Heterosis in relation to genetic diversity in Snakegourd (*Tricosanthes cucumerina L.*)

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Abstract

An investigation on relationship between genetic divergence and heterosis in snakegourd (*Tricosanthes cucumerina*) with eight parents and their fourteen F_1s was conducted during the summer season of 2009 at the experimental farm, Department of Genetics and Plant Breeding, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706. None of the hybrids showed maximum heterosis for all the characters studied. Five hybrids, SG-01 × SG-18, SG-01 × SG-19, SG-18 × SG-25, SG-25 × SG-18 and SG-26x SG-19 showed significant and desirable mid and better parent heterosis for earliness and fruit yield per plant. The parents from high inter-genotypic values produce significant heterotic response for most of the characters in their hybrids. In most of the crosses higher expression of heterosis was observed with the increasing of inter genotypic values. The cross combinations involving the parents having medium genetic divergence between them were found to exhibit considerable heterosis for higher fruit yield and earliness. A positive correlation between Inter genotypic distance (D^2) and heterosis were observed for most of the characters.

Key words: Heterosis, Genetic Diversity, Correlation coefficient

Introduction

Snakegourd (*Trichosanthes cucumerina L.*) belongs to the family *Cucurbitaceae* having chromosome number, 2n = 22 (Chakrabarty, 1982) sub family *Cucurbitoideae*, tribe *Trichosantheae* order *Cucurbitales*, sub-class polyetae and class Dicotyledon. The yield of snakegourd is very poor and its production is also restricted to only 3-4 months in Bangladesh. Present harvestable yield of snakegourd is very low (4.21t/ha) due to unavailability of high yielding variety (BBS, 2009). Snakegourd is monoecious and highly cross pollinated in nature. Such pollination mechanism can be exploited for the production of hybrid variety. Heterosis or hybrid vigor can play a vital role in increasing the yield and quality of vegetable crops. There is a bright scope to study the heterosis and genetic diversity, which is the prerequisite for developing high yielding snakegourd variety or hybrid variety in Bangladesh.

Materials and Methods

Eight parents (P_1=SG-01. P_2=SG-04, P_3=SG-06, P_4=SG-10, P_5=SG-18, P_6=SG-19 P_7=SG-25 and P_8=SG-26) and their fourteen (14) F_1s were used as an experimental materials, supplied from the Department of Genetics and Plant Breeding, BSMRAU, Salna, Gazipur. The experiment was laid out in a Randomized Complete Block Design (RCBD) with two replications. The experiment field was divided into three blocks and the blocks were subdivided into nineteen plots where genotypes were randomly assigned. Beds of each entry containing two pits were raised with 15 – 20 cm made by spade and developed properly. Recommended doses of manure and fertilizer were applied in the experimental field (BARI, 2005). Seeds of the eight parents and their F_1s were first allowed to soak water for 24 hours. The soaked seeds were then sown in polythene bag (size 15 × 15 cm), containing a mixture of soil and well decomposed cow dung (1:1). Thirty five days old seedlings were transplanted in main field. Two pits for every genotype in each replication were maintained. Irrigation, weeding and stacking etc. were done according to schedule and as necessary.

The experiment was conducted at the experimental farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur during the months from March to June, 2009. The location of the site was about 40 km north of the Dhaka city with 24.09 °N latitude and 90.26 °E longitude and an elevation of 8.40 meter from the sea level. The experimental site was situated in the subtropical climate zone, characterized by m rainfall during the month of May to September and scanty rainfall during the rest of the year. The soil of the experimental field was clay loam in texture and acidic in nature having a pH of around 5.8 with poor fertility status. It belongs to the Salna soil series of "Shallow Red Brown Terrace" under "Madhupur tract" (Brammer, 1971; Haider *et al*., 1991).

Data were collected on each of the eight parents and their F1s for Days to first male flowering, Days to 100% male flowering, Days to first female flowering, Days to 100% female flowering, Days to green fruit harvest, Fruit length (cm), Fruit diameter (mm), Fruit weight (g), Total number of fruits per plant, Fruit yield/plant (Kg). The mean data for each character were analyzed statistically using the GeneStat software. For univariate analysis, analyses of variances were done individually by F-test according to Panse and Shukhatma (1978). Heterosis was recorded as mid parent heterosis (Hm) and better parent heterosis (Hb) by the formula by Falconer (1960). Correlation coefficient between inter-genotypic distances of parents and heterosis of the hybrids were computed for all the characters according to Singh and Choudhury (1979).

