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Research Paper

Combining Ability and Heterosis of Fruit Quality and Yield Traits of Bitter Gourd (*Momordica charantia* L.)

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Abstract

Seven improved parental lines of bitter gourd were crossed in diallel pattern to investigate general and specific combining ability along with the extent of heterosis for fruit quality traits and fruit yield in bitter gourd. The techniques of Griffing Method 2 and Model 1 were followed for combining ability analysis. The results revealed that both General Combining Ability (GCA) and Specific Combining Ability (SCA) variances were significant for all the characters. The highest GCA effects were observed in HO-BG 56 for early female flowering, fruit diameter and yield. HO-BG 55 and HO-BG 52 reported highest GCA effects for fruit length and number of fruits per plant, respectively. The highest SCA effect were observed with hybrids of HO-BG 52 X 60 and HO-BG 56 x HO-BG 58 for fruits per plant and average fruit yield respectively. Results indicate the importance of both additive and non additive genetic variance in controlling the above considered characters. The best hybrid based on mid parent heterosis and heterobeltiosis for number of fruits per vine and yield was identified with cross combination of HO-BG 56 x HO-BG 58. Further, two best combinations as judged from SCA estimates for yield, are HO-BG 56 × HO-BG 58 and HO-BG 52 × HO-BG 58. Best performing hybrids were selected for further evaluation towards the recommendation of new bitter gourd hybrids.

Keywords: Bitter gourd, Combining ability, Diallel analysis, Heterosis, Hybrid

Introduction

Bitter gourd (*Momordica charantia* L.) is one of the most important vegetables belonging to family Cucurbitaceae. It is named differently viz. Balsam pear, Bitter melon, Bitter cucumber and African cucumber in different countries and extensively used in folk medicine (Behera *et al*., 2008). Among the cucurbits, it is considered as a prized vegetable because of it's pharmaceutical and high nutritive value (Behera, 2004).

Bitter gourd shows a higher variability in yield and yield contributing components. Therefore, information regarding the nature and magnitude of genetic variation existing in the breeding population is necessary for the development of an efficient and suitable breeding program. Information on combining ability of experimental breeding materials is imperative to crop breeding programs aiming to develop hybrid varieties having high yield and quality.

Significant values for General Combining Ability (GCA) and Specific Combining Ability (SCA) may be interpreted as indicating the involvement of additive and non-additive varience, respectively. Celine and Sirohi (1994) reported that earliness in flowering and fruiting is governed mainly by dominance effects and dominance x dominance effects and yield per plant is governed mainly by dominance and additive x additive gene effects in bitter gourd. Sirohi and Choudry (1980) noted greater involvement of dominance and dominance x dominance gene action for fruit length and diameter in bitter gourd. GCA enables breeder to exploit the existing variability in the breeding materials, to identify individual genotypes conferring desirable attributes. While SCA is serving to determine heterosis patterns among populations or inbred lines, to identify promising single crosses and to assign inbred lines into heterotic groups. A knowledge of GCA and SCA helps to make the choice of the parents for hybridization and to know the nature of gene action (Srivatrava and Premnath, 1976; Sirohi and Choudhury, 1980). The present investigation therefore was undertaken to identify potential parental combinations in order to develop superior hybrids of bitter gourd.

Materials and Methods

Material studied comprised seven inbred lines of bitter gourd with green colored pericarp selected for diversity based on morphological traits. These lines were developed locally using selected germplasm including land races and traditional varieties. Diverse bitter gourd lines viz HO-BG 51, HO-BG 52, HO-BG 55, HO-BG 56, HO-BG 58. HO-BG 59 and HO-BG 60 were selected and were hand-pollinated with each other to produce all possible cross combinations excluding reciprocals. Pollen for crossing was obtained from freshly dehisced anther. The seeds of 21 F_1 hybrids and 7 parental lines (total of 28 genotypes) were planted at the research field of Horticultural Crops Research and Development Institute at Gannoruwa. The crop was established in a randomized complete block design with three replications to assess the performance of 21 selected F_1 hybrids and their 7 parental lines. The crop was planted in rows spaced 1.5 m with a plant to plant spacing of 1.0 m. Recommended cultural practices were adopted to raise a good crop. Data were collected from 21 F_1 s and seven corresponding parents from the first anthesis to the final harvesting stage. The observations were recorded on all 12 plants from each plot for important traits namely number of days to female flowering, fruit length, fruit diameter, number of fruits per plant and average yield.

