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EXPLOITATION OF HETEROSIS FOR YIELD AND ITS COMPONENTS IN BITTER GOURD (*MOMORDICA CHARANTIA* L.)

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Abstract

The present investigation was carried out with 15 bitter gourd varieties, 12 were used as lines and 3 used as testers and their 36 crosses derived through line × tester matting design, for evaluating 9 quantitative characters in summer and rainy season under rainfed condition. The highest standard heterosis was observed for number of fruit per plant in crosses 'NDBT-10' × 'Kalyanpur Sona' (summer) and 'NDBT-19' × 'PDM' (rainy). For fruit yield per plant the highest standard heterosis was in 'NDBT-13'× 'NDBT-12' during summer and in 'NDBT-13' × 'PDM' during the rainy season. For days to anthesis of first pistillate flower, the crosses of 'NDBT-7' × 'Kalyanpur Sona' and 'NDBT-2' × 'PDM' were the most promising crosses for both summer and rainy season

Key words : Anthesis, genotypes, heterobeltiosis, *Momordica charantia*, pistillate and standard heterosis.

Introduction

Bitter gourd (2n = 2x = 22) is a monoecious and cross pollinated crop in which a large amount of variation for most of economically important traits occurs. There are only few cultivars of bitter gourd (*Momordica charantia* L.) available for commercial cultivation and these have poor yield and/or susceptible to various diseases and pests, thus development of varieties/hybrids with superior to yield and quality is necessity. However, the improvement of bitter gourd is largely confined to introduction and selection of desirable varieties. But due to continued selection, much of the genetic variability has rewarded. In order to increase genetic variability and identify promising segregates hybridization between the parents could help with this issue. Moreover, the recent surge in widespread adoption of hybrids by farmers also necessitates the development of new and higher yielding in bitter gourd hybrids, which are able to realize the high degree of heterosis. The choice of parents for hybridization is on the basis of their *per se* performance does not necessarily yield fruitful results (Allard, 1960), whereas as choosing parents on the basis of their combining ability and nature and extent of gene action for yield and yield attributing traits has been found to be useful tool for breeding programs. This information can be effective to identify superior genotypes to be used as parents for hybridization and also could indicate cross combinations likely to yield desirable segregates. In bitter gourd full exploitation of heterosis through development of hybrids has not been successfully commercialized. Variability in shape, size and color of fruit offers possibilities for heterosis breeding to enhance yield.

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Materials and Methods

The present investigation was involving 36 F_1s (derived through line × tester mating design) and their patents *i.e.*, 12 lines (NDBT-1, NDBT-2, NDBT-3, NDBT-4, NDBT-5, NDBT-6, NDBT-7, NDBT-8, NDBT-10, NDBT-13, NDBT-15 and NDBT-19) and 3 testers (Kalyanpur Sona, NDBT-12 and Pusa Do Mausami (PDM)) to estimate the heterosis for the 14 characters and whole experimental materials were evaluated in Complete Randomized Block Design (RBD) with three replications for two seasons, namely summer (S) season and rainy (R) season 2010 at Research Farm, Department of Vegetable Science, N.D. University of

Table 1 : Estimates of heterosis over better parent and standard variety for nine characters during summer and rainy seasons for 36 hybrids in bitter gourd.