Results and Discussion

Analysis of variance in parents and hybrids showed significant differences for all the characters except fruit yield per plant and days to green fruit harvest in parents and number of fruits per plant in F_1s. Parents vs hybrids showed significant differences for all the caharacters studied (Table 1).

The estimates of mid and better parent heterosis observed in the F_1 generation are presented in Table 2 and 3. Out of 14 crosses 7 showed significant mid parent heterosis for Days to first male flowering. Desirable estimates of negative mid parent heterosis were recorded in the crosses SG-04 X SG-06 (-14.776), SG-10 X SG-18 (-15.932), SG-26 X SG-25 (-16.574) and SG-25 X SG-18 (-18.380%) (Table 2). The highest negative better parent heterosis (-47.826 %) was found for this character in hybrid combination SG-18 × SG-25 (Table 3). The highest mid parent heterosis in negative direction (-6.343%) was found for this trait in hybrid SG-25 × SG-18 (Table 2). Thus the cross combination SG-25 × SG-18 may be considered as promising cross combination for getting earliness in male flower opening. The highest negative better parent heterosis (-11.594%) was found for this character in hybrid combination SG-10 × SG-18 (Table 3). The highest positive mid parent heterosis for fruit length was observed in hybrid SG-25 × SG-18 (7.326 %) followed by SG-26 × SG-25 (6.954%) and SG-26 × SG-19 (5.564%) (Table 2). On the contrary all the cross combinations revealed negative better parent heterosis for this trait. The highest significant positive mid parent heterosis for fruit diameter was manifested by the cross combination SG-26 × SG-19 (17.632%), which can be used as a desirable combination for larger fruit size (Table 2). The highest better parent heterosis in positive direction was exhibited by the cross

Table 1. Analysis of variance for yield and yield related characters in snakegourd

Source of Variances			Df	Mean Sum of Squares									
				DFMF	DMF (100%)	DFFF	DFF (100%)	Fruit length (cm)	Fruit dia. (mm)	Fruit weight (gm)	FP	FYP (Kg)	DFGH
Replication	:	r-1	1	0.2	2.0	6.6	542.9	41.0	882.0	8.3	27.0	14.2	54.6
Parents	:	p-1	7	23.2**	263.6**	207.4**	13818.9**	604.2**	14286.4**	4.3*	86.4*	2.0	27.4
Error (01)	:	(r-1) ×(p-1)	7	0.5	0.1	2.4	5.5	0.5	5.5	14.2	153.6	7.2	77.6
F_1s	:	q-1	13	29.9**	129.1**	111.3**	14177.9**	1393.9**	19593.8*	2.7*	1.9ns	13.3*	6.5*
Parents Vs F_1s:		1	1	5.5*	13.1**	18.5**	1279.2**	631.1**	1092.3**	28.1**	304.2**	14.2**	153.6**
Error (02):		(r-1)×(p-1) ×(q-1)	91	1.6	3.7	14.2	153.6	192.4	324.8	0.8	1.8	7.2	77.6

Note: DFMF= Days to first male flowering, DMF (100%)= Days to 100% male flowering, DFFF= Days to first female flowering, DFF (100%)= Days to 100% female flowering and DFGH= Days to green fruit harvest, FP=Fruits per plant, FYP=Fruit yield per plant and * , ** significant at 5% and 1% level of significance respectively.

combination SG-25 × SG-18 (17.108%) followed by SG-18 × SG-25 (9.950%) and SG-25 × SG-10 (8.096%). So the cross combinations might be considered as best heterotic hybrids for higher fruit weight. Based on better parent heterosis, the crosses SG-01 X SG-19 (58.333%), SG-01 X SG-18 (41.297%) and SG-25 X SG-18 (20.455%) might be tested as desirable hybrids for higher number of fruits per plant (Table 3). At least five crosses showed significant positive heterosis over their mid parents which are not desirable. (Table 2). None of the crosses showed significant negative better parent heterosis for this trait. Five crosses were found to show better parent heterosis for late green fruit harvest which is not desirable (Table 3).

