The Pharma Innovation Journal 2021; 10(5): 1501-1506

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(5): 1501-11506

www.thepharmajournal.com
Received: 19-03-2021
Accepted: 30-04-2021

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Studies on heterosis and inbreeding depression in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.)

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Abstract
An investigation was carried out in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) to study heterosis and inbreeding depression for yield and yield contributing characters in four promising crosses (Pusa Naveen x Local Round, Pusa Naveen x Pusa Santhusti, Pusa Sandesh x Punjab Bahar and Pusa Sandesh x Arka Bahar) involving six parents (Pusa Naveen, Local Round, Pusa Santhusti, Pusa Sandesh, Punjab Bahar and Arka Bahar). Relative heterosis and heterobeltiosis was found to be significant and negative for vine length, internodal length, number of nodes per vine, days to first male flower, days to first female flower, days to first harvest, days to last harvest in one or more crosses. Positive relative heterosis was observed for vine length, internodal length, number of nodes per vine, number of branches per plant, days to last harvest, number of fruits per vine, average fruit weight, fruit yield per vine and total soluble solids for most of the crosses. Significant positive heterobeltiosis was also observed for number of branches per plant, number of fruits per vine, average fruit weight, total soluble solids. Significant inbreeding depression coupled with significant relative heterosis and heterobeltiosis were observed in majority of the crosses for all the characters except for total soluble solids. This may be due to close relationship between heterosis and inbreeding depression (i.e. crosses showing high heterosis also exerted high inbreeding depression) and also due to non-additive gene action.

Keywords: Heterosis, Inbreeding depression and Bottle gourd

1. Introduction
Bottle gourd (*Lagenaria siceraria* (Mol.) Standi.) is one of the most important cucurbitaceous vegetable crops grown extensively throughout the tropical and sub-tropical regions of the world. It belongs to the family cucurbitaceae with chromosome number 2n= 22. It is cultivated widely during rainy and summer seasons (Samadia and Khandelwal, 2002) [28]. It is mainly grown for its tender fruits and basically used as vegetable. The tender edible fruits are also used for preparation of sweets, pickles and other delicious preparations. It is a preferred vegetable in many cases of ailments because of its cooling effect and easy digestibility. The various plant parts of bottle gourd also have medicinal value (Singh, 2004) [31]. Bottle gourd is a monoecious and highly cross pollinated crop, it has ample scope for successful exploitation of hybrid vigour. Information on the magnitude of heterosis in different cross combinations is a basic requisite for identifying crosses that exhibit high degree of exploitable heterosis. Hence, the present study was undertaken with the objective of studying the magnitude of heterosis in different crosses and its confirmation through inbreeding depression in F_2 generation and then utilization in future crop improvement programmes.
Inbreeding depression is decrease in fitness and vigour due to inbreeding. The degree of inbreeding is measured by inbreeding coefficient. Inbreeding depression is estimated when both F_1 and F_2 populations of the same cross are available. The inbreeding depression may be high, medium, low or nil depending upon the crop/species.

Material and Methods
The study was carried out at College of Horticulture, Dr. Y. S. R. Horticultural University, Venkataramannagudem, West Godavari district, India during Summer, 2020 and *Kharif*, 2020. The experiment material consisted of 6 parents, 4 F_1s and 4 F_2s sown in completely randomized block design. Seeds were sown at a spacing of 3 m between rows and 0.9 m between the plants. The data were recorded on five selected plants from each parent, F_1 as well as F_2 generations for twelve characters *viz.*, vine length, internodal length, number of nodes per vine, number of branches per plant, days to first male flower, days to first female flower, days

to first fruit harvest, days to last fruit harvest, number of fruits per vine, average fruit weight, fruit yield per vine and total soluble solids (TSS). The mean data of each treatment were used for estimation of heterosis values following the method suggested by Allard (1960) [2]. Inbreeding depression was worked out as percentage loss of vigour and size in F_2 generation over the F_1s.

