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Heterosis studies in sponge gourd for Earliness and qualitative traits

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Abstract
Investigation was carried out insponge gourd [*Luffa cylindrica* (L.) Roem.] to develop potential F_1 hybrids with earliness, quality and quantity parameters. Nine diverse parents were crossed in a half diallel fashion (excluding reciprocals) for generating the 36 F_1 hybrids. All the nine parents, 36 hybrids and one standard check were evaluated in a randomized block design with three replications for various quantitative and qualitative traits. Maximum standard heterosis fordays to first female flower appearance in Kulgod local × Pusa Chikni (-14.42 %), for node at which first female flower appeared in Kulgod local × Pusa Chikni(-80.56 %),for days to first harvest in Kulgod local × KRCCH-1 (-8.21%), for days to last harvest in Kulgod local × Pusa Chikni (11.01 %), for fruiting period in Kulgod local × Pusa Chikni (26.20 %),for fruit yield per plant in Kulgod local × Pusa Chikni (100.74 %), for number of seeds per fruit in SG-6 × KRCCH-1(-42.66 %), for rind thickness in SG-3 × Pusa Chikni (36.70 %), for flesh thickness in Kulgod local × KRCCH-1 (1.45 %), for total soluble solids in Kulgod local × SG-3(12.82 %) and for physiological loss of weight in SG-4 × KRCCH-1 (-56.25 %).

Keywords: Sponge gourd, heterosis, days to first female flower appearance, days to first harvest

Introduction
Sponge gourd [*Luffa cylindrica* (L.) Roem.]is a very popular vegetable in the tropical and subtropical regions of the world. It is an important component of crop rotation during spring-summer and rainy season in North Indian condition and is cultivated both on commercial scale and in kitchen gardens (Choudhury, 1996) [3]. The young tender fruits of the non-bitter types are eaten as cooked vegetable, or used in soups. The seed oil is colourless, odourless and tasteless which is used in cooking. The plants have medicinal properties too. Fiber is obtained from fully ripen and dried fruits which is useful in cleaning the motor car, glassware, kitchen utensils, for insulation in pot-holders, bathmats *etc.* (Porterfield, 1955) [12]. 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) [2] 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 (Raiand Rai, 2006) [13]. According to FAO estimate, cucurbits are cultivated in an area of about 5.46 lakh heaving annual production of 5.40 lakh tonnes. The productivity of this crop is10.52 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 half 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 on11 characters *viz*., days to first female flower appearance, node at which first female flower appeared, days to first harvest, days to last harvest, fruiting period, fruit yield per plant, number of seeds per fruit, rind thickness, flesh thickness, total soluble solids and physiological loss of weight 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 (%):

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

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,

F_1 = Mean value of the F_1

MP = Mean performance of parents

BP = Mean performance of better parent

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 traits *viz*., days to anthesis of first female flower, node number at which first female flower appeared, days to first harvest, number of seeds per fruit and physiological loss of weight. However, for rest of the characters studied positive estimates of heterosis was consider desirable.

A perusal of data presented in Table 1 - 5revealed that maximum standard heterosis for days to first female flower appearance in Kulgod local × Pusa Chikni (-14.42%), for node at which first female flower appeared in Kulgod local × Pusa Chikni(-80.56 %), for days to first harvest in Kulgod local × KRCCH-1 (-8.21%), for days to last harvest in Kulgod local × Pusa Chikni (11.01%), for fruiting period in Kulgod local × Pusa Chikni (26.20%), for fruit set in SG-5 × KRCCH-1 (11.90 %), for fruit yield per plant in Kulgod local × Pusa Chikni (100.74 %), for number of seeds per fruit in SG-6 × KRCCH-1(-42.66 %), for rind thickness in SG-3 × Pusa Chikni (36.70 %), for flesh thickness in Kulgod local × KRCCH-1 (1.45 %), for total soluble solids in Kulgod local × SG-3(12.82 %) and for physiological loss of weight in SG-4 × KRCCH-1 (-56.25 %).Among 36crosses, the top three ranking cross combinations based on average heterosis, heterobeltiosis and standard heterosis for the 11 characters are given in Table 1-5. 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 *perse* per for mance and had average, better parent and standard heterosis for yield per plant. 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, 17]; muskmelon (Mishra and Seshadri, 1985) [8]; bitter gourd (Singh *et al*., 2000) [15] and bottle gourd (Jankiram and Sirohi, 1989) [4]. The highest yielding hybrids also registered for the earliness and 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.