It is generally believed that genetically diverse parents tend to give rise to heterotic hybrids on crossing. Thus diversity may be considered as the function of heterosis. Relationship between genetic distance of the parents as assumed by D^2 analysis and heterosis over mid parent and better parent in the F_{1s} for morphological characters were investigated in this study. Inter genotypic distances of the involving parents of the heterotic crosses ranged from 3.752 to 8.014. The parents from high inter-genotypic values (8.014 and above) produce significant heterotic response for most of the characters in their hybrids. (Table 4 & Table 5). But the parents of less than 3.874 unit divergence value showed poor heterosis in their hybrids for most of the characters. In general, parents from low to medium inter-genotypic (D^2) values ranging between 3.071 to 4.244 unit, exhibited non significant heterosis over MP and BP for most of the characters under study (Table 4) and (Table-5).In most of the crosses higher expression of heterosis was observed with the increasing of inter genotypic values. Similar finding was reported by Behl *et al.* (1985). Parents from different groups were found to exhibit heterotic performance in F1. The parent "SG-01" of the crosses " SG-001x SG-19" belonged to group IV and SG-19 belonged to group I, while SG- 04 belonged to group II, SG- 06" belonged to group VI, SG-18 belonged to group I and SG- 25" belonged to group V. The same fact was also observed for other hybrids. Shamsuddin (1985) also reported similar result in spring wheat. Similar findings were also reported by Mian and Bahl (1989) in chickpea as well.

Table 2. Mid-parent heterosis for ten different characters in Snakegourd

Hybrids	Crosses	Mid Parent Heterosis %									
		DFMF	DMF (100%)	DFFF	DFF (100%)	Fruit length (cm)	Fruit dia. (mm)	Fruit weight (gm)	FP	DFGH	FYP (Kg)
Hybrid 01	01x18	-4.9	0.2	-13.7**	-12.3**	-1.7	-2.4	5.6	54.4**	-0.7	64.1**
Hybrid 02	01x19	-4.6	10.5**	-14.7**	-16.1**	-4.8*	-5.0	14.9**	85.4**	1.4	87.2**
Hybrid 03	04x06	-14.8**	-1.6	13.8**	1.4	-4.6*	14.5*	12.5**	-36.0**	11.0**	4.7
Hybrid 04	06x10	3.8	7.5*	26.6**	13.5**	-6.8*	1.8	10.8*	-22.3	7.4*	-15.5
Hybrid 05	10x06	-3.9	3.0	4.3	-2.0	-4.4	-7.2*	-7.7	-29.8*	-4.7*	-36.3**
Hybrid 06	10x18	-15.9**	-3.7*	-19.6**	-16.9**	-15.9**	-2.4	-5.9	17.6**	4.7*	10.8*
Hybrid 07	10x25	-12.9**	-3.5	-0.7	-0.6	-1.5	1.1	4.7	7.9	-1.4	13.1*
Hybrid 08	18x10	-8.5*	1.8	-11.4**	-9.3*	-4.2*	5.4*	5.1	5.9	0.7	11.4*
Hybrid 09	18x25	-10.3**	-2.6	-3.0	-3.9	-9.5*	6.8*	11.2**	27.2**	-3.4	41.4**
Hybrid 10	18x26	4.5	6.0*	1.9	-1.4	1.5	9.0*	12.2**	-20.0	0.7	8.4*
Hybrid 11	25x10	5.7	7.1*	2.2	1.7	-6.7*	11.4**	9.2	-3.4	1.4	5.6
Hybrid 12	25x18	-18.4**	-6.3*	-0.6	-3.5	7.3*	6.3*	18.5**	40.4**	6.2*	66.7**
Hybrid 13	26x19	0.5	8.0*	-19.8**	-18.6**	5.6*	17.6**	10.1	12.4*	0.7	24.8**
Hybrid 14	26x25	-16.6**	-0.8	-8.9*	-5.3*	7.0*	16.1**	13.1**	-17.6*	6.2*	-5.6
Minimum		**-18.4**	**-6.3**	**-19.8**	**-18.6**	**-15.9**	**-7.2**	**-7.7**	**-36.0**	**-4.7**	**-36.3**
Maximum		**5.7**	**10.5**	**26.6**	**13.5**	**7.3**	**17.6**	**18.5**	**85.4**	**11.0**	**87.2**