Results and Discussion

Bottle gourd is a highly cross pollinated crop and a suitable mechanism to produce hybrid seed on commercial sale is available. Study on heterosis is useful for deciding the direction of future breeding programme and to identify the cross combination which are promising in conventional breeding programme. Heterosis over the mid-parental (relative heterosis) and better parent value (heterobeltiosis) were calculated for each cross combinations. Inbreeding depression was calculated from the data of F_1 and F_2 generations. The percentage values of relative heterosis, heterobeltiosis and inbreeding depression are furnished in table 1. The character wise results and discussion are highlighted here under.

Table 1: Relative heterosis (RH), heterobeltiosis (Hb) and inbreeding depression (ID) expressed in percentage for different characters in four crosses of bottle gourd

Cross combinations	1. Vine length (m)			2. Internodal length (cm)			3. Number of nodes per vine		
	RH	Hb	ID	RH	Hb	ID	RH	Hb	ID
Pusa Naveen x Local Round (Cross 1)	9.58*	-19.28**	10.71**	14.28**	-0.10	7.19**	0.70	-19.40**	6.99**
Pusa Naveen x Pusa Santhusti (Cross 2)	13.78**	1.86	4.06	-1.43	-2.14	-15.75**	5.33*	-6.65*	7.12**
Pusa Sandesh x Punjab Bahar (Cross 3)	29.19**	5.24	19.52**	14.90**	-1.09	-5.47**	15.90**	5.29	17.86**
Pusa Sandesh x Arka Bahar (Cross 4)	16.39**	-4.52	6.37	1.96	-15.86**	-10.40**	-0.24	-7.80*	-2.09*
Cross combinations	**4. Number of branches per plant**			**5. Days to first male flower**			**6. Days to first female flower**		
Pusa Naveen x Local Round (Cross 1)	26.98**	18.81**	6.77**	-14.08**	-25.45**	-2.91**	-15.99**	-26.49**	-8.46**
Pusa Naveen x Pusa Santhusti (Cross 2)	20.22**	14.50**	8.85**	-7.67**	-10.46**	-4.97**	-6.87**	-9.87**	-11.03**
Pusa Sandesh x Punjab Bahar (Cross 3)	7.37	-1.30	5.21**	-1.54	-5.11*	-3.13**	-8.06**	-9.36**	-5.56**
Pusa Sandesh x Arka Bahar (Cross 4)	28.97**	16.92**	6.26**	-5.84*	-11.18**	-9.92**	-8.15**	-12.13**	-7.10**

Cross combinations	7. Days to first fruit harvest			8. Days to last fruit harvest			9. Number of fruits per vine		
	RH	Hb	ID	RH	Hb	ID	RH	Hb	ID
Pusa Naveen x Local Round (Cross 1)	-5.90**	-14.37**	-11.70*	-0.08	-3.28**	0.00	23.66**	20.90**	18.06**
Pusa Naveen x Pusa Santhusti (Cross 2)	-3.16	-8.54**	-10.15**	-4.47**	0.76	2.33**	-3.42	-14.02**	9.57**
Pusa Sandesh x Punjab Bahar (Cross 3)	-6.57**	-11.22	-12.03**	5.00**	2.96**	2.40**	14.77*	14.29*	7.06*
Pusa Sandesh x Arka Bahar (Cross 4)	-5.04**	-11.00**	-8.40**	4.86**	1.33	1.44	18.29**	10.14	6.91*
Cross combinations	**10. Average fruit weight (g)**			**11. Fruit yield per vine (kg)**			**12. Total soluble solids (ºBrix)**		
Pusa Naveen x Local Round (Cross 1)	16.31**	6.35*	12.72**	21.48**	8.51	20.92**	9.35**	-16.28**	-0.70
Pusa Naveen x Pusa Santhusti (Cross 2)	2.92	-10.91**	-8.26**	-10.04*	-24.82**	-7.31*	7.16	-1.44	-0.31
Pusa Sandesh x Punjab Bahar (Cross 3)	15.40**	6.89*	15.44**	14.81**	6.37	22.24**	6.31	5.26	-3.13*
Pusa Sandesh x Arka Bahar (Cross 4)	19.15**	6.12*	7.37**	31.25**	11.31**	13.96**	-4.96	-8.32*	0.68

* and ** Significance at 5% and 1% level respectively.