Earliness is an important economic character, as it gives earliest yield and at the same time may widen the flowering and fruiting span of the plants, which ultimately result in higher fruit yield. Kulgod local × Pusa Chikni (-14.42%) and SG-4 × SG-6 (-11.54%) showed the highest economic heterosis for days to first female flower appeared. The highest economic heterosis for node at which first male flower

appeared was found in cross Kulgod local × Pusa Chikni (-80.56 %) and SG-5 × SG-3 (-80.56 %)followed by Kulgod local × KRCCH-1 (-72.22 %). Similarly, for days to fruit harvesting, Kulgod local × Pusa Chikni and Kulgod local × KRCCH-1 over mid and better parent registered the high heterosis. The heterosis for earliness has also been reported by Hutchins (1939) [6] and Om *et al.* (1987) [11] in cucumber; Maurya and Singh (1994) [7] and Singh *et al.* (1996) [16] in bottle gourd; Munsi and Sirohi (1993) [9] in bitter gourd; Tyagi (1997) [19] and Sharma *et al*. (2002) [14] in ridge gourd which supports the present finding. It was also noted that most of the hybrids which flowered earlier than the better or check variety also showed earliness in maturity indicating the positive association between these two characters. However, the hybrids flowering earlier need not necessarily borne the fruit at lower nodes.

Cross Kulgod local × SG-3(12.82 %) was the best hybrid standard parent for total soluble solids. The findings are in accordance with the reports of Singh *et al*. (2012) [18] for heterobeltosis and 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 byKulgod 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 earliness, quality and quantity per unit area of sponge gourd.

Table 1: Estimation of heterosis for days to first female flower appearance and node at which first female flower appeared in sponge gourd

