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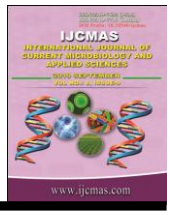

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Heterosis Studies for Earliness and Yield Related Traits in Sponge Gourd [*Luffa cylindrica* (Roem.) L.]

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A B S T R A C T

The present study was carried out for development of hybrids in sponge gourd for earliness and yield traits. Twenty eight crosses were developed by crossing 8 × 8 diallel mating design (excluding reciprocal). Evaluated the crosses and along with their parents in randomized block design (RBD). Analysis of variance indicated highly significant differences for growth, earliness and yields characters, which suggesting presence of wide genetic variability. The magnitude of standard heterosis was found in desirable direction for early and yield traits viz., days to first pistillate flower appearance in the cross IC-284795 x Patna Loca (-23.07), for 50% flowering in the cross IC-284795 x Patna Local (-18.89%), sex ratio in the cross IC-336759 x Patna Local (-53.41%), for number of fruit per vine in the cross IC-284795 x Patna Local (34.56%), average fruit weight in the cross IC-336759 x Patna Local (110.09%). Such crosses could be exploited for practical plant breeding programme in sponge gourd.

Introduction

Sponge gourd [*Luffa cylindrica* (Roem.) L.] (2n=2x=26) is one of the minor cucurbitaceous vegetable crop with Old world origin in subtropical Asian region particularly India (Swarup, 2006). This crop has been cultivating for centuries in the Middle East, India, China, Japan and Malaysia (Porterfield, 1955). In India, it is cultivated on both commercial scale and in kitchen gardens during the spring-summer and rainy season (Chakravarty, 1990). The tender and immature fruits are cooked as vegetable, used in the preparation of chutneys and curries and tender fruits are easily digestible and increase appetite when consumed (Okusanya *et al.*, 1981). Sponge gourd is a highly nutritive vegetable and contains moisture of 93.2 g, protein 1.2 g, fat 0.2 g, carbohydrates 2.9 g, vitamins (thiamine 0.02 mg, riboflavin 0.06 mg, niacin 0.4 mg and β carotene 120 mg), minerals (calcium 36 mg, phosphorous 19 mg and iron 1.1 mg) and fibers 0.20 g per 100 g of edible portion (Gopalan *et al.*, 2012). Sponge gourd fruits contain more protein and carotene than ridge gourd (More and Shinde, 2001).

Sponge gourd being a monoecious and cross pollinated crop, it exhibits considerable heterozygosity in population and does not suffer much due to inbreeding depression, because heterozygosity has been balanced due to primitive form of hermaphrodite flower. Crop improvement depends upon genetic architecture of yield traits and magnitude of positive heterosis towards the yield attributing traits. The wide range of genetic architecture in plant for early and yield related traits and also produce large number of hybrid seed at reasonable cost, very little work has been done to exploit the hybrid vigour in this crop. Heterosis breeding has been a recognized practical tool in providing the breeder a means of increase in yield and other economic traits in this crop. Hence, an attempt was made to study the heterosis in different crosses over better parent, best parent and the commercial check to develop and identify the suitable best performing hybrids for earliness and high yields.

Materials and Methods

Eight promising parental lines of sponge gourd namely P1 (IC-284795), P2 (IC-336759), P3 (IC-284840), P4 (IC-355633), P5 (IC-544806), P6 (IC-284941), P7 (VRSG-199) and P8 (Patna local) and 28 F_1 hybrids obtained by crossing them in half diallel (without reciprocals), during *rabi* 2018 formed the experimental material. Their performance with one standard check was assessed in randomized block design (RBD) with two replications in alluvial zone of West Bengal at Horticultural Research Station, Mandouri, Bidhan Chandra Krishi Viswavidyala, West Bengal, India. Distance between rows was kept 100 cm and plants were spaced at 50 cm apart within the row. Observations were recorded on five randomly selected plants from each replication on vine length, number of primary branches, number of fruiting nodes on main stem, days to first staminate flower appearance, days to first pistillate flower appearance, days to 50% flowering, span of flowering, sex ratio, node of 1st female flower appearance, days to harvestable maturity from anthesis, fruit length, fruit diameter, fruit weight, fruits per plant, number of seeds per fruit, seed index (100 seed weight), yield per plant. Heterosis was calculated as percentage of F_1 over better parent and standard check Pusa chikni. The formula used to estimate heterosis over better parent and standard check was as per Fonseca and Patterson (1968).

