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Full Research Article

Hybrid Vigour and Inbreeding Depression for Yield and its Component Traits in Bitter Gourd (*Momordica charantia* L.)

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Abstract

Twenty eight crosses generated using eight genotypes viz., IC-033227, IC-044417, IC-044438, IC-045339, IC-085622, IC-470550, IC-470558 and IC-470560 were evaluated to study the extent of heterosis and inbreeding depression for yield and yield attributing characters in bitter gourd at College of Horticulture, Rajendranagar, Hyderabad. The experiment was laid out in a randomized block design with three replications. The results revealed that most of the crosses showed significant heterosis over mid parent and better parent for the traits studied. The maximum heterosis (over mid and better parents) for yield vine^{-1} was observed in IC-044438×IC-045339 (96.03 and 58.48%) followed by IC-044417×IC-470558 (60.24 and 54.01%), IC-045339×IC-470558 (54.09 and 38.70%) and IC-045339×IC-085622 (52.64 and 32.44%). Furthermore these crosses were found superior for one or more fruit characters like average fruit weight and fruit length (IC-044438×IC045339) and number of fruits vine^{-1} (IC-044417×IC-470558). The crosses showing significant heterosis for yield also revealed inbreeding depression thus indicated major involvement of non-additive gene action in the inheritance of yield vine^{-1}. However for days to 1st female flower and node number at 1st female flower, significant heterosis in desired direction was observed in IC-045339×IC- 470550 (-9.57 and -7.65%) and IC-044438×IC-045339 (-20.34 and -15.14%) respectively had no inbreeding depression. These results suggesting that it would be useful to utilize these promising cross combinations which showed superior performance for earliness, fruit yield and other yield attributes for exploitation of heterosis. Hence, methods like heterosis breeding, recurrent selection and progeny selection may be employed for improvement in bitter gourd.

1. Introduction

Bitter gourd (*Momordica charantia* L.) is one of the most important monoecious cucurbits grown throughout India owing to its nutritive value and therapeutic properties. Due to wide variability, monoecious nature, conspicuous and convenient flowers and large number of seeds fruit^{-1}, bitter gourd can serve as the most potent material for the exploitation of heterosis on commercial scale (Chaubey and Ram, 2004; Thangamani and Pugalendhi, 2013). Heterosis is the superiority of a hybrid over its corresponding parents and is usually associated with dominance (epistatic effects) and increased heterozygosity. On the other hand inbreeding depression refers to decline in vigour or fitness with decreased heterozygosity due to fixation of unfavourable recessive genes in F_2 and subsequent generations. Fixation of all favourable dominant genes in one homozygous line through inbreeding is impossible due to linkage between some unfavourable recessive and favourable dominant genes (Nadarajan and Gunasekaran, 2008). In spite of the potential economic and medicinal importance of the crop (Welthinda et al., 1986) due attention was not given towards a need based crop improvement programme in bitter gourd. There is a prime need for its improvement and to develop varieties or hybrids suited to specific agro ecological conditions. A speedy improvement approach through assessment of genetic variability and exploitation of hybrid vigour has been neglected so for in this crop. The study of extent of heterosis provides an indication about the type of gene action (Sundaram, 2009) and significance of inbreeding depression indicates the presence of non-additive gene action. Hence, this study was conducted to know the magnitude of heterosis and inbreeding depression in bitter gourd.

2. Materials and Methods

The present investigation was conducted at Model Orchard, College of Horticulture, Rajendranagar, Hyderabad. The eight genotypes viz., IC-033227, IC-044417, IC-044438, IC-045339, IC-085622, IC-470550, IC-470558 and IC-470560 were crossed in diallel mating design excluding reciprocals to get F_1 seeds during *kharif* 2009. All the F_1 seed was sown during summer 2010, and at the time of pollination F_1 hybrids were selfed to get F_2 seeds. The parents, F_1 hybrids and their corresponding F_2 population were field evaluated during summer 2011 in a randomized block design with three replications. Seeds were sown in rows at spacing of 0.5×2.0 m^2. All recommended agronomic package of practices were followed to raise healthy crop. The observations were recorded on five randomly selected competitive plants in parents and F_1s and 20 plants in F_2s for the characters viz., vine length (m), number of laterals vine^{-1}, days to 1st female flower appeared, node number at which 1st female flower appeared, sex ratio (male to female), number of fruits vine^{-1}, average fruit weight (g), fruit length (cm), fruit girth (cm) and yieldvine^{-1} (kg). Relative heterosis and heterobeltiosis were estimated as percentage increase/decrease in F_1 over mid parent and better parent respectively. The data on parents, F_1 hybrids and F_2 population were statistically analysed as per standard procedure given by Panse and Sukhatme (1987).

