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Rajneesh
Department of Vegetable Science, ND University of Agriculture and Technology, Kumaranj, Faizabad Uttar Pradesh, India

VB Singh
Department of Vegetable Science, ND University of Agriculture and Technology, Kumaranj, Faizabad Uttar Pradesh, India

Correspondence
Rajneesh
Department of Vegetable Science, ND University of Agriculture and Technology, Kumaranj, Faizabad Uttar Pradesh, India

Exploitation of heterosis for growth and yield attributes in sponge gourd [*Luffa cylindrica* (Roem) L.]

Rajneesh and VB Singh

Abstract
The present study was conducted with the objective to find out the extent of heterobeltiosis and standard heterosis. The study comprised F_1 hybrids developed through diallel mating design (excluding reciprocals) with the crosses of 9 diverse lines of sponge gourd. The F_1 hybrids and their parents were evaluated for two consecutive years. The observations were recorded on growth and yield attributes. The heterosis for marketable fruit yield per plant ranged from -39.05 (P_1 x P_4) to 46.86 per cent (P_3x P_9) over better parent and over standard variety it varied from -34.55 (P_4 x P_7) to 48.02 per cent (P_3 x P_9) in Y_1. However, in case of Y_2 heterobeltiosis ranged from -32.65 (P_1 x P_4) to 44.81 per cent (P_3x P_9) and standard heterosis for fruit yield varied from -29.15 (P_4x P_7) to 44.81 per cent (P_3 x P_9). Out of 36 crosses five best heterotic crosses for marketable fruit yield per plant P_3 x P_9 (46.86 and 44.81 %) and P_2 x P_3 (26.42 and 27.19 %) were found common in both the years (Y_1 and Y_2) over better parent, while the crosses P_3 x P_9 (48.02 and 44.81%), P_6 x P_9 (44.06 and 38.14 %) and P_1 x P_8 (33.12 and 39.53 %) were found common over standard variety Pusa Chikni during both the years. Crosses P_3 x P_9, P_1 x P_8 and P_1 x P_2 were the best common crosses for fruit yield and number of fruits per plant over standard parent in both the seasons.

Keywords: heterobeltiosis, marketable fruit yield, sponge gourd

Introduction
Luffa [*Luffa cylindrica* (Roem) L. syn. *L. aegyptica* Mill.] commonly called as sponge gourd, loofah, vegetable sponge or dish cloth. It is one of the most important cucurbit, both as rainy and summer season vegetable which is grown throughout the country and world. It belongs to the family Cucurbitaceae with diploid chromosome number 2n = 2x = 26 which includes about 118 genera and 825 species. It originated in subtropical Asian region particularly India (Kalloo, 1993) [4]. *Luffa cylindrica* (L). and [*L. acutangula* (L.) Roxb.] are domesticated species. Sponge gourd is an annual and monoecious cucurbit plant. Among vegetables, cucurbits are associated with the origin of agriculture and dawn of human civilization. In food crops, cucurbits are largest producer of biological water and easily digestive and recommended even to sick and frail patients. Its flowers are yellow in colour and showy having five petals. Several workers have emphasized need of parental diversity in optimum magnitude to obtain superior hybrids/superior segregants, in the segregating generations (Varalakshmi *et al.*, 1994; Badade *et al.*, 2001 and Islam, 2004) [8, 1, 3], Therefore, efforts should be made to increase the wider use of existing diversity from germplasm collection.

Material and Methods
The experimental materials for the present study comprised of eight promising and diverse inbred lines/parents of sponge gourd selected on the basis of genetic variability from the germplasm stock maintained in the Department of Vegetable Science, N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) India. The selected parental lines *viz.*, NDSG-1 (P_1), NDSG-2 (P_2), NDSG-3 (P_3), NDSG-4 (P_4),NDSG-5 (P_5), NDSG-6 (P_6), NDSG-7 (P_7), NDSG-8 (P_8) and Pusa Chikni (P_9) (standard check) were crossed in all possible combinations, excluding reciprocals, during summer, 2014 to get 36 F_1 seeds for the study on heterosis, 15 fruit yield and yield attributing traits. The experiments were conducted in a Randomized Block Design (RBD) with three replications to assess the performance of 36 F_1 hybrids and their 9 parental lines. The crop was planted in rows spaced at 2.5 meters apart with a plant to plant spacing of 0.50 meter. The experiments were sown on 25th February, 2014 and 20 March, 2015. All the recommended agronomic package of practices and protection measures were followed to raise good crops. All the recommended agronomic package of practices and protection measures were followed to raise good crops.

Statistical Analysis

The magnitude of heterosis was studied using information on various quantitative and fruit quality traits. Heterosis expressed as per cent increase or decrease in the mean values of F_1's (hybrid) over better-parent (heterobiltiesis) and standard variety (standard heterosis) was calculated according to method suggested by Hayes *et al.* (1955) [2]. The formula used for estimation of heterosis is as follows:

(a) Heterobeltiosis (%) $$= \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

(b) Standard heterosis (%) $$= \frac{\overline{F_1} - \overline{SV}}{\overline{SV}} \times 100$$

Where,

$\overline{F_1}$ = mean value of F_1

$\overline{BP}$ = mean value of better-parent and

$\overline{SV}$ = mean value of standard variety

The significance of heterosis was tested by 't' tests as given below.

