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Heterosis studies in bottle gourd [*Lagenaria siceraria* (Mol.) Standley.]

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ABSTRACT

A field experiment was conducted at Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India in experimental fields of horticultural research station during spring summer seasons of 2015, 2016 and 2017 with three replications in a Randomized Block Design. Studies were conducted to assess heterosis for yield and yield traits in bottle gourd. The crossing was performed in 6 x 6 half diallel fashion and fifteen hybrids were realized, out of which, four hybrids demonstrated significant heterosis on top of the better parent for yield trait per vine. The four crosses in the order of their performance were Pusa Sandesh x Arka Bahar, RJBGC-140 x Pusa Samridhi, BOGVAR-2 x Arka Bahar and Arka Bahar x RJBGC-140, which may be utilized for commercial trials after undergoing stability analysis.

***Keywords*:** Bottle gourd, heterobeltiosis, relative heterosis, quantitative traits.

Bottle gourd [*Lagenaria siceraria* (Mol.) Standley.] has chromosome number 2n = 22. The tender fruit is harvested and utilized for culinary purposes.Bottle gourd-based pickles, sweets, smoothies, sauces *etc*. are widely consumed in India. In many parts of the country tender shoots with green leaves are used as potherbs. It is highly nutritious food and rich source of vital nutrients such as proteins, carbohydrates, vitamins and minerals. Due to its nutritional benefits bottle gourd has been used in preparation of energy rich diets.

The crop is cross pollinated and is monoecious in nature. Exploitation of heterosis is far easier in this crop due to large flower size, easy pollination which provides ample scope for utilization of hybrid vigour on commercial scale.Therefore, the present investigation was undertaken to study the nature and magnitude of heterosis in bottle gourd for yield and yield attributing traits by half diallel design.

MATERIALS AND METHODS

The 21 genotypes of bottle gourd were sown during spring summer season, 2015, replicated in thrice and laid out in Randomized Block Design (RBD) in experimental fields of Horticultural Research Station, at Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India.Six promising and diverse inbred lines or varieties of bottle gourd such as BOGVAR-2, Pusa Sandesh, RJBGC-140, RJBGC-118, Pusa Samridhi and Arka Bahar were selected as parents on the basis of quality trait of superior mean performance for fruit yield and yield component traits, genetic distances and clustering pattern and crossing was done in 6 x 6 half diallel analysis and produced 15 hybrids during spring summer season, 2016. The 15 F_1 hybrids as well as 6 parental lines were evaluated during 2017 spring summer season with 3 replications in RBD by adopting 3 x 1.5m spacing.

The field observations were recorded on random basis on selected five equally competitive plants in each cross/genotype from every replication for the quantitative yield and yield traits such as days to first female and male flower appearance and 100 seed weight on whole plot basis. Heterosis expressed as per cent increase or decrease in the mean values of F_1's (hybrid) over mid parent (Relative heterosis) and over better-parent (heterobeltiosis) was calculated according to method suggested by Hayes *et al.* (1955).

$$\text{Relative heterosis } (h_1) = \frac{\overline{F_1} - \overline{MP}}{\overline{MP}} x100$$

Where, F_1 = Mean of F_1

MP = Mean of parents

$$\text{Heterobeltiosis } (h_2) = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} x100$$

Where,F_1= Mean of F_1

BP = Mean of better parent

The total soluble solids (TSS) of bottle gourd were measured using ERMA Hand Refractometer. Sugar content in the fruit was determined by Anthrone method as adopted by Dubois *et al*. (1956) and Vitamin-C content of the fruit pulp was estimated by 2, 6 dichlorophenol indophenol dye reduction method developed by Ranganna (1986).

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RESULTS AND DISCUSSION

Heterosis was estimated for yield and yield contributing characters in 15 hybrids and was expressed as increase or decrease over mid parental (MP) value as relative heterosis and over better parent (BP) as heterobeltiosis. The range and the magnitude of heterosis estimated over better-parent (heterobeltiosis) and mid-parent (relative heterosis) is depicted in Table 1. The negative results of heterosis were appraised as desirable for all maturity traits such as days to first male and female flower appearance and days to first fruit picking, sex ratio (M/F) and seed number per fruit. In spite of that, for rest of the traits positive estimates of heterosis was considered as promising characters.