Cross	Days to first female flower appearance			Node at which first female flower appeared		
	MP	BP	SC	MP	BP	SC
Kulgod local × SG-4	10.53	9.38	0.96	2.44	0.00	-41.67**
Kulgod local × SG-6	1.51	-1.94	-2.88	66.67**	59.09**	-2.78
Kulgod local × SG-5	10.64	8.33	0.00	10.64	-3.70	-27.78**
Kulgod local × SG-3	10.53	9.38	0.96	85.71**	30.00	-27.78**
Kulgod local × Pusa Chikni	-7.29**	-7.29**	-14.42**	-56.25**	-65.00**	-80.56**
Kulgod local × KRCCH-2	8.16	6.00	1.92	104.76**	95.45**	19.44*
Kulgod local × Swarna Prabha	-3.09	-4.08	-9.62	51.72**	10.00	-38.89**
Kulgod local × KRCCH-1	-2.00	-5.77	-5.77	-56.52**	-61.54**	-72.22**
SG-4 × SG-6	-6.60**	-10.68**	-11.54**	44.19**	40.91**	-13.89
SG-4 × SG-5	18.28**	17.02*	5.77	37.50**	22.22	-8.33
SG-4 × SG-3	15.96*	15.96*	4.81	31.03	-9.52	-47.22**
SG-4 × Pusa Chikni	12.63*	11.46	2.88	160.61**	104.76**	19.44*
SG-4 × KRCCH-2	22.68**	19.00**	14.42**	25.58*	22.73	-25.00**
SG-4 × Swarna Prabha	4.17	2.04	-3.85	53.33**	9.52	-36.11**
SG-4 × KRCCH-1	-4.04	-8.65	-8.65	-40.43**	-46.15**	-61.11**
SG-6 × SG-5	7.69	1.94	0.96	-14.29	-22.22	-41.67**
SG-6 × SG-3	1.52	-2.91	-3.85	0.00	-31.82*	-58.33**
SG-6 × Pusa Chikni	-6.53**	-9.71**	-10.58	23.53	-4.55	-41.67**
SG-6 × KRCCH-2	0.49	-0.97	-1.92	31.82**	31.82*	-19.44*
SG-6 × Swarna Prabha	0.50	-1.94	-2.88	41.94*	0.00	-38.89**
SG-6 × KRCCH-1	3.38	2.88	2.88	45.83**	34.62**	-2.78
SG-5 × SG-3	2.15	1.06	-8.65	-60.00**	-74.07**	-80.56**
SG-5 × Pusa Chikni	11.70	9.38	0.96	17.95	-14.81	-36.11**
SG-5 × KRCCH-2	11.46	7.00	2.88	42.86**	29.63*	-2.78
SG-5 × Swarna Prabha	14.74*	11.22	4.81	100.00**	33.33**	0.00
SG-5 × KRCCH-1	-1.02	-6.73	-6.73	-1.89	-3.70	-27.78**
SG-3 × Pusa Chikni	1.05	0.00	-7.69	100.00**	66.67*	-44.44**
SG-3 × KRCCH-2	9.28	6.00	1.92	60.00**	9.09	-33.33**
SG-3 × Swarna Prabha	8.33	6.12	0.00	252.94**	233.33**	-16.67
SG-3 × KRCCH-1	7.07	1.92	1.92	94.12**	26.92*	-8.33
Pusa Chikni × KRCCH-2	-3.06	-5.00	-8.65	-17.65	-36.36*	-61.11**
Pusa Chikni × Swarna Prabha	9.28	8.16	1.92	71.43**	50.00	-50.00**
Pusa Chikni × KRCCH-1	16.00**	11.54	11.54	31.58*	-3.85	-30.56**
KRCCH-2 × Swarna Prabha	20.20**	19.00**	14.42*	80.65**	27.27	-22.22*
KRCCH-2 × KRCCH-1	-2.94	-4.81	-4.81	-33.33**	-38.46**	-55.56**
Swarna Prabha × KRCCH-1	-0.99	-3.85	-3.85	82.86**	23.08	-11.11
S.Em±	1.925	2.223	2.223	0.885	1.022	1.022
C.D. @ 5%	3.908	4.513	4.513	1.796	2.074	2.074
C.D. @ 1%	5.068	5.852	5.852	2.330	2.690	2.690

*, ** 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 days to first harvest and days to last harvest in sponge gourd