't' (Heterobeltiosis) = $$\frac{F_1 - BP}{SE}$$

't' (Standard heterosis) = $$\frac{F_1 - SV}{SE}$$

SE of heterosis over better-parent and standard variety = $\sqrt{Me/r}$

Table 1: Extent of per cent heterosis over better parent (BP) and one standard variety (SV) for 14 characters in sponge gourd (Y_1=2014 and Y_2=2015)

Crosses	Node number of male flower				Node number of female flower				Days for anthesis first male flower			
	BP		SV (Pusa Chikani)		BP		SV (Pusa Chikani)		BP		SV (Pusa Chikani)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
$P_1 \times P_2$	-23.50**	-14.03*	16.88*	15.12	-9.97	-10.89*	22.01**	18.76**	-4.42	-2.78	2.86	2.94
$P_1 \times P_3$	-10.00	0.00	37.51**	33.91**	-8.12	-13.16**	24.51**	15.74**	-1.77	5.84	5.71	12.07*
$P_1 \times P_4$	-25.00**	-25.58**	-19.79*	-30.89**	0.33	8.73	35.52**	20.12**	2.78	2.86	5.71	5.88
$P_1 \times P_5$	-12.07	-2.40	-5.96	-9.29	-17.17**	-23.29**	12.26	2.24	2.70	2.78	8.57	8.82
$P_1 \times P_6$	-20.50**	-6.45	21.47*	25.27**	-13.62**	-21.05**	17.06*	5.22	3.54	5.56	11.43*	11.76*
$P_1 \times P_7$	-20.45**	-6.45	21.54*	25.27**	-10.82*	-12.57*	20.86**	16.53**	6.19	16.67**	14.29**	23.53**
$P_1 \times P_8$	-7.42	-40.00**	-15.13	-35.21**	-6.68	-10.89*	26.46**	18.76**	2.78	5.56	5.71	11.76*
$P_1 \times P_9$	-12.91	-28.65**	-12.91	-28.65**	-14.16**	-37.97**	-14.16*	-37.97**	-2.86	2.94	-2.86	2.94
$P_2 \times P_3$	-19.80	-4.19	22.54**	28.29**	-22.76**	-30.74**	39.57**	7.85	-10.53*	-15.42**	-2.86	0.00
$P_2 \times P_4$	-20.71**	-6.98	-15.20	-13.61	-3.33	7.14	30.57**	18.37**	11.11*	20.00**	14.29**	23.53**
$P_2 \times P_5$	78.57**	106.89**	90.99**	92.30**	7.50*	8.82*	125.86**	86.06**	-8.11	-5.26	-2.86	5.88
$P_2 \times P_6$	-11.76**	-3.54	129.18**	137.58**	-9.39*	1.48	50.08**	44.67**	7.14	4.88	28.57**	26.47**
$P_2 \times P_7$	8.00	20.24**	106.26**	105.26**	-18.07**	-23.61**	76.24**	34.63**	-7.32	-7.14	8.57	14.71**
$P_2 \times P_8$	25.00**	26.00**	14.59	36.07**	-16.31**	-15.39**	26.01**	18.37**	-8.33	-5.41	-5.71	2.94
$P_2 \times P_9$	-15.13**	-13.61	-15.13	-13.61	-12.71**	-19.33**	-12.71	-19.33**	17.14**	17.65*	17.14**	17.65**
$P_3 \times P_4$	7.14	2.40	14.59	-4.90	11.11**	33.33**	50.08**	47.30**	-5.24	3.20	-2.53	6.24
$P_3 \times P_5$	17.93**	46.40**	26.13**	36.07**	-15.28**	-5.41	53.08**	47.30**	-2.70	0.00	2.86	11.76
$P_3 \times P_6$	55.00**	79.03**	136.82**	139.74**	-9.39*	-16.97**	50.08**	18.37**	-7.89	-7.96	0.00	8.82
$P_3 \times P_7$	14.00*	39.78**	74.18**	87.19**	-8.64*	-13.85**	65.08**	34.15**	5.61	2.33	14.67**	20.99**
$P_3 \times P_8$	-2.50	-18.00	-10.62	-11.45	39.53**	22.22**	110.11**	70.98**	-11.11*	-8.11	-8.57	0.00
$P_3 \times P_9$	-17.49**	-11.23	-17.49	-11.23	-20.41**	-21.09**	-20.41	-21.09**	3.20	3.28	3.20	3.28
$P_4 \times P_5$	-7.79	18.68	-1.38	10.22	22.22**	19.05**	65.08**	31.52**	-2.78	2.86	0.00	5.88
$P_4 \times P_6$	73.57**	69.84**	85.64**	57.74**	-2.22	10.75*	32.07**	22.36**	-10.81*	-5.40	-8.27	-2.62
$P_4 \times P_7$	-18.57**	-2.33	-12.91	-9.29	33.33**	30.95**	80.09**	44.67**	-2.78	5.71	0.00	8.82
$P_4 \times P_8$	25.00**	41.86**	14.59	31.75**	-5.52	10.71	27.61**	22.31**	-2.45	3.20	0.33	6.24
$P_4 \times P_9$	-15.13*	-4.57	-15.13	-11.38	-11.46**	-19.77**	-11.46	-19.77**	-6.03	-0.33	-6.03	-0.33
$P_5 \times P_6$	24.29**	44.07**	32.93**	33.91**	8.73*	1.48	80.09**	44.67**	10.81*	5.26	17.14*	17.65**
$P_5 \times P_7$	11.43	11.54	19.17*	3.67	7.14*	8.46*	125.11**	85.44**	8.83	3.32	15.05**	15.47**
$P_5 \times P_8$	0.00	-2.40	-8.33	-9.29	9.63*	-5.99	65.08**	31.52**	-8.03	-7.80	-5.40	0.33
$P_5 \times P_9$	-12.91*	4.65	-12.91	-2.74	-20.46**	-19.77**	-20.46*	-19.77**	0.33	6.24	0.33	6.24
$P_6 \times P_7$	-9.96	2.49	71.96**	74.95**	8.73*	19.93**	80.09**	70.98**	2.44	0.00	20.00**	20.59**
$P_6 \times P_8$	102.58**	64.00**	85.71**	77.11**	19.60**	3.42	80.09**	44.67**	-11.11*	-10.81*	-8.57	-2.94
$P_6 \times P_9$	-8.33	10.15	-8.33	10.15	-11.41**	-17.10**	-11.41	-17.10**	8.93	9.19	8.93	9.19
$P_7 \times P_8$	0.00	-13.93	-8.33	-7.06	49.50**	32.56**	125.11**	85.44**	5.56	2.70	8.57	11.76*
$P_7 \times P_9$	-10.62*	-4.61	-10.62	-4.61	-9.95	-9.21	-9.95	-9.21	6.07	12.14*	6.07	12.14*
$P_8 \times P_9$	2.58	-2.74	-5.96	-2.74	-14.46**	-21.09**	-14.46*	-21.09**	-5.71	2.94	-5.71	2.94
No. of crosses with significant positive heterosis	9	10	16	16	10	9	27	25	3	4	9	14
No. of crosses with significant negative heterosis	12	4	1	3	17	18	3	7	4	2	0	0
Range of heterosis	-25.00 to 102.58	-40 to 106.89	-19.79 to 136.82	-35.89 to139.74	-22.76 to 49.50	-37.97 to 33.33	-20.46 to 125.86	-37.97 to 86.06	-11.11 to 10.81	-15.42 to 20.00	-6.03 to 25.57	-2.94 to 23.53