Character	Node number to anthesis of first pistillate flower				Days to anthesis of first pistillate flower			
	Summer		Rainy		Summer		Rainy	
Hybrid	BP	SV	BP	SV	BP	SV	BP	SV
NDBT-1 × K. SONA	-26.67 *	-3.39	-5.00	-15.87**	-2.75	-18.52	-15.38	-10.81
NDBT-1 × NDBT-12	14.81	-3.39	-5.00	-16.67**	-3.67	14.81	-5.26	-2.70
NDBT-1 × PDM	-14.81	0.83	0.83	-11.90**	1.83	-14.81	0.00	0.00
NDBT-2 × K. SONA	-33.33 **	-15.65**	-19.17**	-6.78*	0.92	-25.93 *	-7.69	-2.70
NDBT-2 × NDBT-12	-7.41	-5.31	-10.83**	-11.86**	-4.59	-7.41	-13.16	-10.81
NDBT-2 × PDM	-29.63 *	-15.83**	-15.83**	-16.10**	-9.17**	-29.65 *	-16.22	-16.22
NDBT-3 × K. SONA	0.00	-7.83 *	-11.67**	-2.50	7.34*	11.11	5.13	10.81
NDBT-3 × NDBT-12	-3.57	-2.73	-10.83**	-9.17**	0.00	0.00	2.63	5.41
NDBT-3 × PDM	21.43	2.50	2.50	-9.17**	0.00	25.93 *	-2.70	-2.70
NDBT-4 × K. SONA	25.81 *	-8.20 *	-6.67	-7.63*	0.00	44.44 **	11.63	29.76**
NDBT-4 × NDBT-12	-3.23	-14.75**	-13.33**	-6.84*	0.00	11.11	-16.28*	-2.70
NDBT-4 × PDM	6.45	-6.56	-5.00	-7.69*	-0.92	22.22	0.00	16.22
NDBT-5 × K. SONA	-18.42*	-8.40 *	-9.17 *	-0.85	7.34*	14.81	-26.53**	-2.70
NDBT-5 × NDBT-12	-15.79	-9.24 *	-10.00**	-2.56	4.59	18.52	-32.65**	-10.81
NDBT-5 × PDM	-13.16	-5.83	-5.83	-1.71	5.50	22.22	-20.41**	5.41
NDBT-6 × K. SONA	10.00	-13.91**	-17.50**	6.78*	15.60**	22.22	7.14	21.62*
NDBT-6 × NDBT-12	13.79	0.88	-5.00	0.00	8.26*	22.22	-16.67*	-5.41
NDBT-6 × PDM	13.79	-5.00	-5.00	-7.63*	0.00	22.22	-14.29	-2.70
NDBT-7 × K. SONA	-24.32**	-23.77**	-22.50**	-4.24	3.67	3.70	-7.69	-2.70
NDBT-7 × NDBT-12	-10.81	1.64	3.33	-2.56	4.59	22.22	13.16	16.22
NDBT-7 × PDM	-10.81	0.82	2.50	14.53**	22.94**	22.22	0.00	0.00
NDBT-8 × K. SONA	-18.18	-1.74	-5.83	-3.36	5.50	0.00	-14.29	-2.70
NDBT-8 × NDBT-12	-6.06	-7.08	-12.50**	-7.56*	0.92	14.81	9.52	24.32**
NDBT-8 × PDM	9.09	-0.83	-0.83	0.84	10.09**	33.33 **	7.14	21.62*
NDBT-10 × K. SONA	-5.41	-9.02 **	0.83	3.82	24.77**	29.63 *	20.51*	27.03**
NDBT-10 × NDBT-12	-10.84	-8.27 *	1.67	-3.82	15.60**	22.22	18.42*	21.62*
NDBT-10 × PDM	-2.70	-11.28**	-1.67	1.53	22.02**	33.33 **	13.51	13.51
NDBT-13 × K. SONA	-32.50**	3.48	-0.83	5.76*	34.86**	0.00	-20.00**	-2.70
NDBT-13 × NDBT-12	-7.50	5.31	-0.83	-12.95**	11.01**	37.04 **	0.00	21.62*
NDBT-13 × PDM	-10.00	0.00	0.00	-20.86**	0.92	33.33 **	-17.78*	0.00
NDBT-15 × K. SONA	3.13	-10.40**	-6.67	-6.25*	10.09**	22.22	-26.83**	-18.92*
NDBT-15 × NDBT-12	18.75	-9.60 **	-5.83	0.78	18.35**	40.74 **	2.44	13.51
NDBT-15 × PDM	15.63	0.80	5.00	3.13	21.10**	37.04 **	-12.20	-2.70
NDBT-19 × K. SONA	-20.00**	-4.76	0.00	5.00	15.60**	33.33 **	-25.00**	-2.70
NDBT-19 × NDBT-12	-6.67	-1.59	3.33	9.17**	20.18**	55.56 **	0.00	29.73**
NDBT-19 × PDM	-13.33	3.17	8.33 *	10.83**	22.02**	44.44 **	-10.42	16.22
Significance +ve	1	00	1	5	16	12	2	8
Significance -ve	7	14	11	15	1	2	9	1
Range of heterosis	-33.33 to 25.81	-23.77 to 5.31	-22.50 to 8.33	-20.86 to 14.53	-9.17 to 34.86	-29.65 to 55.50	-35.65 to 20.51	-18.92 to 29.76

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

Table 1 contd...

Character	Days to first fruit harvest				Fruit length (cm)			
	Summer		Rainy		Summer		Rainy	
Hybrid	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**
NDBT-1 × K. SONA	-3.29	-7.11 *	-7.95**	0.72	2.33	0.36	-6.15	-1.83
NDBT-1 × NDBT-12	-3.38	-7.14 *	-13.28**	-5.08	-18.37**	-0.64	-5.23	6.65
NDBT-1 × PDM	-3.25	-3.25	-5.30	3.62	-3.57	-3.57	-0.97	3.58
NDBT-2 × K. SONA	-15.07**	-19.48 **	-10.60**	-2.17	2.45	0.47	3.96	7.80
NDBT-2 × NDBT-12	-2.10	-9.09 **	-10.60**	-2.17	-29.83**	-14.60**	4.55	17.65**
NDBT-2 × PDM	-16.88**	-16.88 **	-13.25**	-5.07	-8.12	-8.12	2.14	5.91
NDBT-3 × K. SONA	-4.79	-9.74 **	-3.27	7.25*	-2.83	-1.20	-11.31**	4.51
NDBT-3 × NDBT-12	-2.13	-10.39 **	-11.11**	-1.45	-20.29**	-2.99	-14.79**	0.41
NDBT-3 × PDM	1.95	1.95	-9.80**	0.00	9.85 *	11.69 **	10.29*	29.96**
NDBT-4 × K. SONA	-9.09 **	-9.09 **	-5.33	2.90	-20.69**	-14.71**	1.21	12.15*
NDBT-4 × NDBT-12	-14.29**	-14.29 **	-6.67*	1.45	-6.33	14.01 **	-13.20**	-2.33
NDBT-4 × PDM	-5.84	-5.84	-6.67*	1.45	0.88	8.48 *	-8.89*	0.96
NDBT-5 × K. SONA	-4.73	-8.44 **	1.34	9.42**	17.99 **	15.71 **	-11.94**	-0.36
NDBT-5 × NDBT-12	-5.41	-9.09 **	1.37	7.25*	-29.72**	-14.46**	-11.51**	0.14
NDBT-5 × PDM	-8.44 **	-8.44 **	2.05	7.97**	0.08	0.08	-1.81	11.11*
NDBT-6 × K. SONA	-8.90 **	-13.64 **	7.38**	15.94**	-9.22 *	-10.97**	-17.97**	-3.94
NDBT-6 × NDBT-12	1.38	-4.55	2.07	7.25*	-12.73 **	6.22	-10.96*	4.27
NDBT-6 × PDM	-5.19	-5.19	-2.76	2.17	-4.69	-4.69	-4.65	11.66*
NDBT-7 × K. SONA	-19.33**	-21.43**	-4.70	2.90	-10.75 *	-10.13 *	-4.91	4.92
NDBT-7 × NDBT-12	1.33	-1.30	-0.68	5.80	-10.53 **	8.90 *	2.87	15.76**
NDBT-7 × PDM	0.65	0.65	14.29**	21.74**	-17.41 **	-16.83**	-2.53	7.55
NDBT-8 × K. SONA	-0.68	-5.84	0.66	10.14**	-7.80	-9.57 *	-3.26	13.79**
NDBT-8 × NDBT-12	-0.71	-9.09 **	-3.31	5.80	-27.10 **	-11.28**	-5.07	11.66*
NDBT-8 × PDM	-5.84	-5.84	-4.64	4.35	7.79	7.79	-16.12**	-1.34
NDBT-10 × K. SONA	-3.75	0.00	5.03	21.01**	-28.93 **	-6.34	-8.93*	7.47
NDBT-10 × NDBT-12	-5.00	-1.30	-2.52	12.32**	-21.75 **	3.13	-0.56	17.35**
NDBT-10 × PDM	-4.38	-0.65	3.77	19.57**	-25.98 **	-2.46	-0.21	17.76**
NDBT-13 × K. SONA	3.42	-1.95	7.83**	29.71**	-2.72	6.89	17.40**	21.48**
NDBT-13 × NDBT-12	7.69 *	0.00	-9.04**	9.42**	-19.58 **	-2.12	1.39	14.09**
NDBT-13 × PDM	-2.60	-2.60	-15.06**	2.17	3.76	14.01 **	16.37**	20.41**
NDBT-15 × K. SONA	-11.04**	-5.84	-7.64**	5.07	-14.04 **	-7.03	-10.96*	-3.94
NDBT-15 × NDBT-12	-12.88**	-7.79 *	2.55	16.67**	-11.53 **	7.68	0.53	13.13**
NDBT-15 × PDM	-4.29	1.30	1.91	15.94**	-3.35	4.52	-8.06	-0.82
NDBT-19 × K. SONA	-3.73	0.65	4.61	15.22**	-14.74 **	-16.38**	-6.76	-4.10
NDBT-19 × NDBT-12	-6.83 *	-2.60	2.63	13.04**	-17.70 **	0.17	6.37	19.70**
NDBT-19 × PDM	-1.24	3.25	5.92*	16.67**	15.13 **	15.13 **	17.13**	20.47**
Significance +ve	1	00	4	17	3	7	4	15
Significance-ve	10	16	12	00	19	9	11	00
Range of heterosis	-19.33 to 7.69	-21.43 to 3.25	-13.28 to 14.29	-5.08 to 29.71	-29.72 to 17.99	-16.63 to 15.71	-17.97 to 17.40	-3.94 to 29.96

