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Heterosis studies for growth and yield parameters in sponge gourd [*Luffa cylindrica* (L.) Roem.]

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Abstract
The present investigation was conducted to determine heterosis in 36 crosses, which were developed by using 9 parents to study the heterosis for growth and yield parameters in sponge gourd. Maximum standard heterosis for vine length (26.07%) was observed in SG-5 × SG-3, for number of leaves per plant in Kulgod local × Pusa Chikni (62.16%), for internodal length in SG-5 × KRCCH-2 (-27.36), for number of branches per plant in Kulgod local × Pusa Chikni (41.71%), for leaf area in Kulgod local × Pusa Chikni (26.50%), for sex ratio in SG-5 × Swarna Prabha (14.14%), for fruit set in SG-5 × KRCCH-1 (11.90%), for fruit length in SG-4 × KRCCH-2 (19.44%), for fruit diameter in SG-6 × Swarna Prabha (-21.13%), for average fruit weight in SG-5 × KRCCH-1 (13.37%), for number of fruits per plant in Kulgod local × Pusa Chikni (66.04%), for fruit yield per plant in Kulgod local × Pusa Chikni (100.74%). The three best performing F_1 hybrids *viz*., the cross Kulgod local × Pusa Chikni (100.74%) followed by SG-5 × SG-3 (95.11%) and Kulgod local × KRCCH-1 (70.08%) exhibited the highest standard heterosis for total fruit yield per plant in order of merit.

Keywords: Sponge gourd, heterosis, number of fruits per plant, fruit yield per plant and genotypes variability

Introduction
Sponge gourd [*Luffa cylindrica* (L.) Roem.] is one of the most important cucurbitaceous vegetable crops grown extensively throughout the tropical and sub-tropical regions of the world. It is commonly called as smooth luffa, climbing okra, dishcloth gourd and Chinese okra. This crop has a long history of cultivation in the tropical countries of Asia and Africa (Oboh and Aluyor, 2009) [10]. *Luffa* is a diploid species with 26 chromosomes (2n = 26). *Luffa* belongs to cucurbitaceous family and it is a cross-pollinated crop (Bal *et al*., 2004) [3] widely cultivated in *kharif* and summer seasons in India. The family Cucurbitaceae comprises of the largest group of summer vegetables. All together there are two well defined subfamilies, eight tribes, about 118 genera and 825 species in this family. Out of these, approximately 20 species belonging to nine genera are under cultivation (Jeffrey, 1990) [5].

Most of the cucurbitaceous vegetables, including sponge gourd are usually cultivated in relatively small area for local consumption and hence exact area and production are unknown. Cucurbits share about 5.6 per cent of the total vegetable production of India (Rai and Rai, 2006) [11]. According to FAO estimate, cucurbits are cultivated in an area of about 5.46 lakh ha having annual production of 5.40 lakh tonnes. The productivity of this crop is 10.52 tonnes per hectare (Anon., 2016) [1]. The main cucurbits producing countries are China, Korea, India, Japan, Nepal and Central America. In India, major cucurbits growing states are U. P., Punjab, Bihar, Jharkhand, Gujarat, Rajasthan, Haryana, Karnataka and Delhi.

Sponge gourd being a monoecious and cross pollinated crop, it exhibits considerable heterozygosity in population and does not suffer much due to inbreeding depression resulting in natural variability in the population. Thus provides ample scope for utilization of hybrid vigour on commercial scale to increase the production and productivity. In spite of the availability of wide range of genetic variability in plant and fruit characters 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. One of the methods to achieve quantum jump in yield and quality is heterosis breeding. Hence, an attempt was made to study the heterosis in different crosses over the mid parent, better parent and commercial check or standard parent to develop and identify the suitable best performing hybrids.

Material and Methods

The present investigation entitled "Heterosis studies in sponge gourd [*Luffa cylindrica* (L.) Roem.]" conducted during *Kharif* season, 2017 at the Horticulture farm of Main Agricultural Research Station (MARS), University of Agricultural Sciences, Raichur, Karnataka, India-584104. Nine diverse parents (Kulgod local, SG-4, SG-6, SG-5, SG-3, Pusa Chikni, KRCCH-2, Swarna Prabha, KRCCH-1, KRCCH-1) were crossed in a diallel fashion (excluding reciprocals) for generating the 36 F_1 hybrids. All the nine parents, 36 hybrids and one standard check were grown in a randomized block design with three replications. Observation were recorded on 12 characters *viz*., vine length, number of leaves per plant, internodal length, number of branches per plant, leaf area, sex ratio, fruit set, fruit length, fruit diameter, average fruit weight, number of fruits per plant, fruit yield per plant in sponge gourd.

Estimation of heterosis

Heterosis was calculated as percentage of F_1 performance in the desirable direction over mid parent, better parent and commercial check or standard parent (Anisha) was computed for each character using following formula.