3. Results and Discussion

Hybrids manifested superiority over parents for almost all the traits however, inbreeding depression was also noticed for most of the traits (Table 1). The results on heterosis over mid parent and better parent and inbreeding depression were presented in Table 2. In the present investigation, for vine length, most of the hybrids which exhibited positive heterosis showed significant inbreeding depression indicating the role of non-additive gene action in its inheritance. Significant heterosis for vine length was also reported earlier by Singh et al. (2001). For number of laterals vine^{-1}, significant inbreeding depression was observed in three crosses, viz., IC-033227×IC-470558 (10.53%), IC-045339×IC-085622 (10.00%) and IC-033227×IC-085622 (9.09%) which showed positive heterosis over mid parent (13.77, 12.36, 14.45 %) and better parent (11.76, 9.89, 8.79%) thus indicated dominance gene effect in controlling this trait. Further, significant negative heterosis was observed over mid parent, better parent in IC-033227×IC-045339 with no inbreeding depression indicated the presence of additive gene action in this particular cross.

For days to 1st female flower appeared, The cross IC-044438×IC-045339 had high heterosis (-7.53%) in desirable direction among the crosses tested, showed no inbreeding depression. Thus, this trait was influenced by both additive and non-additive gene actions. Similar results reported by Mohan et al. (2012) in ash gourd. Among the crosses, IC-033227×IC-470550 and IC-044417×IC-470560 recorded significant inbreeding depression (-25.00 and -20.56% respectively) along with significant negative relative heterosis (-11.48 and -15.69% respectively) for node number at 1st female flower appeared indicating the role of non-additive gene action in inheritance of this trait. However, few crosses showed low inbreeding depression with moderate levels of heterosis. These findings suggested the predominant role of additive as well as non-additive gene action in inheritance of this trait. For sex ratio, seven crosses exhibited significant inbreeding depression ranging from -12.36 to -24.32% along with negative heterosis over mid and better parent. The crosses, IC-044438×IC-045339 (-21.93%)

Table 1: Range and mean performance of parents, F_1 hybrids and F_2 generation for yield and related traits in bitter gourd

Character		Parents	F_1 hybrids	F_2 generation
Vine length (m)	Range	1.64-2.29	1.90-2.77	1.73-2.48
	Mean	1.99	2.45	2.15
No. of lateralsvine^{-1}	Range	5.33-6.27	4.53-7.00	4.53-6.80
	Mean	5.66	6.05	5.75
Days to 1st female flower	Range	45.13-57.27	46.27-57.60	47.13-56.00
	Mean	51.22	51.78	51.95
Node no. at 1st female flower	Range	12.07-17.40	12.00-17.60	12.93-18.00
	Mean	15.54	14.88	15.04
Sex ratio	Range	7.16-9.38	6.54-8.68	7.44-9.40
	Mean	8.09	7.50	8.34
Number of fruits vine^{-1}	Range	13.20-22.47	13.40-25.40	12.80-24.40
	Mean	18.77	20.92	19.49
Average fruit weight (g)	Range	56.88-73.33	58.82-98.57	57.92-91.68
	Mean	65.82	71.63	66.43
Fruit length (cm)	Range	12.63-17.35	13.45-20.99	13.30-19.03
	Mean	15.42	16.40	15.29
Fruit girth (cm)	Range	9.79-12.97	10.98-13.89	10.18-12.83
	Mean	12.05	12.87	12.13
Yield vine^{-1} (kg)	Range	0.75-1.58	0.84-2.50	0.74-2.22
	Mean	1.24	1.51	1.30

