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HETEROSIS IN CUCUMBER (*Cucumis sativus* L.)

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Abstract

Heterosis for quantitative characters in 39 cucumber genotypes (19 parents and 20 F_1 s) were investigated at the farm of Department of Genetics and Plant Breeding in Bangabandhu Sheikh Mujibur Rahman Agricultural University during March-November, 2013. Analysis of variance revealed highly significant differences among the parents and hybrids for 19 characters studied. Considerable coefficient of variation were observed for branches per plant, flesh thickness, placental thickness, fruit length ,fruit width, male and female flowers per plant, leaf length, leaf breadth, vine length, fruits per plant , fruit yield per plant indicating the scope of selection for those characters. The characters like branches per plant, male and female flowers per plant, fruit length, fruit weight, fruits per plant, fruit yield per plant contributed the maximum variability towards divergence among cucumber genotypes. Heterosis study depicted that the crosses Sobujsathi × Baromashi, Sobujsathi × Khira, Himaloy × Khira, exhibited significant positive heterosis for 50 % female flowering; Himaloy × Baromashi, Baromashi× Greenking for fruit length; Baromashi × Hero, Yuvraj × Khira for single fruit weight. Where Sobujsathi × Baromashi, Shila× Khira , Modhumoti × Hero and Modhumoti × Khira exhibited significant positive heterosis and heterobeltiosis for yield per plant. The highest positive heterotic effect for no. of fruits per plant was observed in Modhumoti × Baromashi (20%). The highest heterobeltiosis effect was found in hybrid Himaloy × Yuvraj (24.5%) followed by Sobujsathi× Khira (11.2 %), Modhumoti × Baromashi (10.0 %). Four crosses exhibited significant positive better parent heterotic effect for this trait and the combination Sobujsathi × Baromashi had the maximum heterosis on yield (47.6%). The maximum heterobeltiosis effect was found in Shila × Khira (27.73 %) followed by Modhumoti × Hero (15.14%) and Modhumoti × Khira (10%) for fruit yield.

Keywords: Cucumber, Heterosis, Productivity, Hybrid

Introduction

Cucumber (*Cucumis sativus* L) is an important member of the family cucurbitaceae. The crop is of Asian origin, the progenitor may be closely related to the wild *Cucumis sativus* var. *hardwickii*, which was first found in the Himalayan foothills of Nepal (Hossain *et al*, 2010). It is a common vegetable in Bangladesh with two types: one is known as 'Khira' available in late winter and

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other is 'Shosha' grown round the year. There are 4.61 thousand ha of land under cultivation in Bangladesh and production is about 49 thousand tons (BBS, 2014). It is chiefly grown for its edible tender fruits, preferred salad ingredient, pickles, and desert fruit and as a cooked vegetable. Cucumber contains 0.50 g fiber, 0.65 g protein, 14.3 kilo calories, 16 mg Ca, 24 mg P, 13 mg Mg and 147 mg K per 100 gm of edible portion. It also contains Vitamin B (B_1-0.027 mg and B_6-0.040 mg per 100 g of edible portion and a considerable amount of Niacin and Vitamin-C (Anon, 2011). Although cucumber is not rich in nutrient contents, yet it is considerable as a good source of nutrients for human body as it is mostly taken without cooking. Cucumber has some therapeutic properties as well as it leaves and seeds contain cucrbitaside B and C (Ghani, 2003) which are used for treating different ailments. It is also consumed by diabetic patients and known as fat reducing food.

Heterosis or hybrid vigor is an important biological phenomenon refers to the manifested superiority of the F_1 hybrid resulting from cross of genetically dissimilar homozygous parents over either of the parents. Heterosis or hybrid vigor can play a vital role in increasing the yield quality of cucumber. It refers to the phenomenon in which F_1 hybrid obtained by crossing of two genetically dissimilar inbred lines or genotypes, shows increased or decreased vigor over the better parent or mid parent value (Poehlman, 1979). Heterosis is a useful tool for exploiting dominance and over dominance through the production of hybrids. In commercial production, hybrid seeds are usually heterozygous gynoecious with regard to gynoecious character and are termed predominantly female (Wien, 1997). In cucurbits, heterosis was first noted by Hays and Jones (Hays *et al.,* 1961). Now a day's heterosis breeding is one of the efficient tools to exploit the heterotic response for several traits. Very few research works relating to heterosis of cucumber have been conducted in Bangladesh. So, intensive research efforts are needed in several areas, particularly, selection of superior genotypes. There are a lot of variabilities among the existing cucumber germplasm of Bangladesh (Hossain *et al,* 2010). Based on the information, the present study was undertaken to assess the parental diversity and heterosis in cucumber**.**