The per cent relative heterosis for vine length ranged from 9.58 % (Pusa Naveen × Local Round) to 29.19 % (Pusa Sandesh x Punjab Bahar). All four crosses *viz*., Pusa Naveen × Local Round, Pusa Naveen x Pusa Santhusti, Pusa Sandesh × Punjab Bahar and Pusa Sandesh × Arka Bahar exhibited significant positive relative heterosis. The heterobeltiosis ranged from -19.28 % (Pusa Naveen x Local Round) to 5.24 % (Pusa Sandesh x Punjab Bahar). Only one cross *i.e*., Pusa Naveen × Local Round expressed significant negative heterobeltiosis. For vine length, heterosis is desirable in negative direction, minimum vine length with lesser internodal length accommodates more number of flowers, which ultimately produce more number of fruits even in smaller stature in a short duration of time. Similar findings were reported by earlier workers Shinde *et al*. (2018) and Mishra *et al*. (2019) [30, 17] in bottle gourd; Narasannavar *et al*. (2018) in ridge gourd; Yadav *et al*. (2009) and Thangamani and Pugalendhi (2013) [19, 40, 35] in bitter gourd. Inbreeding depression varied from 4.06 % (Pusa Naveen x Pusa Santhusti) to 19.52 % (Pusa Sandesh x Punjab Bahar). All the four crosses *viz*., Pusa Naveen x Local Round, Pusa Naveen x Pusa Sandesh, Pusa Sandesh x Punjab Bahar, Pusa Sandesh x Arka Bahar showed significant positive inbreeding depression. The results are in agreement with Yadav and

Kumar (2012) and Vasudeo *et al*. (2017) [41, 36] in bottle gourd; Dhumal *et al*. (2019) in ridge gourd; Rani *et al*. (2015) [9, 26] in bitter gourd but are in contrast with findings of Jansi *et al.* (2018) in pumpkin [14].

For internodal length the relative heterosis ranged from -1.43 % (Pusa Naveen x Pusa Santhusti) to 14.90 % (Pusa Sandesh x Punjab Bahar). Two crosses *i.e.,* Pusa Naveen × Local Round and Pusa Sandesh x Punjab Bahar exhibited significant positive average heterosis. The heterobeltiosis ranged from -15.86 % (Pusa Sandesh x Arka Bahar) to -0.10 % (Pusa Naveen × Local Round). Only one cross *i.e*., Pusa Sandesh × Arka Bahar exhibited significant and negative heterosis over better parent. For this trait, heterosis is desirable in negative direction. Several workers Chaudhari *et al*. (2016) [5] reported positive average heterosis and negative heterobeltiosis in bottle gourd, Chittora *et al.* (2018) [6] reported negative average heterosis and negative heterobeltiosis in ridge gourd. Deepadevi *et al.* (2017) [8] also reported negative heterobeltiosis in snake gourd. The estimate of inbreeding depression ranged from -15.75 % (Pusa Naveen x Pusa Santhusti) to 7.21 % (Pusa Naveen × Local Round). Out of four crosses only one cross *i.e.,* Pusa Naveen × Local Round exhibited significant negative inbreeding depression for this trait. These results are in agreement with the findings of Vasudeo *et al*. (2017) in bottle gourd and Rani *et al*. (2015) in bitter gourd [36, 26].

