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Studies on Heterosis and Inbreeding Depression for Yield and Yield Related Traits in Bottle gourd (*Lagenaria siceraria* (Mol.) Standl.)

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ABSTRACT: Different fruit types preferred in different parts of India and development of these phenotypes is challenging in bottle gourd as complex inheritance pattern of fruit related characters. Hence, the present experiment in bottle gourd was conducted during kharif, 2020 at College of Horticulture, Venkataramannagudem, Dr. YSR Horticultural University, Andhra Pradesh, India. Traits, node number at which first male flower appeared, node number at which first female flower appeared, fruit diameter and vitamin-C content recorded significant and negative average and better parent heterosis. Average heterosis and heterobeltiosis in favourable direction was observed for fruit length, fruit yield/vine, fruit yield/plot, fruit yield/hectare, number of seeds per fruit and total sugar content. Economically important traits like fruit yield per vine and fruit yield per plot exhibited negative heterosis and inbreeding depression in Pusa Naveen × Pusa Santhusti. This cross can be handled through pedigree method of plant breeding for development of pureline varieties in bottle gourd.

Keywords: Bottle gourd, F_2 populations, Heterosis, Inbreeding depression, Yield traits.

INTRODUCTION

Bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) is belongs to the family cucurbitaceae with chromosome number 2n=2X= 22. It is one of the most important monoecious cucurbits grown throughout India for its tender fruits and basically used as vegetable (Rambabu *et al*., 2021). Monoecious and andromonoecious sex form of this crop made as cross pollinated (Swiander *et al.*, 1994). Delicious preparations *viz*., sweets, pickles etc. are preparing by using tender edible fruits of bottle gourd. It is considering as good food for those suffering from biliousness and indigestion (Thumburaj and Singh 2003). India has diverse agro ecological conditions so that there is a great need for its genetic improvement to develop hybrids or varieties suited to specific agro ecological conditions. But crop improvement work in bottle gourd is not done extensively because complex inheritance nature of its traits. An investigation on heterosis and inbreeding depression provides information on the type of gene action involved in inheritance pattern of various traits. Hence, the present experiment in bottle gourd conducted to know the magnitude of heterosis and inbreeding depression.

MATERIAL AND METHODS

During *Summer*, 2020 four crosses F_1seed was sown in College Farm at College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari district, Andhra Pradesh, India. The F_1 crosses were selfed to get F_2seeds. Six parents, four F_1 and their F_2populations were evaluated during *Kharif*, 2020 by adopting Randomized Complete Block Design (RCBD) with three replications with 3m × 0.9m spacing. All the recommended package of agronomic practices was followed for raising a good crop and need based plant protection measures were adopted. On five randomly selected F_1 plants and fourty F_2 plants data was recorded on characters *viz*., node no. at which first male flower appeared, node no. at which first female flower appeared, sex ratio (%), fruit length (cm), fruit diameter (cm), fruit yield / vine (kg), fruit yield / plot (kg), fruit yield / hectare (q), number of seeds/fruit, vitamin-C ($mg100g^{-1}$) and total sugars (%). The mean data of mentioned traits was used for calculation of heterosis as per the method suggested by Allard (1960). Inbreeding depression was worked out as percentage loss of vigour and size in F_2 generation over the F_1s.

RESULTS AND DISCUSSION

The results on mid parent heterosis, heterobeltiosis and inbreeding depression are presented in Table 1. Almost all the traits recorded superior heterosis in hybrids however; inbreeding depression was also noticed for most of the traits. Heterosis in negative direction is desirable for node number at which first female flower appeared. The mid parent heterosis ranged from -10.86 % (Pusa Naveen × Local Round) to -19.69 % (Pusa Sandesh ×Punjab Bahar) and heterobeltiosis ranged

from -11.81 % (Pusa Naveen × Pusa Santhusti) to -28.96 % (Pusa Sandesh × Punjab Bahar) for this character. These results are in accordance with Upadhay and Ram (2007) in bottle gourd and Singh *et al*. (2001) in bitter gourd. Non- additive gene action is predominant in controlling this character and it is evident from significant inbreeding depression along with heterosis. Similar findings are also reported by Yadav and Kumar (2012); Vasudeo *et al*. (2017) in bottle gourd and Dhumal *et al*. (2019) in ridge gourd.

All the four cross combinations indicating the role of non-additive gene action in inheritance of node number at which first male flower appeared. This was evident from significant and negative average heterosis and heterobeltiosis coupled with significant negative inbreeding depression. These results are in accordance with the findings of Nileshkumar (2010); Yadav and Kumar (2012) in bottle gourd.

Negative mid parentheterosis and heterobetiosis ranged from -20.77 % to-25.54 % for sex ratio in Pusa Sandesh × Punjab Bahar. Heterosis in negative direction is considered desirable for this trait. Similar findings are also reported by Muthaiah *et al*. (2017) in ridge gourd and Bhatt *et al*. (2017) in bitter gourd. Significant negative inbreeding depression was observed for most of the crosses except cross combination, Pusa Sandesh ×Arka Bahar (5.00 %) which showed positive inbreeding depression. These results are in accordance with findings of Vasudeo *et al*. (2017) in bottle gourd and Jansi *et al*. (2018) in pumpkin.