Note: DFMF= Days to first male flowering, DMF (100%)= Days to 100% male flowering, DFFF= Days to first female flowering, DFF (100%)= Days to 100% female flowering and DFGH= Days to green fruit harvest, FP=Fruits per plant, FYP=Fruit yield per plant and * , ** significant at 5% and 1% level of significance respectively.

Table 3. Better-parent heterosis for ten different characters in Snakegourd

Hybrids	Crosses	Better Parent Heterosis %									
		DFMF	DMF (100%)	DFFF	DFF (100%)	Fruit length (cm)	Fruit diameter (mm)	Fruit weight (gm)	FP	DFGH	FYP (Kg)
Hybrid 01	01x18	-7.8*	-6.9*	-14.2**	-13.0**	-12.4**	-3.7	-1.0	41.3**	-4.0	57.8**
Hybrid 02	01x19	-8.2*	10.0**	-17.6**	-16.6**	-11.1**	-15.8**	3.0	58.3**	0.0	95.4**
Hybrid 03	04x06	-15.9**	-5.3*	11.0**	1.4	-27.3**	11.9**	-2.9	-36.4**	8.0*	-37.6**
Hybrid 04	06x10	-6.4*	1.1	18.4**	8.5*	-22.3**	-0.5	-1.9	-25.5**	6.7*	-26.8
Hybrid 05	10x06	-13.4**	-3.1	-2.5	-6.4	-20.2**	-9.2*	- 18.2**	-32.7**	-5.4	-44.8**
Hybrid 06	10x18	-26.2**	-11.6**	-27.0**	-22.1**	-20.5**	-8.4*	-6.0	0.0	4.0*	-5.6
Hybrid 07	10x25	-20.3**	-8.8*	-5.7*	-3.7	-3.6	0.5	3.6*	6.7*	0.0	10.7*
Hybrid 08	18x10	-19.6**	-6.5*	-19.5**	-15.0**	-9.4	-1.1	5.0*	-10.0	0.0	-5.1*
Hybrid 09	18x25	-47.8**	-5.4*	-7.5*	-7.1*	-16.1**	0.8	10.0*	9.1*	-5.4	23.0**
Hybrid 10	18x26	-14.9**	-7.6*	-8.9*	-9.4*	-9.3**	-11.6**	4.1*	-4.6	0.0	-0.7
Hybrid 11	25x10	-3.3	1.2	-3.0	-1.5	-8.7	10.7**	8.1*	-4.4	2.8	3.4*
Hybrid 12	25x18	-22.0**	-9.1*	-5.2*	-6.8*	-0.6	0.3	17.1**	20.5**	4.0*	44.5**
Hybrid 13	26x19	0.2	5.6*	-23.3**	-19.2**	-6.1	14.2**	-2.1	6.9*	-1.3	16.1**
Hybrid 14	26x25	-18.3**	-2.7	-14.4**	-10.4**	-2.5	6.9	4.0*	-28.4*	4.0*	-11.2
Minimum		**-47.8**	**-11.6**	**-27.0**	**-22.1**	**-27.3**	**-15.8**	**-18.2**	**-36.4**	**-5.4**	**-44.8**
Maximum		**0.2**	**10.0**	**18.4**	**8.5**	**-0.6**	**14.2**	**17.1**	**58.3**	**8.0**	**95.4**

Note: DFMF= Days to first male flowering, DMF (100%)= Days to 100% male flowering, DFFF= Days to first female flowering, DFF (100%)= Days to 100% female flowering and DFGH= Days to green fruit harvest, FP=Fruits per plant, FYP=Fruit yield per plant and * , ** significant at 5% and 1% level of significance respectively.