Cross	Days to first harvest			Days to last harvest		
	MP	BP	SC	MP	BP	SC
Kulgod local × SG-4	15.08**	12.40**	8.21*	8.75*	3.59	-0.31
Kulgod local × SG-6	-3.10	-3.10	-6.72	-10.39**	-10.97*	-13.21**
Kulgod local × SG-5	5.06	4.65	0.75	2.19	-0.98	-4.72
Kulgod local × SG-3	14.40**	10.85*	6.72	-7.69*	-11.18**	-7.55
Kulgod local × Pusa Chikni	-6.25**	-6.98**	-10.45*	20.27**	15.36**	11.01**
Kulgod local × KRCCH-2	1.57	0.00	-3.73	-6.98	-9.57*	-7.86
Kulgod local × Swarna Prabha	-0.40	-3.10	-6.72	2.54	-0.31	1.57
Kulgod local × KRCCH-1	-3.91*	-4.65*	-8.21*	11.22**	8.50	4.40
SG-4 × SG-6	2.38	0.00	-3.73	6.98	1.29	-1.26
SG-4 × SG-5	13.15**	10.94*	5.97	9.93*	8.01	-2.52
SG-4 × SG-3	18.03**	17.07**	7.46	2.63	-5.74	-1.89
SG-4 × Pusa Chikni	1.60	0.00	-5.22	2.15	1.42	-10.38*
SG-4 × KRCCH-2	12.10**	11.20*	3.73	-10.48**	-16.98**	-15.41**
SG-4 × Swarna Prabha	7.76*	7.32	-1.49	-7.82*	-14.51**	-12.89**
SG-4 × KRCCH-1	-1.60	-3.15	-8.21*	10.56**	7.90	-1.26
SG-6 × SG-5	5.84	5.43	1.49	-2.85	-6.45	-8.81*
SG-6 × SG-3	-0.80	-3.88	-7.46	-4.84	-7.85	-4.09
SG-6 × Pusa Chikni	2.34	1.55	-2.24	5.25	0.32	-2.20
SG-6 × KRCCH-2	1.57	0.00	-3.73	-17.67**	-19.44**	-17.92**
SG-6 × Swarna Prabha	3.59	0.78	-2.99	1.89	-0.31	1.57
SG-6 × KRCCH-1	5.47	4.65	0.75	13.81**	10.32*	7.55
SG-5 × SG-3	-2.81	-5.47	-9.70*	8.74*	1.51	5.66
SG-5 × Pusa Chikni	2.75	2.34	-2.24	18.31**	17.07**	5.66
SG-5 × KRCCH-2	1.98	0.78	-3.73	12.93**	6.48	8.49*
SG-5 × Swarna Prabha	8.00*	5.47	0.75	2.13	-3.70	-1.89
SG-5 × KRCCH-1	1.18	0.78	-3.73	16.96**	16.15**	6.29
SG-3 × Pusa Chikni	-0.81	-3.15	-8.21*	4.90	-3.02	0.94
SG-3 × KRCCH-2	4.88	3.20	-3.73	-12.67**	-13.60**	-10.06*
SG-3 × Swarna Prabha	6.17	5.74	-3.73	-2.90	-3.93	0.00
SG-3 × KRCCH-1	7.26	4.72	-0.75	4.82	-1.51	2.52
Pusa Chikni × KRCCH-2	-0.79	-1.57	-6.72	4.13	-2.78	-0.94
Pusa Chikni × Swarna Prabha	3.61	1.57	-3.73	1.16	-5.56	-3.77
Pusa Chikni × KRCCH-1	14.17**	14.17**	8.21*	4.55	2.75	-5.97
KRCCH-2 × Swarna Prabha	1.21	0.00	-6.72	-7.41*	-7.41	-5.66
KRCCH-2 × KRCCH-1	5.56	4.72	-0.75	2.76	-2.47	-0.63
Swarna Prabha × KRCCH-1	6.83	4.72	-0.75	3.41	-1.85	0.00
S.Em±	1.542	1.780	1.780	3.778	4.363	4.363
C.D. @ 5%	3.130	3.614	3.614	7.671	8.857	8.857
C.D. @ 1%	4.060	4.688	4.688	9.948	11.487	11.487

*, ** 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 fruiting period and fruit yield per plant in sponge gourd