Table 2: Estimation of heterosis over mid parent (H_1), better parent (H_2) and inbreeding depression (ID) in bitter gourd

Hybrid	Vine length (m)			Number of laterals vine^{-1}			Days to 1st female flower			Node no. at 1st female flower			Sex ratio		
	H_1	H_2	ID	H_1	H_2	ID	H_1	H_2	ID	H_1	H_2	ID	H_1	H_2	ID
IC-033227×IC-044417	30.94**	25.68**	15.46**	12.35**	10.98**	0.00	1.14	3.00	-2.91	-13.32**	-9.65*	-2.93	-13.86**	-12.65*	-14.40**
IC-033227×IC-044438	25.63**	18.01**	13.37*	15.12**	10.00**	0.00	2.09	8.42**	-1.09	-3.77	-3.08	-5.53	-11.53*	-5.01	-13.27*
IC-033227×IC-045339	29.62**	17.77**	20.87*	-7.69**	-10.34**	-16.67*	0.44	4.36	4.65**	5.42	11.30*	12.25**	-7.95	-2.72	-4.71
IC-033227×IC-085622	28.83**	28.34**	14.25**	14.45**	8.79**	9.09*	0.58	1.71	-2.71*	-4.80	0.46	-6.58	-10.63*	-3.93	-24.32**
IC-033227×IC-470550	17.73**	10.40*	6.47	5.26	-2.44	7.50	-0.25	6.19**	-3.96*	-11.48**	-4.82	-25.00**	-2.67	-2.48	-9.37
IC-033227×IC-470558	29.02**	24.66**	19.38**	13.77**	11.76**	10.53*	0.83	3.55	1.90	0.00	1.36	5.80	-7.09	-3.85	-12.36*
IC-033227×IC-470560	19.95**	13.05**	13.39**	10.23**	3.19	7.22	1.09	4.64	-2.02	-0.98	11.60	-5.45	-9.61	-1.40	-12.32
IC-044417×IC-044438	20.56**	8.99*	11.91*	12.94**	6.67**	0.00	8.15**	12.72**	-1.84	-8.94*	-4.42	-5.61	-5.74	2.57	-12.89
IC-044417×IC-045339	25.55**	18.57**	18.72**	-1.80	-5.75	6.10	3.72	11.04**	2.97	0.60	-1.65	15.54*	-10.58*	-6.90	-16.39*
IC-044417×IC-085622	31.47**	26.65**	11.11**	9.94**	3.30	9.57**	5.69**	8.87**	-1.38	-2.81	-1.65	-2.90	-3.47	5.16	-8.56
IC-044417×IC-470550	5.61	3.07	8.77*	14.67**	7.50**	0.00	5.46**	14.45**	3.10	-4.54	-1.65	2.89	1.00	2.12	-2.81
IC-044417×IC-470558	34.22**	24.66**	8.08*	21.21**	17.65**	3.00	0.78	5.46**	1.16	0.21	5.91	0.00	-12.15**	-7.18	-6.95
IC-044417×IC-470560	27.80**	15.91**	13.94**	12.64**	4.26	7.14	-1.59	0.00	-2.39	-15.69**	-0.58	-20.56**	-10.19*	-0.56	-10.40