*, ** significant at 5 and 1 per cent probability level,

Table 1 contd...

Character	Fruit diameter (cm)				Average fruit weight (g)			
	Summer		Rainy		Summer		Rainy	
Hybrid	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**
NDBT-1 × K. SONA	6.48	29.03 **	-7.35	-8.98	-5.36	-8.23 **	-6.39 *	-13.50**
NDBT-1 × NDBT-12	5.50	27.85 **	-0.57	-2.31	-16.67 **	-15.60 **	-17.83 **	-20.25**
NDBT-1 × PDM	-9.85 *	9.25	-9.07	-9.07	-15.58 **	-15.58 **	-20.25 **	-20.25**
NDBT-2 × K. SONA	2.19	5.48	-0.54	-15.09*	-1.67	2.16	-0.84	0.00
NDBT-2 × NDBT-12	3.64	10.22 *	8.29	-5.65	-2.50	1.30	-2.93	-2.11
NDBT-2 × PDM	-12.40**	-9.57 *	-22.87**	-22.87**	2.50	6.49 *	4.18	5.06
NDBT-3 × K. SONA	13.99 **	18.28 **	7.39	-5.83	9.38 **	6.06 *	12.79 **	4.22
NDBT-3 × NDBT-12	9.10 *	16.02 **	9.08	-4.35	2.56	3.90	5.65	2.53
NDBT-3 × PDM	41.04 **	46.34 **	19.72**	19.72**	0.43	0.43	0.00	0.00
NDBT-4 × K. SONA	-3.96	22.69 **	-8.76	-1.67	3.57	0.43	4.57	-3.38
NDBT-4 × NDBT-12	-12.71**	11.51 *	-8.25	-1.11	-2.56	-1.30	-3.04	-5.91 *
NDBT-4 × PDM	-3.62	23.12 **	-11.25*	-4.35	-9.09 **	-9.29 **	-13.50 **	-13.50**
NDBT-5 × K. SONA	40.88 **	37.10 **	49.13**	19.44**	8.48 **	5.19	10.05 **	1.69
NDBT-5 × NDBT-12	-18.10**	-12.90 **	-18.70**	-29.17**	0.00	1.30	-0.87	-3.80
NDBT-5 × PDM	11.29 *	11.29 *	-7.87	-7.87	-3.90	-3.90	-8.86 **	-8.86**
NDBT-6 × K. SONA	-21.90**	-6.45	-8.94	-16.11**	-9.38 **	-12.12 **	-4.98	-11.39**
NDBT-6 × NDBT-12	0.09	19.89 **	11.56	2.78	5.13	6.49 *	2.61	-0.42
NDBT-6 × PDM	-11.13 **	6.45	4.44	4.44	-9.09 **	-9.09 **	-9.70 **	-9.70**
NDBT-7 × K. SONA	-3.13	26.45 **	-14.46**	-4.72	-16.48 **	-5.63 *	-16.67 **	-9.28**
NDBT-7 × NDBT-12	1.07	31.94 **	-5.74	5.00	-8.05 **	3.90	-7.36 **	0.84
NDBT-7 × PDM	-31.47 **	-10.54 *	-34.41**	-26.94**	-17.24 **	-6.49 *	-13.95 **	-6.33*
NDBT-8 × K. SONA	-33.62 **	-8.06	-38.15**	-27.04**	-10.74 **	-6.49 *	-9.80 **	-6.75*
NDBT-8 × NDBT-12	-36.57 **	-12.15 *	-45.53**	-35.74**	-18.60 **	-14.72 **	-21.63 **	-18.99**
NDBT-8 × PDM	-20.89 **	9.57 *	-4.16	13.06*	0.83	5.63 *	1.63	5.06
NDBT-10 × K. SONA	-16.51**	3.33	-25.06**	-17.78**	-4.46	-7.36 **	-4.98	-11.39**
NDBT-10 × NDBT-12	-8.51 *	13.23 **	-15.53**	-7.31	7.26 **	8.66 **	9.57 **	6.33 *
NDBT-10 × PDM	3.91	28.60 **	-3.63	5.74	1.30	1.30	3.80	3.80
NDBT-13 × K. SONA	20.72 **	47.85 **	34.94**	24.44**	0.00	16.88 **	4.92	16.88 **
NDBT-13 × NDBT-12	5.36	29.03 **	16.37*	7.31	-7.04 **	8.66 **	-4.17	6.75 *
NDBT-13 × PDM	-0.61	21.72 **	5.00	5.00	0.00	16.88 **	5.30 *	17.30 **
NDBT-15 × K. SONA	-24.27 **	-5.38	-8.39	-8.98	6.45 *	14.29 **	10.59 **	10.13 **
NDBT-15 × NDBT-12	-12.05 **	9.89 *	-9.04	-9.63	3.23	10.82 **	8.47 **	8.02 **
NDBT-15 × PDM	7.49	34.30 **	8.52	8.52	3.23	10.82 **	8.02 **	8.02 **
NDBT-19 × K. SONA	-21.30 **	-3.87	-16.25*	-25.09**	-12.24 **	-6.93 *	-8.82 **	-8.44 **
NDBT-19 × NDBT-12	0.88	23.23 **	6.21	-5.00	-11.84 **	-6.49 *	-6.30 *	-5.91 *
NDBT-19 × PDM	-0.26	21.83 **	1.67	1.67	-9.80 **	-4.37	-8.40 **	-8.02 **
Significance +ve	5	24	4	4	4	11	7	7
Significance-ve	15	4	10	9	14	13	14	15
Range of heterosis	-36.57 to 41.08	-12.90 to 47.85	-45.53 to 49.13	-35.74 to 24.44	-18.60 to 9.38	-15.60 to 16.88	-21.63 to 12.79	-20.25 to 17.30