Cross	Fruiting period			Fruit yield per plant		
	MP	BP	SC	MP	BP	SC
Kulgod local × SG-4	3.86	-2.78	-6.42	11.18	2.83	1.32
Kulgod local × SG-6	-15.38*	-16.30*	-17.65*	-5.43	-5.83	-7.22
Kulgod local × SG-5	0.00	-5.00	-8.56	0.50	-5.74	-7.13
Kulgod local × SG-3	-21.63**	-27.70**	-17.65*	-24.06**	-41.14**	5.41
Kulgod local × Pusa Chikni	40.06**	31.11**	26.20**	90.16**	78.27**	100.74**
Kulgod local × KRCCH-2	-12.57	-17.33*	-10.70	-4.98	-9.83	-1.05
Kulgod local × Swarna Prabha	4.42	-1.95	7.49	-31.71**	-46.40**	-7.31
Kulgod local × KRCCH-1	22.19**	17.78*	13.37	58.89**	47.17**	70.08**
SG-4 × SG-6	10.26	2.17	0.53	10.53	2.63	0.27
SG-4 × SG-5	7.21	5.56	-8.56	16.91	15.17	-0.60
SG-4 × SG-3	-7.57	-19.72**	-8.56	-17.73*	-39.63**	8.11
SG-4 × Pusa Chikni	2.55	2.55	-13.90	-0.86	-13.57	-2.68
SG-4 × KRCCH-2	-25.91**	-34.16**	-28.88**	-16.65	-26.53*	-19.37
SG-4 × Swarna Prabha	-18.23**	-27.80**	-20.86**	-30.72**	-48.59**	-11.08
SG-4 × KRCCH-1	19.75**	16.17	3.74	62.63**	40.23**	62.06**
SG-6 × SG-5	-9.25	-14.67	-16.04*	8.16	1.85	-0.49
SG-6 × SG-3	-7.30	-13.62*	-1.60	2.32	-20.92**	41.60**
SG-6 × Pusa Chikni	7.33	-0.54	-2.14	7.49	0.38	13.03
SG-6 × KRCCH-2	-30.05**	-33.17**	-27.81**	18.75	12.24	23.17
SG-6 × Swarna Prabha	0.77	-4.39	4.81	-38.70**	-52.03**	-17.05

SG-6 × KRCCH-1	19.66**	14.13	12.30	8.28	-0.10	15.46
SG-5 × SG-3	16.27*	2.35	16.58*	47.04**	8.96	95.11**
SG-5 × Pusa Chikni	34.17**	32.10**	14.44	16.79	3.15	16.15
SG-5 × KRCCH-2	20.33**	8.42	17.11*	11.11	-0.75	8.91
SG-5 × Swarna Prabha	-1.91	-12.20	-3.74	-23.94**	-42.99**	-1.41
SG-5 × KRCCH-1	28.88**	26.95**	13.37	-3.30	-15.54	-2.39
SG-3 × Pusa Chikni	8.65	-5.63	7.49	-33.71**	-46.01**	-3.33
SG-3 × KRCCH-2	-22.89**	-24.88**	-14.44	-47.30**	-57.50**	-23.91
SG-3 × Swarna Prabha	-8.13	-9.86	2.67	-36.56**	-37.64**	11.66
SG-3 × KRCCH-1	3.16	-7.98	4.81	-26.95**	-39.90**	7.62
Pusa Chikni × KRCCH-2	7.52	-4.46	3.21	20.74*	19.21	34.23**
Pusa Chikni × Swarna Prabha	-0.55	-12.20	-3.74	-13.76	-28.81**	23.12
Pusa Chikni × KRCCH-1	-3.09	-5.99	-16.04*	-21.24*	-22.25*	-10.14
KRCCH-2 × Swarna Prabha	-12.53*	-13.17	-4.81	-37.11**	-48.60**	-11.10
KRCCH-2 × KRCCH-1	0.81	-7.92	-0.53	-12.88	-15.08	-1.85
Swarna Prabha × KRCCH-1	1.08	-8.29	0.53	-43.29**	-52.69**	-18.19
S.Em±	3.999	4.618	4.618	0.160	0.185	0.185
C.D. @ 5%	8.119	9.375	9.375	0.325	0.375	0.375
C.D. @ 1%	10.530	12.158	12.158	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.

Table 4: Estimation of heterosis for TSS and number of seeds per fruit in sponge gourd