IC-044438×IC-045339	41.34**	21.43**	10.59*	18.64**	16.67**	0.00	-7.53**	2.53	-1.87	-20.34**	-15.14**	-5.79	-21.93**	-11.38	-13.86
IC-044438×IC-085622	20.52**	12.82**	13.97**	3.87	3.30	0.00	8.73**	16.84**	-0.38	-6.30	-0.40	-6.28	1.29	1.36	-16.28
IC-044438×IC-470550	10.30**	-2.42	8.08	0.00	-11.11**	0.00	8.20**	22.76**	1.08	5.15	13.86**	8.24*	-9.86*	-3.12	-15.66
IC-044438×IC-470558	13.75**	10.48**	11.89	4.00	1.11	0.00	5.21**	14.93**	-0.51	-2.47	-1.77	-4.15	-5.98	-3.25	-15.55
IC-044438×IC-470560	10.64**	10.25**	9.27*	2.17	0.00	3.19	2.45	0.00	-1.69	10.12*	23.20**	-3.14	-2.64	-1.12	-7.35
IC-045339×IC-085622	37.47**	25.34**	11.62**	12.36**	9.89**	10.00*	-6.24**	3.47	-2.40	-13.66**	-13.51**	-3.67	-17.62**	-6.38	-17.92*
IC-045339×IC-470550	36.49**	31.95**	10.94	7.01	-3.45	3.57	-9.57**	-7.65**	-1.71	-8.56*	-7.11	-4.26	-15.19**	-10.72	-11.22
IC-045339×IC-470558	34.46**	18.46**	17.26**	11.63**	10.34**	7.29	-2.71	-1.38	-2.40	-15.61**	-9.50	-5.00	-15.36**	-6.79	-11.24
IC-045339×IC-470560	35.34**	16.61**	17.53**	7.18**	3.19	7.23	-6.19**	1.26	-1.53	-16.59**	0.00	-7.18	-19.92**	-7.54	-12.38
IC-085622×IC-470550	19.28**	12.25**	7.60	4.35	-7.69*	0.00	5.07**	10.53**	2.33	1.36	3.15	6.15	4.66	12.62*	-9.52
IC-085622×IC-470558	14.88**	10.59**	10.66*	5.68*	2.20	6.45	0.38	1.93	-2.40	-6.13	0.48	-4.51	-3.65	-0.81	-10.76
IC-085622×IC-470560	14.75**	7.76*	6.28	-12.43**	-13.83**	4.94	0.20	4.92*	-3.35	-0.23	19.30**	0.00	-3.78	-2.37	-18.07*
IC-470550×IC-470558	1.45	-7.87*	0.00	-12.26**	-20.00**	0.00	-3.55*	-0.13	3.75**	-5.39	3.19	13.16	5.14	9.74	2.34
IC-470550×IC-470560	2.12	-9.38**	2.27	-2.44	-14.89**	3.75	10.06**	21.52**	3.472	-5.39	45.82**	5.30	9.84	19.97**	-6.13
IC-470558×IC-470560	12.48**	9.61**	8.58*	9.50**	4.26	5.10	0.59	7.03**	0.920	19.46**	15.99**	3.33	0.16	4.61	-8.86