**,* significant at 5 or 1% probability level,.

Table 1 contd.....

Character	Number of fruit per plant				Fruit yield per plant (kg)			
	Summer		Rainy		Summer		Rainy	
Hybrid	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**
NDBT-1 × K. SONA	9.63 *	18.07**	9.79	-5.22	9.66 *	7.91	-4.72	-22.90**
NDBT-1 × NDBT-12	-28.74 **	-23.26**	-41.51 **	-31.83 **	-31.30**	-32.38**	-52.71**	-45.03**
NDBT-1 × PDM	-26.91 **	-21.29 **	-17.27 **	-17.27 **	-33.08**	-33.08**	-24.55**	-24.55**
NDBT-2 × K. SONA	-4.01	-5.72	-4.85	-18.88 **	-4.32	-5.85	-3.63	-19.01**
NDBT-2 × NDBT-12	-0.72	-1.97	-23.92 **	-11.33	1.15	-0.45	-25.33**	-13.20*
NDBT-2 × PDM	-11.63 *	-11.63 *	8.99	8.99	-5.85	-5.85	14.66 *	14.66*
NDBT-3 × K. SONA	-21.13 **	-22.54 **	-26.07 **	-37.77 **	-22.21**	-23.46**	-20.79**	-35.91**
NDBT-3 × NDBT-12	-39.86 **	-40.61 **	-22.38 **	-9.53	-39.41**	-40.36**	-23.06 **	-10.57
NDBT-3 × PDM	3.4	3.4	6.12	6.12	3.31	3.31	7.59	7.59
NDBT-4 × K. SONA	7.83	5.9	-0.64	-16.37 **	10.24 *	8.48	-0.2	-19.25**
NDBT-4 × NDBT-12	15.04 **	13.60 *	-11.73 *	2.88	13.31 **	11.53 *	-12.11 *	2.16
NDBT-4 × PDM	-11.00 *	-10.55 *	12.59 *	12.59 *	-15.94**	-16.12**	-1.61	-1.61
NDBT-5 × K. SONA	3.64	1.79	-16.90 **	-23.92 **	9.52 *	7.77	5	-15.03*
NDBT-5 × NDBT-12	-5.8	-6.98	-21.60 **	-8.63	0.43	-1.15	-22.72 **	-10.17
NDBT-5 × PDM	-3.4	-3.4	-10.79	-10.79	-5.85	-5.85	-17.90 **	-17.90**
NDBT-6 × K. SONA	12.86 **	23.08 **	-1.28	-16.55 **	3.83	8.24	-7.74	-25.34**
NDBT-6 × NDBT-12	-13.22 **	-5.37	-37.35 **	-26.98 **	-2.7	1.43	-37.74 **	-27.62**
NDBT-6 × PDM	2.53	11.81 *	1.08	1.08	-3.6	0.49	-7.4	-7.4
NDBT-7 × K. SONA	23.50 **	21.29 **	15.85 *	2.52	9.69 *	16.93 **	-4.05	-5.24
NDBT-7 × NDBT-12	-0.36	-1.61	-29.63 **	-17.99 **	-5.07	1.2	-28.21**	-16.55**
NDBT-7 × PDM	-16.82 **	-16.82 **	-4.86	-4.86	-27.53**	-22.75**	-11.73 *	-11.73*
NDBT-8 × K. SONA	0.63	14.49 **	-2.24	1.98	-11.28**	8.95 *	-11.77*	-5.31
NDBT-8 × NDBT-12	-11.95 *	0.18	-19.14 **	-5.76	-29.45**	-13.36**	-34.37**	-23.71**
NDBT-8 × PDM	-16.98 **	-5.55	11.21 *	16.01 **	-17.40**	1.43	14.59 **	22.99**
NDBT-10 × K. SONA	-0.67	32.20 **	-9.13	1.98	-2.16	27.73 **	-16.54 **	-11.31
NDBT-10 × NDBT-12	-21.51 **	4.47	-32.25 **	-21.04 **	-11.33**	15.75 **	-26.41 **	-14.45*
NDBT-10 × PDM	-23.79 **	1.43	12.66 *	26.44 **	-21.40**	2.61	24.20 **	31.98**
NDBT-13 × K. SONA	7.1	5.19	-24.03 **	-8.45	14.51 **	22.33 **	-23.54 **	6.03
NDBT-13 × NDBT-12	32.43 **	30.77 **	-5.07	14.39 *	35.23 **	44.47 **	-11.60 **	22.60**
NDBT-13 × PDM	-3.4	-3.4	-0.6	19.78 **	7.54	14.89 **	1.75	41.10**
NDBT-15 × K. SONA	-8.8	1.97	-20.57 **	-4.86	-0.39	19.75**	-13.01 **	5.17
NDBT-15 × NDBT-12	-11.36 *	-0.89	6.91	28.06 **	-13.67**	3.78	13.99 **	37.82**
NDBT-15 × PDM	-21.92 **	-12.70 *	-17.12 **	-0.72	-19.22**	-2.89	-8.95	10.08
NDBT-19 × K. SONA	17.86 **	23.97 **	-1.91	20.32 **	4.35	18.34 **	-8.41	12.03 *
NDBT-19 × NDBT-12	9.69	15.38 **	2.05	25.18 **	-2.69	10.35 *	0.15	22.50 **
NDBT-19 × PDM	23.47 **	29.87 **	11.88 *	37.23 **	9.32 *	23.97 **	3.01	25.99 **
Significance +ve	7	11	5	9	7	12	4	9
Significance-ve	14	8	14	10	11	7	18	15
Range of heterosis	-39.86 to 32.43	-40.61 to 32.20	-41.51 to 15.85	-37.77 to 37.23	-39.41 to 35.23	-40.36 to 44.47	-52.71 to 24.20	45.03 to 41.10

