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ARTICLE

Expression of Heterosis for Productive Traits in Bottle Gourd Hybrids

AKM Quamruzzaman[1*] M.M.R. Salim[1] L. Akhter[1] M.M. Rahman[2] M.A.Z. Chowdhury[2]

1. Olericulture Division, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh
2. Bangladesh Agricultural Research Council, Farmgate, Dhaka-1207, Bangladesh

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ABSTRACT

An intensive study was conducted in bottle gourd to assessment the magnitude of heterosis for yield and its thirteen yield related traits. Twenty one bottle gourd hybrids generated from 7 × 7 diallel cross (excluding reciprocals) along with their seven parents evaluated in a RCBD with three replication at the Olericulture Division of Horticulture Research Centre, BARI, Gazipur, Bangladesh during 2018-19. Maximun cross combinations were found significant heterobeltiosis for earliness. The maximum heterobeltiotic effect was observed in P2XP7 and P4XP7. The best heterotic cross for fruit length was P4XP5. Maximum heterotic effect in respect of fruit number per plant was found in the cross P1XP6 and P4XP6. In terms of yield the highest heterobeltiosis was shown by the crosses P3XP4, P3XP5, P4XP5 and P4XP7. In the overall analysis, both additive and non-additive gene actions were found important with predominance of the additive gene effects in the inheritance of bottle gourd.

1. Introduction

Bottle gourd [*Lagenaria siceraria* (Mol) Standl] is an important vegetable crop of the family cucurbitaceae in Bangladesh. It is very much popular cucurbitaceous vegetables due to its easy to cultivation as well low cost to produce and prolific bearing habit. Commonly itIt are used as a cooked vegetable. Among the six species of *Lagenaria*, it is the only cultivated species having a somatic chromosome number 2n=2x=22. Among the cucurbitaceous vegetables, bottle gourd got an importance due to its high yield potential, considerable market price throughout the season and export potential. It is rich source of potassium, vitamin C, proteins, sulphur, fat and phosphorus [1]. It is highly cross-pollinated and has wide genetic diversity. It is cultivated throughout the country. Inspite of wide genetic base and old history, very less research has been done so far for exploitation of heterosis. The exploitation of heterosis in different commercial crop hybrids has made a massive contribution to 20th century agriculture, though the genetic basis of the phenomenon remains unclear [2,3,4]. Plant breeders describe heterosis as the manifestation of greater vigour in height, leaf area, growth, dry matter accumulation and yield in a F_1 hybrid in comparison with the parents [5,6,7]. Today, with many other hybrid crops all over the world, a lot of in hybrid varieties horticultural crops like bottle gourd, cucumber, watermelon, pumpkin, onion, tomato, capsicum, eggplant, cabbage, cauliflower and broccoli are repeatedly cultivated world wide. F_1 hybrid bottle gourde is one of the most leading vegetable crops in the subcontinent.

It is well known that bottle gourde is being a monoecious vegetable; there is an ample scope for exploitation

**Corresponding Author:*
AKM Quamruzzaman,
Olericulture Division, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh;
Email: akmqzs@gmail.com

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of hybrid vigour. Therefore, selection based on magnitude of heterosis of more than one yield component will be highly realistic. Exploitation of heterosis, even to a small magnitude for individual component characters is a desirable factor as reported by [8]. There is bright scope to get the benefit of heterosis in Bangladesh. Therefore, the present study has been undertaken to find out better bottle gourd hybrids using heterosis study.

2. Materials and Methods

2.1 Experimental Site

The experiment site was the farm of Vegetables Division, Bangladesh Agricultural Research Institute (BARI) during 2018-19. The field was at 23.9920º N Latitude and 90.4125º E Longitudes having an elevation of 8.2 m from sea level under agro-ecological zone (AEZ) 28 [9]. The farm was situated in the sub-tropical climatic zone and characterized by scanty rainfall during the experimental time. The average minimum and maximum temperature were18.37^{0}C and 29.37^{0}C and the average relative humidity varied from 55.55 to 75.70 %. The soil of the experimental field was sandy clay loam in texture having a pH range around 6.0.