In case of vine length, among 15 crosses two exhibited positive significant heterosis over mid parent *viz.*RJBGC-140 x Pusa Samridhi (15.70%) and Pusa Sandesh x Arka Bahar (5.19%). Cross combination *i.e.,*Arka Bahar x RJBGC-140 (3.88%) exhibited positive significant heterosis over the better parent.

For days to first male flower appearance, relative heterosis varied from -26.98 (Pusa Sandesh x Arka Bahar) to 23.09% (Pusa Sandesh x RJBGC-118). Significant negative relative heterosis was recorded in eleven hybrids. The extent of heterobeltiosis varied from -30.69 (Pusa Sandesh x RJBGC-140) to 24.75% (BOGVAR-2 x Pusa Sandesh). In case of days to first female flower appearance, relative heterosis ranged from -28.49 (Pusa Sandesh x RJBGC-140) to 9.20% (Arka Bahar x RJBGC-118). Significant negative relative heterosis was recorded in thirteen hybrids. In hybrids, heterobeltiosis ranged from -35.02 (Pusa Sandesh x RJBGC-140) to 25.69% (BOGVAR-2 x RJBGC-140). Eleven hybrids showed significant desirable negative heterobeltiosis. Selection of hybrids showing negative heterosis over their better-parents for this trait might be useful for developing early commercial hybrids. Negative heterobeltiosis for this character has also been recorded by Sanjay *et al.* (2012) and Yadav and Kumar (2012). For days to first harvest, the relative heterosis ranged from -25.58 (Pusa Sandesh x RJBGC-140) to 1.93% (RJBGC-118 x Pusa Samridhi). The range of heterobeltiosis was from -32.29 (Pusa Sandesh x RJBGC-140) to 6.20% (RJBGC-140 x RJBGC-118), which are synonymous to the findings of Sanjay *et al.* (2012) and Singh *et al.* (2012).

The number of fruits harvested per vine is a determinant of yield in respect of hybrids wherein

