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Combining Ability Studies in Bitter Gourd (*Momordica charantia* L.) for Quantitative Characters

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A B S T R A C T

Nine diverse genotypes of bitter gourd (*Momordica charantia* L.) were crossed during summer season of 2015 in diallel design (excluding reciprocals).The resultant 36 hybrids along with the parents were evaluated in randomized block design with three replications during Kharif 2015 at Horticulture farm, S.K.N. College of Agriculture, Jobner. Each parents/F1 were sown in furrow maintaining 2.25m x 0.75m spacing. The analysis of variance for experimental design revealed the existence of adequate genetic variability in experimental material for all traits under study. Variance due to parents Vs F1's were significant for all characters, except days taken to opening of first female flower,days taken to first fruit set, fruit weight and total fruits yield per vine, thereby indicating the presence of overall average heterosis for all characters. Combining ability analysis revealed importance of both additive and non-additive gene action. On the basis of overall performance the three best crosses were, namely Panipat Local x Phule Green, Phule Green x Pusa Do Mausami and Punjab-14 x Pusa Do Mausami. Panipat Local x Phule Green was superior in respect of days taken to opening first female flower, vine length, days to first fruit harvest, fruit length. Phule Green x Pusa Do Mausami was took fruit length, fruit weight, fruit diameter and total fruits yield per vine. Punjab-14 x Pusa Do Mausami was better with regard to superior for number of node at which first female flower appeared, number of fruits per vine and days to first fruit harvest. Hence could be further evaluated in future breeding programme for their large scale testing.

Introduction

Bitter gourd or balsam pear (*Momordica charantia* L.) is an important nutritive and commercial cucurbits belonging to the Cucurbitaceae. In terms of nutritive value, bitter gourd ranks first among cucurbits due to high value of vitamins and minerals. It is highly cross pollinated due to monoecious nature and has high degree of heterozygosity. Due to efforts of vegetable breeders, improved varieties and hybrids have been developed. Crops improvement involves strategies for enhancing yield potentiality and quality components. In bitter gourd full exploitation of heterosis through development of hybrids has not been successfully commercialized due to one or the other reason. Variability found in shape, size and colour of fruits in most conspicuous which offers tremendous scope for heterosis breeding for yield enhancement. Crossing nature and heterosis in cross pollinated crops has been known to offer good potentialities

for increased yield. Although some information is available about combining ability, they are relevant to the specific region, genetic material involved and enviormental condition. Therefore, this study was conducted to generate information about general and specific combining ability effects for different economic traits.

Materials and Methods

The present investigation was undertaken involving different diverse genotypes/cultivars of bitter gourd were crossed in all possible combinations excluding reciprocals. The 36 F1 hybrids along with their nine parents were evaluated during kharif 2015 in a RBD with three replications at Horticulture Farm, S.K.N. College of Agriculture,Jobner Rajasthan. Observation were recorded on five randomly selected tagged plants from each treatment for yield and yield attributing traits viz vine Length(m), days taken to opening of first female flower, days taken to first fruits set, number of node at which first female flower appeared, male : female ratio, number of fruit per vine, days to first fruit harvest, fruit length (cm) at harvest, fruit weight (g), fruit diameter (cm), total fruits yield per vine (kg) and ascorbic acid (mg)/100 (g).Combining ability were calculated in accordance with Method 2 Model 1 of Griffing (1956).

Results and Discussion

Combining ability analysis is one of the most powerful tools available which gives the estimates of mean squares due to GCA, SCA and combining ability effects and aids in selecting desirable parents and crosses for further exploitation. Analysis of variance for combining ability revealed that the genotypes showed adequate amount of variation for days taken to first female flower, days taken first fruit set, number of node to first female flower appeared, vine length at harvest, fruit weight, fruit length, fruit diameter, number fruits per vine, total fruits yield per vine and ascorbic acid (Table 1). This indicates that both additive and non-additive gene action were involved in determing these characters. Mishra *et al.,* (1994) and Khattra *et al.,* (2000) also reported involvement of additive and non-additive gene action days taken to first female flower, fruit weight, total fruit yield per vine.The GCA mean squares were larger in magnitude than mean SCA squares for days taken first female flower, days taken first fruit set,fruit length at harvest,fruit weight and ascorbic acid.These results are in conformity with the results of Khattra *et al.,* (2000); Mishra *et al.,* (1994) and Dubey and Maurya (2002). The general combining ability is primarily a function of additive and additive x additive gene action. High GCA effect of a parent is a function of breeding value and hence due to additive gene action effect and /or additive x additive interaction effect which represents the fixable component of genetic variation (Griffting, 1956) (Tables 2 and 3).