Cross	TSS			Number of seeds/fruit		
	MP	BP	SC	MP	BP	SC
Kulgod local × SG-4	2.01	-0.49	4.10	0.46	-1.35	-10.33
Kulgod local × SG-6	5.26	2.44	7.69	14.67	0.98	-8.21
Kulgod local × SG-5	0.47	-7.76	9.74	-3.80	-13.73	-21.58
Kulgod local × SG-3	3.77	-4.35	12.82*	10.98	4.95	-4.60
Kulgod local × Pusa Chikni	-3.15	-8.68	2.56	-21.69	-26.66	-33.33**
Kulgod local × KRCCH-2	-6.44	-10.00	-3.08	20.76	17.63	12.78
Kulgod local × Swarna Prabha	-0.23	-8.58	9.23	2.40	-2.61	-11.47
Kulgod local × KRCCH-1	0.00	-1.98	1.54	-13.96	-19.71	-15.77
SG-4 × SG-6	2.69	2.44	7.69	-24.09	-32.07*	-40.48**
SG-4 × SG-5	-11.93**	-17.24**	-1.54	10.27	0.52	-11.92
SG-4 × SG-3	-4.15	-9.57	6.67	13.75	9.46	-4.08
SG-4 × Pusa Chikni	-15.84**	-18.72**	-8.72	11.62	6.35	-6.81
SG-4 × KRCCH-2	-8.70	-10.00	-3.08	3.03	-1.40	-5.46
SG-4 × Swarna Prabha	-5.26	-11.16*	6.15	34.72**	30.40*	14.27
SG-4 × KRCCH-1	3.45	2.94	7.69	-26.04*	-32.13**	-28.80*
SG-6 × SG-5	-2.97	-8.62	8.72	18.82	16.40	-16.04
SG-6 × SG-3	1.15	-4.35	12.82*	13.93	5.62	-14.43
SG-6 × Pusa Chikni	-8.02	-10.96*	0.00	-5.00	-11.08	-29.44*
SG-6 × KRCCH-2	-10.84*	-11.90*	-5.13	15.39	-0.66	-4.76
SG-6 × Swarna Prabha	-9.63*	-15.06**	1.49	10.26	1.65	-16.64
SG-6 × KRCCH-1	-5.65	-6.34	-1.54	-34.13**	-45.34**	-42.66**
SG-5 × SG-3	-13.42**	-13.79**	2.56	-5.64	-10.81	-27.74*
SG-5 × Pusa Chikni	-28.16**	-30.17**	-16.92**	50.06**	43.23**	13.66*
SG-5 × KRCCH-2	-12.67**	-16.81**	-1.03	-10.32	-21.42	-24.66
SG-5 × Swarna Prabha	-12.26**	-12.45*	4.62	34.30*	26.21	3.50
SG-5 × KRCCH-1	1.29	-5.26	12.72*	-27.13*	-38.51**	-35.50**
SG-3 × Pusa Chikni	-18.04**	-20.00**	-5.64	15.74	14.56	-7.19
SG-3 × KRCCH-2	-10.00*	-13.91**	1.54	20.79	11.43	6.84
SG-3 × Swarna Prabha	-17.06**	-17.60**	-1.54	28.44*	27.66	4.70
SG-3 × KRCCH-1	-2.78	-8.70	7.69	18.65	5.14	10.30
Pusa Chikni × KRCCH-2	-7.69	-9.59	1.54	6.73	-2.47	-6.49
Pusa Chikni × Swarna Prabha	-16.81**	-19.31**	-3.59	15.19	13.33	-7.06
Pusa Chikni × KRCCH-1	4.04	0.00	12.31*	0.30	-11.92	-7.60
KRCCH-2 × Swarna Prabha	-15.12**	-19.31**	-3.59	14.44	6.17	1.79
KRCCH-2 × KRCCH-1	-5.34	-7.14	0.00	4.33	-0.16	4.74
Swarna Prabha × KRCCH-1	-0.23	-6.87	11.28	3.33	-7.94	-3.43
S.Em±	0.324	0.374	0.374	31.160	35.981	35.981
C.D. @ 5%	0.658	0.760	0.760	63.258	73.044	73.044
C.D. @ 1%	0.854	0.986	0.986	82.040	94.732	94.732

*, ** 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 rind thickness and flesh thickness in sponge gourd