Combining ability variance and effects were worked out according to the method 2 of model I of Griffing (1956) and heterosis was worked out over mid parent (MP) and better parent (BP).

Results and Discussion

The analysis of variance showed significant difference due to treatments for all the tested characters (Table 1). Analysis of variance for combining ability analysis revealed significant general combining ability (GCA) and specific combining ability (SCA) effects for all the tested characters (Table 2).

Based on the GCA effect, parents HO-BG 56 for early flowering, HO- BG 55 for fruit length, HO-BG 56 for fruit diametere, HO-BG 52 for number of fruits per plant and HO-BG 56 for yield were the best general combiners (Table 3). The genotype difference of GCA effects for different traits has also been reported in bitter gourd by Hayman (1954), Sirohi and Choudhury (1980), Thangamani and Pugalendhi (2013).

Table 1. Analysis of variance for yield, yield components and fruit Characters in half diallele crosses of bitter gourd (mean square)

Source of variation	df	50% female flowering	Fruit length (mm)	Fruit diameter (mm)	No of fruits per plant	Yield (t ha^{-1})
Replication	2	9.57	2.18	0.01	2.61	3.06
Treatment	27	20.53*	28.72*	0.24*	16.89*	14.27*
Error	54	2.71	2.95	0.034	1.87	2.17

**significant at 5% probability level*

Table 2. Analysis of variance due to general and specific combining ability effects for quality traits and yield in bitter gourd (mean square)

Source	d.f	No of days to female flowering	Fruit length (mm)	Fruit diameter (mm)	No of Fruits/ plant	Yield (t ha^{-1})
GCA	6	5.29*	7.29*	0.045*	10.18*	9.08*
SCA	21	7.28*	10.23*	0.08	4.32*	3.52*
Error	54	0.9	0.98	0.01	0.62	0.72

**significant at 5% probability level*

Table 3. General combining ability (GCA) effects of parents for different fruit and yield traits in bitter gourd parents

Parents	No of days to 50% female flowering	Fruit length (mm)	Fruit diameter (mm)	No of Fruits per plant	Yield (t ha^{-1})
HO-BG 51	-0.417**	-1.285**	0.002	-1.201**	-1.160**
HO-BG 52	-0.044	-0.396	-0.023	1.502**	1.287**
HO-BG 55	1.582**	0.973**	-0.119**	-1.015**	-0.779**
HO-BG 56	-0.714**	-1.026**	0.080**	0.873**	1.757*
HO-BG 58	-0.455**	0.492	-0.049	0.873**	1.065**
HO-BG 59	0.285*	0.751*	0.039	-0.497*	-0.742**
HO-BG 60	-0.232*	0.492	0.069*	-0.534*	-0.427*
SE	0.11	0.3	0.03	0.24	0.26

*significant at 5%, ** significant at 1% probability levels

Majority of cross combinations showed significant GCA effects which will be helpful in parental line selection in the bitter gourd breeding program. The crosses HO-BG 51 × HO-BG 60, BG 51 × BG 59, HO-BG 51 × HO-BG 55 and HO-BG 52 × HO-BG 60 revealed the highest significant positive SCA effects for advantage in early female flowering, fruit diameter, fruit length and the number of fruits per plant, respectively (Table 4). Best combination for SCA estimates for yield is HO-BG 56 × HO-BG 58. The SCA effects of certain crosses were related to GCA of their parents.

The hybrid HO-BG 56 x HO-BG 58 showed maximum heterosis over mid parent and better parent in fruits per plant and the hybrid HO-BG 56 x HO-BG 58 showed highest significant positive heterosis for the yield (Table 5). Hererosis of above traits are effective in overall performance of the hybrids. Based on these results some of the best performing crosses such as HO-BG 51 x HO-BG 60, HO-BG 51 x HO-BG 55, HO- BG 52 x HO-BG 60 and HO-BG 56 x HO-BG 58 were selected for further testing.