2.2 Plant Materials

Twenty one cross combinations viz., P1xP2, P1xP3, P1xP4, P1xP5, P1xP6, P1xP7, P2xP3, P2xP4, P2xP5, P2xP6, P2xP7, P3xP4, P3xP5, P3xP6, P3xP7, P4xP5, P4xP6, P4xP7, P5xP6, P5xP7 and P6xP7 along with seven parents viz., P1[code LS14], P2[code LS01], P3 [code LS02], P4[code LS03], P5 [code LS04], [P6 code LS07], P7 [code LS09] of bottle gourd were used in this study. The seeds of these germplasm were sown on the seedbed on 05October, 2018. Twenty days old planting materials were placed in the main field on 25October, 2018.

2.3 Experimental Design and Layout

Twenty one bottle gourd hybrids generated from 7 × 7 diallel cross (excluding reciprocals) along with their seven parents placed in a RCBD (Randomized Complete Block Design) with three replication. Each planting material was represented by a single row of 10 m length. Row to row and plant to plant distance was 2.5m and 2m, respectively with 0.5m drain.

2.4 Land, Pit Preparation and Fertilization

The experimental land was fertilized with organic manure, N, P, K, S, B and Zn @ 3000, 80, 45, 88, 25, 1.8 and 4.5 kg/ha, respectively. The fertilization procedure was followed as-half of organic manure and all of S, Zn and B each of P and K @ 30 kg/ha was applied during final land preparation. Rest of organic manure and P and K @ 15 kg/ha were applied as basal in pit. Rest of N and K were applied in 4 equal installments after 20 days of transplanting at 20 days interval starting.

2.5 Intercultural Operation and Plant Protection

The recommended necessary agronomic practices and plant protection measures (especially adult red pumpkin beetle, fruit fly) were adopted for raising a good crop. GI steel pipes were used to support the growing plants and allowed them to grow along string netting. Irrigation was applied as and when required.

2.6 Data Recorded

Data were recorded on the following parameters viz., days to 1st harvest, days to edible fruit maturity, fruiting duration, fruit length, fruit diameter, exocarp thickness, endocarp thickness, TSS, branches per plant, vine length, fruits number per plant, Average fruit weight and yield per plant.

2.7 Analysis of Variance (ANOVA)

All the quantitative data taken were subjected to ANOVA. The total variances of each character were partitioned into block, genotype and error differences. The differences within the classes of effects were tested by F-test.

2.8 Estimation of Heterosis

Percent heterosis was estimated as -

H (BP) = {[(F_1 - BP) x100] / BP} [when BP for better parent, H for heterosis]

Where,

F1 = Mean of F_1 generation, BP = Mean of better parent

The significance test for heterosis was calculated by

Critical difference (CD) for heterobeltiosis over better parent

$$CD\ (BP)\ =\ \frac{\sqrt{(2MSE)\times t}}{r}$$

Where,

MSE= Error mean square,

r= Number of replication

t= Tabulated value of t at 1% and 5% level of significance.

CD was used to compare the observed differences

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among different treatments. If the difference was greater than CD value it was considered as significance or vice versa.

The significance test for heterosis was done by using standard error of the value of better parent as -

SE (BP) = sqrt [3/2 x (MSE)/r] [MSE for Mean Squared Error]

3. Results and Discussion

Analysis of variance for genotypes i.e. parents and crosses showed a significant difference for the maximum characters studied (Table 1). The estimates of percent heterosis observed in F_1 generation over better parent are presented through Table 2 to Table 4.

3.1 Days to 1st Harvest

Out of 21 cross combinations 20 F1s showed negative heterosis over better parent. Of them 15 crosses exhibited significant negative heterosis. Negative heterosis ranged from-0.86 to -12.70% over better parent. Negative heterosis ranged from -1.00 to -24.61% over better parent in bottle gourd reported by [1], while other negative range-0.10 to -6.24% mentioned by [10]. In present study maximum negative heterosis were observed in cross P2xP7 (-12.70%) followed by P4xP7 (-10.58%) (Table 2). Maximum negative heterosis (-15.7%) over mid parent in bottle gourd was mentioned by [11]. These findings of the present investigation are in conformity with the findings of [12, 13] in bottle gourd.