The average heterosis for number of nodes per vine ranged from -0.24 % (Pusa Sandesh × Arka Bahar) to 15.90 % (Pusa Sandesh × Punjab Bahar). Two crosses *i.e*., Pusa Naveen x Pusa Santhusti and Pusa Sandesh × Punjab Bahar exhibited significant positive average heterosis. Per cent increase in number of nodes per vine over better parent ranged from -19.40 % (Pusa Naveen × Local Round) to 5.29 % (Pusa Sandesh × Punjab Bahar). Three crosses expressed significant negative heterobeltiosis for this trait. Number of nodes per plant is known to directly contribute towards more number of female flowers where fruit yield can be exploited. For this character, heterosis is desirable in positive direction. Both positive and negative heterosis for this character was also reported by Yadav *et al*. (2009) [40] in bitter gourd; negative heterobeltiosis reported by Yadav and Kumar (2012) and Gautam (2017) [41, 12] in bottle gourd and ridge gourd respectively. The minimum (-2.09 %) and maximum (17.86 %) values of inbreeding depression were observed in Pusa Sandesh x Arka Bahar and Pusa Sandesh x Punjab Bahar. Three crosses, Pusa Naveen x Local Round, Pusa Naveen x Pusa Santhusti and Pusa Sandesh x Punjab Bahar showed significant positive inbreeding depression while the cross, Pusa Sandesh x Arka Bahar exhibited significant negative inbreeding depression. For this trait significant positive heterosis followed by significant inbreeding indicates the presence of non-additive gene action inheritance of this trait. Inbreeding depression in both positive and negative direction was also reported by Christopher *et al*. (1999) [7].

Average heterosis for number of branches per plant varied from 7.37 % (Pusa Sandesh × Punjab Bahar) to 28.97 % (Pusa Sandesh × Arka Bahar). Heterobeltiosis ranged from -1.30 % (Pusa Sandesh × Punjab Bahar) to 18.81 % (Pusa Naveen × Local Round). All the four crosses except Pusa Sandesh × Punjab Bahar exhibited significant and positive average heterosis and heterobeltiosis. The number of branches per plant is known to directly contribute towards fruit yield and can be exploited. However for this trait, heterosis is desirable in positive direction. These results are in conformity with the findings of Arafin (2010) in bottle gourd; Chittora *et al*. (2018) in ridge gourd; Pandey *et al*. (2005) in cucumber and Omran *et al*. (2012) in water melon [3, 6, 5]. The highest (8.85 %) and the lowest (5.21 %) values of inbreeding depression were observed in Pusa Naveen x Pusa Santhusti and Pusa Sandesh × Punjab Bahar. All the four crosses exhibited significant and positive inbreeding depression which indicating that effective number of branches per vine were reduced in F_2 generation over F_1. These outcomes are in accordance with the findings of Dhumal *et al*. (2019) in ridge gourd; Rani *et al*. (2015) in bitter gourd and Vinaykumar (2010) and Kamer *et al*. (2015) in musk melon [9, 26, 37, 15].

In respect to days to first male flower relative heterosis ranged from -1.54 % (Pusa Sandesh x Punjab Bahar) to -14.08 % (Pusa Naveen x Local Round). Heterobeltiosis ranged from -5.11 % (Pusa Sandesh x Punjab Bahar) to -25.45% (Pusa Naveen x Local Round). All the four crosses exhibited significant and negative relative heterosis and heterobeltiosis. The negative heterosis is considered desirable for days to first male flower. Negative estimates of heterosis and heterobeltiosis for the traits has also been reported by Chaudhari *et al*. (2016) in bottle gourd; Narasannavar *et al*. (2018) in ridge gourd; Yadav *et al*. (2009) in bitter gourd [5, 19, 40] . This may be due to presence of more dominant genes for earliness. The estimates of inbreeding depression ranged from -2.91 % (Pusa Naveen x Local Round) to -9.92 % (Pusa Sandesh x Arka Bahar). All the four crosses expressed significant and negative inbreeding depression. Presence of significant negative inbreeding depression for this trait also reported by Nileshkumar (2010) and Yadav and Kumar (2012) in bottle gourd; Pandey *et al*. (2004) and Singh *et al*. (2015) in cucumber [20, 41, 23, 33].