Table 1: 1contd

Crosses	Days for anthesis first female flower				Days to First Marketable fruit harvest				Node No. to First Fruit harvest			
	BP		SV (Pusa Chikani)		BP		SV (Pusa Chikani)		BP		SV (Pusa Chikani)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
$P_1 \times P_2$	-2.56	1.56	1.69	-0.48	-5.77	-3.29	-2.65	-4.48	0.00	-8.88	32.79**	18.38**
$P_1 \times P_3$	1.20	11.11	5.61	8.88	0.00	-1.36	3.31	-2.57	-5.83	-11.18*	25.05**	15.38**
$P_1 \times P_4$	2.63	13.26	4.36	4.63	3.92	8.33	5.30	-0.66	0.33	4.66	32.79**	17.09**

$P_1 \times P_5$	-5.13	-1.04	-0.99	-3.03	0.00	-1.36	3.31	-2.57	-11.70*	-21.32**	17.25*	2.22
$P_1 \times P_6$	2.56	6.77	7.04	4.63	5.77	8.31	9.27	6.98	-11.41*	-19.08**	17.65*	5.13
$P_1 \times P_7$	5.13	9.37	9.71	7.18	7.69	10.24	11.26	8.89	-4.13	-12.57**	27.30**	13.59*
$P_1 \times P_8$	10.26	9.37	15.07	7.18	3.85	6.38	7.28	5.07	0.00	-7.89	32.79**	19.66**
$P_1 \times P_9$	7.04	1.56	7.04	-0.48	5.30	-0.77	5.30	-1.99	-11.47	-35.68**	-11.47	-35.68**
$P_2 \times P_3$	-22.22**	21.05**	-6.34	-8.13	2.47	-4.37	16.05**	7.04	-19.61**	-28.21**	47.06**	8.97
$P_2 \times P_4$	15.79*	24.31**	17.74*	14.83	7.84	12.50	9.27	3.16	-3.33	3.13	27.94**	15.38**
$P_2 \times P_5$	2.17	0.65	25.77**	17.39*	1.75	-2.72	15.23	8.89	7.50	7.99	121.32**	81.37**
$P_2 \times P_6$	-3.08	-0.23	12.39	9.73	-4.71	-3.85	7.28	5.07	-9.39	4.21	47.06**	44.83**
$P_2 \times P_7$	4.22	-3.06	28.28**	19.73**	5.26	0.69	19.21**	12.71*	-18.07*	-23.61**	72.70**	31.24**
$P_2 \times P_8$	4.88	-2.33	15.07	7.18	5.45	1.79	15.23*	8.89	-11.20*	-9.71	31.03**	23.12**
$P_2 \times P_9$	9.71	9.73	9.71	9.73	5.30	-0.66	5.30	-0.66	-11.47	-21.37**	-11.47	-21.37**
$P_3 \times P_4$	7.89	18.78*	9.71	9.73	11.76	16.67**	13.25*	6.98	11.11	28.34**	47.06**	43.59**
$P_3 \times P_5$	-4.44	-7.89	15.07	7.18	1.75	-1.69	15.23*	10.80	-18.01**	-5.41	50.00**	43.59**
$P_3 \times P_6$	-3.08	-0.23	12.39	9.73	2.35	3.15	15.23*	12.71*	-9.39	-16.97**	47.06**	15.38**
$P_3 \times P_7$	4.44	0.88	25.77**	17.39*	1.69	-2.64	19.21**	12.71*	-9.97	-13.85**	64.71**	30.77**
$P_3 \times P_8$	-2.44	-9.30	7.04	-0.48	-1.82	-1.79	7.28	5.07	39.53**	22.22**	105.88**	66.67**
$P_3 \times P_9$	-9.02	-8.13	-9.02	-8.13	-0.66	-2.57	-0.66	-2.57	-14.71*	-23.08**	-14.71	-23.08**
$P_4 \times P_5$	15.79*	24.31**	17.74*	14.83	7.84	16.67**	9.27	6.98	22.22**	16.88**	61.76**	30.77**
$P_4 \times P_6$	2.63	10.50	4.36	2.08	1.96	6.25	3.31	-2.57	-2.22	6.61	29.41**	19.27**
$P_4 \times P_7$	10.53	21.55**	12.39	12.28	13.73*	20.00**	15.23*	10.04	36.70**	26.05**	80.93**	41.03**
$P_4 \times P_8$	2.63	13.26	4.36	4.63	1.96	6.87	3.31	-2.00	-5.52	6.57	25.05**	19.23**
$P_4 \times P_9$	-6.34	2.21	-6.34	-5.58	-2.65	4.58	-2.65	-4.10	-10.29*	-16.67**	-10.29	-16.67**
$P_5 \times P_6$	1.54	0.46	17.74*	10.50	2.35	-0.17	15.23*	9.08	8.73*	3.32	76.47**	43.59**
$P_5 \times P_7$	1.44	5.03	25.77**	22.49**	5.26	5.08	19.21**	18.44**	7.14	7.63	120.59**	80.77**
$P_5 \times P_8$	-9.76	-9.30	-0.99	-0.48	-7.27	5.36	1.32	12.71*	13.62**	-2.23	67.65**	33.33**
$P_5 \times P_9$	9.71	7.18	9.71	7.18	5.30	-0.66	5.30	-0.66	-11.76*	-19.23**	-11.76	-19.23**
$P_6 \times P_7$	-7.69	-4.87	7.04	4.63	-4.71	-7.34	7.28	1.25	8.73	19.93**	76.47**	66.67**
$P_6 \times P_8$	0.00	-6.98	9.71	2.08	-3.64	-3.57	5.30	3.16	24.58**	6.24	83.82**	44.87**
$P_6 \times P_9$	7.04	4.63	7.04	4.63	3.31	1.25	3.31	1.25	-10.25	-17.95**	-10.25	-17.95**
$P_7 \times P_8$	-7.32	-9.30	1.69	-0.48	-7.27	-7.14	1.32	-0.66	49.50**	32.56**	120.59**	80.77**
$P_7 \times P_9$	17.74*	14.83*	17.74*	14.83	9.27	3.16	9.27	3.16	-7.30	-11.50	-7.30	-11.50
$P_8 \times P_9$	7.04	7.18	7.04	7.18	3.31	1.25	3.31	1.25	-11.76	-20.51**	-11.76	-20.51**
No. of crosses with significant positive heterosis	3	5	8	4	1	3	10	5	7	6	28	23
No. of crosses with significant negative heterosis	1	1	0	0	0	0	0	0	9	15	0	7
Range of heterosis	-22.22 to 17.74	-21.05	-9.02 to 28.28	-8.13 to 22.49	-7.27 to 13.73	-7.34 to 20.00	-2.65 to 19.21	-4.48 to 18.44	-19.61 to 49.30	-35.68 to 32.08	-14.71 to 121.32	-35.68 to 80.77