Materials and Methods

A total of 19 parental genotypes of cucumber namely Piyas, Yuvraj, Himaloy, Shilla Hreo, Modhumoti, Baromashi, Greenboy, Sobujsathi, Sobujsathi, Tripti, Greenking, Khira, 4307, 4315, 4240, 4239, 4308, 4249, 4263 and 20 F_1s namely Modhumoti × Tripti, Baromashi × Greenking, Baromashi × Hero, Modhumoti × Baromashi, Modhumoti × Hero, Hero × Piyas, Modhumoti × Khira, Baromashi × Khira, Yuvraj × Khira, Himaloy × Tripi, Himaloy × Yuvraj, Himaloy × Baromashi, Sobuhsathi×Khira, Himaloy × Khira, Sobujsathi × baromashi, Greenboy × Tripti, Hreo × Khira, Hero × Tripti, Tripti × Khira and Shila × Khira were used in this experiment. No specific crossing pattern

was used in this experiment. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications at the experimental field, Department of Genetics and plant Breeding, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur during the summer season March to November 2013 on an upland soil. Seeds of cucumber were sown in 10 cm x 5.5 cm polybag. The unit plot size was 7.5 m x 1.2 m accommodating 5 plants in each plot. The pits were dug prior to two weeks of planting in a dimension of 0.5 m x 0.5 m x 0.5 m at spacing of 1.5 m pit to pit. The treatments were randomly assigned to different plots of each block separately. The healthy seedling of 20 days old was transplanted in the pit of the experimental field. All the recommended agronomic practices were adopted to raise a good crop. Data on 19 quantitative characters: viz. Days to first male flowering, Days to first female flowering, Male flowers per plant, Female flowers per plant, Days to 50% male flowering (staminate flowers), Days to 50% female flowering (pistillate flowers), Leaf length (cm), Leaf width (cm), Petiole length (cm), Branches per plant, Vine length, Fruit length (cm), Fruit diameter (cm), Fruit weight (g), Flesh thickness (cm), Placental thickness (cm), Fruits per plant, Yield per plant (gm), 1000 seed weight (g) (dried seed) were recorded. The collected data were statistically analyzed. Analysis of variance for each of the character was performed. For estimating the heterosis in each character the mean values of F_{1s} have been compared with better parent (BP) for heterobeltosis and with mid parent (MP) for heterosis over mid parent value. Percent heterosis was calculated as follows;

Estimation of Heterosis over Better Parent (HBP):

$$\text{HBP} = \frac{F_1 - BP}{BP} \times 100$$

Where,

F_1 = Mean of the F_1 hybrid, BP = mean of the two parents of that particular F_1 cross

Estimation of Heterosis over Mid Parent (HMP):

$$\text{HMP} = \frac{F_1 - MP}{MP} \times 100$$

Where,

F_1 = Mean of the F_1 hybrid, MP = mean of the two parents of that particular F_1 cross

$$\text{Mid parent value} = \frac{P_1 - P_2}{2} \times 100$$

Test of significance of Heterosis:

The significance test for heterosis was done by using standard error of the value of better parent and mid parent.

$$\text{SE (BP)} = \sqrt{3/2X \frac{M.S.S.Error}{r}}$$

$$\text{SE (MP)} = \sqrt{2X \frac{M.S.S.Error}{r}}$$

Critical difference (CD) = SE X t at 5 %

Where,

Me = Error mean sum of squares

r = Number of replications

Results and Discussion

Heterosis

The mean sum of square from analysis of variance for different yield contributing characters is presented in the Table 1. The analysis of variance revealed highly significant differences among the genotypes for all the characters. The mean sum of square due to parent differed significantly, indicating great deal of diversity among them. The heterotic responses of F_1 hybrids over mid parent (MP) and better parent (BP) for 19 characters are presented in Table 2. Both positive and negative heterosis was observed for quantitative characters in F_1 hybrids of cucumber. It was noticed that the heterotic performance of the hybrids over their mid parental values were mostly positive. Character wise heterotic performances of the crosses are discussed below:

Leaf length (cm)

The cross Modhumoti × Khira showed highly significant positive heterosis (28.18%). The cross Baromashi × Khira showed significant positive heterosis (25.24%) followed by Modhumoti × Tripti (15.34%), Baromashi × Hero (7.79%) and Modhumoti × Hero (3.58%). The highest negative heterosis was observed in the cross Sobujsathi × Baromashi (-33.33 %). The highest positive heterobeltiosis was observed in cross Modhumoti × Khira (17.5%) followed by Baromashi × Khira (6.52 %) and Modhumoti × Tripti (4.25 %) (Table 2).