Average heterosis for four crosses, ranged from -6.87 % (Pusa Naveen x Pusa Santhusti) to -15.99 % (Pusa Naveen x Local Round) for days to first female flower. Heterobeltiosis ranged from -26.49 % (Pusa Naveen x Local Round) to 9.36 % (Pusa Sandesh x Punjab Bahar). All the four cross exhibited significant and negative average heterosis and heterobeltiosis. Earliness is considered as an important character in any crop improvement programme, which is manifested in F_1 hybrids and preferred for commercial cultivation when the high yield is coupled with earliness. The negative heterosis is considered desirable for days to first female flower. The results are in line with the findings of Chaudhari *et al*. (2016) in bottle gourd; Narasannavar *et al*. (2018) in ridge gourd; Yadav *et al*. (2009) in bitter gourd. [5, 19, 41] Inbreeding depression values varied from -5.56 % (Pusa Sandesh x Punjab Bahar) to -11.03 % (Pusa Naveen x Pusa Santhusti). All the crosses showed significant and negative inbreeding depression. In all the crosses significant heterosis along with significant inbreeding depression was recorded indicating the role of non-additive gene action in inheritance of this trait. The presence of negative inbreeding depression for this trait was also reported by Nileshkumar (2010), Yadav and Kumar (2012) and Vasudeo *et al*. (2017) in bottle gourd; Dhumal *et al*. (2019) in ridge gourd; Rani *et al*. (2015) in bitter gourd; Singh *et al*. (2015) in cucumber and Jansi *et al.* (2018) in pumpkin [20, 41, 36, 9, 26, 14]

For days to first harvest, heterosis over the mid-parental value ranged from -3.16 % (Pusa Naveen x Pusa Santhusti) to -6.57 % (Pusa Sandesh x Punjab Bahar). All the crosses except Pusa Naveen x Pusa Santhusti recorded significant and negative relative heterosis. Heterobeltiosis ranged from -8.54 % (Pusa Naveen x Pusa Santhusti) to -14.37 % (Pusa Naveen

x Local Round). All the crosses except Pusa Sandesh x Punjab Bahar showed significant and negative heterobeltiosis. The negative heterosis is considered desirable for this trait. Similar results were reported by Quamruzzaman *et al*. (2009) and Chaudhari *et al*. (2016) in bottle gourd; Chittora *et al*. (2018) in ridge gourd; Thangamani and Pugalendhi (2013) in bitter gourd [25, 5, 6]. The minimum (-8.40 %) and maximum (-12.03 %) values of inbreeding depression were observed in Pusa Sandesh x Arka Bahar and Pusa Sandesh x Punjab Bahar respectively. All crosses showed significant and negative inbreeding depression for days to first harvest. All crosses exhibited significant heterosis along with significant inbreeding depression indicated that this character is governed by non-additive gene action. Similar results were reported by Vasudeo *et al*. (2017) in bottle gourd; Dhumal *et al*. (2019) in ridge gourd and Pandey *et al*. (2004) in cucumber [36, 9, 23].

In case of days to last fruit harvest relative heterosis was in the ranged of -4.47 % (Pusa Naveen x Pusa Santhusti) to 5.00 % (Pusa Sandesh x Punjab Bahar). Two crosses *i.e.*, Pusa Sandesh x Punjab Bahar and Pusa Sandesh x Arka Bahar expressed significant and positive relative heterosis for this trait. The heterobeltiosis ranged from -3.28 % (Pusa Naveen x Local Round) to 2.96 % (Pusa Sandesh x Punjab Bahar). Only one cross *i.e*., Pusa Sandesh x Punjab Bahar expressed significant and positive heterobeltiosis. The positive heterosis is considered desirable for this trait. The results are in accordance with Mole *et al*. (2001) [18] in ridge gourd and Reddy *et al*. (2019) [27] in sponge gourd. The highest (2.40 %) and the lowest (0.00 %) values of inbreeding depression were observed in Pusa Sandesh x Punjab Bahar and Pusa Naveen x Local Round respectively. It is inferred from results that the cross Pusa Naveen x Local Round showed significant heterosis (over better parent) and no inbreeding depression for days to last harvest indicated that this cross can be utilized for development of pure lines. These results are in line with Thakarshi (2006) in sponge gourd [34].