Table 1: contd

Crosses	Primary Branches/ Plant				Nodes Per Vine				Internodal Length (cm)			
	BP		SV (Pusa Chikani)		BP		SV (Pusa Chikani)		BP		SV (Pusa Chikani)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
$P_1 \times P_2$	15.38**	-20.31**	-37.50**	-52.73**	8.43	12.20	38.46**	43.75**	-8.10	-1.45	-19.15**	-13.08*
$P_1 \times P_3$	15.38**	-25.93**	-37.50**	-56.06**	18.75*	17.72*	46.15**	45.31**	20.48**	4.18	5.99	-8.11
$P_1 \times P_4$	5.56	8.71	-20.83**	-31.89**	40.26**	37.66**	66.15**	65.63**	-12.86	-4.27	-23.33**	-15.56**
$P_1 \times P_5$	15.38**	0.00	-37.50**	-40.68**	28.57**	30.99**	38.46**	45.31**	25.29**	26. 70**	10.22	11.75
$P_1 \times P_6$	-21.05**	-32.43**	-37.50*	-45.08**	18.31*	17.81	29.23**	34.38**	15.71*	25.29**	1.80	10.51
$P_1 \times P_7$	-20.00**	-24.24**	-50.00**	-45.08**	17.78*	14.13	63.08**	64.06**	30.05**	40.78**	14.41*	24.17**
$P_1 \times P_8$	-33.68**	-30.14**	-47.50**	-43.98**	3.41	8.14	40.00**	45.31**	15.76*	9.81	1.84	-3.15
$P_1 \times P_9$	-50.00**	-41.78**	-50.00**	-41.78**	25.71**	22.54**	35.38**	35.94**	6.19	-0.05	-6.58	-11.84
$P_2 \times P_3$	-25.00**	-13.95*	-62.50**	-59.36**	16.87*	17.07*	49.23**	50.00**	0.25	-2.21	0.80	-2.86
$P_2 \times P_4$	5.06	-1.81	-21.21**	-38.48**	27.71**	28.05**	63.08**	64.06**	1.25	1.25	1.80	0.58
$P_2 \times P_5$	0.00	-13.04*	-50.00**	-56.06**	21.69**	21.95**	55.38**	56.25**	1.29	16.29*	1.84	15.52**
$P_2 \times P_6$	-21.05**	-32.43**	-37.50*	-45.08**	19.28*	19.51*	52.31**	53.13**	-23.75**	-5.75	-23.33**	-6.37
$P_2 \times P_7$	16.00**	-30.30**	-27.50**	-49.47**	12.22*	11.96	55.38**	60.94**	-35.83**	-18.71**	-35.48**	-19.25**
$P_2 \times P_8$	-36.84**	-27.35**	-50.00**	-41.74**	34.09**	34.88**	81.54**	81.25**	9.58	0.00	10.18	-0.66
$P_2 \times P_9$	-25.00**	-28.56**	-25.00**	-28.56**	14.46*	13.41	46.15**	45.31**	-35.86**	-25.00**	-35.86**	-25.50**
$P_3 \times P_4$	-16.39**	-12.04	-37.29**	-44.89**	51.25**	51.90**	86.15**	87.50**	25.09**	16.04*	27.40**	16.76*
$P_3 \times P_5$	-10.00	-6.52	-62.50**	-52.76**	10.00	12.66	35.38**	39.06**	53.43**	35.87**	56.26**	36.71**
$P_3 \times P_6$	-21.05**	-22.97**	-37.50**	-37.39**	66.25**	68.35**	104.62**	107.81**	3.66	12.30	5.57	13.00*
$P_3 \times P_7$	-19.73**	-28.59**	-49.83**	-48.22**	12.22	10.87	55.38**	59.38**	12.34	1.69	14.41*	2.32
$P_3 \times P_8$	-40.00**	-41.14**	-52.50**	-52.80**	50.00**	51.16**	103.08**	103.13**	24.64**	11.31	26.94*	12.00
$P_3 \times P_9$	-49.83**	-22.85**	-49.83**	-22.85**	16.25	15.19	43.08**	42.19**	1.84	-3.15	1.84	-3.15
$P_4 \times P_5$	-16.67*	-21.04**	-37.50**	-50.53**	55.84**	53.25**	84.62**	84.38**	1.15	21.15**	14.41*	35.39**
$P_4 \times P_6$	-4.95	-1.04	-24.75**	-19.55**	11.69	14.29	32.31**	37.50**	1.11	1.11	14.37*	13.00*
$P_4 \times P_7$	-33.33**	-24.24**	-50.00**	-45.08**	-2.22	-6.52	35.38**	34.38**	23.37**	11.56	39.55**	24.67**
$P_4 \times P_8$	-20.79**	-36.76**	-37.29**	-49.29**	12.50	16.28*	52.31**	56.25**	-3.57	-6.67	1.80	4.30
$P_4 \times P_9$	-10.29	-21.16**	-10.29**	-21.16**	14.29	12.99	35.38**	35.94**	40.30**	24.17**	40.30**	24.17**
$P_5 \times P_6$	-21.05**	-32.43**	-37.50**	-45.08**	38.03**	32.88**	50.77**	51.56**	-9.00	-6.36	14.37*	27.90**
$P_5 \times P_7$	-19.47**	-28.33**	-49.67**	-48.04**	22.22**	18.48*	69.23**	70.31**	-9.33	-19.70**	13.95*	-0.29
$P_5 \times P_8$	-20.79**	-23.01**	-37.29**	-38.26**	18.18*	18.60*	60.00**	59.38**	33.89**	11.11	41.35**	24.17**
$P_5 \times P_9$	-24.75**	-41.45**	-24.75**	-41.45**	33.82**	34.78**	40.00**	45.31**	58.99**	36.59**	58.99**	36.59**
$P_6 \times P_7$	-21.05**	-32.43**	-37.50**	-45.08**	24.44**	19.57*	72.31**	71.88**	-17.27*	8.10	14.37*	34.23**
$P_6 \times P_8$	-2.11	-14.86*	-22.50**	-30.79**	0.00	0.00	35.38**	34.38**	4.37	8.89	10.18	21.69**