Apparently, parents with good GCA effect may be presumed to possess more favourable genes for the concerned traits. In terms of better general combiner, Punjab-14 and Arka Harit were found good general combiner for earliness and vine length. Panipat Local and Phule Green were also found good general combiner for fruit weight, fruit diameter and fruit length.Punjab-14 was also found good general combiner increase the total yield per vine, number of fruits per plant whereas Punjab-14 and Panipat Local were found good general combiner for ascorbic acid content. In most of the cases, it was observed that per se performance of the parents gave a direct reflection of their respective GCA effects the parents showing highest GCA effect for a particular characters were also observed to have high mean with respect to the characters.

Table.1 Analysis of variance for combining ability of parents and crosses for various traits in bitter gourd

S. No.	Characters	Source			
		GCA	SCA	Error	σ^2g/σ^2s
	df	8	36	88	
1	Days taken to opening of first female flower	59.138**	3.588*	2.227	3.800
2	Days taken to first fruit set	48.532**	3.860*	2.411	2.892
3	Number of node at which first female flower	0.502**	0.508**	0.043	0.089
4	Vine length (m) at harvest	0.089**	0.046**	0.012	0.202
5	Male:female ratio	49.433**	8.135**	1.190	0.631
6	Number of fruit/vine	7.479**	3.834**	0.525	0.191
7	Days to first fruit harvest	137.227**	22.027**	2.651	0.631
8	Fruit length (cm) at harvest	56.497**	1.890**	0.615	3.983
9	Fruit weight (g)	67.454**	6.254**	2.830	1.715
10	Fruit diameter (cm)	0.592**	0.201**	0.048	0.322
11	Total yield per vine(kg)	0.022**	0.003**	0.000	0.848
12	Ascorbic acid (mg/100 g)	0.019**	0.002*	0.001	1.701

Table.2 Estimates of general combining ability effect of parents for days taken to opening of first female flower, days taken to first fruit set, number of node at which first female flower appeared, vine length (m) at harvest, male:female ratio and number of fruit/vine

S.No	Parents	Days taken to opening of first female Flower	Days taken to first fruit Set	Number of node at which first female flower appeared	Vine length (m) at harvest	Male: Female Ratio	Number Of fruit/vine
1	Punjab-14	-2.87**	-2.56**	0.14*	0.08*	-3.89**	1.77**
2	Arka Harit	-2.14**	-1.83**	-0.31**	-0.09**	3.15**	0.40
3	Panipat Local	0.13	-0.19	0.14*	0.08*	2.33**	-0.60**
4	Phule Green	2.86**	2.72**	0.23**	0.10**	0.75*	0.13
5	Pusa Vishesh	2.68**	2.44**	-0.04	0.08*	-1.41**	-1.05**
6	Pusa Do Mausami	2.68**	2.54**	0.23**	0.00	0.88**	-0.69**
7	Kalyanpur Barahmasi	0.50	0.17	0.05	0.00	-0.10	0.31
8	Kalyanpur Sona	-2.14**	-1.92**	-0.13*	-0.12**	-1.42**	0.04
9	Pant Karela-1	-1.69**	-1.37**	-0.31**	-0.12**	-0.30	-0.32
	Standard error (SEd±)						
	Gi	0.978	1.017	0.136	0.071	0.715	0.475
	Gi-Gj	1.467	1.526	0.205	0.107	1.073	0.713

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

Table.3 Estimates of general combining ability effect of parents for days to first fruit harvest, fruit length (cm) at harvest. fruit weight (g), fruit diameter (cm), total yield per vine (kg) and ascorbic acid (mg/100g)

S.No	Parents	Days to first harvest	Fruit length (cm) at harvest	Fruit weight (g)	Fruit diameter (cm)	Toatal yield per vine (kg)	Ascorbic acid (mg/100g)
1	Punjab-14	0.30	-4.17**	-3.21**	-0.39**	0.07**	0.06**
2	Arka Harit	-3.24**	-2.10**	-1.03*	0.12	0.04**	0.02
3	Panipat Local	5.12**	1.12**	2.61**	0.44**	0.03**	0.06**
4	Phule Green	4.58**	3.38**	2.97**	0.12	0.01	0.01
5	Pusa Vishesh	-0.42	-0.90**	-0.85	-0.17**	-0.07**	0.00
6	Pusa Do Mausami	-4.97**	2.05**	3.70**	0.01	0.01	-0.02
7	Kalyanpur Barahmasi	2.76**	0.96**	-1.03*	-0.06	-0.04**	-0.05**
8	Kalyanpur Sona	-1.33**	-0.75**	-2.48**	-0.12	-0.05**	-0.04**
9	Pant Karela-1	-2.79**	0.41	-0.67	0.06	-0.01	-0.05**
	Standard error (SEd+)						
	Gi	1.067	0.514	1.102	0143	0.017	0.022
	Gi-Gj	1.601	0.771	1.654	0.215	0.026	0.034