For number of fruits per vine, the range of average heterosis varied from -3.42 % (Pusa Naveen x Pusa Santhusti) to 23.66 % (Pusa Naveen x Local Round) and heterobeltiosis ranged from -14.02 % (Pusa Naveen x Pusa Santhusti) to 20.90 % (Pusa Naveen x Local Round). All the crosses except the cross, Pusa Naveen x Pusa Santhusti exhibited significant positive average heterosis and two crosses, Pusa Naveen x Local Round and Pusa Sandesh × Punjab Bahar expressed significant and positive heterobeltiosis for this trait. More number of fruits per plant is a commercially important trait to gain high market value through high productivity. Majority of the crosses in the present study recorderd significant positive heterosis. These results are similar to the findings of Singh *et al*. (2012) and Chaudhari *et al*. (2016) in bottle gourd; Niyaria in ridge gourd; Sapodiya *et al*. (2013) [33, 5, 21, 5] in water melon. Inbreeding depression varied from 6.91 % (Pusa Sandesh × Arka Bahar) to 18.06 % (Pusa Naveen x Local Round). All the four crosses showed significant and positive inbreeding depression. The results might be due to the dominance or dominance interaction effects in F_1 hybrids which dissipate in F_2 segregating generations due to reduction in heterozygocity. Thus, selection would be effective in F_2 and subsequent generation for this trait. The results are in line with the results reported by Nileshkumar (2010) and Yadav and Kumar (2012) in bottle gourd; Dhumal *et al*. (2019) in ridge gourd; Rani *et al*. (2015) in bitter gourd and Singh *et al*. (2015) in cucumber [20, 41, 9, 26, 33].

Among the four crosses, Pusa Sandesh × Arka Bahar (19.15 %) exhibited maximum average heterosis, whereas Pusa Naveen x Pusa Santhusti (2.92 %) recorded minimum average heterosis for average fruit weight. Heterobeltiosis ranged from -10.91 per cent (Pusa Naveen x Pusa Santhusti) 6.89 per cent (Pusa Sandesh x Punjab Bahar). All the four crosses except the cross, Pusa Naveen x Pusa Santhusti showed significant and positive average heterosis and heterobeltiosis. Fruit weight is one of the yield attributing characters which directly influence fruit yield. Presence of both negative and positive heterosis was reported earlier by Gautam *et al*. (2017), Shinde *et al*. (2018) and Mishra *et al*. (2019) in bottle gourd; Wakale *et al*. (2018) in ridge gourd; Jadhav *et al*. (2009) in bitter gourd [12, 30, 17, 39, 13]. The maximum (15.44 %) and the minimum (-8.26 %) values of inbreeding depression were observed in Pusa Sandesh × Punjab Bahar and Pusa Naveen x Pusa Santhusti respectively. All the crosses recorded significant and positive inbreeding depression except for the cross, Pusa Naveen x Pusa Santhusti which showed significant and negetive inbreeding depression. The results are in line with Nileshkumar (2010) in bottle gourd; Dhumal *et al*. (2019) in ridge gourd; Rani *et al*. (2015) in bitter gourd; Singh *et al*. (2015) in cucumber and Kamer (2015) in musk melon [20, 9, 33, 26, 15].