$P_6 \times P_9$	-24.75**	-15.12*	-24.75**	-15.12**	15.49	9.59	26.15*	25.00*	15.71**	15.48	15.71**	15.48**
$P_7 \times P_8$	-3.68	-13.74*	-23.75**	-30.83**	35.56**	35.87**	87.69**	95.31**	20.28**	14.48	26.98**	27.94*
$P_7 \times P_9$	-24.75**	-31.64**	-24.75**	-31.64**	36.67**	32.61**	89.23**	90.63**	-23.33**	-12.29	-23.33**	-12.29
$P_8 \times P_9$	-12.50	-19.85**	-12.50**	-19.85**	10.23	13.95	49.23**	53.13**	39.55**	24.17**	39.55**	24.17**
No. of crosses with significant positive heterosis	4	0	0	0	24	21	36	36	15	10	17	17
No. of crosses with significant negative heterosis	23	30	36	36	0	0	0	0	5	3	6	4
Range of heterosis	-50.00 to 16.00	-41.78 to 8.71	-62.50 to -10.29	-59.36 to -19.85	-2.22 to 66.25	6.52 to 68.35	29.23 to 104.62	25.00 to 107.81	-35.83 to 58.99	-25.00 to 40.78	-35.48 to 58.99	-25.50 to 36.71

Table 1: contd.