1) Relative heterosis (%):

$$\text{Per cent heterosis over mid parent (MP)} = \frac{\overline{F_1} - \overline{MP}}{\overline{MP}} \times 100$$

2) Heterobeltiosis (%):

$$\text{Per cent heterosis over better parent (BP)} = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

3) Standard heterosis (%):

$$\text{Per cent heterosis over check/standard parent (SC)} = \frac{\overline{F_1} - \overline{SC}}{\overline{SC}} \times 100$$

Where,

$\overline{F_1}$ = Mean value of the F_1

$\overline{MP}$ = Mean performance of parents

$\overline{BP}$ = Mean performance of better parent

$\overline{SC}$ = Mean performance of standard check

Results and Discussion

The magnitude of heterosis was calculated as per cent increase or decrease of F_1 values over the mid parent (MP), better parent (BP) and standard parent (SP). The hybrid 'Anisha' was used as check or standard parent. The negative estimates of heterosis were considered desirable for the trait like internodal length. However, for rest of the characters studied positive estimates of heterosis was consider desirable.

Among 36 crosses, the top three ranking cross combinations based on average heterosis, heterobeltiosis and economic heterosis for the 22 characters are given in Table 1-6. In cross combinations, Kulgod local × Pusa Chikni (90.16%), SG-4 × KRCCH-1 (62.63%) and Kulgod local × KRCCH-1 (58.89%) exhibited the significant relative heterosis for yield per plant whereas crosses Kulgod local × Pusa Chikni (78.27%), Kulgod local × KRCCH-1 (47.17%) and SG-4 × KRCCH-1 (40.23%) exhibited over better parent and Kulgod local × Pusa Chikni (100.74%), SG-5 × SG-3 (95.11%) and Kulgod local × KRCCH-1 (70.08%) over standard parent. The cross Kulgod local × Pusa Chikni was the best performing cross based on *per se* performance for yield per plant and had average heterosis for seven yield and yield attributing characters *viz.*, vine length, number of leaves per plant, number of branches per plant, leaf area, fruit length, number of fruits per plant and fruit yield per plant in sponge gourd. This cross exhibited superior performance over better parent and economic heterosis for seven yield and yield attributing characters *viz.*, vine length, number of leaves per plant, number of branches per plant, leaf area, fruit length, number of fruits per plant and fruit yield per plant in sponge gourd. Increase in yield due to increasing of yield attributing characters and high non-additive gene action involved. Similar results have also been reported in cucumber (Hutchins, 1939 and Singh *et al.*, 1970) [6, 14]; muskmelon (Mishra and Seshadri, 1985) [8]; bittergourd (Singh *et al*., 2000) [12] and bottle gourd (Jankiram and Sirohi, 1989) [4]. The highest yielding hybrids also registered for setting the fruit at the minimum nodal position. This result suggests that from economic point of view, it is useful to select parental lines having one or more economic character in order to achieve high yield in the F_1 hybrids through heterosis breeding.

For fruit length, Kulgod local × Pusa Chikni (45.39%), Pusa Chikni × Swarna Prabha (38.71%) and SG-4 × Pusa Chikni (34.54%) were the best three hybrids over mid parent. The hybrids registered significant positive heterobeltiosis were Kulgod local × Pusa Chikni (20.66%), SG-4 × KRCCH-2 (18.49%) and Kulgod local × Swarna Prabha (15.65%). The crosses SG-4 × KRCCH-2 (19.44%) and Kulgod local × Pusa Chikni (16.64%) reported significant positive heterosis over the check parent. High heterosis for this trait was also noted by Hutchins (1939) [6], Singh *et al.*, (1970) [14], Mishra and Seshadri (1985) [8], Jankiram and Sirohi (1989) [4] and Singh *et al*. (2000) [12] in cucurbits which support the present findings. Besides recording high heterosis for this trait, they also recorded contribution of this character in increasing the yield potential of a cross. The cross Kulgod local × Pusa Chikni was the best hybrid over mid parent (37.07%), better parent (27.00%) and standard parent (26.50%) for leaf area. These results are in accordance with the reports of Arinia *et al.* (2013) [2] for heterobeltosis and standard heterosis in cucumber. Number of fruits per plant is an important character for which 6, 3 and 8 crosses exhibited significant heterosis over mid, better and check parent, respectively. For this trait, the cross KRCCH-2 × KRCCH-1 had maximum and significant positive heterosis over mid parent followed by KRCCH-2 × KRCCH-1 for heterobeltiosis and Kulgod local × Pusa Chikni for standard heterosis.

The extent of heterosis over the three best crosses for total yield per plant (58.89 - 90.16% over mid parent; 40.23 - 78.27% over better parent and 70.08 - 100.74% over check variety) revealed that there was a great scope of realizing higher yield in sponge gourd through heterosis breeding. Six cross combinations showed significant and positive standard heterosis for fruit yield per plant. The range of standard heterosis was from -23.91 (SG-3 × KRCCH-2) to 100.74 per cent (Kulgod local × Pusa Chikni). The top three hybrids were Kulgod local × Pusa Chikni (100.74%), SG-5 × SG-3 (95.11%) and Kulgod local × KRCCH-1 (70.08%).