Leaf Width (cm)

The hybrid Modhumoti × Khira showed highly significant positive heterosis (24.35 %). The cross Hero ×Tripti showed significant positive heterosis (

20.25%) followed by Baromashi × Hero (20.06%), Greenboy × Tripti (17.58 %).The highest negative heterosis was observed in the cross Sobuhsathi × Khira(-72.43 %). The highest positive heterobeltiosis was observed in Greenboy × Tripti (13.23 %) followed by Hero × Tripti (7.98 %) and Modhumoti × Khira (2.93 %) (Table 2).

Vine length (cm)

All the cross combinations showed significant better parent heterosis for this trait (Table 2). Six combinations had significant positive heterosis while rest of the 13 showed negative heterosis. The highest negative heterotic response for this trait was found in Modhumoti × Khira (-24.34 %) followed by Hero × Khira (-19.58 %) and Sobuhsathi × Khira (-19.11 %). The highest negative heterobeltiosis for this trait was found in Modhumoti × Khira (-41.92 %) followed by Modhumoti × Tripti (-37.38 %).

Length of petiole

The hybrid Modhumoti × Hero showed highly significant positive heterosis (14.27 %) (Table 2). followed by Modhumoti × Khira (12.21%). The highest negative heterosis was observed in the cross Sobujsathi × Baromashi (-57.14%). The highest positive heterobeltiosis was observed in cross Modhumoti × Hero (3.23 %).

No. of branches / plant

The hybrid Sobuhsathi × Khira showed highly significant positive heterosis (29.04 %) followed by Greenboy × Tripti (17.6%) and Himaloy × Yuvraj (9.09%) (Table 2). The highest negative heterosis was observed both in the cross Baromashi × Hero and Baromashi × Khira (-33.33 %). The highest positive heterobeltiosis was observed in cross Sobuhsathi×Khira (21.82%) followed by Greenboy × Tripti (4.32 %).

No. of male flowers per plant

All the cross combination showed negative mid parent heterosis except Baromashi × Hero which showed positive heterosis (8.33%) (Table 2). The highest negative heterotic effect was observed in cross Himaloy × Tripi (-59.73%).

No. of female flowers per plant

All the cross combinations showed negative mid and better parent heterosis. The highest negative mid parent heterotic effect was found in the cross Sobuhsathi×Khira (-87.23 %) and the highest negative heterobeltiosis was observed in the cross Sobuhsathi × Khira (-88.88%) (Table 2).

Table 1. Analysis of variance for different quantitative characters in cucumber

Source of variation	Df	LL	LW	VL	LP	NBPP	DFMF	DFFF	DHMF	DHFF	NMF	NFF
Replication	2	5.16	6.93	2438.32	2.84	1.92	9.21	3.87	8.05	13.62	36.98	26.02
Genotype	38	7.02**	8.09**	6026.92**	5.03**	3.01**	20.03**	1.32**	31..93**	29.43**	51.09**	3.8**
Parents	18	3.85**	3.41**	2163.25**	1.25**	1.98**	8.5**	0.34**	20.03**	10.36**	21.85**	1.52**
Hybrids	20	3.17*	4.68**	3863.67**	3.78**	1.03**	11.53**	0.98**	11.90**	19.07**	29.24**	2.35**
Error	76	1.99	1.74	8.02	1.47	3.35	9.52	37.71	9.03	6.61	81.72	60.32

** and * Significant at 5% and 1% level of probability, respectively; NS- Non Significant

Table 1. Continued

Source of variation	df	FT	PT	FL	FW	NFPP	SFW	YPP	100 SW
Replication	2	27.90	13.75	23.09	6.21	15.94	264.47	8.32	0.92
Genotype	38	31.23**	19.78**	58.13**	8.03**	52.09**	1619.32**	10.42**	1.32**
Parents	18	12.98**	5.36**	23.48**	4.05**	21.18**	71.36**	4.89**	0.6**
Hybrids	20	18.25**	14.42**	34.65**	3.98**	30.91**	1547.96**	5.53**	0.72**
Error	76	1.92	2.31	4.31	0.65	1.03	27.38	16.5	0.06

** and * Significant at 5% and 1% level of probability, respectively; NS- Non Significant.

Note: LL= leaf length, LW= leaf width, VL=Vine length, LP=Length of petiole, NBPP= No. of branches/plants, NMF=Number of male flower, NFF= Number of female flower, DFMF= Days to first male flower, DFFF=Days to first female flower, DHMF=Days to 50% male flowering, DHFF =Days to 50% female flowering , FT = Flesh thickness , PT= Placental thickness, NFPP=No .of fruit/plant, SFW=Single fruit weight , FL=Fruit length, FW=Fruit width, YPP=Yield peer plant.