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

Table.4 Estimates of specific combing ability effect of crosses for days taken to opening of first female flower, days taken to first fruit set, number of node at which first female flower appeared, vine length (m) at harvest, male:female ratio and number of fruit/vine

S.No	Genotype	Days taken to opening of first female flower	Days Taken to first Fruit Set	Number of node at which first female flower appeared	Vine length (m) at harvest	Male: female ratio	Number Of fruits/vine
1	Punjab-14 x Arka Harit	-2.75	-2.13	-0.07	0.45**	-2.56*	0.67
2	Punjab-14 x Panipat Local	-0.02	-0.76	-0.53**	-0.11	-3.62**	1.67*
3	Punjab-14 x Phule Green	1.25	2.33	1.38**	0.07	-0.53	-1.05
4	Punjab-14 x Pusa Vishesh	0.44	0.60	-0.35	-0.11	0.39	3.13**
5	Punjab-14 x Pusa Do Mausami	1.44	0.51	0.38	-0.24*	-1.19	2.76**
6	Punjab-14 x Kalyanpur Barahmasi	1.62	1.87	-1.44**	-0.64**	1.97	-0.24
7	Punjab-14 x Kalyanpur Sona	0.25	0.96	-0.25	-0.11	1.05	-0.96
8	Punjab-14 x Pant Karela-1	-4.20**	-4.58**	-0.07	0.09	0.82	-0.60
9	Arka Harit x Panipat Local	-0.75	-0.49	-0.07	-0.15	-0.26	0.04
10	Arka Harit x Phule Green	-0.48	-1.40	-0.16	0.04	4.80**	1.31
11	Arka Harit x Pusa Vishesh	-0.29	-0.13	-0.89**	-0.35**	-1.80	0.49
12	Arka Harit x Pusa Do Mausami	0.71	-0.22	-0.16	-0.07	3.41**	1.13
13	Arka Harit x Kalyanpur Barahmasi	-1.11	0.15	0.02	-0.07	1.35	-0.87
14	Arka Harit x Kalyanpur Sona	1.53	2.24	1.20**	0.26*	0.42	0.40
15	Arka Harit x Pant Karela-1	0.07	-0.31	-0.62**	-0.15	3.45**	-1.24
16	Panipat Local x Phule Green	0.25	-0.04	0.38	0.07	-2.32*	-1.69*
17	Panipat Local x Pusa Vishesh	-3.56*	-2.76	-0.35	-0.11	3.87**	2.49**
18	Panipat Local x Pusa Do Mausami	-1.56	-1.85	0.38	0.16	1.38	-0.87
19	Panipat Local x Kalyanpur Barahmasi	-0.38	-0.49	-0.44*	-0.04	4.16**	0.13
20	Panipat Local x Kalyanpur Sona	1.25	1.60	-0.25	-0.11	0.70	-1.60*
21	Panipat Local x Pant Karela-1	0.80	1.05	-0.07	0.09	3.02**	1.76*
22	Phule Green x Pusa Vishesh	-0.29	-0.67	0.56**	0.27*	-1.64	-0.24
23	Phule Green x Pusa Do Mausami	-2.29	-0.76	-0.71**	-0.05	-1.31	-0.60
24	Phule Green x Kalyanpur Barahmasi	1.89	1.60	-0.53**	-0.05	1.16	0.40
25	Phule Green x Kalyanpur Sona	1.53	1.69	-0.35	-0.13	0.70	1.67*
26	Phule Green x Pant Karela-1	-0.93	-0.85	-1.16**	-0.33**	4.75**	-0.96
27	Pusa Vishesh x Pusa Do Mausami	1.89	1.51	0.56**	0.16	-3.28**	-1.42*
28	Pusa Vishesh x Kalyanpur Barahmasi	0.07	-0.13	-0.25	-0.04	-0.53	-3.42**
29	Pusa Vishesh x Kalyanpur Sona	1.71	1.96	0.93**	0.09	0.81	-3.15**
30	Pusa Vishesh x Pant Karela-1	0.25	0.42	0.11	-0.11	0.40	0.22
31	Pusa Do Mausami x Kalyanpur Barahmasi	0.07	-0.22	0.47*	0.24*	-1.38	-1.78*
32	Pusa Do Mausami x Kalyanpur Sona	0.71	0.87	-0.35	-0.04	4.86**	-1.51*
33	Pusa Do Mausami x Pant Karela-1	-0.75	-0.67	-1.16**	-0.24*	1.03	1.85**
34	Kalyanpur Barahmasi x Kalyanpur Sona	-1.11	-0.76	-0.16	-0.04	-1.32	3.49**
35	Kalyanpur Barahmasi x Pant Karela-1	0.44	-0.31	1.02**	0.16	0.14	1.85**
36	Kalyanpur Sona x Pant Karela-1	-4.93**	-5.22**	-0.80	-0.11	-3.34**	4.13**
	Standard error						
	Sii	2.451	2.550	0.342	0.180	1.792	1.190
	Sij	2.771	2.882	0.387	0.203	2.026	1.346
	Sij-ik	4.085	4.250	0.570	0.300	2.987	1.984
	Sij-Skl	3.876	4.032	0.41	0.285	2.834	1.883