Relative heterosis besides epistatic effect also indicates presence of dominace effects (intra allelic interaction), while heterobeltiosis is indicative of over dominace. In such situation economic heterosis or mean performance of a cross is more reliable criteria for identifying a commercially valuable cross. The crosses showing high heterosis for yield and also exhibiting high heterosis for different yield contributing characters by Kulgod local × Pusa Chikni and Kulgod local × KRCCH-1 are more suitable because has

strong heterotic capability compared to other ones during hybridization process. These crosses may be further tested and recommended for commercial cultivation to boost the fruit yield per unit area of sponge gourd.

Table 1: Estimation of heterosis for vine length and number of leaves per plant in sponge gourd

Cross	Vine length			Number of leaves per plant		
	MP	BP	SC	MP	BP	SC
Kulgod local × SG-4	34.46**	33.35**	5.61	-2.75	-7.63	1.75
Kulgod local × SG-6	12.99	-7.64	13.33	2.31	-0.22	15.61
Kulgod local × SG-5	-10.62	-19.64*	-21.58*	3.43	2.46	12.86
Kulgod local × SG-3	-3.09	-15.15	-12.01	0.98	-15.56**	38.31**
Kulgod local × Pusa Chikni	45.86**	32.94**	25.85**	55.02**	47.22**	62.16**
Kulgod local × KRCCH-2	26.14**	9.60	15.72	-9.97	-10.26	-1.16
Kulgod local × Swarna Prabha	8.59	-10.46	7.43	-18.72**	-31.46**	9.97
Kulgod local × KRCCH-1	23.11**	3.85	17.72	32.99**	29.09**	51.04**
SG-4 × SG-6	13.41	-6.70	14.49	17.61*	9.11	26.41**
SG-4 × SG-5	28.07**	16.01	13.21	9.25	4.71	13.19
SG-4 × SG-3	18.06*	4.11	7.97	-27.81**	-42.06**	-5.10
SG-4 × Pusa Chikni	31.84**	21.07*	14.62	27.64**	27.61**	26.47**
SG-4 × KRCCH-2	3.21	-9.69	-4.64	-8.07	-12.41	-4.15
SG-4 × Swarna Prabha	6.02	-12.00	5.58	-28.94**	-42.52**	-7.77
SG-4 × KRCCH-1	22.10**	3.71	17.57	39.21**	28.56**	50.43**
SG-6 × SG-5	-10.38	-19.56**	-1.29	6.64	3.06	19.41*
SG-6 × SG-3	-12.27	-19.07**	-0.69	6.37	-9.20	48.74**
SG-6 × Pusa Chikni	11.63	-1.12	21.33*	5.66	-2.00	13.54
SG-6 × KRCCH-2	-5.14	-11.76	8.28	-1.07	-3.82	11.43
SG-6 × Swarna Prabha	-13.61*	-14.57	4.83	-26.17**	-36.43**	2.00
SG-6 × KRCCH-1	-1.14	-4.91	16.69	6.17	5.65	23.62**
SG-5 × SG-3	25.26**	21.57*	26.07**	17.39**	-2.57	59.59**
SG-5 × Pusa Chikni	9.22	7.59	4.99	-6.92	-10.80	-3.59
SG-5 × KRCCH-2	-7.33	-10.84	-5.87	-9.87	-10.42	-1.98
SG-5 × Swarna Prabha	4.04	-5.67	13.17	-19.77**	-32.86**	7.73
SG-5 × KRCCH-1	15.06*	7.06	21.36*	-24.53**	-27.40**	-15.06
SG-3 × Pusa Chikni	12.05	7.17	11.14	-19.38**	-35.31**	5.97
SG-3 × KRCCH-2	-3.30	-4.16	1.19	-31.70**	-43.04**	-6.69
SG-3 × Swarna Prabha	-23.99**	-29.15**	-14.99	-28.21**	-28.94**	16.40
SG-3 × KRCCH-1	-26.50**	-29.63**	-20.23*	-32.78**	-42.39**	-5.63
Pusa Chikni × KRCCH-2	9.84	4.16	9.97	35.89**	29.46**	41.66**
Pusa Chikni × Swarna Prabha	5.01	-6.07	12.70	-12.88*	-29.54**	13.05
Pusa Chikni × KRCCH-1	3.74	-4.81	7.90	-5.33	-12.59	2.28
KRCCH-2 × Swarna Prabha	-16.95*	-21.93**	-6.34	-23.31**	-35.51**	3.48
KRCCH-2 × KRCCH-1	6.07	2.43	16.12	-9.89	-12.81	2.02
Swarna Prabha × KRCCH-1	-1.20	-3.92	15.28	-30.38**	-39.81**	-3.42
S.Em±	0.811	0.936	0.936	6.256	7.224	7.224
C.D. @ 5%	1.646	1.900	1.900	12.701	14.666	14.666
C.D. @ 1%	2.134	2.465	2.465	16.472	19.021	19.021

*, ** Significant at 5% and 1% level, respectively

MP, BP and SC represent heterosis values over mid, better and standard parent/check, respectively.