Table 4. Specific combing ability (SCA) effectects for F_1 hybrids for different fruit and yield traits in bitter gourd

Parents		HO-BG-52	HO-BG-55	HO-BG-56	HO-BG-58	HO-BG-59	HO-BG-60
HO-BG-51	FlD	-3.546**	-2.509**	0.787	-0.472	-1.212	-4.027**
	FL	-1.722**	7.907**	-0.092	0.388	-2.537**	1.722**
	FW	-0.072	0.190	-0.409**	0.187	0.864**	-0.098
	F/p	-2.361**	1.490*	0.935	-0.731	1.638**	-0.324
	Yield	-1.407*	0.959	-0.611	-1.351*	1.288*	0.240
HO-BG-52	FlD		-1,212	-0.25	3.490**	2.083**	-2.731**
	FL		-1.648**	3.018**	-0.166	3.574**	2.833**
	FW		-0.216*	0.316**	-0.020	-0.075	-0.238*
	F/p		-0.212	-0.435	3.898**	-1.731**	4.305**
	Yield		-0.422	-1..159*	4.033**	0.240	3.092**
HO-BG-55	FlD			-3.212**	-2.138**	0.212	5.638**
	FL			-0.018	0.129	1.537**	0.537*
	FW			-0.287**	0.042	-0.112	0.042
	F/p			-0.25	-1.916**	-1.787**	-0.175
	Yield			0.807	-1.566*	1.240	0.107
HO-BG-56	FlD				0.157	-0.25	1.935*
	FL				1.129	1.870**	-5.203**
	FW				0.042	-0.246*	-0.490**
	F/p				4.194**	-1.101	-1.064
	Yield				4.496**	-0.696	-0.577
HO-BG-58	FlD					-1.175*	0.342
	FL					1.018*	2.944**
	FW					-0.183	-0.012
	F/p					-0.435	-1.398*
	Yield					-0.503	1.018
HO-BG-59	FlD						1.268*
	FL						2.352**
	FW						-0.102
	F/p						-2.027*
	Yield						-1.444*

**significant at 5%, ** significant at 1% probability levels*
Note: FlD- Days to 50% flowering, FL –Fruit length, FW- Fruit width, F/P Fruits per plant

Table 5. Heterosis (%) over mid parent and better parent (Heterobeltiosis) for different yield traits in selected hybrid bitter gourd

Hybrid	Heterosis %			
	No of fruits per plant		Yield(t ha^{-1})	
Combination	Mid parent	Better parent	Mid parent	Better parent
HO-BG 51 x HO-BG 52	-10.5	-2	-4	-12
HO-BG 51 x HO-BG 55	16.8	15	9	8
HO-BG 51 x HO-BG 56	13.54	0	-2	-10
HO-BG 51x HO-BG 58	6	7	-4	-12
HO-BG 51 x HO-BG 59	11	0	2.4	-5
HO-BG 51 x HO-BG 60	5.4	2	-3	-11
HO-BG 52x HO-BG 55	6	7	14.4	3.8
HO-BG 52 x HO-BG 56	6.7	4	46	46
HO-BG 52x HO-BG 58	40	33.6	4.2	3
HO-BG 52 x HO-BG 59	-9.7	-13.6	28.8	26
HO-BG 52 x HO-BG 60	36.4	26	4	3
HO-BG 55x HO-BG 56	4	7	7.6	-2
HO-BG 52x HO-BG 58	-6	-15	-2.7	10
HO-BG 55 x HO-BG 59	12.5	2	5.8	-2.9
HO-BG 55 x HO-BG 60	-1	8	-2.5	10
HO-BG 56x HO-BG 58	41	37	42	45
HO-BG 56 x HO-BG 59	-7	-1	-7	-8
HO-BG 56x HO-BG 60	-5	-10	-3	-4
HO-BG 58 x HO-BG 59	0	0	2	-2
HO-BG 59x HO-BG 60	-5	-7	3	-3
HO-BG 59 x HO-BG 60	-20	-22	-20	-21

Conclusion

This study attempted to identify suitable parental genotypes to develop F_1 hybrids having better performances. It can be concluded that the GCA and SCA effects were significant for all the characters studied which indicated that both additive and non-additive genetic varience were important in the inheritance of these characters. In the improvement of these traits, both selection and heterosis breeding can be effective. The cross combinations of HO-BG 51 x HO-BG 60, HO-BG 51 x HO-BG 55, HO- BG 52 x HO-BG 60 and HO-BG 56 x HO-BG 58 involving better parental lines having higher GCA values could be selected and they will be further exploited.

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