*Significant at (p=0.05) probability; ** Significant at (p=0.01) probability

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Hybrid	Number of fruitsvine^{-1}			Average fruit weight (g)			Fruit length (cm)			Fruit girth (cm)			Yield vine^{-1} (kg)		
	H_1	H_2	ID	H_1	H_2	ID	H_1	H_2	ID	H_1	H_2	ID	H_1	H_2	ID
IC-033227×IC-044417	12.73**	10.67**	6.63*	4.27	4.22	10.16*	11.31**	8.24**	9.39*	0.03	-0.31	4.64	17.92**	15.35**	15.86*
IC-033227×IC-044438	9.94**	5.86	6.12**	10.52**	7.44	6.77**	7.75**	3.38	10.0	3.33	1.19	6.19	21.37**	13.71**	12.25**
IC-033227×IC-045339	13.06**	5.33	16.14**	5.80	-3.64	6.45*	9.99**	-1.46	8.40	-3.15	-14.80**	7.29	19.22**	1.69	21.42**
IC-033227×IC-085622	21.38**	17.33**	9.38*	0.07	-1.12	6.65	11.16**	10.46**	8.37*	2.58	0.78	9.65*	21.61**	19.17**	15.52**
IC-033227×IC-470550	8.03*	-10.33**	7.44*	5.79	-3.30	8.40*	-11.61**	-15.68**	-6.35	-6.16**	-12.93**	-13.07**	12.26**	-13.13**	15.51**
IC-033227×IC-470558	7.26*	1.00	4.95	4.49	4.33	8.31	-0.52	-1.56	9.10	-1.27	-3.10	7.48**	12.06**	5.46	13.23 *
IC-033227×IC-470560	14.91**	8.61**	8.47**	10.24*	3.43	13.66**	2.22	1.88	4.51	0.34	-0.98	5.23	27.27**	26.41**	21.31**
IC-044417×IC-044438	9.95**	4.01	4.15	5.65	2.65	7.09	9.85**	2.61	7.75*	2.40	-0.05	8.74	16.43**	6.88	10.98
IC-044417×IC-045339	13.14**	7.27	10.65	-6.67	-14.96**	-1.70	13.91**	4.69*	5.58**	-2.64	-14.59**	4.81*	5.72	-8.13	9.62 *
IC-044417×IC-085622	4.75	3.11	6.71	12.19**	10.80*	8.34	25.75**	23.03**	11.12**	2.65	0.51	6.49**	17.46**	17.25**	14.63**
IC-044417×IC-470550	-8.83*	-23.18**	7.66	6.49	-2.61	5.90	2.53	0.53	4.31	6.44**	-1.54	4.18	-4.91	-25.24**	12.90*
IC-044417×IC-470558	37.55**	31.83**	3.94	16.20**	16.09**	5.84	25.11**	20.43**	5.91	-0.66	-2.83	2.64	60.24**	54.01**	9.21*
IC-044417×IC-470560	10.54**	2.67	5.20*	1.25	-4.96	9.64*	3.75*	1.22	6.99*	1.88	0.21	6.62	12.92**	11.21**	14.83**
IC-044438×IC-045339	30.70**	17.59**	4.72	51.41**	34.43**	6.99*	40.00**	20.94**	9.34*	22.25**	9.55**	5.17	96.03**	58.48**	11.34
IC-044438×IC-085622	12.58**	4.94	6.47*	2.39	0.72	10.28**	0.46	-4.19*	5.70*	11.94**	11.58**	10.43	15.05**	5.78	16.43**
IC-044438×IC-470550	-11.11**	-28.40**	10.34	19.79**	6.73	9.36	-13.09**	-20.28**	3.86	15.03**	8.85**	4.86	3.25	-23.67**	18.46**
IC-044438×IC-470558	8.32**	-1.54	5.02	5.04	1.96	8.01*	-4.52**	-7.45**	7.02	8.40**	8.17**	9.19*	13.65**	0.63	13.21**
IC-044438×IC-470560	11.65**	9.50**	5.96	-3.30	-11.64**	10.30	-3.72*	-7.91**	5.84*	-0.19	-0.96	3.00	8.09*	0.63	15.51**
IC-045339×IC-085622	23.19**	18.57**	5.72*	24.28**	11.97**	5.63*	17.43**	5.80**	6.72	23.61**	10.46**	8.54*	52.64**	32.44**	11.13*
IC-045339×IC-470550	22.98**	8.49*	6.76	20.07**	19.58**	5.83	10.13**	3.08	8.58**	24.28**	17.29**	6.75**	48.31**	31.67**	12.47*
IC-045339×IC-470558	27.86**	26.42**	5.67	20.54**	9.94*	5.75*	9.98**	-2.37	6.12	20.46**	7.74**	4.09	54.09**	38.70**	11.41**
IC-045339×IC-470560	14.77**	1.48	7.02*	14.96**	11.36*	8.88	7.40**	-3.49	5.23	24.36**	10.68**	8.64*	31.75**	13.02**	15.764*
IC-085622×IC-470550	-15.90**	-28.21**	4.48	-2.42	-11.77**	7.45	-0.22	-4.23*	4.69	14.75**	8.26**	11.14	-19.15**	-36.52**	12.44
IC-085622×IC-470558	9.36**	6.43	4.36	-0.04	-1.38	11.97*	-1.81	-3.44	8.05**	10.52**	10.40**	6.80	9.25	4.83	15.79*
IC-085622×IC-470560	-0.81	-9.20**	4.25	1.18	-6.13	5.71	8.36**	8.04**	8.03*	0.61	0.16	4.78	1.07	-0.29	10.16
IC-470550×IC-470558	9.72*	-4.15	16.14**	1.43	-7.16	-2.07*	-0.41	-5.94**	13.06**	7.31**	1.34	7.64*	9.69	-11.11	14.41**
IC-470550×IC-470560	1.31	-19.58**	7.75*	11.71*	8.64	4.75	-0.88	-5.13**	3.99	5.49*	-0.90	2.74*	12.37**	-12.63**	12.61*
IC-470558×IC-470560	16.28**	3.86	3.14	8.46	1.90	6.90	4.05*	2.62	3.79*	3.93	3.35	2.06	26.25**	19.58**	9.54