Table 2: Estimation of heterosis for internodal length and number of branches per plant in sponge gourd

Cross	Internodal length			Number of branches per plant		
	MP	BP	SC	MP	BP	SC
Kulgod local × SG-4	-12.23	-14.83	-18.14	-14.25	-20.62*	-33.52**
Kulgod local × SG-6	10.67	9.63	5.36	4.20	-7.81	-22.79**
Kulgod local × SG-5	13.39	9.91	5.63	9.22	-0.08	-16.32*
Kulgod local × SG-3	13.44	9.91	5.63	-18.87**	-33.62**	-12.63
Kulgod local × Pusa Chikni	4.53	0.20	4.99	68.90**	68.58**	41.71**
Kulgod local × KRCCH-2	15.66	8.43	19.09	-23.87**	-25.63**	-34.70**
Kulgod local × Swarna Prabha	13.08	10.13	11.67	-24.52**	-37.00**	-21.17**
Kulgod local × KRCCH-1	-1.90	-2.32	-6.12	60.28**	59.86**	33.87**
SG-4 × SG-6	34.50**	31.72*	24.23*	-5.85	-10.37	-36.10**
SG-4 × SG-5	10.87	10.74	0.12	11.66	10.24	-21.40**
SG-4 × SG-3	15.35	15.17	4.12	-23.22**	-40.81**	-22.10**
SG-4 × Pusa Chikni	2.57	-4.47	0.10	-24.32**	-30.06**	-41.21**
SG-4 × KRCCH-2	14.50	4.37	14.64	-0.16	-9.54	-20.57*
SG-4 × Swarna Prabha	-9.04	-13.97	-12.76	-17.47*	-35.22**	-18.95*
SG-4 × KRCCH-1	14.41	11.49	6.23	63.24**	51.49**	26.19**
SG-6 × SG-5	25.15*	22.43	15.46	33.25**	28.41*	-10.76
SG-6 × SG-3	11.21	8.75	2.56	22.22**	-8.97	19.81*

SG-6 × Pusa Chikni	26.20*	19.89	25.63*	10.86	-2.08	-17.68*
SG-6 × KRCCH-2	-1.99	-8.92	0.04	-2.00	-15.04	-25.40**
SG-6 × Swarna Prabha	1.05	-2.48	-1.11	-28.09**	-45.52**	-31.84**
SG-6 × KRCCH-1	12.02	11.45	6.19	-27.12**	-35.37**	-46.16**
SG-5 × SG-3	0.53	0.48	-9.36	32.57**	1.28	33.30**
SG-5 × Pusa Chikni	-2.38	-9.17	-4.82	23.55**	12.84	-5.14
SG-5 × KRCCH-2	-27.38**	-33.87**	-27.36*	-3.94	-13.96	-24.44**
SG-5 × Swarna Prabha	7.01	1.10	2.52	-10.64	-30.50**	-13.05
SG-5 × KRCCH-1	17.83	14.69	9.28	-3.22	-11.24	-26.06**
SG-3 × Pusa Chikni	-11.90	-18.06	-14.14	-33.03**	-45.13**	-27.78**
SG-3 × KRCCH-2	-4.45	-13.03	-4.47	-41.93**	-51.59**	-36.29**
SG-3 × Swarna Prabha	12.69	6.43	7.92	-48.73**	-50.00**	-34.19**
SG-3 × KRCCH-1	9.32	6.36	1.34	-5.67	-22.99**	1.37
Pusa Chikni × KRCCH-2	-11.42	-13.46	-4.95	43.66**	40.60**	23.46**
Pusa Chikni × Swarna Prabha	5.68	3.97	8.95	-4.48	-20.15**	-0.10
Pusa Chikni × KRCCH-1	1.41	-3.19	1.44	1.86	1.40	-14.76
KRCCH-2 × Swarna Prabha	-7.02	-10.59	-1.79	-33.53**	-43.44**	-29.24**
KRCCH-2 × KRCCH-1	-1.61	-8.13	0.91	2.75	0.11	-12.10
Swarna Prabha × KRCCH-1	-4.50	-7.38	-6.08	-35.66**	-46.41**	-32.95**
S.Em±	1.633	1.886	1.886	0.712	0.823	0.823
C.D. @ 5%	3.315	3.828	3.828	1.446	1.670	1.670
C.D. @ 1%	4.300	4.965	4.965	1.875	2.166	2.166

*, ** Significant at 5% and 1% level, respectively

MP, BP and SC represent heterosis values over mid, better and standard parent/check, respectively.