3.2 Days to Days to Edible Fruit Maturity

Nineteen crosses showed negative heterosis over better parent, while ranged from -2.08 to -26.67 percent and maximum heterosis was observed in cross P1xP5 (-26.67 percent). [1] reported heterosis ranged from 11.26 to -19.99% over better parent in bottle gourd. Three crosses viz., P1xP5 (-26.67%), P1xP4 (-23.33%), P1xP7 (-21.67%) showed more than 20 percent negative heterosis over better parent. In maximum cases the crosses involving parent P1 showed negative heterosis for this trait. Higher range of heterobeltiosis was -19.99 to 11.26%, while best three crosses were -19.99%, -18.16% and -16.92% [1], which is similar to the present findings. These results were in accordance with findings of [14,15].

3.3 Fruiting Duration

Fruiting duration showed negative heterosis in 12 crosses, of them 8 crosses exhibited significant positive heterosis over their better parent, while the ranges of negative heterosis was -0.29 to -9.94 percent. The highest significant positive heterosis percent was P5xP6 (-9.94%) followed by P3xP4 (-8.99%) percent.

3.4 Fruit Length

Twelve crosses showed significant positive heterosis for this trait while ranged from 4.07 to 42.06 percent. More than 15% heterosis was obtained by 4 crosses (P4xP5, P3xP5, P1xP2, P1xP7). Highest value of percent heterosis was observed in P4xP5 (42.06%). [11] recorded six crosses showed more than 20% heterosis over mid parent in Bangladesh condition. Where as [16] reported 0.06% to 31.02% heterosis in summer season while [1,17] reported -8.34% to 61.57% and -20.36% to 13.62%, respectively in spring season of India. Similar results were also reported by [13].

3.5 Fruit Diameter

Three combinations exhibited significant positive heterobeltiosis, while percent positive heterosis ranged from 0.86 to 3.65 with the highest value 3.65% (P3xP6) (Table

Table 1. Analysis of variance for genotypes (parents and crosses) in winter season

Source of variation	d.f.	Mean sum of square						
		Days to 1st harvest	Days to edible fruit maturity	Fruiting duration	Fruit length	Fruit diameter	Exocarp thickness	Endocarp thickness
Genotypes (Parents & F_1s)	27	13.49**	4.60**	24.60**	207.10**	11.60**	0.11	9.65**
Replication	2	9.52	3.86	30.20	2.00	0.60	0.02	1.08
Error	54	2.16	0.83	3.18	3.50	0.37	0.01	0.40

Contd. Table 1.

Source of variation	d.f.	Mean sum of square					
		TSS	Branches per plant	Vine length	Fruits number per plant	Average fruit weight	Yield per plant
Genotypes (Parents & F_1s)	27	0.20	81.71**	5.12**	7.35**	0.20	63.97**
Replication	2	0.01	63.37	0.59	0.04	0.06	6.72
Error	54	0.01	0.11	0.01	0.80	0.01	6.60

Note: ** Significant at 1% level of probability; * Significant at 5% level of probability.

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2). [11] recorded the range of over mid parent heterosis was -11.6% to 19.2% in Bangladesh. Where as [16] reported 0.06% to 31.02% heterosis in summer season while [1,17] reported -8.34% to 61.57% and -20.36% to 13.62%, respectively in spring season of India. Similar results were also reported by [13] in bottle gourd.

3.6 Exocarp Thickness

Ten crosses showed significant positive heterosis over better parent, while the range was 1.49 to 23.33 percent and maximum heterosis was in cross P1xP5 (23.33%). In maximum cases the crosses involving parent P1 and P3 showed heterosis for fruit exocarp thickness (Table 2). [18] reported three best parent heterosis were 21.50%, 19.62% and 16.36% in pumpkin.

