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Research Article

Studies on Heterosis and Inbreeding Depression in Bottle Gourd (*Lagenaria siceraria* (Mol.) Standl)

Odedara Geeta N.*, Patel, J. B. and Gauswami Jyoti J.

Department of Genetics and Plant Breeding College of Agriculture

Junagadh Agricultural University, Junagadh – 362 001, Gujarat, India

*Corresponding Author E-mail: odedarageeta33@gmail.com

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ABSTRACT

The present Investigation was carried out to study the extent of heterosis and inbreeding depression through six generation mean analysis (P_1, P_2, F_1, F_2, BC_1 and BC_2 derived) of five crosses for fruit yield and yield contributing character in bottle gourd (Lagenaria siceraria (Mol.) Standl.). The material was evaluated in a compact family block design (CFBD) with three replications during kharif 2019. The significant and desirable heterosis and heterobeltiosis was noted for fruit yield per plant in NDBG 132 x DBG 6, Pusa Naveen x DBG 5 and Pusa Naveen x DBG 6. Low to moderate inbreeding depression was observed in the present study as a whole. The observed and the expected estimates for heterosis, heterobeltiosis and inbreeding depression were in close agreement with one another for all the characters in all five crosses.

Key words: *Generation mean, Heterosis, Inbreeding depression.*

INTRODUCTION

Bottle gourd (*Lagenaria siceraria* (Mol.) Standl. 2n = 2x = 22), is one of humankind's first domesticated plants. It is also known as white flower gourd, Ghiakadoo or Lauki, is an important cucurbitaceous vegetable crop belonging to family *Cucurbitaceae* and subfamily *Cucurbitoidae*. Bottle gourd has greater economic importance. It is commonly grown for vegetable and it has medicinal value to human being. It can be used for making sweets (e.g. halva, kheer, petha and burfi) and pickle. A decoction made from the leaf is very good medicine for curing jaundice. The pulp is good for overcoming constipation, cough, night blindness, and as an antidote against certain poisons. The plant extract is used as a cathartic and the seed are used in dropsy. The fruit contain 0.2 per cent protein, 0.1 per cent fat, 2.5 g carbohydrates, 0.5 g mineral matter, 0.3 mg thiamine, 0.01 mg riboflavin, 0.2 mg niacin, 12 k cal energy per 100 g fresh weight and 11 mg of vitamin C per 100 g fresh weight.

Bottle gourd is highly cross pollinated crop. Cross pollination per cent ranges from 60 to 80 per cent, results into large variation in shape and size of fruits varies from very long slender to thick and round.

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Nature and magnitude of heterosis is one of the important aspects for selection of the right parents for crosses and also help in identification of superior cross combinations that may produce desirable transgressive segregants in advanced generations. Bottle gourd being a monoecious and cross pollinated crop, heterosis has long been known to offer good potentialities for increased fruit yield. On the other hand, inbreeding depression reflects on reduction or loss in vigour, fertility and yield. Proportion of inbreeding depression in any generation becomes essential for the plant breeders.

MATERIALS AND METHODS

Plant material

The experimental materials comprised of six basic generations *viz*., P_1, P_2, F_1, F_2, BC_1 and BC_2 of five cross namely ABG 1 × DBG 5, NDBG 132 × DBG 6, Pusa Naveen × DBG 5, Pusa Naveen × DBG 6 and DBG 5 × DBG 6 were made between five parents by manual emasculation and pollen transfer. F_1 plants were selfed to obtain seed for the F_2 generation and backcrossed with their respective parents to generate BC_1 and BC_2 generations. Thus, a total of six generations were obtained.