Results and Discussion

The analysis of variance for experimental design (Table 1) revealed highly significant mean squares differences due to genotypes, parents and hybrids for all the characters indicating sufficient amount of genetic variability of parents and hybrids for the 17 traits studied. The aim of heterosis study is to identifying the best heterotic combinations and its exploitation for commercial purpose. *Per se* performance and range (mean performance) of parents and crosses for various heterotic effects as well as heterotic responses of F_1 hybrids over mid parent (MP), better parent (BP) and standard check (CC) for 17 characters; and the best heterotic crosses identified on the basis of earliness and yield parameters are presented in the table 2 and 3.

In the present investigation, fruit yield per vine was found to be the most heterotic trait as heterosis for fruit yield per vine ranged from -42.93 to 66.01%, -62.71 to 51.99% and -76.02 to 127.74% over mid parent, better parent and standard check respectively (Table 2). The magnitude of heterotic effects were high for fruit yield per vine, fruit length, fruit diameter, individual fruit weight, seed index and number of fruiting nodes on main stem, while significant heterosis was low to moderate for rest of the traits. The cross IC-336759 x Patna local showed significant and positive standard

heterosis (127.74%) for fruit yield per vine followed by cross IC-284795 x Patna local (120.20%) and IC-284795 x IC-336759 (94.83%) (Table 3). In such crosses expression of heterotic response over better parent and standard check indicates the real superiority of hybrids from the commercial point of view and these hybrids can be commercially exploited after large scale testing. These results are akin to the findings of Muthaiah *et al.,* (2017), Bairwa *et al.,* (2017), Poshiya *et al.,* (2015), Prakash *et al.,* (2014), Narasannavar *et al.,* (2014), Karthik (2014), Lodam *et al.,* (2014), Dodiya *et al.,* (2013) and Singh (2013) have reported high values of heterosis for fruit yield in ridge gourd. Sonavane *et al.,* (2013), Islam *et al.,* (2012), Sanandia *et al.,* (2008) and Naliyadhara *et al.,* (2007) in sponge gourd.

Other yield related parameters like fruit length, fruit diameter, average fruit weight and number of fruits per plant, etc. are desirable features in sponge gourd cultivation. Therefore, significant and positive heterosis for these characters is desirable. The cross IC-336759 x Patna local showed significant and positive standard heterosis (44.07%) for fruit length followed by cross IC-284840 x IC-355633 (42.75%) and IC-336759 x VRSG-199 (39.90%). The cross IC-284795 x Patna local showed significant and positive standard heterosis (148.72%) for fruit diameter followed by cross IC-284840 x Patna local (136.29%) and IC-336759 x Patna local (129.59%). The cross IC-336759 x Patna local showed significant and positive standard heterosis (110.09%) for average fruit weight followed by cross IC-284795 x Patna local (93.50%) and IC-336759 xVRSG-199 (88.72%). The cross IC-284795 x Patna local showed significant and positive standard heterosis (34.56%) for number of fruits per plant followed by cross IC-284795 x IC-336759 (31.00%) and IC-336759 x Patna local (27.04%).