3.7 Endocarp Thickness

Eighteen F1s showed significant negative heterosis over better parent. Negative heterosis ranged from -3.95 to -40.48%, while maximum negative heterosis were observed in cross P3xP7 (- 40.48**). More than 20 percent heterosis for endocarp thickness over better parent was observed in 12 crosses viz., P3xP7 (-40.48**), P4xP6 (-38.76**), P1xP3 (-36.56**), P2xP3 (-34.44**), P2xP6 (-33.59**), P3xP4 (-32.93**), P6xP7 (-31.52**), P1xP5 (-31.43**), P3xP5 (-31.42**), P5xP6 (-27.39**), P1xP2 (-24.29**), P1xP4 (-22.86**) (Table 2).

3.8 TSS

Four F_1s showed significant positive heterosis ranging from 1.11 to 17.95 percent in winter, while highest positive heterosis was observed in the crosses P2xP4 (17.95%). More than 15% heterosis was observed in two crosses (P2xP4 and P5xP7). These results partially confirmed the observations of [16] as they recorded moderate estimates of standard heterosis.

Table 2. Percent heterosis over better parent for days to 1st harvest, days to edible fruit maturity, fruiting duration, fruit length, fruit diameter and exocarp thickness and endocarp thickness

Cross	Days to 1st harvest	Days to edible fruit maturity	Fruiting duration	Fruit length	Fruit diameter	Exocarp thickness	Endocarp thickness
P1 x P2	-7.26**	-15.00**	7.14**	18.77**	-5.56**	6.67**	-24.29**
P1 x P3	-7.26**	-15.00**	2.47	-2.44	-28.42**	-9.72**	-36.56**
P1 x P4	-9.14**	-23.33**	- 4.35**	4.07**	-5.56**	3.33**	-22.86**
P1 x P5	-7.80**	-26.67**	-1.81	8.13**	-5.56**	23.33**	-31.43**
P1 x P6	-7.26**	-9.17**	3.54**	-24.39**	-11.71**	- 4.48**	-14.21**
P1 x P7	-9.26**	-21.67**	0.65	17.89**	2.78**	6.67**	-13.57**
P2 x P3	-1.64	-8.33**	2.78*	-5.75**	-29.47**	-18.06**	-34.44**
P2 x P4	-2.29*	-7.84**	-0.29	-16.09**	2.94**	-3.28**	6.42**
P2 x P5	- 4.00**	-2.08**	1.81	4.60**	-3.08**	-3.28**	- 4.83**
P2 x P6	-1.67	-14.81**	-2.25	-25.29**	-28.02**	-11.94**	-33.59**
P2 x P7	-12.70**	0.00	17.75**	9.20**	- 4.29**	- 4.92**	-3.95**
P3 x P4	-1.09	-7.84**	-8.99**	11.11**	-22.11**	2.78**	-32.93**
P3 x P5	-7.10**	- 4.17**	0.30	23.81**	-27.37**	-18.06**	-31.42**
P3 x P6	- 4.92**	-5.56**	2.47	6.17**	3.65**	2.78**	1.29**
P3 x P7	-1.06	-7.84**	-6.48**	-11.54**	-27.37**	2.78**	- 40.48**
P4 x P5	-0.86	10.78**	-8.12**	42.06**	0.00	-3.28**	1.83**
P4 x P6	-3.89**	-5.56**	-2.61*	-3.17*	-31.86**	-11.94**	-38.76**
P4 x P7	-10.58**	-7.84**	-6.67**	8.97**	0.86	13.11**	-5.70**
P5 x P6	2.22	-5.56**	-9.94**	-3.17*	-18.43**	7.46**	-27.39**
P5 x P7	-7.41**	-7.84**	-3.31*	8.97**	- 4.29**	-3.28**	- 4.82**
P6 x P7	-2.38*	-5.56**	-2.25	-9.62	-23.03**	1.49**	-31.52**
S.E.	1.04	0.64	1.26	1.32	0.43	0.07	0.44
C.D Value (0.05)	2.13	1.31	2.58	2.71	0.88	0.14	0.90
C.D Value (0.01)	2.88	1.77	3.49	3.66	1.19	0.19	1.22

Notes: * Significant at 5% level of probability ; ** Significant at 1% level of probability.