Days to 50% male flowering

Out of 20 crosses, 17 showed negative mid parent heterosis and three showed positive heterosis (Table 2). Heterosis for earliness ranged from -1.17% to -27.91%. The highest significant negative heterotic response for days to 50 % male flowering was observed in cross Himaloy × Khira (-27.91%) followed by Modhumoti × Tripti (-27.27%) and Sobujsathi × Baromashi (-23.59 %). All cross combinations showed significant negative better parent heterobeltiosis for this trait indicated earliness. The highest significant negative heterobeltiosis for earliness was observed in cross Modhumoti × Tripti (-33.33%) followed by Shilla × Khira (-30.41%) and Himaloy × Khira (-27.91%).

Days to 50% female flowering

Out of 20 crosses, 17 showed significant negative heterosis and two showed positive heterosis and one (Hero × Piyas) did not show heterosis (Table 2). Heterosis for earliness in female flowering of 50 % plant ranged from -1.03 % to -33.33 %. The highest significant heterotic effect (-33.33 %) for this trait was noticed in Sobujsathi × Baromashi followed by Sobujsathi × Khira (-29.91%), Greenboy × Tripti (-25%), Himaloy × Khira (-23.07%), Hero × Tripti (-22.64%) and Himaloy ×Tripi (-18.18 %). All the 18 cross combinations showed significant negative heterosis and only Himaloy × Khira (3.77%) show positive heterosis for this trait. The highest negative heterobeltiosis response for earliness was observed in cross Sobujsathi × Baromashi (-40.63 %) followed by Himaloy × Yuvraj (-35.94 %), Greenboy × Tripti (-33.89%). Uddin (2008) observed the highest heterobeltiotic effect (-36.26%) for $F_4 \times M_2$ in cucumber.

Days to first male flowering

All the crosses showed significant negative heterosis except Hero × Piyas (0.00) which did not show heterosis (Table 2). Heterosis for earliness in days to first male flowering plant ranged from -3.23% to -36.1%. The highest significant mid parent heterotic effect (-36.1 %) for this trait was found in Shilla × Khira followed by Tripti × Khira (-29.4 %) and Himaloy × Khira (-25.6 %). The highest negative heterobeltiosis for earliness was observed in cross Hero × Khira (-36.25 %) followed by Greenboy × Tripti (-36.20%) and Tripti × Khira (-33.36%). Uddin (2008) observed the highest heterobeltiotic effect (-36.26%) for $F_4 \times M_2$ in cucumber.

Days to first female flowering

Out of 20 crosses, 15 showed significant negative heterosis and four showed significant positive heterosis except Hero × Piyas (0.00) which did not show heterosis (Table 2). Mis parent heterosis for earliness in days to first female flowering ranged from -1.27 % to -34.69 %. The highest significant mid parent

heterotic effect (-34.69 %) for this trait was found in Sobujsathi × Baromashi followed by Baromashi × Greenking (-31.6%) and Sobujsathi × Khira (-31.03 %). The highest negative heterobeltiotic response for earliness was observed in cross Sobujsathi × Baromashi (-44.83 %) followed by Sobujsathi × Khira (-39.65%).

Flesh thickness (cm)

The highest heterotic effect was found in Modhumoti × Khira (35.02 %) followed by the crosses Himaloy × Tripti (33.33%), Sobujsathi × Baromashi (16.35 %) and Baromashi × Khira (2.54%). The highest negative effect was observed in the cross Greenboy × Tripti (-45.65%) (Table 2).

Placental thickness (cm)

The cross Modhumoti × Khira (38.29 %) showed the highest significant positive mid parent heterosis followed by Tripti × Khira (32.30%) and Himaloy × Yuvraj (9.21 %). The highest negative mid parent heterosis was observed in the cross Modhumoti × Baromashi (-33.33 %) (Table 2). The highest heterobeltiosis was observed in Modhumoti × Khira (28.51%) followed by Himaloy × Yuvraj (7.81%)

Fruit length (cm)

All the cross combinations exhibited significant negative mid parent heterosis except Modhumoti × Khira (13.58 %) which showed positive heterosis (Table 2). As consumer does not prefer bigger fruit, therefore, negative heterosis for this trait is preferable. The highest negative heterotic effect was observed in cross Himaloy × Baromashi (-64.28%) followed by Baromashi× Greenking (-62.02%), Sobuhsathi × Khira (-61.04 %), Baromashi × Hero (-59.63 %) and Tripti × Khira (-57.77 %). The highest negative heterobeltiotic effect was observed in cross Baromashi × Greenking (-70.0%) followed by Greenboy × Tripti (-67.74 %), Himaloy × Baromashi (-65.53%) and Tripti × Khira (-65.26%). Uddin (2008) found the highest negative heterobeltitic effect in $F_1 \times M_2$ (-31.44%).