Early flowering, lower nodal position of flowers, early picking and lower sex ratio are desirable features in sponge gourd cultivation. Therefore, significant and negative heterosis for these characters is desirable. For days to first female flower appearance maximum and significant negative heterosis over better parent was observed in the cross IC-284941 x VRSG-199 (-32.08%) followed by IC-355633 x Patna local (-29.89%) and IC-284941 x Patna local (-28.08%); negative heterosis over standard check was observed in the cross IC-284795 x Patna local (-18.89%) followed by IC-284795 x IC-336759 (-16.42%) and IC-284941 x VRSG-199 (-12.66%). For lower sex ratio maximum and significant negative heterosis over better parent was observed in the cross IC- 336759 x Patna local (-52.07) followed by VRSG-199 x Patna local (-49.78) and IC-284840 x Patna local (-44.55); negative heterosis over commercial check was observed in the cross IC-336759 x Patna local (-53.41) followed by IC-284795 x Patna local (-40.09) and IC-284840 x Patna local (-35.85). For node at first female flower appearance maximum and significant negative heterosis over better parent was observed in the cross IC-355633 x Patna local (-52.19) followed by IC-544806 Patna local (-47.24) and IC-284795 x Patna local (-35.83); negative heterosis over commercial check was observed in the cross IC-336759 x Patna local (-46.82) followed by IC-284795 x Patna local (-45.45) and IC-284795 x IC-336759 (-40.91). For the character on days to harvestable maturity significant negative heterosis over better parent was observed in the cross VRSG-199 x Patna local (-40.29) followed by IC-355633 x Patna local (-40.00) and IC-284840 x Patna local (-35.56); negative heterosis over commercial check was observed in the cross IC-336759 x Patna local (-12.30) followed by VRSG-199 x Patna local (-8.47) and IC-284795 x IC-336759 (-7.70).

Table.1 Analysis of variance for seventeen characters in 8x8 diallel cross (without reciprocals) in sponge gourd

Sl.NO	Character	Mean sum of square					
		Replication	Genotypes	Parents	Hybrids	Parents Vs Hybrids	Error
	df	2	35	7	27	1	70
1	Vine length (m)(90 DAS)	0.0013	3.5747**	2.4244**	3.2857**	19.4276**	0.0215
2	No. of primary branches	0.0109	5.2561**	3.3691**	4.8961**	28.1862**	0.0500
3	No. of fruiting nodes on main stem	0.0762	9.8931**	10.9128**	8.2420**	47.3362**	0.0792
4	Days to first staminate flower appearance	2.4901	77.8996**	70.8257**	66.4901**	435.4728**	2.1578
5	Days to first pistillate flower appearance	0.1330	113.9509**	105.7898**	103.0003**	466.7444**	0.6700
6	Days to 50% flowering	0.4811	126.2748**	112.0302**	93.2411**	1117.8969**	0.7283
7	Span of flowering	0.1193	162.1880**	104.6576**	153.6242**	796.1231**	0.6427
8	Sex ratio (M/F)	0.4294	64.8522**	45.8872**	60.9544**	302.8501**	0.2652
9	Node of 1st female flower appearance	0.0138	27.0008**	38.1359**	23.8305**	34.6529**	0.0668
10	Days to harvestable maturity from anthesis	0.0424	11.5035**	4.6537**	12.0885**	43.6560**	0.0186
11	Fruit length (cm)	0.0407	109.5278**	98.6901**	92.9672**	632.5306**	0.1415
12	Fruit diameter (cm)	0.2497	15.6355**	6.2459**	17.1107**	41.5313**	0.1228
13	Average fruit weight (g)	3.0589	6277.6372**	4829.4780**	5933.8525**	25696.9434**	5.0996
14	Fruits per plant	0.1499	35.6331**	30.7599**	35.5249**	72.6669**	0.1283
15	No. of seeds per fruit	0.9628	2459.9255**	2088.7559**	2554.4856**	2504.9861**	1.4259
16	Seed index (100 seed weight)	0.0020	11.4730**	9.5163**	11.3336**	28.9366**	0.1016
17	Yield per plant (kg)	0.0010	3.9514**	2.5734**	3.9918**	12.5060**	0.0060