Field trial

The six generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) for each population were planted during *kharif* 2019. Six populations were planted in compact family block design (CFBD) with three replications. Each replication was divided in to five compact blocks, each consists of single cross and blocks were consisted of six plots of six basic generation of each cross. The crosses were assigned to each block and six generations of a cross were relegated to individual plot within the block. Each block was comprised of eleven rows consisting single row each of P_1, P_2 and F_1; four rows of F_2 and two rows each of BC_1 and BC_2 generations with 10 plants in each row. Each row spaced 2 m apart and plant to plant distance within row was 1 m. Fertilizers were applied as per recommended doses and other cultural practices were carried out at regular intervals during the course of experimentation. The observations were recorded on five competitive and randomly selected plants from P_1, P_2 and F_1, ten plants from BC_1 and BC_2 generations and twenty plants from F_2 generations in each replication for days to opening first female flower, days to opening first male flower, number of node bearing first female flower, number of node bearing first male flower, vine length (m), days to first picking, fruit length (cm), fruit equatorial diameter (cm), number of fruits per plant, average fruit weight per plant (kg), days to last picking and fruit yield per plant (kg).

Statistical analysis

The analysis of variance was performed to test the significance of difference among the genotypes for all the characters following fixed effect model as suggested by Panse and Sukhatme (1985), heterotic effects in term of superiority of F_1 over better parent (heterobeltiosis) as per Fonseca and Patterson (1968) and over mid parent value (relative heterosis) as per Briggle (1963).

RESULTS AND DISCUSSION

The analysis of variance among progenies within each family indicated significant differences among six generation means for all the characters studied in all the five crosses.

Heterosis

The perusal of results of heterosis presented in Table 1 to Table 4 indicated that the extent of heterosis over mid-parent and better parent was not pronounced for various characters recorded in five crosses. For the characters like days to opening first female flower, days to opening first male flower, number of node bearing first female flower, number of node bearing first male flower and days to first picking, the low scoring parent was considered as better parent.

The significant and desirable heterosis was noted for days to opening first female flower, days to opening first male flower, vine length, fruit length, fruit equatorial diameter, number of fruits per plant and fruit yield per plant in ABG 1 x DBG 5, NDBG 132 x DBG 6, Pusa Naveen x DBG 5, Pusa Naveen x DBG 6 and DBG 5 x DBG 6; for number of node bearing first female flower and days to first picking in Pusa Naveen x DBG 5 and Pusa Naveen x DBG 6; for number of node bearing first male flower in NDBG 132 x DBG 6 and Pusa Naveen x DBG 5; and for average fruit weight per plant in ABG 1 x DBG 5, NDBG 132 x DBG 6, Pusa Naveen x DBG 5 and DBG 5 x DBG 6. None of the cross manifested significant and desirable heterosis for days to last picking.

The significant and desirable heterobeltiosis was noted for days to opening first female flower in ABG 1 x DBG 5, NDBG 132 x DBG 6, Pusa Naveen x DBG 5, Pusa Naveen x DBG 6 and DBG 5 x DBG 6; for days to opening first male flower in ABG 1 x DBG 5, NDBG 132 x DBG 6, Pusa Naveen x DBG 6 and DBG 5 x DBG 6; for number of node bearing first female flower in Pusa Naveen x DBG 5; for vine length in NDBG 132 x DBG 6, Pusa Naveen x DBG 5 and Pusa Naveen x DBG 6; for fruit length in NDBG 132 x DBG 6, Pusa Naveen x DBG 5, Pusa Naveen x DBG 6 and DBG 5 x DBG 6; for fruit equatorial diameter in Pusa Naveen x DBG 6 and DBG 5 x DBG 6; for average fruit weight per plant in Pusa Naveen x DBG 5; and for fruit yield per plant in NDBG 132 x DBG 6, Pusa Naveen x DBG 5 and Pusa Naveen x DBG 6. None of the cross manifested significant and desirable heterobeltiosis for number of node bearing first male flower, days to first picking, number of fruits per plant and days to last picking.

The observed heterosis was found to have resulted either due to the action of dominance component only or due to the combinations with either digenic or trigenic types of epistasis for different characters in five crosses of bottle gourd. In most of the cases, the observed heterosis was either due to dominance [h] and dominance x dominance [l] interaction.