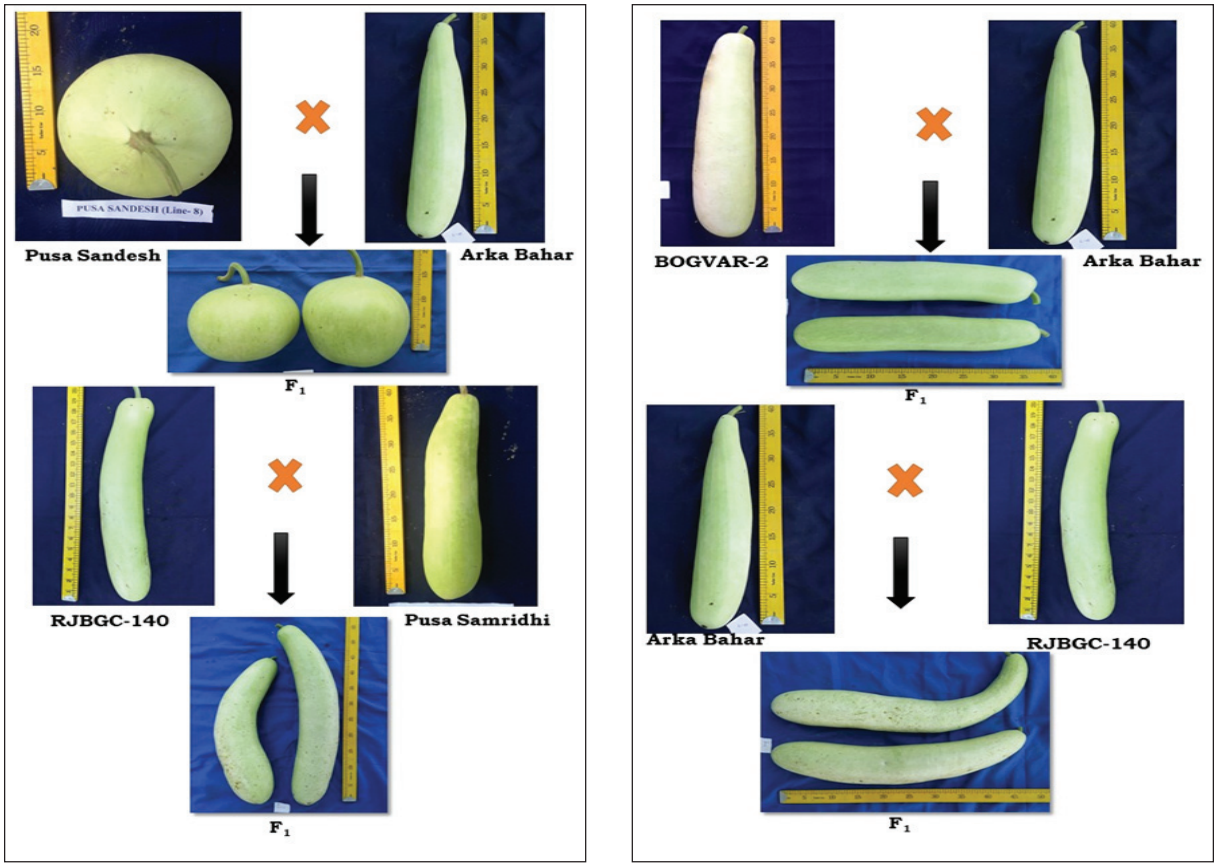

Fig 1: Best cross combinations in the present study

Table 1. : Heterosis (%) over mid parent and better parent different yield contributing characters of bottle gourd along with yield

Sl.No	Crosses	Vine length (m)		Number of primary branches		Days to first male flower appearance		Days to first female flower appearance	
		MP	BP	MP	BP	MP	BP	MP	BP
1.	BOGVAR-2 x Pusa Sandesh	-24.35**	-26.93**	-25.60**	-29.54**	-23.69**	24.75**	-24.54**	25.28**
2.	BOGVAR-2 x Arka Bahar	-5.64**	21.66**	-12.42**	-23.13**	-14.95**	-15.74**	-17.08**	-19.15**
3.	BOGVAR-2 x RJBGC-140	-35.27**	-47.05**	-28.09**	-34.95**	19.20**	24.55**	-18.96**	25.69**
4.	BOGVAR-2 x RJBGC-118	-37.40**	-48.21**	-34.60**	-39.92**	-23.59**	-28.49**	-26.92**	-32.44**
5.	BOGVAR-2 x Pusa Samridhi	-14.69**	-19.95**	-23.60**	-24.80**	-25.04**	-28.50**	-19.81**	-25.44**
6.	Pusa Sandesh x Arka Bahar	3.86**	16.12**	5.19**	-20.57**	-26.98**	-28.66**	-20.91**	-23.62**
7.	Pusa Sandesh x RJBGC-140	-34.42**	-47.78**	-26.26**	-36.45**	-24.81**	-30.69**	-28.49**	-35.02**
8.	Pusa Sandesh x RJBGC-118	-29.22**	-43.02**	-21.30**	-31.19**	23.09**	-28.95**	-14.56**	-21.72**
9.	Pusa Sandesh x Pusa Samridhi	-18.03**	-20.45**	-21.67**	-24.68**	-24.38**	-28.82**	-14.27**	-21.01**
10.	Arka Bahar x RJBGC-140	-1.53	-3.34*	-0.57	3.88*	-6.89**	-12.28**	-8.95**	-14.52**
11.	Arka Bahar x RJBGC-118	-25.21**	-25.53**	-31.72**	-35.05**	-4.64*	-9.96**	9.20**	-14.03**
12.	Arka Bahar x Pusa Samridhi	21.27**	-4.26**	-2.85	-15.89**	-12.53**	-15.80**	-10.00**	-14.29**
13.	RJBGC-140 x RJBGC-118	-24.13**	-25.21**	-26.51**	-27.74**	0.41	0.17	-5.49**	-6.34**
14.	RJBGC-140 x Pusa Samridhi	27.50**	-0.70	15.70**	3.19	-4.76**	-6.87**	-0.31**	11.66**
15.	RJBGC-118 x PusaSamridhi	-4.54**	-24.88**	-20.09**	-27.65**	-1.01	-2.97	6.60**	7.18**
	SEd±	**0.110**	**0.127**	**0.099**	**0.114**	**0.798**	**0.922**	**0.283**	**0.327**

**Significant at 5% level, ** Significant at 1%level, MP-Mid Parent and BP-Better Parent*

Contd.