**,* significant at 5 or 1% probability level.

Table 1 contd.…

Character	Vine length(m)			
	Summer		Rainy	
Hybrid	**BP**	**SV**	**BP**	**SV**
NDBT-1 x K. SONA	-0.18	-9.00	-7.09*	-0.91
NDBT-1 x NDBT-12	-9.01	-12.44*	-9.99**	-3.65
NDBT-1 x PDM	-24.55**	-24.55**	-13.30**	-13.30**
NDBT-2 x K. SONA	-7.31	-10.80	-11.37**	-5.48
NDBT-2 x NDBT-12	-17.01**	-20.13**	3.78	11.08**
NDBT-2 x PDM	3.93	3.93	17.53**	21.51**
NDBT-3 x K. SONA	-32.57**	-13.26*	-21.01**	7.82*
NDBT-3 x NDBT-12	-19.85**	3.11	-11.46**	20.86**
NDBT-3 x PDM	-10.81*	14.73*	-10.12**	22.69**
NDBT-4 x K. SONA	-0.90	-9.66	-3.18	3.26
NDBT-4 x NDBT-12	19.22**	14.73*	14.62**	22.69**
NDBT-4 x PDM	-1.80	-2.00	3.11	7.95*
NDBT-5 x K. SONA	5.82	-1.80	0.00	7.17
NDBT-5 x NDBT-12	-2.04	-5.73	-3.77	3.13
NDBT-5 x PDM	9.66	9.66	5.96	13.56**
NDBT-6 x K. SONA	3.95	-5.24	-4.65	1.69
NDBT-6 x NDBT-12	-0.68	-4.42	-4.38	2.35
NDBT-6 x PDM	-19.15**	-19.15**	-15.08**	-10.43**
NDBT-7 x K. SONA	12.27*	27.33**	8.56**	27.38**
NDBT-7 x NDBT-12	1.73	15.38**	-0.67	16.56**
NDBT-7 x PDM	-24.96**	-14.89*	-18.78**	-4.69
NDBT-8 x K. SONA	-8.98	-17.02**	-10.88**	-4.95
NDBT-8 x NDBT-12	-4.93	-8.51	-3.41	3.39
NDBT-8 x PDM	51.39**	51.39**	50.20**	50.20**
NDBT-10 x K. SONA	57.48**	51.55**	16.32**	51.50**
NDBT-10 x NDBT-12	38.44**	33.22**	7.31*	39.77**
NDBT-10 x PDM	44.03**	44.03**	5.51	37.42**
NDBT-13 x K. SONA	3.37	45.66**	8.21**	40.94**
NDBT-13 x NDBT-12	-2.90	36.82**	6.01*	38.07**
NDBT-13 x PDM	12.66**	58.76**	17.92**	53.59**
NDBT-15 x K. SONA	-1.20	-6.06	-5.99	0.26
NDBT-15 x NDBT-12	-11.90	-15.22*	-7.67*	-1.17
NDBT-15 x PDM	12.60*	12.60*	28.42**	28.42**
NDBT-19 x K. SONA	10.36*	60.39 **	26.23**	64.41 **
NDBT-19 x NDBT-12	10.92**	61.21**	23.52**	60.89**
NDBT-19 x PDM	-1.01	43.86**	6.91*	39.24**
Significance +ve	10	15	13	21
Significance-ve	7	8	11	2
Range of heterosis	-32.57 to 57.48	-24.55 to 61.21	-21.01 to 50.20	-13.30 to 64.41

*, ** significant at 5 or1% probability level.