The varied degree of heterosis for fruit yield and its component traits in bottle gourd has been reported by Kumar et al. (2014), Chaudhari et al. (2016), Ghuge et al. (2016), Adarsh et al. (2017), Chaudhari (2017), Doloi et al. (2018), Khote et al. (2018), Jayanth et al. (2019), Mishra et al. (2019) and Quamruzzaman et al. (2019).

The observed heterosis and heterobeltiosis either significant or non-significant showed a close association with expected heterosis and heterobeltiosis in almost all the crosses for all the characters, which indicated that the estimation of genetic parameters, on which the expected heterosis was based, has been carried out using most appropriate model. However, minor discrepancy observed between actual and expected relative heterosis and heterobeltiosis in some of the cases might be due to involvement of higher order interaction and/or presence of linkage.

Inbreeding depression

Estimate of inbreeding depression for all character presented in Table 1 to Table 4. The estimates for inbreeding depression was found significant and negative for days to opening first female flower, days to opening first male flower and days to last picking in ABG 1 x DBG 5, NDBG 132 x DBG 6, Pusa Naveen x DBG 5, Pusa Naveen x DBG 6 and DBG 5 x DBG 6; for number of node bearing first female flower in NDBG 132 x DBG 6, Pusa Naveen x DBG 5 and Pusa. Naveen x DBG 6; for number of node bearing first male flower in Pusa Naveen x DBG 5 and Pusa Naveen x DBG 6; and for days to first picking in ABG 1 x DBG 5, NDBG 132 x DBG 6, Pusa Naveen x DBG 5 and Pusa Naveen x DBG 6. Likewise, significant and positive inbreeding depression was observed for number of node bearing first female flower in ABG 1 x DBG 5; for vine length in Pusa Naveen x DBG 5; for fruit length in NDBG 132 x DBG 6, Pusa Naveen x DBG 6 and DBG 5 x DBG 6; for equatorial diameter in ABG 1 x DBG 5, NDBG 132 x DBG 6, Pusa Naveen x DBG 5, Pusa Naveen x DBG 6 and DBG 5 x DBG 6; for number of fruits per plant in ABG 1 x DBG 5, NDBG 132 x DBG 6, Pusa Naveen x DBG 5 and DBG 5 x DBG 6; for average fruit weight per plant in ABG 1 x DBG 5, Pusa Naveen x DBG 5, Pusa Naveen x DBG 6 and DBG 5 x DBG 6; and for fruit yield per plant in ABG 1 x DBG 5, Pusa

Naveen x DBG 6 and DBG 5 x DBG 6. The observed and the expected estimates of inbreeding depression were in close agreement with one another for all the characters studied in all five crosses. It is desirable to have high, significant and positive heterosis with low inbreeding depression for characters like fruit yield and its components. This is equally applicable to developmental traits.

Table 1: Heterosis, heterobeltiosis and inbreeding depression for days to opening first female flower, days to opening first male flower and number of node bearing first female flower of five crosses in bottle gourd