*: Significant at p = 0.05, **: Significant at p = 0.01

Table.2 Range and heterosis for growth and yield characters in sponge gourd

Sl.NO	Character	*Per se* performance (range)		Heterosis (%)		
		Parents	Crosses	MP	BP	CC
1	Vine length (m)(90 DAS)	2.25 to 4.80	2.68 to 6.23	9.92 to 55.09	-14.06 to 32.98	–27.22 to 69.02
2	No. of primary branches	2.50 to 5.50	1.55 to 7.00	-46.09 to 63.35	-52.31 to 42.97	-61.73 to 72.84
3	No. of fruiting nodes on main stem	2.85 to 7.20	2.00 to 8.95	-31.58 to 73.42	-33.33 to 40.14	-68.99 to 38.76
4	Days to first staminate flower appearance	34.00 to 48.00	28.35 to 45.35	-23.91 to 8.11	-33.37 to 2.86	-26.36 to 17.80
5	Days to first pistillate flower appearance	40.00 to 56.35	33.35 to 55.00	-22.32 to 8.25	-31.06 to 4.39	-23.07 to 26.87
6	Days to 50% flowering	49.50 to 66.25	41.00 to 63.36	-27.02 to -2.65	-32.08 to -5.58	-18.89 to 25.34
7	Span of flowering	32.65 to 52.00	31.14 to 60.00	-11.22 to 29.32	-16.96 to 24.38	-15.95 to 61.94
8	Sex ratio (M/F)	14.5 to 27.00	8.32 to 29.00	-47.48 to 14.85	-52.07 to 7.41	-53.41 to 62.46
9	Node of 1st female flower appearance	6.50 to 16.00	5.85 to 17.00	-32.00 to 10.49	-52.19 to -9.87	-46.82 to 54.55
10	Days to harvestable maturity from anthesis	7.00 to 10.65	5.35 to 14.55	-31.70 to 37.59	-40.29 to 36.62	-12.30 to 138.52
11	Fruit length (cm)	11.50 to 27.00	13.10 to 32.80	-8.43 to 94.90	-6.04 to 48.74	-42.46 to 44.07
12	Fruit diameter (cm)	4.75 to 9.00	4.05 to 13.00	-36.06 to 73.58	-40.00 to 44.44	-22.51 to 148.72
13	Average fruit weight (g)	115.50 to 235	102.25 to 298.85	-16.82 to 40.94	-44.55 to 29.57	-28.12 to 110.09
14	Fruits per plant	5.36 to 13.58	4.55 to 17.00	-26.81 to 56.78	-37.54 to 25.86	-63.98 to 34.56
15	No. of seeds per fruit	60 to 130	54.00 to 165.15	-22.67 to 47.47	-36.44 to 27.04	-48.82 to 56.54
16	Seed index (100 seed weight)	9.65 to 14.35	7.55 to 15.95	-22.56 to 24.34	-23.35 to 20.78	-38.37 to 30.20
17	Yield per plant (kg)	0.62 to 3.19	0.51 to 4.84	-42.93 to 66.01	-62.71 to 51.99	-76.02 to 127.74