Table 1 Contd.

Sl.No	Crosses	Days to first harvest		Number of fruits per vine		Average fruit weight (kg)		Fruit length (cm)	
		MP	BP	MP	BP	MP	BP	MP	BP
1.	BOGVAR-2 x Pusa Sandesh	-21.79**	-25.03**	-17.08**	-23.19**	-25.41**	-35.00**	69.81**	16.45**
2.	BOGVAR-2 x Arka Bahar	-15.79**	-17.00**	35.25**	32.59**	-1.64	7.38*	5.51**	3.58*
3.	BOGVAR-2 x RJBGC-140	-15.26**	-19.77**	-20.27**	-26.09**	-12.26**	-19.05**	-25.34**	-33.28**
4.	BOGVAR-2 x RJBGC-118	-21.80**	-25.54**	-1.32	-8.71**	-17.86**	-25.00**	-16.39**	-29.26**
5.	BOGVAR-2 x Pusa Samridhi	-8.98**	-20.02**	3.66	2.72	-22.16**	-22.62**	11.79**	10.32**
6.	Pusa Sandesh x Arka Bahar	-21.00**	-23.20**	40.22**	27.54**	7.17	-1.35	-36.39**	-55.93**
7.	Pusa Sandesh x RJBGC-140	-25.58**	-32.29**	-17.78**	-17.85**	-34.93**	-38.87**	-55.44**	-71.20**
8.	Pusa Sandesh x RJBGC-118	-15.19**	-22.42**	-19.78**	-19.90**	-37.78**	-40.92**	-60.99**	-75.48**
9.	Pusa Sandesh x Pusa Samridhi	-8.04**	-22.08**	-18.53**	-23.89**	-28.75**	-37.59**	-36.24**	-55.95**
10.	Arka Bahar x RJBGC-140	-10.72**	-16.62**	20.30**	9.50**	10.47**	8.09*	23.37**	8.47**
11.	Arka Bahar x RJBGC-118	-10.79**	-16.22**	-11.82**	-19.90**	9.47**	5.93	7.96**	-10.03**
12.	Arka Bahar x Pusa Samridhi	-3.29**	-16.07**	21.37**	17.93**	-4.07	-9.16*	15.20**	14.60**
13.	RJBGC-140 x RJBGC-118	-5.63**	6.20**	-3.91	-4.13	-7.69*	-8.73*	-29.77**	-34.02**
14.	RJBGC-140 x Pusa Samridhi	-0.04	-7.65**	21.56**	13.65**	1.82	-5.54	24.93**	10.35**
15.	RJBGC-118 x Pusa Samridhi	1.93**	-6.35**	-0.86	-7.51**	-9.45**	-16.87**	-1.08	-17.22**
	SEd±	**0.337**	**0.389**	**0.151**	**0.174**	**0.041**	**0.047**	**0.450**	**0.520**

**Significant at 5% level, ** Significant at 1%level, MP-Mid Parent and BP-Better Parent*

Contd.

Table 1 Contd.