Crosses/Characters		Heterosis	Heterobeltiosis	Inbreeding depression
Days to opening first female flower				
ABG 1 x DBG 5	Observed	-3.63** ± 0.37	-3.13** ± 0.37	-1.05* ± 0.42
	Expected	-3.33	-2.94	-1.07
NDBG 132 x DBG 6	Observed	-2.90** ± 0.31	-2.00** ± 0.38	-2.23** ± 0.33
	Expected	-2.91	-2.01	-2.20
Pusa Naveen x DBG 5	Observed	-2.73** ± 0.35	-1.73* ± 0.35	-1.62** ± 0.44
	Expected	-2.73	-1.73	-1.62
Pusa Naveen x DBG 6	Observed	-3.83** ± 0.30	-2.73** ± 0.37	-3.83** ± 0.39
	Expected	-3.83	-2.73	-3.83
DBG 5 x DBG 6	Observed	-2.50** ± 0.36	-2.40** ± 0.42	-3.55** ± 0.49
	Expected	-2.50	-2.40	-3.55
Days to opening first male flower				
ABG 1 x DBG 5	Observed	-3.33** ± 0.36	-2.93** ± 0.33	-2.88** ± 0.39
	Expected	-3.33	-2.93	-2.88
NDBG 132 x DBG 6	Observed	-2.27** ± 0.38	-1.80** ± 0.47	-3.80** ± 0.38
	Expected	-2.31	-1.98	-3.80
Pusa Naveen x DBG 5	Observed	-1.00* ± 0.36	0.00 ± 0.41	-1.88** ± 0.44
	Expected	-1.00	-0.03	-1.88
Pusa Naveen x DBG 6	Observed	-4.60** ± 0.37	-3.60** ± 0.39	-4.27** ± 0.52
	Expected	-4.57	-3.72	-4.27
DBG 5 x DBG 6	Observed	-2.40** ± 0.30	-2.33** ± 0.33	-1.38** ± 0.43
	Expected	-2.40	-2.33	-1.38
Number of node bearing first female flower				
ABG 1 x DBG 5	Observed	3.27** ± 0.34	4.33** ± 0.41	1.30** ± 0.39
	Expected	3.27	4.33	1.30
NDBG 132 x DBG 6	Observed	0.10 ± 0.32	1.47** ± 0.38	-0.83* ± 0.40
	Expected	0.10	1.44	-0.83
Pusa Naveen x DBG 5	Observed	-1.87* ± 0.29	-0.87* ± 0.32	-2.18** ± 0.39
	Expected	-1.89	-0.86	-2.13
Pusa Naveen x DBG 6	Observed	-0.80** ± 0.27	1.33** ± 0.34	-0.92* ± 0.35
	Expected	-0.80	1.33	-0.92
DBG 5 x DBG 6	Observed	-0.53 ± 0.30	0.87* ± 0.38	-0.43 ± 0.36
	Expected	-0.53	0.87	-0.43

***and** significant at 5 per cent and 1 per cent levels, respectively**

Table 2: Heterosis, heterobeltiosis and inbreeding depression for number of node bearing first male flower, vine length (m) and days to first picking of five crosses in bottle gourd

Crosses/Characters		Heterosis	Heterobeltiosis	Inbreeding depression
Number of node bearing first male flower				
ABG 1 x DBG 5	Observed	1.77** ± 0.28	2.47** ± 0.33	0.05 ± 0.30
	Expected	1.75	2.61	0.05
NDBG 132 x DBG 6	Observed	-1.80** ± 0.31	-0.20 ± 0.38	-0.62 ± 0.32
	Expected	-1.80	-0.20	-0.62
Pusa Naveen x DBG 5	Observed	-0.97** ± 0.28	0.13 ± 0.34	-1.37** ± 0.31
	Expected	-0.97	0.13	-1.52
Pusa Naveen x DBG 6	Observed	-0.47 ± 0.35	1.13* ± 0.42	-1.00* ± 0.38
	Expected	-0.42	1.27	-1.00
DBG 5 x DBG 6	Observed	-0.30 ± 0.30	0.80 ± 0.39	-0.62 ± 0.33
	Expected	-0.26	0.97	-0.62
Vine length (m)				
ABG 1 x DBG 5	Observed	0.11** ± 0.04	-0.26** ± 0.04	0.05 ± 0.04
	Expected	0.13	-0.24	0.06
NDBG 132 x DBG 6	Observed	0.35** ± 0.01	0.10** ± 0.01	0.05 ± 0.03
	Expected	0.35	0.10	0.05
Pusa Naveen x DBG 5	Observed	0.41** ± 0.02	0.30** ± 0.03	0.11** ± 0.03
	Expected	0.41	0.30	0.11
Pusa Naveen x DBG 6	Observed	0.35** ± 0.02	0.10** ± 0.02	0.05 ± 0.03
	Expected	0.35	0.10	0.05
DBG 5 x DBG 6	Observed	0.19** ± 0.06	0.04 ± 0.03	0.05 ± 0.03
	Expected	0.27	0.03	0.05
Days to first picking				
ABG 1 x DBG 5	Observed	1.30** ± 0.44	2.27** ± 0.51	-1.42* ± 0.56
	Expected	1.28	2.44	-1.34
NDBG 132 x DBG 6	Observed	0.07 ± 0.55	0.80 ± 0.71	-1.62** ± 0.54
	Expected	0.13	1.32	-1.56
Pusa Naveen x DBG 5	Observed	-1.33** ± 0.46	0.40 ± 0.54	-1.87** ± 0.51
	Expected	-1.30	0.57	-2.24
Pusa Naveen x DBG 6	Observed	-1.10* ± 0.51	-0.13 ± 0.69	-1.52** ± 0.51
	Expected	-0.96	0.23	-1.95
DBG 5 x DBG 6	Observed	0.63 ± 0.41	1.40** ± 0.43	-0.75 ± 0.39
	Expected	0.58	1.48	-0.82