*Significant at (p=0.05) probability; ** Significant at (p=0.01) probability and IC-045339×IC-470560 (-19.92%) which exhibited highly significant heterosis had no inbreeding depression (Table 2) can be utilized for development of pure lines. However the crosses, IC-033227×IC-044417, IC-033227×IC-085622, IC-044417×IC-45339 and IC-045339×IC-085622 showed inbreeding depression also expressed significant heterosis in desired direction. These crosses may be exploited for improvement of this trait through heterosis breeding.

One of the important yield components, number of fruitsvine^{-1} was under the strong influence of non-additive gene action which is evident from significant positive heterosis accompanied by significant inbreeding depression suggesting the importance of heterosis breeding towards improvement of this trait. With respect to average fruit weight, 12 crosses showed significant inbreeding depression suggesting the governance of non-additive gene action in its inheritance. Christopher and Todd (1997) also observed inbreeding depression for fruit weight in cucumber. However, the crosses IC-470550×IC-470558, IC-044417×IC-045339, IC-044438×IC-470560 and IC-085622×IC-470550 had significant negative heterobeltiosis without inbreeding depression indicated the role of additive gene action in inheriting this trait and simple selection could be possible to improve this trait in these crosses. Significant heterosis for this trait was reported by Sundaram (2008) in bitter gourd.

Inbreeding depression was significant in 14 crosses coupled with significant positive heterosis over mid and better parent for the fruit length. Chaubey and Ram (2004) also reported significant heterosis for this trait in bitter gourd. However, the cross, IC470550×IC470558 exhibited highly significant inbreeding depression recorded negative heterosis indicating additive gene action. In case of fruit girth, ten crosses showed significant positive heterosis along with inbreeding depression. These results strongly suggested that this trait is under control of non-additive gene action; hence, heterosis breeding might be fruitful to improve this trait. For yieldvine^{-1}, heterosis was observed in positive direction with higher magnitude and similar trend was reflected regarding inbreeding depression also. The crosses viz., IC-033227×IC-045339, IC-033227×IC-470560, IC-033227×IC-044417, IC-033227×IC085622, IC-033227×IC-470550, IC-044438×IC-085622, IC-045339×IC-470560 and IC-045339×IC-470550 were significantly superior in performance over their corresponding better parent had shown highly significant depression in F_2, thus indicating mostly the involvement of non-additive gene action in the inheritance of yieldvine^{-1}. Similar results were reported by Patel et al. (2005) in bitter gourd, Yadav and Sanjay (2011) in bottle gourd and Singh et al. (2012) in cucumber. However, IC-044438×IC-045339 (96.03 and 58.48%), IC-044417×IC-044438 (16.43%) and IC-470558×IC-470560 (26.25 and 19.58%) recorded significant heterosis over mid parent and better parent respectively had comparatively lower inbreeding depression indicating a better scope for direct selection. Significant heterobeltiosis was observed for yield and its related traits by Maurya et al. (2009) in bitter gourd.

4. Conclusion

The present study suggesting that it would be useful to utilize promising cross combinations viz., IC-044438×IC-045339, IC-044417×IC-470558, IC-045339×IC-470558 and IC-045339×IC-085622 for enhancing fruit yield and other yield attributes. Similarly IC-045339×IC-470550 and IC-044438×IC-045339 were found superior for earliness for exploitation of heterosis. Hence, methods like heterosis breeding, recurrent selection and progeny selection may be employed for improvement in bitter gourd.

5. References

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