Table 3: Estimation of heterosis for leaf area and sex ratio in sponge gourd

Cross	Leaf area			Sex ratio		
	MP	BP	SC	MP	BP	SC
Kulgod local × SG-4	-2.29	-4.69	-0.15	33.75**	33.37**	-8.61
Kulgod local × SG-6	2.32	0.54	0.14	65.03**	58.80**	8.82*
Kulgod local × SG-5	3.03	-2.55	-2.93	13.89	6.90	-26.75**
Kulgod local × SG-3	-9.91	-15.55*	-3.85	15.10	8.49	-16.00
Kulgod local × Pusa Chikni	37.07**	27.00**	26.50**	3.46	2.87	-28.70**
Kulgod local × KRCCH-2	-2.66	-7.51	-7.87	-8.62	-20.32*	-26.60**
Kulgod local × Swarna Prabha	-7.11	-9.37	-5.10	19.32	15.24	-15.24
Kulgod local × KRCCH-1	25.41**	13.85*	13.40	-5.13	-16.55	-24.67**
SG-4 × SG-6	10.34	5.80	10.84	20.54	16.30	-20.75*
SG-4 × SG-5	-3.39	-10.74	-6.49	35.45**	27.47*	-13.14
SG-4 × SG-3	9.33	4.96	19.51*	-0.67	-6.62	-27.70**
SG-4 × Pusa Chikni	-7.71	-16.42*	-12.44	43.32**	42.11**	-1.50
SG-4 × KRCCH-2	-8.23	-14.84	-10.78	3.03	-10.38	-17.44*
SG-4 × Swarna Prabha	-7.74	-7.76	-3.37	6.63	2.71	-24.46**
SG-4 × KRCCH-1	8.69	-3.51	1.09	-9.66	-20.73*	-28.44**
SG-6 × SG-5	16.14*	11.72	7.40	41.63**	38.01**	-12.57
SG-6 × SG-3	-1.35	-9.03	3.58	4.52	-4.98	-26.43**
SG-6 × Pusa Chikni	21.42**	14.38	9.96	31.68**	26.02*	-12.65
SG-6 × KRCCH-2	19.17*	15.16	10.71	5.03	-11.37	-18.36*
SG-6 × Swarna Prabha	13.72	9.07	14.21	27.42**	18.59	-12.78
SG-6 × KRCCH-1	23.79**	14.21	9.79	-7.04	-20.90*	-28.59**
SG-5 × SG-3	16.90*	4.04	18.46*	1.86	-9.53	-29.95**
SG-5 × Pusa Chikni	17.89*	15.34	2.44	21.36	13.30	-21.47**
SG-5 × KRCCH-2	14.15	13.60	1.87	29.77**	7.23	-1.23
SG-5 × Swarna Prabha	12.35	3.82	8.71	70.79**	55.19**	14.14**
SG-5 × KRCCH-1	2.80	-1.59	-12.59*	18.37	-1.41	-11.00
SG-3 × Pusa Chikni	-2.24	-14.64	-2.81	29.60**	22.80*	-4.92
SG-3 × KRCCH-2	-2.26	-12.64	-0.54	-0.66	-8.58	-15.79
SG-3 × Swarna Prabha	-16.67*	-20.02**	-8.93	4.87	2.24	-20.84*
SG-3 × KRCCH-1	11.37	-4.58	8.65	25.13**	16.22	4.92
Pusa Chikni × KRCCH-2	20.84*	17.67	5.52	-10.19	-21.31*	-27.51**
Pusa Chikni × Swarna Prabha	12.35	1.76	6.56	7.95	4.84	-22.89**
Pusa Chikni × KRCCH-1	23.45**	20.74*	2.60	-2.38	-13.71	-22.11**
KRCCH-2 × Swarna Prabha	-9.89	-16.36*	-12.42	16.02	4.33	-3.90
KRCCH-2 × KRCCH-1	2.63	-2.19	-12.29	-17.95*	-18.78*	-25.18**
Swarna Prabha × KRCCH-1	-5.16	-15.79	-11.82	4.26	-5.40	-14.60
S.Em±	8.931	10.312	10.312	1.096	1.266	1.266
C.D. @ 5%	18.130	20.934	20.934	2.225	2.570	2.570
C.D. @ 1%	23.513	27.150	27.150	2.886	3.333	3.333

*, ** Significant at 5% and 1% level, respectively

MP, BP and SC represent heterosis values over mid, better and standard parent/check, respectively.