MP = mid parent, BP = better parent and CC= standard check

Table.3 Promising hybrids with favourable heterosis for seventeen characters

S. No	Chara-cter	Top three crosses with significant Heterosis		
		Heterosis (%)	**Heterobeltiosis (%)**	**Standard Heterosis (%)**
1	**VL**	IC-544806 xVRSG-199 (55.09) IC-336759 x IC-355633 (47.91) IC-336759 xVRSG-199 (44.93)	IC-544806 xVRSG-199 (32.98) IC-336759 xVRSG-199 (31.40) IC-336759 x PATNA LOCAL (29.86)	IC-336759 x PATNA LOCAL (69.08) IC-284795 x PATNA LOCAL (60.94) IC-284840 x PATNA LOCAL (55.88)
2	**PB**	IC-284840 x IC-355633 (65.35) IC-284795 x PATNA LOCAL (35.31) IC-284840 x PATNA LOCAL (29.24)	IC-284840 x IC-355633 (30.41) IC-284795 x VRSG-199 (37.04) IC-284795 x IC-336759 (34.93)	IC-284795 x PATNA LOCAL (72.84) VRSG-199 x PATNA LOCAL (67.98) IC-284795 x IC-336759 (66.58)
3	**FN**	IC-544806 xVRSG-199 (73.42) IC-355633 xVRSG-199 (59.30) IC-355633 x PATNA LOCAL (59.26)	IC-544806 x IC-284941 (40.14) IC-544806 xVRSG-199 (38.73) IC-284840 x VRSG-199 (25.65)	IC-336759 x PATNA LOCAL (38.76) IC-284795 x IC-336759 (35.71) IC-284795 x PATNA LOCAL (31.78)
4	**DSF**	IC-284941x PATNA LOCAL (-23.91) IC-284941x VRSG-199 (-23.52) IC-544806 x PATNA LOCAL (-21.93)	IC-284941x PATNA LOCAL (-33.37) IC-355633 x PATNA LOCAL (-32.81) IC-544806 x PATNA LOCAL (-30.62)	IC-336759 x PATNA LOCAL (-26.36) IC-284795 x PATNA LOCAL (-23.38) IC-284941x PATNA LOCAL (-21.69)
5	**DFF**	IC-284941x VRSG-199 (-22.32) IC-284795 x IC-355633 (-21.24) IC-544806 x IC-284941 (-20.10)	IC-284795 x IC-355633 (-31.06) IC-355633 x PATNA LOCAL (-30.79) IC-284941x PATNA LOCAL (-28.80)	IC-284795 x PATNA LOCAL (-23.07) IC-336759 x PATNA LOCAL (-21.91) IC-284795 x IC-336759 (-18.02)
6	**DPF**	IC-284941x VRSG-199 (-27.02) IC-355633 x PATNA LOCAL (-19.74) IC-544806 x IC-284941 (-19.59)	IC-284941x VRSG-199 (-32.08) IC-355633 x PATNA LOCAL (-29.89) IC-284941x PATNA LOCAL (-28.08)	IC-284795 x PATNA LOCAL (-18.89) IC-284795 x IC-336759 (-16.42) IC-284941x VRSG-199 (-12.66)
7	**SF**	IC-336759 x IC-355633 (29.32) IC-355633 x PATNA LOCAL (26.74) IC-284840 x IC-544806 (25.95)	IC-284840 x IC-544806 (24.38) IC-284795 x IC-336759 (21.14) IC-336759 xVRSG-199 (16.82)	IC-336759 x PATNA LOCAL (61.4) IC-284795 x PATNA LOCAL (57.89) IC-284840 x PATNA LOCAL (55.81)
8	**SR**	IC-336759 x PATNA LOCAL (-47.78) VRSG-199 x PATNA LOCAL (-38.40) IC-284795 x PATNA LOCAL (-36.39)	IC-336759 x PATNA LOCAL (-52.07) VRSG-199 x PATNA LOCAL (-49.78) IC-284840 x PATNA LOCAL (-44.55)	IC-336759 x PATNA LOCAL (-53.41) IC-284795 x PATNA LOCAL (-40.09) IC-284840 x PATNA LOCAL (-35.85)
9	**NFA**	IC-355633 x PATNA LOCAL (-32.00) IC-284795 x IC-284840 (-27.65) IC-284795 x IC-336759 (-25.07)	IC-355633 x PATNA LOCAL (-52.19) IC-544806 x PATNA LOCAL (-47.24) IC-284795 x PATNA LOCAL (-35.83)	IC-336759 x PATNA LOCAL (-46.82) IC-284795 x PATNA LOCAL (-45.45) IC-284795 x IC-336759 (-40.91)
10	**DHM**	VRSG-199 x PATNA LOCAL (-31.70) IC-284795 x IC-336759 (-31.31) IC-284840 x IC-544806 (-30.08)	VRSG-199 x PATNA LOCAL (-40.29) IC-355633 x PATNA LOCAL (-40.00) IC-284840 x PATNA LOCAL (-35.56)	IC-336759 x PATNA LOCAL (-12.30) VRSG-199 x PATNA LOCAL (-8.47) IC-284795 x IC-336759 (-7.70)
11	**FL**	IC-284840 x IC-355633 (94.90)	IC-284840 x IC-355633 (48.74)	IC-336759 x PATNA LOCAL (44.07)