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3.9 Branches Per Plant

Three crosses showed significant positive heterosis over better parent (Table 3). Percent heterosis (positive) ranged from 2.08 to 12.42 percent, while maximum percent positive heterosis was observed in P2xP4 (12.42%). [1] also reported three best crosses which heterobeltiosis were 79.15%, 73.0% and 66.47% in bottle gourd which was much higher than the present findings.

3.10 Vine Length

It is evident from the Table 3 that heterosis over better parent for vine length was significant positive in 7 crosses. Range of significant positive heterosis was 6.64 to 27.88 percent, while highest positive heterosis was observed in the cross P3xP5. More then 15% heterobeltiosis was observed in 4 crosses viz., P3xP5, P1xP3, P3xP4, P3xP6. [1, 12] reported that most hybrids in their study showed positive heterosis over the better parent for vine length in summer and spring season with the range of -15.54 to 64.30% and 6.27 to 26.29%, respectively in India.

3.11 Fruits Number Per Plant

More than 70% of the cross combinations studied showed positive heterosis for fruits number per plant which showed significant in all crosses. The range of positive heterosis for the trait was 3.70 to 32.14 percent, while maximum positive heterosis observed in the cross P1xP6 (32.14%) (Table 3). Findings are in agreement with [12,17] where the range was 17.63 to 100.14% and -42.60 to 34.80%, respectively. [11] reported the range was -22.4 to 82.6% mid parent heterosis in Bangladesh condition. Similar results were also reported by [13,18,19,20,21,22].

More than 20 percent heterosis over better parent was observed in 4 crosses viz., P1xP5 (22.22**), P1xP6 (32.14**), P1xP7 (30.77**), P4 xP6 (32.00**). Similar findings of higher yield were reported by [1, 10] where the range of heterobeltiosis were -13.49 to 20.40% in summer and -32.12 to 93.79% in spring, respectively in India.

Table 3. Percent heterosis over better parent for TSS, branch per plant, vine length, fruits number per plant, average fruit weight and yield per plant

Cross	TSS	Branch per plant	Vine length	Fruits number per plant	Average fruit weight	Yield per plant
P1 x P2	-15.24**	0.00	-19.03**	3.85**	- 4.93**	3.41
P1 x P3	-11.43**	2.08**	24.88**	-3.70**	-7.04**	-0.35
P1 x P4	-14.29**	-6.74**	-12.44**	7.69**	-13.38**	1.05
P1 x P5	-9.52**	-17.95**	-1.33**	22.22**	-21.83**	6.27**
P1 x P6	-5.71**	-16.85**	-1.33**	32.14**	-13.38**	10.64**
P1 x P7	-10.48**	0.00	8.53**	30.77**	-11.27**	23.42**
P2 x P3	-5.49**	-29.17**	-29.10**	7.41**	6.67**	18.57**
P2 x P4	17.95**	12.42**	-26.87**	7.69**	5.56**	13.29**
P2 x P5	8.54**	-27.18**	-32.46**	11.11**	6.67**	22.66**
P2 x P6	-16.98**	-14.46**	-22.39**	-7.14**	8.80**	-2.04
P2 x P7	1.11**	-8.05**	-21.27**	11.54**	13.33**	26.24**
P3 x P4	-3.30**	- 4.17**	24.88**	15.00**	30.77**	49.72**
P3 x P5	6.59**	-11.79**	27.88**	7.41**	35.90**	44.97**
P3 x P6	1.89**	-1.04**	19.91**	7.14**	11.97**	15.89**
P3 x P7	1.11**	- 44.79**	-5.53**	3.70**	5.62**	13.74**
P4 x P5	9.76**	- 48.72**	-37.17**	14.81**	21.79**	39.47**
P4 x P6	-13.21**	10.84**	7.96**	32.00**	-13.38**	10.79**
P4 x P7	2.22**	-25.29**	-17.97**	7.69**	20.00**	28.26**
P5 x P6	-6.60**	- 48.72**	-23.89**	10.71**	3.52**	10.79**
P5 x P7	17.78**	-54.87**	- 47.79**	7.41**	5.62**	17.72**
P6 x P7	-15.09**	- 4.60**	6.64**	0.00	22.54**	18.37**
S.E.	0.07	0.23	0.07	0.63	0.07	1.81
C.D Value (0.05)	0.14	0.47	0.14	1.29	0.14	3.71
C.D Value (0.01)	0.19	0.64	0.19	1.75	0.19	5.01