Sl.No	Crosses	Fruit width (cm)		Fruit yield/vine (kg)		Sex ratio (M/F)		Seed number/fruit	
		MP	BP	MP	BP	MP	BP	MP	BP
1.	BOGVAR-2 x Pusa Sandesh	-35.49**	-53.62**	-37.36**	-41.39**	134.10**	132.26**	-11.23**	-15.59**
2.	BOGVAR-2 x Arka Bahar	-10.84**	-12.27**	32.81**	22.76**	-11.24**	-15.19**	-27.15**	-38.79**
3.	BOGVAR-2 x RJBGC-140	18.83**	8.67**	-29.76**	-30.12**	64.36**	31.99**	13.92**	12.13**
4.	BOGVAR-2 x RJBGC-118	23.09**	4.52	-18.26**	-19.40**	53.03**	21.33**	9.39**	5.55**
5.	BOGVAR-2 x Pusa Samridhi	-7.63**	-11.44**	-19.23**	-19.48**	96.22**	95.91**	-3.63**	-6.01**
6.	Pusa Sandesh x Arka Bahar	-5.18**	-32.51**	51.54**	49.58**	-12.88**	-16.12**	-31.28**	-44.55**
7.	Pusa Sandesh x RJBGC-140	8.65**	-25.96**	-46.53**	-49.74**	88.16**	52.01**	-18.30**	-21.12**
8.	Pusa Sandesh x RJBGC-118	-6.40**	-38.90**	-50.16**	-52.75**	100.19**	59.66**	-24.24**	-25.39**
9.	Pusa Sandesh x Pusa Samridhi	-0.35	-26.40**	-41.30**	-45.24**	112.63**	110.63**	-3.69**	-6.16**
10.	Arka Bahar x RJBGC-140	-1.38	-8.45**	33.16**	23.66**	-30.79**	-42.37**	-22.52**	-35.73**
11.	Arka Bahar x RJBGC-118	32.93**	14.41**	-3.13	-9.28*	6.51*	-12.50**	-9.57**	-26.18**
12.	Arka Bahar x Pusa Samridhi	-0.87	-6.43**	16.20**	7.10	17.51**	12.11**	-31.90**	-43.93**
13.	RJBGC-140 x RJBGC-118	-1.71	-9.47**	-11.30**	-12.09**	-14.50**	-15.94**	6.48**	4.34**
14.	RJBGC-140 x Pusa Samridhi	-5.78*	-17.06**	24.49**	23.48**	-26.99**	-41.44**	-26.07**	-26.76**
15.	RJBGC-118 x Pusa Samridhi	-18.58**	-33.21**	-9.61**	-11.14**	26.47**	0.15	-0.87	-1.96
	SEd±	**0.210**	**0.242**	**0.324**	**0.374**	**0.186**	**0.215**	**4.843**	**5.592**

**Significant at 5% level, ** Significant at 1%level, MP-Mid Parent and BP-Better Parent*

Table 2: The range and the magnitude of heterosis over mid parent and better parent for qualitative traits

Sl.No	Crosses	TSS of the pulp (^{0}Brix)		Total sugar content (%)		Ascorbic acid content (mg/100g)	
		MP	BP	MP	BP	MP	BP
1.	BOGVAR-2 x Pusa Sandesh	3.33**	2.39	2.60**	0.61	10.78**	4.37**
2.	BOGVAR-2 x Arka Bahar	6.42**	3.49**	-11.03**	-15.71**	16.46**	0.30
3.	BOGVAR-2 x RJBGC-140	13.90**	9.72**	-6.98**	-13.14**	18.77**	11.94**
4.	BOGVAR-2 x RJBGC-118	12.46**	-1.47	10.08**	2.02**	27.25**	19.17**
5.	BOGVAR-2 x Pusa Samridhi	-7.73**	-8.56**	21.72**	-7.32**	33.73**	33.12**
6.	Pusa Sandesh x Arka Bahar	4.10**	2.15	-3.34**	-6.67**	-5.42**	-14.08**
7.	Pusa Sandesh x RJBGC-140	11.35**	8.22**	-15.14**	-19.28**	14.77**	14.72**
8.	Pusa Sandesh x RJBGC-118	-5.71**	-16.73**	6.27**	-3.28**	9.89**	9.19**
9.	Pusa Sandesh x Pusa Samridhi	-8.62**	-10.27**	28.11**	-3.76**	12.72**	5.74**
10.	Arka Bahar x RJBGC-140	3.04	2.04	-17.58**	-18.84**	10.52**	0.36*
11.	Arka Bahar x RJBGC-118	32.65**	19.13**	-4.93**	-16.16**	5.68**	-3.44**
12.	Arka Bahar x Pusa Samridhi	-8.32**	-11.62**	23.48**	-9.38**	2.97**	-11.67**
13.	RJBGC-140 x RJBGC-118	33.22**	20.69**	5.35**	-8.32**	-4.95**	-5.59**
14.	RJBGC-140 x Pusa Samridhi	-3.21*	-7.57**	24.94**	-9.20**	13.16**	6.19**
15.	RJBGC-118 x Pusa Samridhi	53.16**	33.15**	42.20**	14.64**	19.61**	11.54**
	SEd±	**0.048**	**0.056**	**0.013**	**0.015**	**0.014**	**0.016**