Cross	Rind thickness			Flesh thickness		
	MP	BP	SC	MP	BP	SC
Kulgod local × SG-4	39.62**	39.20**	1.75	3.00	-1.55	-8.04
Kulgod local × SG-6	31.59**	19.64**	6.87	10.87*	3.77	1.34
Kulgod local × SG-5	-3.37	-24.69**	-1.46	0.12	-5.57	-9.26
Kulgod local × SG-3	-22.84**	-37.58**	-26.17**	-11.27*	-18.23**	-17.41**
Kulgod local × Pusa Chikni	52.29**	30.62**	33.48**	12.98*	10.84	-1.90
Kulgod local × KRCCH-2	34.29**	21.29**	9.94	-1.66	-7.31	-10.83
Kulgod local × Swarna Prabha	3.44	-17.34**	1.02	4.55	-2.60	-3.91
Kulgod local × KRCCH-1	61.77**	59.42**	20.03**	17.59**	16.09*	1.45*
SG-4 × SG-6	21.84**	10.47	-1.32	-3.86	-5.94	-8.15
SG-4 × SG-5	15.37**	-10.28*	17.40**	1.53	0.12	-3.79
SG-4 × SG-3	4.75	-15.45**	0.00	-1.72	-5.41	-4.46
SG-4 × Pusa Chikni	13.31*	-3.06	-0.94	-2.21	-4.78	-11.05
SG-4 × KRCCH-2	21.22**	9.19	-1.02	0.65	-0.81	-4.58
SG-4 × Swarna Prabha	-5.78	-24.88**	-8.19	-10.87*	-13.24*	-14.40*
SG-4 × KRCCH-1	61.26**	58.45**	19.30**	11.85*	8.24	1.12
SG-6 × SG-5	4.78	-11.84*	15.35*	-3.46	-4.23	-6.47
SG-6 × SG-3	11.13*	-2.47	15.35*	0.11	-1.55	-0.56
SG-6 × Pusa Chikni	24.58**	16.74**	19.30**	-6.24	-10.63	-12.72*
SG-6 × KRCCH-2	-4.96	-5.65	-14.47*	-1.67	-2.40	-4.69
SG-6 × Swarna Prabha	-4.35	-17.22**	1.17	-5.40	-5.88	-7.14
SG-6 × KRCCH-1	38.90**	27.99**	14.33*	6.03	0.46	-1.90
SG-5 × SG-3	-4.69	-9.27	18.71**	4.53	1.99	3.01
SG-5 × Pusa Chikni	-20.20**	-28.94**	-7.02	7.01	2.79	-1.23
SG-5 × KRCCH-2	12.21*	-5.03	24.27**	-3.54	-3.60	-7.25
SG-5 × Swarna Prabha	-20.39**	-23.02**	0.73	-3.72	-4.98	-6.25
SG-5 × KRCCH-1	-29.65**	-44.58**	-27.49**	4.50	-0.23	-4.13
SG-3 × Pusa Chikni	24.01**	15.57**	36.70**	-3.65	-9.61	-8.71
SG-3 × KRCCH-2	3.15	-8.90	7.75	3.00	0.55	1.56
SG-3 × Swarna Prabha	7.60	5.86	29.39**	-10.34*	-11.38*	-10.49
SG-3 × KRCCH-1	33.08**	8.90	28.80**	-3.67	-10.17	-9.26
Pusa Chikni × KRCCH-2	21.15**	14.31*	16.81*	2.24	-1.86	-5.58
Pusa Chikni × Swarna Prabha	2.15	-6.22	14.62*	3.40	-1.92	-3.24
Pusa Chikni × KRCCH-1	33.61**	16.02*	18.57**	11.80*	11.10	-1.67
KRCCH-2 × Swarna Prabha	0.27	-12.68*	6.73	0.69	-0.57	-1.90
KRCCH-2 × KRCCH-1	32.69**	21.45**	10.09	5.90	1.04	-2.79
Swarna Prabha × KRCCH-1	25.09**	1.08	23.54**	1.14	-4.64	-5.92
S.Em±	0.128	0.148	0.148	0.144	0.166	0.166
C.D. @ 5%	0.260	0.300	0.300	0.292	0.338	0.338
C.D. @ 1%	0.337	0.389	0.389	0.379	0.438	0.438

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

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

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