Crosses	Vine Length (m)				Fruit Length (cm)				Fruit Diameter (cm)			
	BP		SV (Pusa Chikani)		BP		SV (Pusa Chikani)		BP		SV (Pusa Chikani)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
$P_1 \times P_2$	-14.43*	-3.06	8.98	14.05	-6.74	-6.41	3.70	14.64**	-5.18	2.48	0.80	13.64*
$P_1 \times P_3$	2.35	-3.53	33.54**	19.61**	-13.16**	-6.68	-14.81**	-6.56	-4.38	-2.65	-4.88	7.95
$P_1 \times P_4$	6.76	8.63	31.94**	25.88**	-6.27	-0.76	0.37	2.08	-4.02	-19.04**	-4.53	-10.23
$P_1 \times P_5$	-21.35**	-16.40**	0.49	1.63	-4.67	-4.02	-4.56	6.01	-6.16	-12.64**	-6.66	-3.12
$P_1 \times P_6$	-17.05**	-11.96*	35.77**	33.33**	-10.04*	-11.26**	4.07	2.08	-11.16*	-5.12	3.91	10.51
$P_1 \times P_7$	-33.30**	-23.54**	23.94**	24.38**	-5.67	-12.57**	0.38	0.92	-5.86	-7.77	1.24	2.27
$P_1 \times P_8$	1.27	-5.73	44.61**	27.97**	-4.10	0.89	-5.93	1.02	-11.61	-5.72	-12.08	4.55
$P_1 \times P_9$	65.55**	39.67**	65.55**	39.67**	-11.11*	-7.84	-11.11*	-7.72	1.24	-7.77	1.24	2.27
$P_2 \times P_3$	36.00**	31.26**	77.45**	62.75**	-19.73**	-18.91**	-10.74*	-0.67	-7.27	-12.22*	-1.42	-3.41
$P_2 \times P_4$	24.64**	20.00**	58.73**	41.18**	-3.06	-2.87	7.79	18.98**	-22.22**	-17.90**	-17.32**	-9.66
$P_2 \times P_5$	14.76*	13.44*	46.62**	37.91**	-0.63	-1.79	10.49*	20.30**	-9.86	-14.72**	-4.17	-6.16
$P_2 \times P_6$	-11.99*	-8.07	44.05**	39.22**	-3.63	-2.14	11.49*	19.88**	-13.82**	-12.20*	0.80	2.27
$P_2 \times P_7$	-9.81*	-2.77	67.57**	58.17**	-0.85	-5.35	10.25*	15.94**	-6.52	-8.26	0.53	0.95
$P_2 \times P_8$	28.65**	19.84**	83.72**	62.68**	-9.73	-17.62**	0.38	0.92	-12.53*	-14.72*	-7.02	-6.16
$P_2 \times P_9$	21.69**	20.44**	54.98**	41.70**	-6.74	-8.00	3.70	12.69*	-7.18	-11.02	-1.33	-2.08
$P_3 \times P_4$	69.60**	53.40**	121.29**	90.20**	-13.25**	-23.78**	-7.10	-21.59**	-5.82	3.04	-9.41	-0.47
$P_3 \times P_5$	10.45*	-0.32	44.12**	23.59**	1.85	-3.40	1.98	6.69	-2.95	-12.76*	-6.66	-4.83
$P_3 \times P_6$	40.31**	34.66**	129.65**	103.92**	-16.76*	-13.65**	-3.70	-0.67	-15.64**	-7.32	-1.33	7.95
$P_3 \times P_7$	21.35**	14.54*	125.47**	86.34**	-19.34**	-24.92**	-14.16**	-13.34**	-0.91	0.00	6.57	7.95
$P_3 \times P_8$	75.44**	60.33**	150.52**	117.65**	-3.52	8.27	-28.27**	-18.60**	2.59	3.82	-1.33	0.28
$P_3 \times P_9$	16.85**	10.70	52.47**	37.25**	-10.81**	-8.72	-10.81*	-8.72	-4.09	-3.41	-4.09	-3.41
$P_4 \times P_5$	47.06**	48.39**	87.89**	80.39**	-6.04	-4.55	0.62	5.42	-8.04	-17.97**	-18.74**	-10.51
$P_4 \times P_6$	-20.41**	-8.03	30.27**	39.28**	-8.68*	-8.91*	5.65	4.79	-19.67**	-6.10	-6.04	9.37
$P_4 \times P_7$	15.77**	18.12**	115.10**	92.16**	0.30	-4.08	7.41	10.72*	-20.07**	-16.58**	-14.03*	-9.94
$P_4 \times P_8$	8.04	6.88	54.28**	45.10**	-17.52**	-7.70	-11.68*	-5.05	-7.94	-8.89	-28.95**	20.45**
$P_4 \times P_9$	-20.61**	-1.86	-1.88	13.73	-13.25**	2.71	-7.10	5.65	-12.08**	2.27	-12.08	2.27
$P_5 \times P_6$	-3.06	0.99	58.66**	52.94**	-3.96	-1.02	11.11*	13.86**	-11.54**	-19.51**	3.46	-6.25
$P_5 \times P_7$	15.77**	12.13	115.10**	82.42**	-6.22	-7.55	-0.20	6.71	-15.11**	-23.09**	-8.70	-16.10*
$P_5 \times P_8$	28.65**	2.60	83.72**	39.28**	-8.08	-21.53**	-7.96	-13.34**	-9.55	-22.92**	-20.07**	-15.91*
$P_5 \times P_9$	16.01**	11.29	48.23**	35.29**	-2.63	-7.51	-2.51	2.15	-6.66	-4.17	-6.66	4.55
$P_6 \times P_7$	-24.68**	-14.38*	39.94**	39.28**	-3.96	-1.36	11.11*	13.86**	-11.09**	-8.46	4.00	6.63
$P_6 \times P_8$	9.69	15.24*	79.54**	74.51**	-19.97**	-11.26**	-7.41	2.08	-15.34**	-14.55**	-0.98	-0.47
$P_6 \times P_9$	-20.92**	-9.37	29.44**	37.25**	-10.06*	-7.54	4.05	6.36	-13.44**	-21.95**	1.24	-9.09
$P_7 \times P_8$	0.00	0.08	85.80**	62.81**	-17.13**	-22.52**	-11.81*	-10.56*	-15.77**	-18.33**	-9.41	-11.84
$P_7 \times P_9$	7.87	18.12**	100.42**	92.16**	1.26	-4.44	7.77	10.30*	-10.82	-15.79*	-4.09	-9.09
$P_8 \times P_9$	8.19	2.55	54.49**	39.22**	-13.21**	-9.70	-13.21**	-9.70	-16.25**	-14.77*	-16.25**	-14.77*
No. of crosses with significant positive heterosis	17	14	33	33	0	0	5	10	0	0	0	1
No. of crosses with significant negative heterosis	10	4	0	0	15	11	9	5	15	18	6	4
Range of heterosis	-33.38 to 75.44	-23.54 to 60.33	-1.88 to 150.52	1.63 to 117.65	-19.97 to 1.85	-24.29 to 11.47	-28.27 to 11.49	-21.59 to 20.30	-22.22 to 2.59	-23.9 to 3.82	28.95 to 6.57	-20.45 to 13.64