Agriculture & Technology, Kumarganj, Faizabad (U.P.), India. The sowing was done with a 3.0 m for row length spaced 3.0 m apart where, 0.5 m plant to plant spacing was maintained. All the recommended agronomic package and practices, plant protection measures were followed to raise a good and healthy crop. Among the 14 characters the observations were recorded on plot basis for node number to anthesis of first staminate flower, node number to anthesis of first pistillate flower, days to anthesis of first staminate flower, days to anthesis of first pistillate flower, days to first fruit harvest, fruit length (cm), fruit diameter (cm), average fruit weight (g), number of fruits per plant, fruit yield per plant (kg), number of primary branches per plant, number of nodes per plant, inter-nodal length (cm) and vine length (m) data recorded on 10 randomly selected plants. The estimation of nature and magnitude of heterosis for yield and its components, expressed as percent increase or decrease by hybrids (F_1's) over better parent (heterobeltiosis) and standard parent heterosis was done as per the method of Fonseca and Patterson (1968) in F_1 over the better parent and over the best standard variety (PDM).

Results and Discussion

The estimates of heterosis were calculated as per cent of increase or decrease over better parent as well as standard variety for all the nine characters are presented in table 1. In the persesnt study, node number to anthesis of first pistillate flower had a high degree of heterosis in the 'NDBT-7' × 'Kalyanpur Sona' cross during summer and for the rainy season in the cross 'NDBT-13' × 'PDM'. The heterosis over better parent and standard variety for days to anthesis of first pistillate flower indicated 14 crosses had higher values over the better parent and 11 crosses over the standard variety in summer, and 15 crosses over better parent and 1 cross over standard variety had negative and significant heterosis. A high degree of heterosis occurred in 'NDBT-7' × 'Kalyanpur Sona' during summer and 'NDBT-2' × 'PDM' during the rainy season for days to anthesis of first pistillate flower. For days to first fruit harvest, 10 crosses had higher values over the better parent and standard variety and 16 crosses over the standard variety in summer and 12 crosses had higher values over the better parent and no cross was better than the standard variety in the rainy season. The highest standard heterosis was for 'NDBT-7' × 'Kalyanpur Sona' in summer.

For fruit length 3 crosses had higher values over the better parent and 7 crosses over the standard variety in summer and 4 crosses had higher values over the better parent and 15 crosses over the standard variety in the

Table 2 : Ranking of five desirable crosses based on *per se* performance and sca effects in F_1 generation for 14 characters during summer and rainy seasons in bitter gourd.

S. no.	Characters	Desirable crosses based on *per se* performance		Best specific combiners		Best parents based on *per se* performance and *sca* effects	
		Summer	Rainy	Summer	Rainy	Summer	Rainy
1.	Node no. to anthesis of first staminate flower	NDBT-1× K.Sona	NDBT-1× K.Sona	NDBT-19× NDBT-12	NDBT-4× PDM	-	NDBT-19× K.Sona
		NDBT-2× K.Sona	NDBT-4× PDM	NDBT-8× K.Sona	NDBT-19× K.Sona	-	NDBT-4 × PDM
		NDBT-3 × K.Sona	NDBT-13 × PDM	NDBT-4 × PDM	NDBT-6 × NDBT-12	-	-
		NDBT-3 × NDBT-12	NDBT-15× K.Sona	NDBT-13× NDBT-12	NDBT-8 × PDM	-	-
		NDBT-5 × PDM	NDBT-19× K.Sona	NDBT-6 × K.Sona	-	-	-
2.	Node no. to anthesis of first pistillate flower	NDBT-2 × PDM	NDBT-2 × PDM	NDBT-4 × NDBT-12	NDBT-4 × NDBT-12	NDBT-1 × PDM	NDBT-15 × K.Sona
		NDBT-1× K.Sona	NDBT-15× K.Sona	NDBT-13× K.Sona	NDBT-8 × K.Sona	-	-
		NDBT-2 × K.Sona	NDBT-1× K.Sona	NDBT-3 × NDBT-12	NDBT-19× K.Sona	-	-
		NDBT-1 × PDM	NDBT-2 × NDBT-12	NDBT-1 × PDM	NDBT-15 × K.Sona	-	-
		NDBT-2 × NDBT-12	NDBT-5×NDBT-12	-	-	-	-
3.	Days to anthesis of first staminate flower	NDBT-5× K.Sona	NDBT-1× K.Sona	NDBT-10× NDBT-12	NDBT-1× K.Sona	NDBT-3 × K.Sona	NDBT-1 × K.Sona
		NDBT-3 × K.Sona	NDBT-7 × K.Sona	NDBT-10 × PDM	NDBT-10 × PDM	NDBT-7× K.Sona	-
		NDBT-7 × K.Sona	NDBT-2× PDM	NDBT-8 × K.Sona	NDBT-10× 12	NDBT-8× K.Sona	-
		NDBT-8× K.Sona	NDBT-3× K.Sona	NDBT-3 × K.Sona	NDBT-6× PDM	-	-
		NDBT-1 × K.Sona	NDBT-5 × K.Sona	NDBT-7 × K.Sona	NDBT-15 × K.Sona	-	-
4.	Days to anthesis of first pistillate flower	NDBT-7 × K.Sona	NDBT-2 × PDM	NDBT-7 × K.Sona	NDBT-13 × PDM	NDBT-7 × K.Sona	NDBT-2 × PDM
		NDBT-2× K.Sona	NDBT-1 × K.Sona	NDBT-10 × PDM	NDBT-7 × K.Sona	NDBT-8 × NDBT-12	-
		NDBT-6 × K.Sona	NDBT-1× NDBT-12	NDBT-8 × NDBT-12	NDBT-15× K.Sona	-	-
		NDBT-2 × PDM	NDBT-2× NDBT-12	-	NDBT-19× K.Sona	-	-
		NDBT-8 × NDBT-12	NDBT-3 × NDBT-12	-	NDBT-2 × PDM	-	-
5.	Days to first fruit harvest	NDBT-7 × K.Sona	NDBT-2 × PDM	NDBT-7×K.Sona	NDBT-13×PDM	NDBT-2× PDM	-
		NDBT-2×K.Sona	NDBT-1×NDBT-12	NDBT-4×NDBT-12	NDBT-13×K.Sona	NDBT-4 × NDBT-12	-
		NDBT-2×PDM	NDBT-2× K.Sona	NDBT-2×PDM	NDBT-7×K.Sona	NDBT-7 × K.Sona	-
		NDBT-6×K.Sona	NDBT-2×NDBT-12	-	NDBT-6×PDM	-	-
		NDBT-4×NDBT-12	NDBT-1×NDBT-12	-	-	-	-