Table 4. Relationship between genetic divergence of the parents and heterosis of F_1 over mid parent in respect of 10 characters in Snakegourd

Cluster	Parent 01	Cluster	Parent 02	IGD	Percent Heterosis over Mid Parent									
					DFMF	DMF (100%)	DFFF	DFF (100%)	Fruit length (cm)	Fruit dia. (mm)	Fruit weight (gm)	FP	DFGH	FYP (Kg)
IV	SG 01	I	SG 18	4.1	-5.0	0.2	-13.7**	-12.3**	-1.7	-2.4	5.6	54.4**	-0.7	64.1**
IV	SG 01	I	SG 19	3.9	-4.6	10.5**	-14.7**	-16.1**	-4.8*	-5.0	14.9*	85.4**	1.4	87.2**
II	SG 04	VI	SG 06	4.2	-14.8**	-1.6	13.8**	1.4	-4.7	14.5**	12.5*	-36.0*	11.0*	4.7
VI	SG 06	III	SG 10	11.5	3.8	7.5*	26.6**	13.5**	-6.8*	1.8	10.8*	-22.3*	7.4*	-15.5
III	SG 10	VI	SG 06	11.5	-3.9	3.0	4.3	-2.0	-4.4	-7.2*	-7.7*	-29.8*	-4.7*	- 36.3**
III	SG 10	I	SG 18	3.1	-15.9**	-3.7*	-19.6**	-16.9**	- 15.9**	-2.4	-5.9*	17.6**	4.7*	10.8*
III	SG 10	V	SG 25	3.1	-12.9**	-3.5	-0.7	-0.6	-1.5	1.1	4.7	7.9*	-1.4	13.1*
I	SG 18	III	SG 10	3.1	-8.5*	1.8	-11.4**	-9.3*	-4.2*	5.4*	5.1	5.9*	0.7	11.4*
I	SG 18	V	SG 25	3.8	-10.3*	-2.6	-3.0	-3.9	-9.5*	6.8*	11.2*	27.2**	-3.4*	41.4**
I	SG 18	IV	SG 26	8.4	4.5	6.0*	1.9	-1.4	1.5	9.0*	12.2*	-20.0**	0.7	8.4*
V	SG 25	III	SG 10	3.1	5.7	7.1*	2.2	1.7	-6.7*	11.4	9.2	-3.4	1.4	5.6
V	SG 25	I	SG 18	3.8	-18.4**	-6.3*	-0.6	-3.5	7.3*	6.3	18.5*	40.4**	6.2*	66.7**
IV	SG 26	I	SG 19	8.0	0.5	8.0*	-19.8**	-18.6**	5.6	17.6	10.1*	12.4**	0.7	24.8**
IV	SG 26	V	SG 25	8.3	-16.6**	-0.8	-8.9**	-5.3*	7.0*	16.1	13.1*	-17.6*	6.2*	-5.6

Note: DFMF= Days to first male flowering, DMF (100%)= Days to 100% male flowering, DFFF= Days to first female flowering, DFF (100%)= Days to 100% female flowering and DFGH= Days to green fruit harvest, FP=Fruits per plant, FYP=Fruit yield per plant and * , ** significant at 5% and 1% level of significance respectively.

Table 5. Relationship between genetic divergence of the parents and heterosis of F_1 over better parent in respect of 10 characters in Snakegourd