Table 4: Estimation of heterosis for fruit length and fruit set in sponge gourd

Cross	Fruit length			Fruit set		
	MP	BP	SC	MP	BP	SC
Kulgod local × SG-4	13.07	9.64	5.99	-1.01	-3.84	-4.87
Kulgod local × SG-6	8.54	4.46	9.19	10.72*	5.50	4.37
Kulgod local × SG-5	-28.99**	-33.29**	-26.63*	-3.53	-8.30	0.67
Kulgod local × SG-3	-1.40	-8.59	3.46	-14.95**	-18.71**	-11.79*
Kulgod local × Pusa Chikni	45.39**	20.66**	16.64*	13.03**	10.73*	9.54
Kulgod local × KRCCH-2	-8.97	-10.83	-10.12	8.11	8.00	6.84
Kulgod local × Swarna Prabha	16.36	15.65*	13.18	7.09	4.27	8.89
Kulgod local × KRCCH-1	14.43	8.37	17.18	12.73**	8.31	7.14
SG-4 × SG-6	8.66	1.53	6.13	20.04**	17.67**	9.76
SG-4 × SG-5	5.17	-4.00	5.59	5.99	-1.97	7.61
SG-4 × SG-3	11.36	0.35	13.58	6.37	-1.09	7.32
SG-4 × Pusa Chikni	34.54**	14.52	3.99	13.68**	12.72*	6.96
SG-4 × KRCCH-2	24.67*	18.49**	19.44**	13.94**	10.81*	9.39
SG-4 × Swarna Prabha	18.00	13.74	11.32	0.13	-5.22	-1.01
SG-4 × KRCCH-1	11.91	2.96	11.32	18.57**	17.22**	9.35
SG-6 × SG-5	-3.91	-6.30	3.06	8.84	-1.16	8.50
SG-6 × SG-3	-0.18	-4.00	8.66	4.59	-4.53	3.60
SG-6 × Pusa Chikni	24.68*	0.38	4.93	16.86**	13.60*	7.80
SG-6 × KRCCH-2	-4.02	-5.73	-1.46	13.62**	8.36	6.98
SG-6 × Swarna Prabha	-3.42	-6.50	-2.26	14.69**	6.54	11.26*
SG-6 × KRCCH-1	-3.07	-4.68	3.06	16.55**	15.54**	5.33
SG-5 × SG-3	-8.95	-10.24	1.60	-1.65	-2.21	7.35
SG-5 × Pusa Chikni	31.95**	4.24	14.65	2.99	-3.99	5.40
SG-5 × KRCCH-2	4.49	0.12	10.12	1.32	-3.78	5.63
SG-5 × Swarna Prabha	3.91	-1.82	7.99	-3.32	-5.67	3.55
SG-5 × KRCCH-1	-6.11	-6.90	2.40	11.38*	1.94	11.90*
SG-3 × Pusa Chikni	10.01	-14.00	-2.66	4.84	-1.73	6.63
SG-3 × KRCCH-2	-19.10	-23.53*	-13.45	-14.09**	-17.97**	-10.99*
SG-3 × Swarna Prabha	-15.46	-21.18*	-10.79	3.03	1.10	9.70
SG-3 × KRCCH-1	-20.70*	-22.47*	-12.25	7.70	-0.91	7.52
Pusa Chikni × KRCCH-2	19.42	-2.51	-1.73	7.33	5.25	3.90
Pusa Chikni × Swarna Prabha	38.71**	14.56	12.12	11.38*	6.29	11.01*
Pusa Chikni × KRCCH-1	8.60	-13.67	-6.66	14.65**	12.40*	6.66
KRCCH-2 × Swarna Prabha	-4.02	-5.42	-4.66	3.77	0.93	5.41
KRCCH-2 × KRCCH-1	-7.84	-10.96	-3.73	10.65*	6.41	5.05
Swarna Prabha × KRCCH-1	17.00	11.45	20.51	6.63	-0.14	4.29
S.Em±	2.536	2.928	2.928	3.477	4.014	4.014
C.D. @ 5%	5.148	5.945	5.945	7.058	8.150	8.150
C.D. @ 1%	6.677	7.710	7.710	9.153	10.569	10.569

*, ** Significant at 5% and 1% level, respectively
MP, BP and SC represent heterosis values over mid, better and standard parent/check, respectively.

Table 5: Estimation of heterosis for average fruit weight and fruit diameter in sponge gourd

Cross	Average fruit weight			Fruit diameter		
	MP	BP	SC	MP	BP	SC
Kulgod local × SG-4	31.57**	24.39**	3.15	3.18	-0.76	0.43
Kulgod local × SG-6	27.47**	23.50**	-2.72	-3.10	-5.06	-11.25
Kulgod local × SG-5	48.67**	44.59**	6.81	6.61	6.41	-0.17
Kulgod local × SG-3	14.20*	-4.33	4.63	-4.40	-8.28	-6.70
Kulgod local × Pusa Chikni	24.73**	24.71**	-7.84	-2.44	-5.82	-5.41
Kulgod local × KRCCH-2	20.27*	7.44	-20.64**	5.34	1.36	2.49
Kulgod local × Swarna Prabha	3.78	-4.77	-15.77*	5.78	5.59	-0.95
Kulgod local × KRCCH-1	38.89**	27.39**	-5.89	-4.09	-8.46	-14.43*
SG-4 × SG-6	1.67	-0.88	-17.80**	-5.85	-11.21	-10.14
SG-4 × SG-5	45.35**	33.85**	11.00	4.32	0.51	1.72
SG-4 × SG-3	8.84	-4.32	4.64	-8.04	-8.28	-6.70
SG-4 × Pusa Chikni	29.62**	22.56**	1.64	-8.82	-9.17	-8.08
SG-4 × KRCCH-2	-17.93*	-30.21**	-42.13**	2.25	2.21	3.44
SG-4 × Swarna Prabha	-22.22**	-24.65**	-33.35**	1.06	-2.63	-1.46
SG-4 × KRCCH-1	43.79**	25.33**	3.93	6.14	-2.38	-1.20
SG-6 × SG-5	-35.73**	-39.39**	-52.26**	13.30*	10.81	3.95
SG-6 × SG-3	-13.06*	-25.22**	-18.21**	-4.67	-10.30	-8.76
SG-6 × Pusa Chikni	-32.36**	-34.45**	-48.36**	5.38	-0.26	0.17
SG-6 × KRCCH-2	36.37**	18.49*	-6.67	5.18	-0.76	0.34
SG-6 × Swarna Prabha	-1.85	-7.22	-17.94**	-14.04*	-15.93*	-21.13**