Table 2 continued....

Table 2 continued....

6.	**Fruit length (cm)**	NDBT-5×K.Sona	NDBT-13×K.Sona	NDBT-5×K.Sona	NDBT-3×PDM	NDBT-5 × K.Sona	-
		NDBT-19×PDM	NDBT-19×PDM	NDBT-7×NDBT-12	NDBT-4×K.Sona	NDBT-4×NDBT-12	-
		NDBT-13×PDM	NDBT-13×PDM	NDBT-19×NDBT-12	NDBT-15×NDBT-12	-	-
		NDBT-4×NDBT-12	NDBT-19×K.Sona	NDBT-2×K.Sona	NDBT-8×K.Sona	-	-
		NDBT-3×PDM	NDBT-10×PDM	NDBT-4×NDBT-12	NDBT-13×K.Sona	-	-
7.	**Fruit diameter (cm)**	NDBT-13× K.Sona	NDBT-13× K.Sona	NDBT-5× K.Sona	NDBT-5× K.Sona	NDBT-3 × PDM	NDBT-3 × PDM
		NDBT-3 × PDM	NDBT-3 × PDM	NDBT-15 × PDM	NDBT-8 × PDM	NDBT-5× K.Sona	NDBT-8 × PDM
		NDBT-5× K.Sona	NDBT-4×PDM	NDBT-3× PDM	NDBT-7× NDBT-12	NDBT-7 × NDBT-12	-
		NDBT-15× PDM	NDBT-8× PDM	NDBT-7× NDBT-12	NDBT-13× K.Sona	NDBT-13× K.Sona	-
		NDBT-7 × NDBT-12	NDBT-15 × PDM	NDBT-13 × K.Sona	NDBT-3 × PDM	NDBT-15× PDM	-
8.	**Average fruit weight (g)**	NDBT-13×PDM	NDBT-13× PDM	NDBT-8× PDM	NDBT-8× PDM	-	NDBT-15× NDBT-12
		NDBT-13×K.Sona	NDBT-13× K.Sona	NDBT-6× NDBT-12	NDBT-10× NDBT-12	-	-
		NDBT-15 ×K.Sona	NDBT-15 × K.Sona	NDBT-10 × NDBT-12	NDBT-6 × NDBT-12	-	-
		NDBT-15× NDBT-12	NDBT-15× NDBT-12	NDBT-7× NDBT-12	NDBT-7× NDBT-12	-	-
		NDBT-15× PDM	NDBT-15× PDM	NDBT-1× K.Sona	NDBT-5× K.Sona	-	-
9.	**Number of fruits per plant**	NDBT-10 × K.Sona	NDBT-19 × K.Sona	NDBT-3 × PDM	NDBT-15 ×NDBT-12	NDBT-13×NDBT-12	NDBT-10 × PDM
		NDBT-13×NDBT-12	NDBT-15× NDBT-12	NDBT-13× NDBT-12	NDBT-1× K.Sona	NDBT-19×PDM	NDBT-15× NDBT-12
		NDBT-19×PDM	NDBT-10× PDM	NDBT-1× K.Sona	NDBT-7× K.Sona	-	-
		NDBT-19 × K.Sona	NDBT-19 × NDBT-12	NDBT-7 × K.Sona	NDBT-10 × PDM	-	-
		NDBT-6× K.Sona	NDBT-15× K.Sona	NDBT-19× PDM	NDBT-3× PDM	-	-
10.	**Fruit yield per plant (kg)**	NDBT-13× NDBT-12	NDBT-13× PDM	NDBT-3×PDM	NDBT-15× NDBT-12	NDBT-19×PDM	NDBT-8× PDM
		NDBT-10× K.Sona	NDBT-15× NDBT-12	NDBT-1× K.Sona	NDBT-10× PDM	-	NDBT-15× NDBT-12
		NDBT-19 × PDM	NDBT-10 × PDM	NDBT-4 × NDBT-12	NDBT-1 × K.Sona	-	NDBT-10 × PDM
		NDBT-13× K.Sona	NDBT-19×NDBT-12	NDBT-19× PDM	NDBT-8× PDM	-	-
		NDBT-15× K.Sona	NDBT-8× PDM	NDBT-7× K.Sona	NDBT-7× K.Sona	-	-
11.	**No. of primary branches per plant**	NDBT-5 × PDM	NDBT-19 × NDBT-12	NDBT-19 × K.Sona	NDBT-1 × PDM	NDBT-1× K.Sona	NDBT-19× NDBT-12
		NDBT-13× NDBT-12	NDBT-5× NDBT-12	NDBT-1× K.Sona	NDBT-13× K.Sona	NDBT-2× PDM	-
		NDBT-2× PDM	NDBT-2× K.Sona	NDBT-13× NDBT-12	NDBT-10× NDBT-12	NDBT-13× NDBT-12	-
		NDBT-1 × K.Sona	NDBT-1 × K.Sona	NDBT-3 × NDBT-12	NDBT-8 × NDBT-12	-	-
		NDBT-5× NDBT-12	NDBT-12× NDBT-12	NDBT-2× NDBT-12	NDBT-19× NDBT-12	-	-

Table 2 continued....