***and** significant at 5 per cent and 1 per cent levels, respectively**

Table 3: Heterosis, heterobeltiosis and inbreeding depression for fruit length (cm), fruit equatorial diameter (cm) and number of fruits per plant of five crosses in bottle gourd

Crosses/Characters		Heterosis	Heterobeltiosis	Inbreeding depression
Fruit length (cm)				
ABG 1 x DBG 5	Observed	3.47** ± 0.32	-4.93** ± 0.35	0.50 ± 0.39
	Expected	3.47	-4.93	0.50
NDBG 132 x DBG 6	Observed	3.07** ± 0.30	1.33** ± 0.37	1.12** ± 0.30
	Expected	3.07	1.33	1.12

Pusa Naveen x DBG 5	Observed	3.43**	±	0.39	1.87**	±	0.45	0.10	±	0.49
	Expected	3.43			1.87			0.10		
Pusa Naveen x DBG 6	Observed	3.83**	±	0.29	0.80*	±	0.36	1.13*	±	0.44
	Expected	3.83			0.80			1.13		
DBG 5 x DBG 6	Observed	3.47**	±	0.36	2.00**	±	0.41	1.40**	±	0.49
	Expected	3.47			2.00			1.40		
Fruit equatorial diameter (cm)										
ABG 1 x DBG 5	Observed	0.38**	±	0.13	0.09	±	0.17	0.69**	±	0.10
	Expected	0.38			0.09			0.69		
NDBG 132 x DBG 6	Observed	0.36*	±	0.15	0.06	±	0.15	0.78**	±	0.15
	Expected	0.61			0.33			1.05		
Pusa Naveen x DBG 5	Observed	0.45*	±	0.21	0.18	±	0.27	0.75**	±	0.19
	Expected	0.45			0.18			0.75		
Pusa Naveen x DBG 6	Observed	0.35*	±	0.14	0.32*	±	0.15	0.85**	±	0.13
	Expected	0.15			-0.07			0.85		
DBG 5 x DBG 6	Observed	0.59**	±	0.16	0.36*	±	0.14	0.83**	±	0.14
	Expected	0.54			0.31			0.77		
Number of fruits per plant										
ABG 1 x DBG 5	Observed	0.87*	±	0.38	0.33	±	0.38	0.93*	±	0.38
	Expected	0.87			0.33			0.93		
NDBG 132 x DBG 6	Observed	0.80*	±	0.37	0.73	±	0.42	1.03**	±	0.37
	Expected	0.80			0.73			1.03		
Pusa Naveen x DBG 5	Observed	0.73*	±	0.35	0.20	±	0.39	0.85*	±	0.37
	Expected	0.73			0.20			0.85		
Pusa Naveen x DBG 6	Observed	0.73*	±	0.34	0.43	±	0.38	0.35	±	0.35
	Expected	0.73			0.43			0.35		
DBG 5 x DBG 6	Observed	0.73*	±	0.34	0.63	±	0.39	0.77*	±	0.29
	Expected	0.73			-0.67			0.77		