Fruit width (cm)

All the crosses except Modhumoti × Khira exhibited significant negative heterosis over mid and better parent for this trait (Table 2). The highest mid parent heterosis was observed in hybrid Modhumoti×Khira (29.02%). Out of 20 crosses only one (Modhumoti × Khira) showed the positive heterobeltiosis effect (6.66 %). This result also coincided with the findings of Chaudhary (1987) in bitter gourd, Shukla and Goutam (1990) in okra. Uddin (2008) observed positive heterosis in $F_8 \times M_2$ (32.50) of cucumber.

Table 2. Mid parent and Better parent heterosis for different quantitative characters in cucumber

Crosses	Leaf Length		Leaf Width		Vine length		Length of Petiole		No. of branches / plant		No. of male flowers /plant	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
Modhumoti × Tripti	15.38**	4.25**	-5.75**	-19.38**	-15.15**	-37.38**	-18.32**	-32.24**	-14.98**	-15.42**	-46.22**	-53.62**
Baromashi × Greenking	1.31**	0.91**	-12.06**	-24.66**	-1.35**	-8.33**	-20**	-33.33**	-11.7**	-19.33**	-48.39**	-50**
Baromashi × Hero	7.79**	-19.52**	20.06**	-1.03**	-1.55**	-7.77**	-3.2**	-19.3**	-10.89**	-33.33	8.33**	-6.67**
Modhumoti × Baromashi	-9.04*	-20.45	-40.32**	-57.23**	-13.4**	-34.46**	-20**	-20**	5.88**	-18.18**	-44**	-53.33**
Modhumoti × Hero	3.58**	-22.02	-39.7**	-41.23**	-7.69**	-26.67**	14.27**	3.23**	-1.32**	-4.93**	-34.74**	-38**
Hero × Piyas	1.25**	-14.75**	-33.33**	-39.21**	1.17**	-4.44**	-53.85**	-62.5**	-30.43**	-46.67**	-8.23**	-13.33**
Modhumoti × Khira	28.18**	17.5**	24.35**	2.93*	-24.34**	-41.92**	12.21**	-0.54**	-1.37**	-3.33**	-22.07**	-40**
Baromashi × Khira	25.24**	6.52**	-34.21**	-37.89**	38.61	35.93*	-37.32**	-50.00**	-33.33**	-33.33**	-11.76**	-40**
Yuvraj × Khira	-3.04**	-15.12**	-15.13**	-26.33**	-12.79**	-24.24**	-20**	-35.43**	1.02**	5.05*	-15.46**	-41.43**
Himaloy × Tripi	-23.01**	-29.77**	0.51**	-14.31**	7.38**	1.26**	-52.32**	-62.1**	9.09**	0	-59.73**	-62.5**
Himaloy × Yuvraj	3.21*	-1.47*	-22.6**	-33.33**	20.28**	17.81**	-12.32**	-19.2**	1.54**	0	-30.67**	-35**
Himaloy ×	-13.29**	-33.33**	-47.09**	-81.47**	9.25**	-8.25**	-3.70**	-13.33**	-1.29**	-6.57**	-49.67**	-51.25**

Crosses	Leaf Length		Leaf Width		Vine length		Length of Petiole		No. of branches / plant		No. of male flowers /plant	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
Baromashi												
Sobuhsathi × Khira	-4.32**	-15.12	-72.43**	-80.00**	-19.11**	-21.43**	-54.21**	-59.42**	29.04**	21.82**	-48.98**	-64.78**
Himaloy × Khira	-25.33**	-30.00**	4.82**	0.21**	-11.24**	-14.65**	-55.5**	-60.0**	-9.09**	-16.67**	-47.66**	-65**
Sobujsathi × Baromashi	-33.33**	-46.32**	-41.2**	-50.17**	-6.25**	-7.14**	-57.14**	-66.67**	2.22**	-5.29**	-45.5**	-46.67**
Greenboy × Tripti	-8.90**	-13.45**	17.58**	13.23**	13.79**	4.43**	1.14**	0	17.6**	4.32**	-43.07**	-43.38**
Hreo × Khira	-33.33**	-53.2**	-33.33**	-41.43**	-19.58**	-23.23**	-3.39**	-13.25**	-1.24**	-3.98**	-16.67**	-33.33**
Hero × Tripti	-26.54**	-50.00**	20.25**	7.98**	0.59**	-5.56**	-40.0**	-43.4**	11.11**	0**	-26.32**	-39.13**
Tripti × Khira	-35.86**	-43.00**	-65.43**	-78.43**	-7.3**	-16.67**	-53.43**	-59.9**	0**	-28.51**	-56.25**	-65.56**
Shila × Khira	-43.56**	-52.12**	-15.45	-24.14**	-5.06**	-10**	-39.33**	-43.14**	-1.32**	-2.09**	-18.75**	-43.38**