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

Table.5 SCA effect for days to first fruit harvest, fruit length (cm) at harvest, fruit weight (g), fruit diameter (cm), total fruits yield per vine (kg) and ascorbic acid (mg/100g)

S.No	Genotype	Days to first fruit harvest	Fruit Length (cm) at Harvest	Fruit weight (g)	Fruit diameter (cm)	Total fruits yield per vine(kg)	Ascorbic acid (mg/ 100g)
1	Punjab-14 x Arka Harit	1.87	2.08**	2.51	0.28	0.13**	0.00
2	Punjab-14 x Panipat Local	-3.49*	1.74*	0.87	0.36	-0.07*	-0.07*
3	Punjab-14 x Phule Green	-5.95**	-2.79**	-7.49**	-1.12**	-0.05	0.03
4	Punjab-14 x Pusa Vishesh	3.05*	0.68	0.33	0.37	-0.01	0.01
5	Punjab-14 x Pusa Do Mausami	5.60**	-1.67*	-2.22	-0.81**	0.00	0.05
6	Punjab-14 x Kalyanpur Barahmasi	-4.13**	-0.37	0.51	-0.73**	0.08**	0.04
7	Punjab-14 x Kalyanpur Sona	0.96	1.33	3.96*	-0.28	0.02	0.03
8	Punjab-14 x Pant Karela-1	1.42	-0.63	-3.85*	-0.06	-0.06*	0.06
9	Arka Harit x Panipat Local	-7.95**	-1.41	0.69	0.25	0.09**	-0.05
10	Arka Harit x Phule Green	-5.40**	-1.87*	0.33	-0.43*	-0.05*	-0.01
11	Arka Harit x Pusa Vishesh	-0.40	-0.19	0.15	0.27	0.07*	-0.01
12	Arka Harit x Pusa Do Mausami	3.15*	-0.14	1.60	-0.12	-0.09**	0.04
13	Arka Harit x Kalyanpur Barahmasi	-3.58*	0.35	-3.67*	-0.24	-0.08**	0.02
14	Arka Harit x Kalyanpur Sona	1.51	-0.54	-4.22**	-0.19	-0.07**	0.03
15	Arka Harit x Pant Karela-1	1.96	-1.10	-2.04	-0.17	-0.07**	0.06
16	Panipat Local x Phule Green	-0.76	-0.88	-1.31	-0.35	-0.05	0.00
17	Panipat Local x Pusa Vishesh	4.24**	-0.81	-1.49	-0.26	-0.05	-0.01
18	Panipat Local x Pusa Do Mausami	6.78**	0.64	-0.04	0.16	0.00	0.05
19	Panipat Local x Kalyanpur Barahmasi	-2.95	1.13	0.69	-0.17	-0.04	0.06
20	Panipat Local x Kalyanpur Sona	4.15**	-0.76	-1.85	-0.32	-0.02	0.05
21	Panipat Local x Pant Karela-1	4.60**	1.88*	0.33	-0.30	0.02	0.08*
22	Phule Green x Pusa Vishesh	3.78*	-0.67	0.15	0.27	0.09***	-0.02
23	Phule Green x Pusa Do Mausami	4.33**	-0.21	-0.40	0.28	0.06*	-0.01
24	Phule Green x Kalyanpur Barahmasi	0.60	-1.12	-1.67	-0.24	-0.02	0.05
25	Phule Green x Kalyanpur Sona	1.69	-1.01	-0.22	0.01	0.00	0.00
26	Phule Green x Pant Karela-1	4.15**	-0.37	1.96	-0.37	0.00	0.04
27	Pusa Vishesh x Pusa Do Mausami	2.33	-0.94	1.42	-0.03	0.02	0.05
28	Pusa Vishesh x Kalyanpur Barahmasi	-4.40**	-0.25	0.15	-0.15	0.02	0.01
29	Pusa Vishesh x Kalyanpur Sona	-4.31**	0.86	-0.40	-0.30	-0.04	0.02
30	Pusa Vishesh x Pant Karela-1	-1.85	0.10	-0.22	-0.08	-0.04	0.02
31	Pusa Do Mausami x Kalyanpur Barahmasi	-6.85**	0.61	-0.40	0.27	0.03	-0.02
32	Pusa Do Mausami x Kalyanpur Sona	-6.76	-0.08	3.05	-0.08	0.00	-0.01
33	Pusa Do Mausami x Pant Karela-1	-4.31**	0.75	-0.76	-0.06	0.01	-0.04
34	Kalyanpur Barahmasi x Kalyanpur Sona	7.51**	0.61	1.78	0.79**	0.05	-0.03
35	Kalyanpur Barahmasi x Pant Karela-1	8.96**	0.44	1.96	0.21	-0.03	-0.05
36	Kalyanpur Sona x Pant Karela-1	0.05	0.15	3.42*	0.27	0.03	0.02
	Standard error						
	Sii	2.674	1.288	2.763	0.360	0.044	0.057
	Sij	3.023	1.456	3.123	0.407	0.049	0.064
	Sij-ik	4.457	1.796	4.605	0.600	0.073	0.095
	Sij-Skl	4.229	2.146	4.368	0.569	0.069	0.090