Notes: * Significant at 5% level of probability; ** Significant at 1% level of probability.

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3.12 Average Fruit Weight

Significant positive heterosis was observed in 14 combinations, while percent heterosis (positive) ranged from 3.52 to 35.90 and highest positive heterosis exhibited in the cross P3xP5 (35.90%). More than 20% positive heterosis was observed in 5 crosses (P3xP5, P3xP4, P6xP7, P4xP5, P4xP7). [11] reported the range was -7.9 to 45.5% over mid parent heterosis in Bangladesh condition. Similar findings of higher Average fruit weight were reported by [10,12] where the range of heterobeltiosis were -14.29 to 14.17% and 0.92 to 24.32%, respectively in summer while [1, 17] reported the range of heterobeltiosis were -29.85 to 86.33% and -32.65 to 41.81%, respectively in spring of India. Similar results were also reported by [13, 18, 19, 20, 21, 22].

3.13 Yield Per Plant

Ninteen crosses out of 21 crosses exhibited positive heterosis for yield per plant over better parent (Table 3). Percent of positive heterosis ranged from 1.05 to 49.72%, while highest significant positive heterosis was found in cross P3xP4 (49.72%). More than 25% heterosis over better parent was observed in 5 combinations for yield per plant. [11] reported 10 crosses showed more than 25% mid parent heterosis. Higher heterobeltiosis was observed in P3xP4 (49.72%), P3xP5 (44.97%), P4xP5 (39.47%), P4xP7 (28.27%) and P2xP7 (26.24%) while [1] reported 41.37 to 97.47% heterobeltiosis for yield per plant. [10,17] also reported range of heterosis over better parent in yield per plant -16.57 to 23.77% and -30.05 to 59.73%. Similar results were reported earlier by [13,14,16,18,20,22-28].

4. Conclusions

The data of the present investigation supported the use of hybrids to facilitate development of cultivars of bottle gourd for the tropics. The present results also indicated that in bottle gourd total yield per plant was mainly dependent on the number of fruits number per plant and average fruit weight. The fruits number per plant was influenced by the size of the fruit (fruit length, fruit diameter) and vegetative vigour (vine length and branches per plant). The outstanding crosses were P2xP7, P4xP7 (days to 1st harvest), P1xP5, P1xP4 (days to edible fruit maturity), P5xP6, P3xP4 (fruiting duration), P4xP5, P3xP5 (fruit length), P3xP6 (fruit diameter), P1xP5 (fruit exocarp thickness), P3xP7, P4xP6 (fruit endocarp thickness), P2xP4, P5xP7 (TSS), P2xP4 (branches per plant), P3xP5, P1xP3 (vine length), P1xP6, P4xP6 (fruits number per plant), P3xP5, P3xP4 (average fruit weight), P3xP4, P3xP5, P4xP5, P4x P7 (yield per plant) may be considered for selection. The results indicates that the study of heterosis will allow us to select better hybrid combinations in respect of higher yield, earliness and increased fruit number, bigger sized fruit etc. There was considerable heterobeltiosis for almost all the 13 yield contributing characters studied. It also shows the possibility of increasing yield by exploiting heterosis. The presence of high heterosis indicated genetic diversity among parents. Therefore, with increased diversity between parental stocks higher level of heterosis is expected in F_1 hybrids.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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