Crosses	Fruits/ Plant				Average Fruit Weight (g)				Marketable Fruit Yield/ Plant (kg)			
	BP		SV (Pusa Chikani)		BP		SV (Pusa Chikani)		BP		SV (Pusa Chikani)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
$P_1 \times P_2$	-13.75**	-6.63	29.33**	38.62**	-3.42	-0.77	-21.32**	-16.40**	1.58	19.18**	42.63**	35.81**
$P_1 \times P_3$	-21.25**	-14.41**	18.09**	27.07**	18.03**	14.88**	-3.85	-3.22	-11.96**	18.37**	23.61**	34.88**
$P_1 \times P_4$	-47.50**	-37.75**	-21.27**	-7.59	-14.18**	-11.94**	-9.96*	-6.32	-39.05**	-32.65**	-14.42**	-23.26**
$P_1 \times P_5$	-40.00**	-37.75**	-10.03	-7.59	-12.06**	-3.63	-4.17	-0.52	-25.17**	-4.08	5.07	9.30
$P_1 \times P_6$	-17.50**	-16.35**	23.71**	24.18**	-15.68**	-7.90	-16.67**	-5.92	-18.62**	4.49	14.26**	19.07**
$P_1 \times P_7$	-38.75**	-40.46**	-8.15	-11.61	-5.97	-0.90	-11.59**	-5.94	-39.05**	-20.82**	-14.42**	-9.77
$P_1 \times P_8$	-12.50*	-11.30**	31.21**	31.69**	-6.25	3.84	-9.96*	-0.37	-5.19	22.45***	33.12**	39.53**
$P_1 \times P_9$	-10.00*	-6.63	34.96**	38.62**	-3.53	2.08	-3.53	2.08	1.58	14.29**	42.63**	30.23**
$P_2 \times P_3$	2.19	2.92	18.76**	20.08	23.45**	17.47**	-6.62	-6.05	26.42**	27.19**	27.42**	28.37**
$P_2 \times P_4$	-22.95**	-14.00**	-11.90*	-4.12	-15.27**	-11.81**	-11.11**	-6.18	-8.32	-15.21**	-9.19	14.42**
$P_2 \times P_5$	-16.39**	-15.54**	-4.40	-5.83	-7.93*	-2.55	0.33	0.59	9.60	16.59**	8.56	17.67**
$P_2 \times P_6$	0.00	5.47	14.34*	22.45**	-10.49*	-7.64	-11.54**	-5.66	-3.33	12.32**	19.49**	24.34**
$P_2 \times P_7$	-31.15**	-22.29**	-21.27**	-13.36*	-3.54	1.02	-9.31*	-4.12	-18.40**	-11.67*	-19.18**	-10.85*
$P_2 \times P_8$	4.92	11.40*	19.96**	24.20**	-9.23	-1.07	-12.82**	-5.09	20.16**	24.88**	19.02**	26.05**
$P_2 \times P_9$	-6.56	-5.72	6.84	5.12	-17.68**	-10.65	-17.68**	-10.65*	4.12	2.15	4.12	3.10
$P_3 \times P_4$	-32.26**	-34.65**	-21.27**	-23.76**	-9.57*	-6.18	-5.13	-0.19	-14.78**	-14.11**	-14.10**	-

												14.11**
$P_3 \times P_5$	-17.74**	-19.80**	-4.40	-6.43	-12.06**	-2.18	-4.16	0.97	7.08	-2.17	7.92	-2.17
$P_3 \times P_6$	1.61	-0.99	18.09**	15.52*	-22.17**	-12.31**	-23.08**	-10.43*	-11.15**	6.86	9.83	18.29**
$P_3 \times P_7$	6.45	7.44	23.71**	25.36**	-14.77**	-8.41	-19.87**	-13.07**	9.91	17.98**	10.78*	17.98**
$P_3 \times P_8$	3.23	-0.50	19.96**	16.10**	-19.91**	-7.51	-23.08**	-11.27**	1.42	3.72	2.22	3.72
$P_3 \times P_9$	17.74*	16.83**	36.83**	36.31**	-13.46**	-16.68**	-13.46**	-16.68**	46.86**	44.81**	48.02**	44.81**
$P_4 \times P_5$	18.18**	9.70	-26.90**	-28.38**	-11.76**	-11.32*	-3.85	-5.66	17.96**	12.50*	-6.34	-3.72
$P_4 \times P_6$	-21.31**	-19.90**	-10.03**	-7.01	-6.52	-12.05*	-1.92	-6.44	-15.77**	-3.08	4.12	7.29
$P_4 \times P_7$	10.00*	16.47*	-38.14**	-30.69**	-7.74	-5.75	-3.21	0.26	7.83	0.00	-34.55**	29.15**
$P_4 \times P_8$	-17.65**	-25.68**	-21.27**	-21.45**	-5.09	-8.42	-0.43	-2.57	-9.83	-8.99	-14.26**	-8.99
$P_4 \times P_9$	4.97	10.34	4.97	10.34	-9.57*	-18.22**	-5.13	-13.01*	14.26**	23.88**	14.26**	23.88**
$P_5 \times P_6$	-16.39**	-16.42	-4.40	-2.96	-4.51	-0.31	4.06	2.90	-6.79	8.40	15.21**	20.00**
$P_5 \times P_7$	18.18**	14.16	-26.90**	-25.47**	-10.20**	-3.18	-2.14	-0.06	-3.59	-5.80	-23.45**	19.38**
$P_5 \times P_8$	-5.88	-6.56	-10.03*	-1.23	-17.65**	-3.12	-10.26*	0.00	0.33	-1.09	-4.60	-1.09
$P_5 \times P_9$	-15.65**	-7.59	-15.65**	-7.59	-3.73	2.31	4.91	5.60	0.16	7.44	0.16	7.44
$P_6 \times P_7$	-21.31**	-23.86**	-10.03*	-11.61	-1.85	-2.54	-2.99	-0.45	-15.38**	-7.14	4.60	2.79
$P_6 \times P_8$	8.20	4.48	23.71**	21.29**	-9.20*	-3.04	-10.26*	-0.96	0.13	17.65**	23.77**	30.23**
$P_6 \times P_9$	13.11**	8.96	29.33**	26.49**	2.99	2.13	2.99	4.32	16.54**	24.79**	44.06**	38.14**
$P_7 \times P_8$	19.61**	7.10	14.34**	13.21	-3.23	4.23	-7.05	0.00	29.17**	12.71**	22.82**	12.71**
$P_7 \times P_9$	-10.03*	-0.65	-10.03**	-0.65	-3.21	0.45	-3.21	0.45	1.27	4.81	1.27	4.81
$P_8 \times P_9$	29.33**	19.69**	29.33**	26.51**	-13.46**	-18.93**	-13.46**	-18.93**	23.77**	30.23**	23.77**	30.23**
No. of crosses with significant positive heterosis	7	4	16	14	2	2	0	0	8	16	16	18
No. of crosses with significant negative heterosis	19	14	13	6	18	8	17	8	10	5	7	6
Range of heterosis	-47.50 to 29.33	-40.46 to 19.69	-38.14 to 36.83	-30.69 to 38.62	-17.68 to 2.99	-18.93 to 17.47	-23.08 to 4.06	-18.93 to 5.60	-39.05 to 46.86	-32.65 to 44.81	-34.65 to 48.02	-29.15 to 44.81

Results and Discussion

The exploitation of heterosis refers as the superiority of F_1 hybrid over its parent in terms of yield and its attributing traits. The exploitation of heterosis requires an intensive evaluation of germplasm to find out diverse donors with high nicking of genes and further identification of heterotic crosses. In the present study the estimates of heterosis over better parent (BP) and standard variety (SV) Pusa Chikni were calculated for thirty six F_1's in two years.