SG-6 × KRCCH-1	53.10**	36.46**	7.49	16.08**	13.03	1.37
SG-5 × SG-3	12.06	-8.20	0.40	1.76	-2.20	-0.52
SG-5 × Pusa Chikni	33.85**	30.14**	-3.83	1.90	-1.45	-1.03
SG-5 × KRCCH-2	40.54**	28.76**	-10.11	-2.51	-6.03	-4.98
SG-5 × Swarna Prabha	30.39**	16.65*	3.17	1.19	1.19	-5.07
SG-5 × KRCCH-1	72.50**	62.41**	13.37**	7.83	2.75	-3.61
SG-3 × Pusa Chikni	12.23	-5.97	2.84	1.57	0.93	2.66
SG-3 × KRCCH-2	12.95	-13.52*	-5.42	-11.48*	-11.74	-10.22
SG-3 × Swarna Prabha	6.47	-3.72	5.31	3.34	-0.68	1.03
SG-3 × KRCCH-1	15.15*	-9.97	-1.54	10.72	1.60	3.35
Pusa Chikni × KRCCH-2	34.60**	20.21*	-11.16	-6.91	-7.22	-6.19
Pusa Chikni × Swarna Prabha	13.14	3.84	-8.15	5.62	2.14	2.58
Pusa Chikni × KRCCH-1	29.64**	18.89*	-12.14	-7.23	-14.37*	-14.00*
KRCCH-2 × Swarna Prabha	-19.92*	-33.66**	-41.32**	3.39	-0.34	0.77
KRCCH-2 × KRCCH-1	63.36**	58.67**	-2.19	7.57	-1.02	0.09
Swarna Prabha × KRCCH-1	-19.08*	-31.34**	-39.27**	10.81	5.59	-0.95
S.Em±	10.903	12.589	12.589	0.204	0.235	0.235
C.D. @ 5%	22.133	25.558	25.558	0.414	0.478	0.478
C.D. @ 1%	28.705	33.146	33.146	0.537	0.620	0.620

*, ** Significant at 5% and 1% level, respectively
MP, BP and SC represent heterosis values over mid, better and standard parent/check, respectively.

Table 6: Estimation of heterosis for number of fruits per plant and fruit yield per plant in sponge gourd

Cross	Number of fruits per plant			Fruit yield per plant		
	MP	BP	SC	MP	BP	SC
Kulgod local × SG-4	-31.01**	-33.33**	-14.01	11.18	2.83	1.32
Kulgod local × SG-6	-20.93	-26.05*	2.17	-5.43	-5.83	-7.22
Kulgod local × SG-5	-24.10*	-36.16**	12.56	0.50	-5.74	-7.13
Kulgod local × SG-3	-26.91*	-32.67**	-3.86	-24.06**	-41.14**	5.41
Kulgod local × Pusa Chikni	37.62**	37.21**	66.04**	90.16**	78.27**	100.74**
Kulgod local × KRCCH-2	35.70**	22.89	47.83**	-4.98	-9.83	-1.05
Kulgod local × Swarna Prabha	-12.45	-18.66	14.01	-31.71**	-46.40**	-7.31
Kulgod local × KRCCH-1	30.25*	13.25	36.23*	58.89**	47.17**	70.08**
SG-4 × SG-6	-4.88	-8.04	27.05	10.53	2.63	0.27
SG-4 × SG-5	-20.73*	-31.37**	21.01	16.91	15.17	-0.60
SG-4 × SG-3	-8.45	-12.87	24.40	-17.73*	-39.63**	8.11
SG-4 × Pusa Chikni	-15.94	-18.54	5.07	-0.86	-13.57	-2.68
SG-4 × KRCCH-2	3.62	-8.99	17.39	-16.65	-26.53*	-19.37
SG-4 × Swarna Prabha	-11.87	-15.39	18.60	-30.72**	-48.59**	-11.08
SG-4 × KRCCH-1	47.07**	24.21*	60.22**	62.63**	40.23**	62.06**
SG-6 × SG-5	-27.65**	-35.48**	13.77	8.16	1.85	-0.49
SG-6 × SG-3	-0.18	-1.79	40.22*	2.32	-20.92**	41.60**
SG-6 × Pusa Chikni	-7.18	-12.94	20.29	7.49	0.38	13.03
SG-6 × KRCCH-2	-1.43	-15.91	16.18	18.75	12.24	23.17
SG-6 × Swarna Prabha	-9.57	-10.22	25.85	-38.70**	-52.03**	-17.05
SG-6 × KRCCH-1	9.36	-10.14	24.15	8.28	-0.10	15.46
SG-5 × SG-3	-7.17	-16.00	48.12**	47.04**	8.96	95.11**
SG-5 × Pusa Chikni	-25.59**	-37.26**	10.63	16.79	3.15	16.15
SG-5 × KRCCH-2	-20.46*	-38.22**	8.94	11.11	-0.75	8.91
SG-5 × Swarna Prabha	-41.54**	-47.53**	-7.49*	-23.94**	-42.99**	-1.41
SG-5 × KRCCH-1	-12.02	-33.84**	16.67	-3.30	-15.54	-2.39
SG-3 × Pusa Chikni	-15.03	-21.50	12.08	-33.71**	-46.01**	-3.33
SG-3 × KRCCH-2	-11.37	-25.39*	6.52	-47.30**	-57.50**	-23.91
SG-3 × Swarna Prabha	-11.05	-11.86	25.85	-36.56**	-37.64**	11.66
SG-3 × KRCCH-1	-17.42	-33.01**	-4.35	-26.95**	-39.90**	7.62
Pusa Chikni × KRCCH-2	15.36	4.19	26.09	20.74*	19.21	34.23**
Pusa Chikni × Swarna Prabha	-11.40	-17.46	15.70	-13.76	-28.81**	23.12
Pusa Chikni × KRCCH-1	28.19*	11.18	34.54*	-21.24*	-22.25*	-10.14
KRCCH-2 × Swarna Prabha	-10.60	-24.18*	6.28	-37.11**	-48.60**	-11.10
KRCCH-2 × KRCCH-1	55.70**	48.76**	45.17**	-12.88	-15.08	-1.85
Swarna Prabha × KRCCH-1	-14.16	-29.86**	-1.69	-43.29**	-52.69**	-18.19
S.Em±	1.896	2.189	2.189	0.160	0.185	0.185
C.D. @ 5%	3.848	4.444	4.444	0.325	0.375	0.375
C.D. @ 1%	4.991	5.763	5.763	0.421	0.486	0.486