** and * Significant at 5% and 1% level of probability, respectively; NS- Non Significant

Table 2. Contd

Crosses	No. of female flower		Days to first male flowering		Days to first female flowering		Days to 50% male flowering		Days to 50% female flowering		Flesh Thickness	
	MP	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**
Modhumoti × Tripti	-68.57**	-78.85**	-22.22**	-33.31**	-25**	-37.74**	-27.27**	-33.33**	-13.46**	-23.73**	-43.38**	-61.53**
Baromashi × Greenking	-60.49**	-76.81**	-16.7**	-18.6**	-3.6**	-16.36**	-7.69**	-14.28**	-7.27**	-15*	-2.32**	-9.37**
Baromashi × Hero	-67.01**	-76.81**	-14.7**	-25.58**	-1.27**	-3.5**	-6.17**	-9.52**	-1.03**	-4.00**	-5.90**	-12.58**
Modhumoti × Baromashi	-75.21**	-78.26**	-15.1**	-27.91**	25.3	17.5	-9.75**	-11.9**	13.56	-13.85**	-28.37**	-46.89**
Modhumoti × Hero	-75**	-80.76**	-3.23**	-6.25**	-13.5**	-17.9**	-13.92**	-15**	-15.22**	-17.02*	-43.21**	-52.68**
Hero × Piyas	-75.44**	-75.86**	0	12.5	0	-15.79**	-4.76**	-11.11**	0	-9.83**	1.02**	-2.06**
Modhumoti × Khira	-83.33**	-88.46**	-15.1**	-33.33**	15	2.22**	-8.43**	-11.63**	12.24	3.77**	35.02	21.66
Baromashi × Khira	-82.02**	-88.41**	-18.6**	-18.6**	-12.9**	-17.78**	-1.17**	-2.33**	-6.79**	-9.43**	2.54**	-1.57**
Yuvra j ×Khira	-63.26**	-68.69**	-15.1**	3.33*	-2.4**	-8.89*	3.79*	-4.65**	-3.92**	-11.76**	-5.32**	-8.67**
Himaloy × Tripi	-42.86**	-50**	-19.5**	-22.43**	-16.4**	-28.3**	-14.28**	-18.75**	-18.18**	-23.73**	33.33**	31.59**
Himaloy × Yuvraj	-28.3**	-34.48**	4.6	-2.85	1.29**	0	-3.79**	-11.63**	-10**	-35.94**	-1.24**	-5.79**
Himaloy × Baromashi	-74.19**	-82.61**	-17.9**	-25.58**	2.5**	0	-3.53**	-4.65**	-8.91**	-9.8**	-6.38**	-8.07**

Crosses	No. of female flower		Days to first male flowering		Days to first female flowering		Days to 50% male flowering		Days to 50% female flowering		Flesh Thickness	
	MP	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**
Sobuhsathi × Khira	-87.23**	-88.88**	-23.1**	-30.23**	-31.03**	-39.65**	-22.22**	-25.53**	-29.91**	-35.94**	-35.43**	-41.88**
Himaloy × Khira	-44.6**	-61.72**	-25.6**	-32.56**	-15.67**	-22.22**	-27.91**	-27.91**	-23.07**	-24.53*	-25.65**	-36.97**
Sobujsathi × Baromashi	-41.67**	-50**	-23.1**	-30.23**	-34.69**	-44.83**	-23.59**	-27.66**	-33.33**	-40.63**	-41.63**	-54.36**
Greenboy × Tripti	-47.82**	-57.14**	-19.5**	-36.20**	-23.6**	-35.85**	-18.6**	-27.08**	-25**	-33.89**	-45.65**	-59.53**
Hreo × Khira	-72.72**	-75**	-20**	-36..25**	-23.81**	-28.89*	12.19	-16.28**	-22**	-26.42**	-3.95**	-6.67**
Hero × Tripti	-72.91**	-81.16**	-10.92**	-29.60**	-17.4**	-28.30**	19.54	-27.08**	-22.64**	-30.51**	-12.98**	-35.94**
Tripti × Khira	-68.42**	-70**	-29.4**	-33.36**	-22.45**	-28.83**	-23.07**	-27.08**	-19.64**	-23.73**	2.10**	0.32**
Shila × Khira	-27.78**	-35**	-36.1**	-32.56**	-11.83**	-14.58**	-15.2**	-30.41**	-10.48**	-11.32**	-43.87**	-55.55**