For fruit length, average heterosis ranged from 3.03 % (Pusa Naveen × Local Round) to 54.98 % (Pusa Sandesh × Arka Bahar) and better parent heterosis ranged from-17.96 % (Pusa Naveen × Local Round) to 16.65 % (Pusa Sandesh × Arka Bahar). All the hybrids showed positive average heterosis and heterobeltiosis for this character. Adarsh *et al*. (2017); Mishra *et al*. (2019) also reported similar findings in bottle gourd. Significant inbreeding depression was recorded in all the four cross combinations except, Pusa Sandesh × Arka Bahar which recorded significant heterosis followed by low inbreeding depression revealing role of additive gene action. Yadav and Kumar (2012) in bottle gourd and Dhumal *et al*. (2019) in ridge gourd found similar findings.

Mid parent heterosis ranged from -1.93 % (Pusa Naveen × Pusa Santhusti) to -14.81 % (Pusa Sandesh × Arka Bahar) and better parent heterosis ranged from-2.48 % (Pusa Sandesh × Punjab Bahar) to 26.10 % (Pusa Sandesh × Arka Bahar) for fruit diameter. All the cross combinations, recorded negative heterosis (average heterosis and heterobeltiosis) for this trait. Pusa Naveen × Pusa Santhusti recorded significant negative inbreeding depression, while other crosses showed significant positive inbreeding depression for this trait. Similar results were reported by Ghuge *et al*. (2016); Vasudeo *et al*. (2017) in bottle gourd and Chittora *et al*. (2018) in ridge gourd.

Fruit yield/vine recorded the highest mid parent heterosis (31.25 %) and heterobeltiosis (11.31 %) for the hybrid, Pusa Sandesh × Arka Bahar. All the cross combinations recorded significant positive heterosis except, Pusa Naveen × Pusa Santhusti showed significant negative average heterosis and better parent heterosis (-10.04 % and -24.82%). Heterosis for fruit yield / vine is the product of simultaneous manifestation of heterosis for all yield contributing traits. Similar findings were also reported by Ray *et al*. (2015); Doloi *et al*. (2018) in bottle gourd. Three cross combinations exhibited significant heterosis followed by significant inbreeding depression but the hybrid, Pusa Naveen × Pusa Santhusti (-7.36 %) showed significant and negative heterosis with negative inbreeding depression for this trait indicating transgressive segregation in F_2 generation and thus this cross combination can be utilized for development of pure line varieties in bottle gourd. Similar results were also reported by Rambabu *et al*. (2021); Nileshkumar (2010); Yadav and Kumar (2012) in bottle gourd; Dhumal *et al*. (2019) in ridge gourd and Jansi *et al*. (2018) in pumpkin.

Fruit yield / plot and fruit yield/hectare recorded highest relative heterosis (33.06 %) and heterobeltiosis (11.85 %) observed for the cross combination, Pusa Sandesh × Arka Bahar. All the four crosses exhibited significant positive heterosis except the cross combination, Pusa Naveen × Pusa Santhusti recorded significant negative average heterosis and better parent heterosis (-5.84 % and -21.48 %). These results are in accordance with the results of Yadav *et al*. (2009) in bitter gourd and Duradundi (2017) in muskmelon. All the four crosses showed significant positive inbreeding depression except the cross combination, Pusa Naveen × Pusa Santhusti (-5.71 %) in which inbreeding depression was in negative direction. According to results, heterosis was observed with higher magnitude in positive direction and similar trend was reflected with inbreeding depression, thus indicating the involvement of non-additive gene action in controlling these traits. Similar results were also reported by Vasudeo *et al*. (2017) in bottle gourd and Dhumal *et al*. (2019) in ridge gourd.

Number of seeds/fruit exhibited average heterosis from 2.40 % (Pusa Sandesh × Punjab Bahar) to 16.69 % (Pusa Naveen × Pusa Santhusti). Heterobeltiosis ranged from -7.51 % (Pusa Sandesh × Punjab Bahar) to 6.94 % (Pusa Naveen × Local Round). Majority of the crosses exhibited significant and positive heterosis over mid parent and better parent. Presence of both negative and positive heterosis was reported earlier by Narasannavar *et al*. (2014) in ridge gourd; Reddy *et al.* (2019) in sponge gourd and Sapovadiya *et al.* (2013) in watermelon. All the crosses showed significant and positive inbreeding depression except the cross, Pusa Naveen × Pusa Santhusti showed significant negative inbreeding depression for this trait. These results are in agreement with Vasudeo *et al*. (2017) in bottle gourd.