*, ** Significant at 5% and 1% level, respectively
MP, BP and SC represent heterosis values over mid, better and standard parent/check, respectively.

Reference

1. Anonymous. Indian horticulture database, National Horticulture Board, 2016.
2. Arinia CK, Pradeepkumar T, George TE, Sadhankumar PG, Krishnan S. Heterosis breeding exploiting gynoecy in cucumber (*Cucumis sativus* L.). J Tropic. Agri. 2013; 51(1, 2):144-148.
3. Bal KJ, Hari BKC, Radha KT, Bhuwon RS, Madhusudan PU. Descriptors for sponge gourd [*Luffa cylindrica* (L.) Roem.]. NARC, LIBIRD & IPGRI, 2004.
4. Jankiram T, Sirohi PS. Heterosis studies in round fruited bottle gourd. Madras Agri. J Sci. 1989; 76(6):339-342.
5. Jeffrey C. Systematics of the cucurbitaceae: an overview. In: Biology and Utilization of the Cucurbitaceae, Cornell University Press, Itlvaca, New York, 1990, 3-9.
6. Hutchins AE. Some examples of heterosis in cucumber. J Ame. Soc. Hort. Sci. 1939; 36:660-664.
7. Maurya IB, Singh SP. Studies in gene action in long fruited bottle gourd [*Lagenaria siceraria* (Molina.) Standl.]. Crop Res. 1994; 8(1):100-104.
8. Mishra JP, Seshadri VC. I. Male sterility in muskmelon (*Cucumis melo* L.). II Studies on heterosis. Gen. Agric. 1985; 39:367-376.
9. Munshi AD, Sirohi PS. Combining ability estimates in bitter gourd (*Momordica charantia* L.), Veg. Sci. 1993; 20(2):147-151.
10. Oboh O, Aluyor EO. *Luffa cylindrica* - an emerging cash crop. Afr. J Agric. Res. 2009; 4(8):684-688.
11. Rai N, Rai M. Hetrosis breeding in vegetable crops. New India publishing agency, Pitampur, New Delhi, 2006, 353-356.
12. Singh AK, Pan RS, Bhavana P. Heterosis and combining ability analysis in bitter gourd (*Momordica charantia* L.). Int. J life sci. 2000; 8(4):1533-1536.
13. Singh I, Sharma JR, Kumar JC. Heterosis studies in fruited genotypes of ridge gourd. Indian J Hort. 1996; 53(1):64-67.
14. Singh JP, Gill HS, Ahluwalia KS. Studies in hybrid vigour in cucumber (*Cucumis sativus* L.). Indian J Hort. 1970; 27:36-38.
15. Singh R, Singh AK, Kumar S, Singh BK. Heterosis and inbreeding depression for fruit characters in cucumber. Indian J Hort. 2012; 69(2):200-204.
16. Tyagi SVS. Studies on combining ability and stability parameters in ridge gourd (*Luffa acutangula* Roxb.). Ph.D. Thesis, Rajasthan Agriculture University, Bikaner, Rajasthan, 1997.