**Significant at 5% level, ** Significant at 1%level,MP-Mid Parent and BP-Better Parent*

positive heterosis are preferable. The range of relative heterosis was from -20.27 (BOGVAR-2 x RJBGC-140) to 40.22% (Pusa Sandesh x Arka Bahar) with 5 hybrids exhibiting significantly positive relative heterosis. The heterobeltiosis ranged from -26.09 (BOGVAR-2 x RJBGC-140) to 32.59% (BOGVAR-2 x Arka Bahar) and five hybrids recorded positive significant heterobeltiosis. Similar positive significant heterosis for number of fruits per vine in bottle gourd was reported by Sanjay *et al.* (2012) and Yadav and Kumar (2012).

In case of average fruit weight, relative heterosis ranged from -37.78 (Pusa Sandesh x RJBGC-118) to 10.47% (Arka Bahar x RJBGC-140). Significant positive relative heterosis was recorded in two hybrids for average fruit weight. Heterobeltiosis ranged from -40.92 (Pusa Sandesh x RJBGC-118) to 8.09% (Arka Bahar x RJBGC-140) and two hybrids exhibited significant positive heterobeltiosis. Positive heterosis for this character has also been recorded by Sanjay *et al.* (2012) and Yadav and Kumar (2012). Singh *et al.*(2005) stated that fruit yield per vine was a complex trait and was a reproductive product of many basic component traits.The increased yield may not be correlated to the improvement in heterosis for yield component. In contradiction to the above statement Pandit *et al.*, 2009 stated that the increased fruit yield was due to increase in one or more component traits. In the present study, maximum positive heterosis over the mid parent was observed in the cross Pusa Sandesh x Arka Bahar (51.54%) followed by Arka Bahar x RJBGC-140 (33.16%). Maximum positive and significant heterosis over the better parent was observed in the cross BOGVAR-2 x Pusa Sandesh (49.58%) followed by RJBGC-140 x Pusa Samridhi (23.66%). Out of 15 crosses, five crosses over mid parent and four crosses over the better parent showed positive and significant heterosis for the trait under consideration. These results are in conformity with the results of Sanjay *et al.* (2012) and Yadav and Kumar (2012).

The range and the magnitude of heterosis over mid parent and better parent for qualitative traits is depicted in Table 2. The better cross combination derived from this investigation RJBGC-118 x Pusa Samridhi is showing the maximum extent of heterosis for TSS (53.16 % over mid parent and 33.15% over better parent) and for total sugar content of the pulp (42.20% over mid parent and 14.64% over better parent) respectively. And the cross combination BOGVAR-2 x Pusa Samridhi was showing the maximum extent of heterosis (33.73% over mid parent and 33.12% over better parent) for ascorbic acid content of the pulp. The positive and significant heterosis for this character was also studied by Sit and Sirohi (2002).

Diverse range of heterosis was exhibited by all the 15 hybrids for all the yield traits. Out of these 15 hybrids, four hybrids (Fig 1) exhibited marked positive heterosis over the better parent for fruit yield per vine. The four crosses in the order of their merit are Pusa Sandesh x Arka Bahar, RJBGC-140 x Pusa Samridhi, BOGVAR-2 x Arka Bahar and Arka Bahar x RJBGC-140, which

could be explored for commercial cultivation. However, the promising hybrids need to be studied over locations and seasons for stability before commercial cultivation.

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