		IC-355633 xVRSG-199 (57.95) IC-355633 x PATNA LOCAL (53.25)	IC-284840 x VRSG-199 (31.53) IC-336759 xVRSG-199 (25.23)	IC-284840 x IC-355633 (42.75) IC-336759 xVRSG-199 (39.90)
12	**FD**	IC-284840 x PATNA LOCAL (73.58) IC-284795 x PATNA LOCAL (65.08) IC-284795 x VRSG-199 (55.65)	IC-284795 x PATNA LOCAL (44.44) IC-284840 x PATNA LOCAL (37.22) IC-544806 x IC-284941 (35.72)	IC-284795 x PATNA LOCAL (148.72) IC-284840 x PATNA LOCAL (136.29) IC-336759 x PATNA LOCAL (129.59)
13	**FW**	IC-355633 x PATNA LOCAL (40.94) IC-355633 xVRSG-199 (40.57) IC-336759 xVRSG-199 (39.33)	IC-284840 x VRSG-199 (29.57) IC-336759 x PATNA LOCAL (27.17) IC-336759 xVRSG-199 (26.63)	IC-336759 x PATNA LOCAL (110.09) IC-284795 x PATNA LOCAL (93.50) IC-336759 xVRSG-199 (88.72)
14	**FPP**	IC-355633 x PATNA LOCAL (56.78) IC-284941x PATNA LOCAL (36.58) IC-544806 x PATNA LOCAL (35.55)	IC-284795 x IC-336759 (25.86) IC-284795 x PATNA LOCAL (25.15) IC-284795 x IC-284840 (19.62)	IC-284795 x PATNA LOCAL (34.56) IC-284795 x IC-336759 (31.00) IC-336759 x PATNA LOCAL (27.04)
15	**NSF**	IC-355633 xVRSG-199 (47.47) IC-355633 x PATNA LOCAL (46.68) IC-284941x VRSG-199 (35.38)	IC-284795 x PATNA LOCAL (27.04) IC-544806 x IC-284941 (24.98) VRSG-199 x PATNA LOCAL (18.85)	IC-284795 x PATNA LOCAL (56.54) VRSG-199 x PATNA LOCAL (46.45) IC-336759 x PATNA LOCAL (41.23)
16	**SI**	IC-355633 x PATNA LOCAL (24.34) IC-355633 x VRSG-199 (23.47) IC-336795 x IC-336759 (21.29)	IC-355633 x VRSG-199 (20.78) IC-284795 x IC-336759 (19.92) IC-544806 x IC-284941 (10.50)	IC-284795 x IC-336759 (30.20) IC-355633 x PATNA LOCAL (28.65) IC-284795 x PATNA LOCAL (27.76)
17	Y	IC-355633 x PATNA LOCAL (92.82) IC-336759 x PATNA LOCAL (66.01) IC-284941 x VRSG-199 (65.03)	IC-336759 x PATNA LOCAL (51.98) IC-284795 x IC-336759 (48.51) IC-284795 x PATNA LOCAL (46.97)	IC-336759 x PATNA LOCAL (127.74) IC-284795 x PATNA LOCAL (120.2) IC-284795 x IC-336759 (94.83)

(VL)- Vine length (m); (PB)-No. of primary branches; (FN)-Number of fruiting nodes on main stem; (DSF)-Days to first staminate flower appearance; (DPF)-Days to first pistillate (female) flower appearance; (DFF)-Days to 50% flowering; (SF)-Span of flowering; (SR)-Sex ratio (M/F); (NFA)-Node of 1st female flower appearance; (DHM)-Days to harvestable maturity from anthesis; (FL)-Fruit length (cm); (FD)-Fruit diameter (cm); (FW)-Average fruit weight (g); (FPP)-Fruits per plant (no); (NSF)- Number of seeds per fruit; (SI)-Seed index (100 seed weight); (Y)- Yield per plant (kg).

Similar results were reported for the earliness of above mentioned characters by Sonavane *et al.,* (2013), Islam *et al.,* (2012), Sanandia *et al.,* (2008) and Naliyadhara *et al.,* (2007) in sponge gourd; and Muthaiah *et al.,* (2017), Bairwa *et al.,* (2017), Prakash *et al.,* (2014), Narasannavar *et al.,* (2014), Karthik (2014), Lodam *et al.,* (2014), Dodiya *et al.,* (2013) and Singh (2013) in ridge gourd.

In conclusion the results discussed above are quite indicative of the fact that hybrids in sponge gourd have greater potential for maximizing yields with earliness. Based on heterosis study the F_1 hybrids IC-284795 x Patna Local, IC-336759 x Patna Local and IC-284795 x IC-336759 were found best performers keeping in view the earliness as well as increased yield over standard check and their respective better parent and may be entered in multi-locational trials.

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