Perusal of table-1 revealed that nature and magnitude of heterosis differed for different traits and over seasons in various hybrid combinations. The heterobeltiosis for fruit yield per plant ranged from -39.05 (P_1 x P_4) to 46.86 per cent (P_3 x P_9) and over standard variety it varied from -34.55 (P_4 x P_7) to 48.02 per cent (P_3 x P_9) in Y_1. However, in case of Y_2 heterosis over better parent for fruit yield varied from -32.65 (P_3 x P_8) to 44.81 per cent (P_3 x P_9) and standard parent it varied from -29.15 (P_4 x P_7) to 44.81 per cent (P_3 x P_9). A wide range of variations in positive and negative direction of heterosis were also recorded for remaining traits in both the years. In contrast none of the crosses showed significant and desirable heterosis for all the traits. The above results are in conformity with the findings of Naliyadhara *et al.* (2007) [8], Sanandia *et al.* (2008) [7] and Sabina *et al* (2008) [6].

For maturity traits negative heterosis is desirable. Since hybrids with heterosis for earliness produce first fruit earlier as compared to parents, thereby increasing their productivity per day per unit area and as a consequence fetch good prices in the market by early supply of produce. A close examination of heterosis values of five maturity traits *viz*., days taken for anthesis first staminate and pistillate flower, node number to first staminate and pistillate flower, node number of first staminate and pistillate flower appearance and days to first fruit harvest, revealed that none of the hybrids exhibited significant and desirable heterosis in respect to better and standard parent for days to first harvest over seasons. However, top ranked crosses for fruit yield were almost at par for earliness and thereby showing good scope for early hybrids.

Our study further revealed that atleast one parent (P_1, P_3 and P_9) with early days to first fruit harvest was invariably involved in the three top ranked F_1 hybrids (P_3 x P_9, P_1 x P_8 and P_1 x P_2) for fruit yield over standard parent in both the seasons. Likewise, the top ranked F_1 (P_3 x P_9 and P_1 x P_2) for marketable fruit yield per plant over better parent also possessed both the early parent for days to first fruit harvest. Although the top ranked crosses were not significantly early for days to first fruit harvest over top/standard parent. Even though the earliness of parents as well as crosses were directly associated with the crosses having high magnitude of heterosis. It may therefore, safely be concluded that either of parents, P_1, P_3, P_4 and P_9 or any two of them may be a better choice in any heterosis breeding programme intended to breed high yielding hybrids with considerable earliness. The present observations are in agreement with the findings of Sabina *et al.* (2008) [6] Bin sponge gourd and Yadav and Kumar (2012) in bottle gourd.

Eight crosses over better parent and fourteen crosses over standard parents showed significant heterosis in both the years for fruit yield. Increased yield in crosses of sponge gourd observed in present investigation is in conformity with the findings of various workers (Naliyadhara *et al.* (2007) [8], Sanandia *et al.* (2008) [7] and Sabina *et al.* (2008) [6]. Fruit yield per plant being complex trait is a multiplicative product of several basic component traits of yield. The improvement in heterosis for yield component may not necessarily be reflected in increased yield. Contrarily the increased fruit yield will definitely be cause of increase in one or more component traits. In the present study, the best performing heterobeltiotic F_1 (P_3 x P_9) for yield common over seasons also showed significant and top ranked heterobeltiosis for number of fruits per plant in both the seasons. This hybrid also showed significant and desirable heterosis for fruit length and average fruit weight. Likewise, out of six crosses found significant heterotic over standard parent common over both the seasons, only one crosses showed significant standard heterosis for number of fruits per plant in both the seasons. Among top heterotic crosses some of the parents were more frequently involved. The above findings indicated that some inbreds had more heterotic capability compared to other ones during hybridization process. As the performance of hybrids depends upon the heterotic capability of parents involved, from economic point of view it will be useful to select and utilize the parental inbreds with strong heterotic capability for important economic traits associated with yield in order to achieve higher gains in F_1 hybrids through exploitation of heterosis.

Five crosses on the basis of desirable significant heterobeltiosis, *per se* performance and common crosses for fifteen traits in both the years revealed that common crosses on the basis of *per se* performance and better parent heterosis for marketable fruit yield per plant was P_3 x P_9 common during both the years. The extent of heterosis of five best crosses (33.12 to 48.02% and 34.88 to 44.81) in year Y_1 and Y_2 respectively for fruit yield per plant revealed that there was a great scope of realizing higher yield in sponge gourd through heterosis breeding.

Since, earliness, desirable fruit shape, size, colour, number of fruits and fruit yield are important consideration for choice of elite high yielding F_1 hybrids. The decision for final selection of a hybrids for commercial cultivation should also take into account the earlier mentioned features. Out of five top ranking hybrids based on fruit yield over seasons, the three best common hybrids were P_3 x P_9, P_1 x P_8 and P_1 x P_2 which exhibited high standard heterosis of 48.02 and 44.81 per cent, 44.06 and 39.53 per cent and 42.63 and 35.81 per cent in Y_1 and Y_2, respectively. These three top hybrids were also at par for earliness and produced first fruit within 50.00 and 51.00 days (P_3 x P_9), and 49.00 and 50.00 days (P_1 x P_2). Perusal of Table 1 showed that out of 36 F_1's very less number of hybrids *viz*. P_1 x P_3, P_1 x P_4, P_1 x P_5, P_1 x P_7, P_2 x P_3, P_2 x P_4, P_2 x P_5, P_2 x P_8, P_4 x P_6, P_4 x P_7, P_5 x P_7, P_6 x P_8 and P_7 x P_8 beared desirable attractive fruits. Therefore, making the three footer criteria *ie*. fruit yield, earliness and fruit shape of the hybrids, P_3 x P_9, P_1 x P_2 and P_1 x P_8 should be selected for promotion towards commercial cultivation.

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