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

The results are in conformity with the finding of Munshi and Sirohi (1994), Munshi and Verma (1999) in muskmelon and Tiwari *et al.*, (2001) in bitter gourd. The crosses having high desirable SCA effects for the economically important characters were Kalyanpur Sona x Pant Karela-1 and Punjab-14 x Pant Karela-1 for days taken to opening of first female flower, Kalyanpur Sona x Pant Karela-1 and Punjab-14 x Pant Karela-1 days taken to first fruit set,

Punjab-14 x Phule Green and Kalyanpur Barahamasi x Pant Karela-1 for number of node at which female flower appeared, Punjab-14 x Arka Harit for vine length, Pusa Do Mausami xKalyanpur Sona and Arka Harit x Phule Green for male : female ratio, Kalyanpur Sona x Pant Karela-1 and Kalyanpur Barahamasi x Pant Karela-1 for number of fruits per plant, Arka Harit x Panipat Local, Pusa Do Mausami xKalyanpur Barahamasi for days to first fruit harvest, Punjab-14 x Arka Harit, Punjab-14 x Panipat Local for fruit length, Punjab-14 x Kalyanpur Sona for fruit weight, Kalyanpur Barahamasi x Kalyanpur Sona for fruit diameter, Punjab-14 x Arka Harit, Phule Green x Pusa Do Mausami for total fruits yield per plant, Panipat Local x Pant Karela-1 for ascorbic acid content. Another important fact worth mentioning here is that the above mentioned hybrids along with possessing high SCA effects, also exhibited considerable amount of heterosis over their better parents for economically important character like earliness, number of fruits per plant (Tables 4 and 5). The mean performance of the hybrids showed more or less parallel trend with SCA effects for the above mentioned character. The hybrids which gave good per se performance also mentioned characters. The hybrids which gave good per se performance also expressed favourable high SCA effects. This explained that per se performance of hybrids was reflected in their respective SCA effects. It is noteworthy that the crosses which manifested greater SCA effects in desirable direction also exhibited favourable high heterosis over better parent. Hence, the mean performance of hybrid could be envisaged as a criteria of SCA effects and selection of crosses based on per se performance would be realistic. The present finding corroborated the earlier work of Sharma *et al.*, (1993) in bottle gourd, Kumar and Singh (1997) in bottle gourd and Khattra *et al.*, (2000) in bitter gourd.

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