For fruit yield per vine the average heterosis varied from minimum of -10.04 per cent (Pusa Naveen x Pusa Santhusti) to the maximum of 31.25 per cent (Pusa Sandesh × Arka Bahar). All the crosses except Pusa Naveen x Pusa Santhusti exhibited significant positive heterosis. Heterosis over better parent ranged from minimum of -24.82 per cent (Pusa Naveen x Pusa Santhusti) to 11.31 per cent (Pusa Sandesh × Arka Bahar). Out of four crosses one cross *i.e*., Pusa Sandesh × Arka Bahar showed significant positive heterobeltiosis and the cross, Pusa Naveen x Pusa Santhusti expressed significant and negative heterobeltiosis. Fruit yield per vine is the ultimate and most important trait. Heterosis for fruit yield is the product of simultaneous manifestation of heterosis for yield attributing traits. The results are in line with Doloi *et al*. (2018) in bottle gourd; Chittora *et al*. (2018) in ridge gourd and Aravindkumar (2004) in muskmelon [10, 6, 4]. Inbreeding depression ranged -7.31 per cent (Pusa Naveen x Pusa Santhusti) to 22.24 per cent (Pusa Sandesh × Punjab Bahar). All the crosses except Pusa Naveen x Pusa Santhusti expressed significant positive inbreeding depression. The results might be due to the dominance or dominance interaction effects in F_1 hybrids which dissipate in F_2 segregating generation due to reduction in heterozygocity. Thus, selection would be effective in F_2 and subsequent generations for this trait. The similar results also reported by Nileshkumar (2010) and Yadav and Kumar (2012) in bottle gourd; Dhumal *et al*. (2019) in ridge gourd; Rani *et al*. (2015) in bitter gourd; Singh *et al*. (2015) in cucumber; Jansi *et al*. (2018) in musk melon [20, 40,9, 26, 14].

The relative heterosis for TSS ranged from -4.96 % (Pusa Sandesh x Arka Bahar) to 9.35 % (Pusa Naveen x Local Round). Out of four crosses, only one cross *i.e.*, Pusa Naveen x Local Round expressed significant and positive heterosis over mid parent. Heterobeltiosis ranged from -16.28 % (Pusa Naveen x Local Round) to 5.26 % (Pusa Sandesh x Punjab Bahar). Two crosses, Pusa Naveen x Local Round and Pusa Sandesh x Arka Bahar registered significant negative heterosis over better parent. For this trait, the positive heterosis is desirable. Similar findings were reported by Gautam *et al*. (2017) and Doloi *et al*. (2018) in bottle gourd. Mallikarjunarao *et al*. (2018) in bitter gourd; Vishwanatha

(2003) in muskmelon and Durgaprasad (2005) in pumpkin [12, 10, 16, 38, 11]. The estimates of inbreeding depression in F_2 population ranged from -3.13 % (Pusa Sandesh x Punjab Bahar) to 0.68 % (Pusa Sandesh x Arka Bahar). The results revealed that no significant inbreeding depression was observed in majority of the crosses for this trait indicating involvement of additive gene action in its inheritance. These results are in agreement with Kamer *et al.* (2015) and Vinaykumar (2010) in musk melon and Al-Araby (2004) in cucumber [15, 37, 1].

Conclusion

Relative heterosis and heterobeltiosis were found to be significant and negative for vine length, internodal length, number of nodes per vine, days to first male flower, days to first female flower, days to first harvest, days to last harvest in one or more crosses. Positive relative heterosis was observed for vine length, internodal length, number of nodes per vine, number of branches per plant, days to last harvest, number of fruits per vine, average fruit weight, fruit yield per vine and total soluble solids for most of the crosses. Significant positive heterobeltiosis was also observed for number of branches per plant, number of fruits per vine, average fruit weight, total soluble solids. Significant inbreeding depression coupled with significant relative heterosis and heterobeltiosis in majority of the crosses for all the characters except for total soluble solids indicated close relationship between heterosis and inbreeding depression (i.e. crosses showing high heterosis also exerted high inbreeding) and also due to non-additive gene action. Under such a situation, the emphasis should be given to those hybrids which, exhibited positive heterosis coupled with either low or non-significant inbreeding depression, which indicated the transgressive segregation in F_2 generation.

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