Table 2 continued....

12.	No. of nodes per plant	NDBT-13 × PDM	NDBT-13× PDM	NDBT-7 × K.Sona	NDBT-7 × K.Sona	NDBT-10 × PDM	NDBT-2 × PDM
		NDBT-10 × PDM	NDBT-2 × PDM	NDBT-15 × PDM	NDBT-2 × PDM	-	NDBT-10× PDM
		NDBT-10 × NDBT-12	NDBT-13 × K.Sona	NDBT-10 × PDM	NDBT-15 × PDM	-	-
		NDBT-2 × PDM	NDBT-19 × K.Sona	NDBT-1 × K.Sona	NDBT-10 × PDM	-	-
		NDBT-13 × K.Sona	NDBT-10 × PDM	NDBT-10 × NDBT-12	NDBT-4 × NDBT-12	-	-
13.	Internodal length (cm)	NDBT-2 × K.Sona	NDBT-1 × PDM	NDBT-8 × K.Sona	NDBT-10 × PDM	-	-
		NDBT-1 × K.Sona	NDBT-1 × K.Sona	NDBT-10 × PDM	NDBT-8 × K.Sona	-	-
		NDBT-2 × NDBT-12	NDBT-1 × NDBT-12	NDBT-8 × NDBT-12	NDBT-8 × NDBT-12	-	-
		NDBT-2 × PDM	NDBT-2 × K.Sona	NDBT-15 × K.Sona	NDBT-13 × PDM	-	-
		NDBT-1 × NDBT-12	NDBT-2 × PDM	NDBT-10 × NDBT-12	NDBT-7 × PDM	-	-
14.	Vine length (m)	NDBT-19 × NDBT-12	NDBT-19 × NDBT-12	NDBT-8 × PDM	NDBT-8 × PDM	NDBT-10 × K.Sona	NDBT-8 × PDM
		NDBT-19 × K.Sona	NDBT-19 × PDM	NDBT-7 × K.Sona	NDBT-7 × K.Sona	NDBT-8 × PDM	NDBT-10 × K.Sona
		NDBT-13 × PDM	NDBT-13 × PDM	NDBT-4 × NDBT-12	NDBT-15 × PDM	-	-
		NDBT-8 × PDM	NDBT-10 × K.Sona	NDBT-10 × K.Sona	NDBT-4 × NDBT-12	-	-
		NDBT-10 × K.Sona	NDBT-8 × PDM	NDBT-2 × PDM	NDBT-10 × K.Sona	-	-

rainy season. A high degree of standard heterosis occurred in the 'NDBT-5' × 'Kalyanpur Sona' cross during summer and in 'NDBT-3' × 'PDM' in the rainy season. For fruit diameter 5 crosses had higher values over the better parent and 24 crosses over the standard variety during summer and 4 crosses had higher values over the better parent and standard variety. The highest degree of standard heterosis was for the 'NDBT-13' × 'Kalyanpur Sona' cross in both seasons. For average fruit weight four and eleven crosses in summer and seven crosses in rainy seasons had positive and significant heterosis over better parent and standard variety and the highest degree of standard heterosis was observed in the 'NDBT-13' × 'Kalyanpur Sona' cross in summer. The 'NDBT-13' × 'PDM' cross had the highest heterosis in both seasons. For number of fruit per plant heterosis was exhibited by seven and eleven crosses in summer and five and nine crosses in the rainy season. The highest standard heterosis for number of fruit per plant was for the 'NDBT-10' × 'Kalyanpur Sona' and 'NDBT-19' × 'PDM' crosses during summer and rainy seasons, respectively. For fruit yield per plant 7 and 12 crosses in summer and 4 and 9 crosses in the rainy season had positive and significant heterosis over the better parent and standard variety, respectively. For fruit yield per plant the most promising hybrids were 'NDBT-13' × 'NDBT-12', 'NDBT-10' × 'Kalyanpur Sona', 'NDBT-19' × 'PDM', 'NDBT-13' × 'Kalyanpur Sona' and 'NDBT-15' × 'Kalyanpur Sona' in summer and 'NDBT-13'× 'PDM', 'NDBT-15' × 'NDBT-12', 'NDBT-10' × 'PDM', 'NDBT-19' × 'PDM', 'NDBT-8' × 'PDM', 'NDBT-13' × 'NDBT-12' and 'NDBT-19' × 'NDBT-12' in the rainy season. Increased yield due to increased number of fruit per plant and fruit yield per plant in heterotic hybrids in bitter gourd agrees with Ram *et al*. (1997), Sundaram (2008), Maurya *et al*. (2009) and Jadhav *et al*. (2009). These are references and almost result is same but genotypes and crosses are different. For vine length 10 and 15 crosses had positive and significant heterosis over the better parent and standard variety respectively, in summer; 13 and 21 crosses had positive and significant heterosis over the better parent and standard variety, respectively, in the rainy season. The highest standard heterosis was for the 'NDBT-19' × 'NDBT-12' cross in summer and the 'NDBT-1' × 'Kalyanpur Sona' in the rainy season. These data agree with Singh *et al*. (2001), Sundaram (2007), Dey *et al*. (2008), Yadav *et al*. (2009) and Hedau and Sirohi (2004) in ridge gourd. Bitter gourd could be a better utilized for summer and rainy seasons than through expending time

and effort on development of improved varieties through simple selection.

The results discussed above indicated that hybrid variety of bitter gourd could be better preposition for summer and rainy seasons, where a breeder may choose to depend on the development of variety through selection to bring about effective improvement or hybridization that has great scope to boost yield per unit area by developing potential hybrid cultivars.

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