. 2013; 19:109-125.
11. Thangamani C, Pugalendhi L, Sumathi T, Kavitha C,Rajashree V. Estimation of combining ability and heterosis for yield and quality characters in bitter gourd (*Momordica charantia* L.). Electronic Journal of Plant Breeding. 2011; 2:62-66.