***and** significant at 5 per cent and 1 per cent levels, respectively**

Table 4: Heterosis, heterobeltiosis and inbreeding depression for average fruit weight per plant (kg), days to last picking and fruit yield per plant (kg) of five crosses in bottle gourd

Crosses/Characters		Heterosis			Heterobeltiosis			Inbreeding depression		
Average fruit weight per plant (kg)										
ABG 1 x DBG 5	Observed	0.06*	±	0.03	0.04	±	0.04	0.11**	±	0.03
	Expected	0.06			0.03			0.12		
NDBG 132 x DBG 6	Observed	0.06**	±	0.02	0.02	±	0.03	0.03	±	0.02
	Expected	0.06			0.02			0.03		
Pusa Naveen x DBG 5	Observed	0.07**	±	0.02	0.07**	±	0.02	0.07**	±	0.02
	Expected	0.07			0.07			0.07		
Pusa Naveen x DBG 6	Observed	0.05	±	0.04	0.03	±	0.04	0.08*	±	0.03
	Expected	0.05			0.03			0.08		
DBG 5 x DBG 6	Observed	0.06*	±	0.02	0.04	±	0.03	0.08**	±	0.02
	Expected	0.06			0.04			0.08		
Days to last picking										
ABG 1 x DBG 5	Observed	-1.23**	±	0.43	-1.93**	±	0.48	-3.07**	±	0.59
	Expected	-1.19			-2.07			-3.24		
NDBG 132 x DBG 6	Observed	0.07	±	0.55	-0.67	±	0.60	-1.63**	±	0.54
	Expected	0.12			-0.83			-1.62		

Pusa Naveen x DBG 5	Observed	-1.27*	±	0.46	-2.93**	±	0.49	-1.93**	±	0.51
	Expected	-1.24			-3.03			-2.23		
Pusa Naveen x DBG 6	Observed	-1.03	±	0.51	-2.00**	±	0.50	-1.42**	±	0.52
	Expected	-0.95			-2.06			-1.79		
DBG 5 x DBG 6	Observed	0.63	±	0.41	-0.13	±	0.61	-1.03**	±	0.39
	Expected	0.58			-0.32			-0.92		
Fruit yield per plant (kg)										
ABG 1 x DBG 5	Observed	0.29*	±	0.11	0.13	±	0.11	0.23*	±	0.10
	Expected	0.29			0.13			0.23		
NDBG 132 x DBG 6	Observed	0.23*	±	0.09	0.22*	±	0.09	0.10	±	0.09
	Expected	0.23			0.22			0.10		
Pusa Naveen x DBG 5	Observed	0.35*	±	0.15	0.32*	±	0.15	0.23	±	0.15
	Expected	0.35			0.32			0.23		
Pusa Naveen x DBG 6	Observed	0.37*	±	0.14	0.32*	±	0.15	0.43**	±	0.15
	Expected	0.36			0.30			0.42		
DBG 5 x DBG 6	Observed	0.24*	±	0.12	0.21	±	0.12	0.25*	±	0.12
	Expected	0.04			0.01			0.02		

***and** significant at 5 per cent and 1 per cent levels, respectively**

CONCLUSION

The significant and desirable heterosis and heterobeltiosis was noted for fruit yield per plant in NDBG 132 x DBG 6, Pusa Naveen x DBG 5 and Pusa Naveen x DBG 6. These cross also manifested desirable heterosis as well as heterobeltiosis in some of the important yield components could be exploited for commercial cultivation after multi-locational testing. Low to moderate inbreeding depression was observed in the present study as a whole. The observed and the expected estimates for heterosis, heterobeltiosis and inbreeding depression were in close agreement with one another for all the characters in all five crosses.

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