** and * Significant at 5% and 1% level of probability, respectively; NS- Non Significant

Table 2. Contd

Crosses	Placental Thickness		Fruit length		Fruit width		No. of fruit /plant		Singles fruit wt.		Yield/plant		100 gm seed wt.	
	MP	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**
Modhumoti × Tripti	-12.08**	-20.51**	-19.7**	-45.41**	-30.76**	-47.7**	-20**	-33.33**	-6.11**	-76.6**	5.09**	1.39**	33.33**	22.58**
Baromashi × Greenking	-14.87**	-29.24**	-62.02**	-70**	-56.47**	-58.47**	-50**	-66.67**	-83.05**	-87.5**	-2.19**	-13.21**	-1.32**	-4.31**
Baromashi × Hero	-1.24**	-5.77**	-59.63**	-62.6**	-25.93**	-32.58**	-17.65**	-22.22**	-75.75**	-78.95**	-3.33**	-8.36**	-4.93**	-14.30**
Modhumoti × Baromashi	-33.33**	-54.03**	-40.23**	-55.17**	-12.03**	-31.79**	20**	10.02	-52**	-68.42**	-10.36**	-23.13**	-27.32**	-44.69**
Modhumoti × Hero	-2.74**	-6.67**	-20**	-37.26**	-17.05**	-30.68**	14.28	2.58	-40**	-57.14**	-0.38**	-8.61**	-13.79**	-29.87**
Hero × Piyas	-5.54**	-6.15**	-37.8**	-38.46**	-33.33**	-35.06**	-57.14**	-62.5**	-50**	-55.55**	-0.90**	-5.43**	1.54**	0
Modhumoti × Khira	38.29**	28.51**	13.58**	-11.54**	29.02	6.66	-63.63**	-66.66**	37.5**	10*	0.37**	-5.40**	46.36**	23.84**
Baromashi × Khira	-4.97**	-15.71**	-34.55**	-37.93**	3.91**	-1.57**	-57.14**	-66.66**	-44.83**	-57.89**	-29.45**	-35.36**	-51.82**	-56.52**
Yuvraj × Khira	-18.37**	-29.04**	-25**	-30.77**	-2.78**	-6.67**	-20**	-17.25**	-33.33**	-36.3**	-7.57**	-8.71**	-12.78**	-24.24*
Himaloy × Tripi	-3.81**	-10.29**	-46.51**	-55.33**	-37.54**	-47.59**	-25**	-32.68**	-76.19**	-83.33**	2.15*	-0.89**	-19.12**	-21.43**
Himaloy × Yuvraj	9.21**	7.81**	-42.86**	-48.15**	-54.75**	-55.79**	11.11	0	-82.6**	-83.33**	-23.67**	-41.38**	9.28**	-2.13**
Himaloy × Baromashi	1.02**	-4.25**	-64.28**	-65.53**	-60.59**	-65.77**	-38.46**	-55.55**	-87.09**	-89.47**	-25.92**	-33.27**	-39.97**	-54.45**
Sobuhsathi × Khira	-19.11**	-37.43**	-61.4**	-64.52**	-36.48**	-39.88**	-40**	-40**	-75.75**	-82.6**	0	-10.56**	-23.21**	-42.8**

Crosses	Placental Thickness		Fruit length		Fruit width		No. of fruit /plant		Singles fruit wt.		Yield/plant		100 gm seed wt.	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
Himaloy × Khira	-3.24**	-17.65**	-13.2**	-14.81**	-26.14**	-30.67**	-33.33**	-40**	9.09**	0	2.65*	-28.54**	3.47**	1.03**
Sobujsathi × Baromashi	-6.25**	-9.14**	-40**	-41.93**	-30.64**	-32.58**	-42.85**	-55.55**	-47.6**	-52.17**	-10.87**	-21.65**	-11.02**	-32.38**
Greenboy × Tripti	-14.02**	-28.30**	-56.15**	-67.74**	-51.51**	-58.33**	-9.09**	-28.57**	-79.45**	-86.67**	-4.75**	-15.29**	13.28**	1.34**
Hreo × Khira	3.88**	1.92**	-53.39**	-53.85**	-45.95**	-46.67**	-53.85**	-62.5**	-66.66**	-71.43**	-11.68**	-37.03**	-6.43**	-14.95*
Hero × Tripti	0.59**	-1.56**	-48.33**	-57.83**	-44.38**	-51.04**	-33.33**	-56**	-63.64**	-73.33**	-48.30**	-55.32**	-9.56**	-12.5**
Tripti × Khira	32.30**	-21.67**	-57.77**	-65.26**	-29.36**	-37.08**	-55.55**	-60.0**	-70**	-80**	-29.52**	-36.47**	4.9**	0.54**
Shila × Khira	-3.21**	-9.2**	-29.33**	-32.14**	-41.1**	-45.45**	-55.55**	-60.0**	62.5**	-72.73**	-32.76**	-48.32**	1.32**	-3.97**