The maximum relative heterosis and heterobeltiosis for vitamin-C content observed in Pusa Naveen × Pusa Santhusti (35.30 %and 26.07 %). In the present investigation both positive and negative average

heterosis and heterobeltiosis was recorded for this trait. These results are in conformation with Kumar *et al*. (2018) in pumpkin. Two crosses *i.e.*, Pusa Naveen×Local Round (-29.77 %), Pusa Sandesh × Punjab Bahar (-17.52 %) recorded significant and negative inbreeding depression while the cross Pusa Sandesh × Arka Bahar (7.11 %) showed significant positive inbreeding depression for this trait. Kamer *et al*. (2015) in muskmelon also reported similar kind of findings.

For the character, total sugars all the four crosses exhibited non-significant average heterosis and heterobeltiosis. Gautam *et al*. (2017) in bottle gourd also reported similar results. Most of the cross combinations were exhibited non- significant inbreeding depression for this trait. These results are in agreement with Kamer *et al*. (2015) in muskmelon.

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	Node no. at which first female flower appeared			Node no. at which first male flower appeared			Sex ratio (%)		
	MH	BH	ID	MH	BH	ID	MH	BH	ID
Pusa Naveen × Local Round (Cross I)	-10.86**	-27.63**	-7.73**	-5.75*	-25.52**	-16.20**	33.93**	12.08*	-3.59*
Pusa Naveen × Pusa Santhusti (Cross II)	-11.25**	-11.81**	-21.29**	-3.60	-10.77**	-19.11**	17.32**	4.65	-4.12
Pusa Sandesh × Punjab Bahar (Cross III)	-19.69**	-28.96*	-10.32**	-2.48	-6.35**	-16.24**	-20.77**	-25.54**	-22.51**
Pusa Sandesh × Arka Bahar (Cross IV)	-14.29**	-26.90**	-10.91*	-15.60**	-23.96**	-27.27**	2.64	-8.13	5.00*
Cross combinations	**Fruit length (cm)**			**Fruit diameter (cm)**			**Fruit yield / vine (kg)**		
Pusa Naveen × Local Round (Cross I)	3.03	-17.96**	12.23**	-3.45	-23.21**	8.77**	21.48**	8.51	20.92**
Pusa Naveen × Pusa Santhusti (Cross II)	22.54**	16.39**	17.44**	-1.93	-19.02**	-14.61**	-10.04*	-24.82**	-7.36*
Pusa Sandesh × Punjab Bahar (Cross III)	6.64**	0.76	12.88**	-2.35	-2.48	10.42**	14.81**	6.37	22.24**
Pusa Sandesh × Arka Bahar (Cross IV)	54.98**	16.65**	1.55	-14.81**	-26.10**	2.96	31.25**	11.31**	13.96**
Cross combinations	**Fruit yield / plot (kg)**			**Fruit yield / hectare (q)**			**Number of seeds /fruit**		
	MH	BH	ID	MH	BH	ID	MH	BH	ID
Pusa Naveen × Local Round (Cross I)	21.86**	8.96	21.39**	21.86**	8.96	21.39**	14.93**	6.94*	2.98**
Pusa Naveen × Pusa Santhusti (Cross II)	-5.84	-21.48**	-5.71**	-5.84	-21.48**	-5.71**	16.69**	-6.01*	-2.40*
Pusa Sandesh × Punjab Bahar (Cross III)	15.75*	6.74	21.10**	15.75*	6.74	21.10**	2.40	-7.51**	1.37
Pusa Sandesh × Arka Bahar (Cross IV)	33.06**	11.85*	13.96**	33.06**	11.85*	13.96**	13.12**	4.08	3.56**
Cross combinations	**Vitamin-C (mg 100g^{-1})**			**Total sugars (%)**					
Pusa Naveen × Local Round (Cross I)	-17.56**	-29.77**	-27.34**	25.22	-0.34	12.40**			
Pusa Naveen × Pusa Santhusti (Cross II)	35.30**	26.07**	4.90	4.04	-1.65	-13.06**			
Pusa Sandesh × Punjab Bahar (Cross III)	-18.32**	-30.44**	-17.52**	5.67	3.56	3.60			
Pusa Sandesh × Arka Bahar (Cross IV)	27.24**	4.20	7.11*	0.92	0.23	6.72			

* Significance at 5% ** Significance at 1% level.
MH: Mid Parent Heterosis; BH: Better Parent Heterosis; ID: Inbreeding Depression

CONCLUSIONS

The present investigation revealed that cross combinations *viz.*, Pusa Sandesh × Arka Bahar and Pusa Naveen × Local Round are promising for increasing fruit yield and its contributing attributes. The hybrid, Pusa Sandesh × Punjab Bahar was found superior for earliness for exploitation of heterosis. Significant heterosis coupled with significant inbreeding depression was observed for most of the traits in majority of the cross combinations indicate non-additive gene action in the inheritance of these traits. Hence, methods like recurrent selection, heterosis breeding and pure line selection can be used for genetic improvement of bottle gourd.

FUTURE SCOPE

The cross combination, Pusa Naveen × Pusa Santhusti exhibited significant negative heterosis followed by negative inbreeding depression for some economically important characters like fruit yield per vine and fruit yield per plot indicating more chances to appear superior transgressive segregants in $F_2$and further generations and thus this cross can be employed for development of region specific stable pure line varieties in bottlegourd.

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