Cluster	Parent 01	Cluster	Parent 02	IGD	Percent Heterosis over Better Parents									
					DFMF	DMF (100%)	DFFF	DFF (100%)	Fruit length (cm)	Fruit dia. (mm)	Fruit weight (g)	FP	DFGH	FYP (Kg)
IV	SG 01	I	SG 18	4.1	-7.7*	-6.9	-14.2**	-13.0**	-12.4**	-3.7	-1.0	41.3**	-4.0	57.8**
IV	SG 01	I	SG 19	3.9	-8.2*	10.0**	-17.6**	-16.6**	-11.1**	-15.8**	3.0	58.3**	0.0	95.4**
II	SG 04	VI	SG 06	4.2	-15.9**	-5.3	11.0*	1.4	-27.3**	11.9**	-2.9	-36.4**	8.0*	-37.6**
VI	SG 06	III	SG 10	11.5	-6.4	1.1	18.4**	8.5*	-22.3**	-0.5	-1.9	-25.5**	6.7*	-26.8
III	SG 10	VI	SG 06	11.5	-13.4**	-3.1	-2.5	-6.4*	-20.2**	-9.2*	-18.2*	-32.7**	-5.4	-44.8**
III	SG 10	I	SG 18	3.2	-26.2**	-11.6*	-27.0**	-22.1**	-20.5**	-8.4*	-6.0*	0.0	4.0	-5.6
III	SG 10	V	SG 25	3.1	-20.3**	-8.8**	-5.7	-3.7	-3.6	0.5	3.6	6.7*	0.0	10.7*
I	SG 18	III	SG 10	3.1	-19.6**	-6.5*	-19.5*	-15.0**	-9.4*	-1.1	5.0*	-10.0*	0.0	-5.1*
I	SG 18	V	SG 25	3.8	-47.8**	-5.4	-7.5	-7.1	-16.1**	0.8	10.0*	9.1*	-5.4	23.0**
I	SG 18	IV	SG 26	8.4	-14.9*	-7.6	-8.9*	-9.4*	-9.3	-11.6**	4.1	-4.6*	0.0	-0.7
V	SG 25	III	SG 10	3.1	-3.3	1.2	-3.0	-1.5	-8.7	10.7*	8.1*	-4.4*	2.8	3.4*
V	SG 25	I	SG 18	3.8	-22.0**	-9.1	-5.2	-6.8	-0.6	0.3	17.1**	20.5**	4.0	44.5**
IV	SG 26	I	SG 19	8.0	0.2	5.6	-23.3**	-19.2*	-6.1	14.2**	-2.1	6.9	-1.3	16.1**
IV	SG 26	V	SG 25	8.3	-18.3*	-2.7	-14.4**	-10.4**	-2.5	6.9*	4.0	-28.4**	4.0	-11.2

Note: IGD= Inter genotypic distance, DFMF= Days to first male flowering, DMF (100%)= Days to 100% male flowering, DFFF= Days to first female flowering, DFF (100%)= Days to 100% female flowering and DFGH= Days to green fruit harvest, FP=Fruits per plant, FYP=Fruit yield per plant and * , ** significant at 5% and 1% level of significance respectively.

Correlation coefficient between inter-genotypic distances and their heterotic effects in 14 hybrids were computed to quantify the relationship between them (Table-6). Significant and positive relationship was found in case of fruit length, fruit weight and fruit yield per plant against mid parent and better parent. Whereas, negatively significant correlation coefficient was found for number of fruits per plant against mid parent (Table 6).

Table 6. Correlation coefficients (r) between parental distances and heterosis of 14 F_1s for 10 characters in Sanakegourd

Sl. No.	Characters	Correlation coefficients	
		MP	BP
1	Days to first male flowering	0.1	0.1
2	Days to 100% male flowering	-0.1	-0.3
3	Days to first female flowering	-0.2	-0.4
4	Days to 100% female flowering	-0.3	-0.3
5	Fruit length (cm)	0.9**	0.8**
6	Fruit diameter (mm)	0.5	0.3
7	Fruit weight (g)	0.6**	0.6**
8	No. of fruits per plant	-0.5*	-0.2
9	days to green fruit harvest	0.3	0.4
10	Fruit yield per plant (kg)	0.6*	0.6**

Non-significant and negative correlation coefficient was found for days to 100% male flowering, days to first female flowering, days to 100% female flowering. Positive but non-significant correlation was observed in days to first male flowering, fruit diameter (mm) and days to green fruit harvest against both for mid parent and better parent (Table 6). On overall basis, positive correlation between inter genotypic distance and heterosis were observed for most of the characters.

Conclusion

The results of the study indicate that five hybrids, SG-01 × SG-18, SG-01 × SG-19, SG-18 × SG-25, SG-25 × SG-18 and SG-26x SG-19 showed significant and desirable mid and better parent heterosis for earliness and fruit yield per plant. So, these hybrids might be considered as promising combinations for development of commercial snakegourd hybrid varieties.

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