** and * Significant at 5% and 1% level of probability, respectively; NS- Non Significant.

Number of fruits per Plant

Three crosses showed significant positive and 17 showed significant negative mid parent heterosis for this trait (Table 2). The positive mid parent heterosis varied from 11.11% to 20 %. The highest positive heterotic effect was observed in Modhumoti × Baromashi (20%) followed by Modhumoti× Hero (14.28 %) and Himaloy × Yuvraj (11.11%). The highest heterobeltiosis was found in the cross Modhumoti × Baromashi (10.02%) followed by Modhumoti × Hero (2.58%). But the cross Himaloy × Yuvraj did not show any heterosis. Solanki *et al.* (1982) observed the maximum heterosis for the number of fruits per plant in the hybrid CL x S (42.12 %) in cucumber. Karim *et al.* (2001) reported desirable better parent heterosis in two crosses of ash gourd (F_1 s HF x Local and MK x Local). Uddin (2008) observed the maximum heterosis for this trait in the hybrid $F_6 \times M_3$ (50.0%) in cucumber.

Single fruit weight (g)

The cross Shila × Khira showed highly significant positive mid parent heterosis (62.5%) which was followed by Modhumoti × Khira (37.50%) (Table 2). The highest negative mid parent heterosis was observed in the cross Himaloy × Baromashi (-87.09 %). The cross Modhumoti × Khira showed positive heterobeltiosis (10.00%). Heterosis for single fruit weight was the minimum in cross F_6 x M_2 (-4.32%) in cucumber (Uddin, 2008).

Yield per plant

The cross Modhumoti × Tripti (5.09%) showed highly significant positive mid parent heterosis followed by Himaloy × Khira (2.65%) (Table 2). The highest negative mid parent heterosis was found in Hero × Tripti (-48.23%). The highest heterobeltiosis was observed in Modhumoti × Tripti (1.39%). The minimum negative heterobeltiosis was found in Baromashi × Greenking (-1.86%) which was followed by Himaloy × Tripti (-0.89 %) and Modhumoti × Khira (-5.40 %).

100 seed weight

The cross Modhumoti × Khira showed significant positive heterosis (46.36%) in respect of mid parent heterosis followed by Modhumoti × Tripti(33.33%), Greenboy × Tripti (13.28%) and

Himaloy × Yuvraj (9.28%) (Table 2). The highest negative heterosis was observed in the cross Baromashi × Khira (-51.82 %).

Conclusion

Considerable variability for most of the quantitative traits of cucumber observed among the studied genotypes. The crosses Modhumoti × Khira , Hreo × Khira , Sobuhsathi × Khira exhibited significant heterosis for vine length; Sobujsathi ×

Baromashi, Sobujsathi × Khira, Himaloy × Khira for 50 % female flowering; Himaloy × Khira for 50 % male flowering; Himaloy × Baromashi, Baromashi × Greenking for fruit length; Baromashi × Hero, Yuvraj× Khira for single fruit weight; Sobujsathi × Baromashi and Shila × Khira, Modhumoti × Hero, Modhumoti × Khira exhibited significant positive heterosis and heterobeltiosis for yield per plant. The highest negative heterotic response for vine length was found in Modhumoti × Khira (-24.34 %) followed by Hreo × Khira (-19.58 %), Sobuhsathi × Khira (-19.11 %). The crosses Sobujsathi × Baromashi, Sobujsathi × Khira, Himaloy × Khira could be considered as early 50% female flowering, Modhumoti × Baromashi, Himaloy × Yuvraj for number of fruits per plant. The highest positive heterotic effect for no. of fruit per plant was observed in Modhumoti × Baromashi (20%) followed by Modhumoti × Hero (14.28 %), Himaloy × Yuvraj (11.11%). The highest negative heterotic effect for fruit length (cm) was observed in cross Himaloy × Baromashi (-64.28 %) followed by Baromashi × Greenking (-62.02 %), Sobuhsathi × Khira (-61.04 %). Considering heterotic performance the crosses Modhumoti × Khira, Himaloy × Yuvraj, Sobujsathi × Khira, Modhumoti × Baromashi, Sobujsathi × Baromashi, Shilla × Khira appeared to be promising. The highest number of fruits per plant was found in the cross with heterobeltiosis in Himaloy × Yuvraj followed by Sobujsathi × Khira and Modhumoti × Baromashi. It also showed the possibility of increasing yield by exploiting heterosis. The presence of high heterosis indicated genetic diversity between parents. Based on quantitative characters and genetic diversity eight genotypes viz. Greenking , Modhumoti, Baromashi, Tripti, Shilla, Khira, 4249, 4263 were found superior and may be selected for hybrid variety development in cucumber.

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