

Original Research Article

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Studies on Heterosis for Yield and its Contributing Traits in Sponge Gourd (*Luffa cylindrica* Roem.)

Vijay Bahadur Singh Chauhan^{1,2*}, Dinesh Kumar Singh¹ and
Harshawardhan Choudhary^{1,3}

¹Department of Vegetable Science, Govind Ballabh Pant University of Agriculture and
Technology, Pantnagar-263145, U.S. Nagar, Uttarakhand, India

²ICAR- Central Tuber Crops Research Institute, Regional Centre, Bhubaneswar-751019,
Odisha, India

³ICAR-Indian Agricultural Research Institute, New Delhi-110012, India

*Corresponding author

ABSTRACT

Keywords

Sponge gourd, *Luffa cylindrica*, Half diallel, Heterosis, Hybrid, Yield traits

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The present study was carried out on heterosis for fruit yield and yield related traits in sponge gourd. Fifteen hybrids of sponge gourd were developed using six parents in half diallel fashion were studied for estimation of heterosis for 10 yield contributing traits. Hybrids PSG-82 × PSG-07-04, PSG-07-04 × PSG-161 and PSG-07-04 × PSG-199 were found most promising for earliness and yield. These hybrids exhibited heterosis to the tune of 59.36, 48.45 and 43.85 per cent over their better parents and 81.58, 69.16 and 63.91 per cent, respectively over the check cultivar for fruit yield per hectare. The cross combination PSG-82 × PSG-07-04 recorded highest significant heterobeltiosis for yield and its contributing traits and it was identified for evaluation in multi-location trial and commercial exploitation.

Introduction

Smooth gourd (*Luffa cylindrica* Roem.) is one of the important member of the family Cucurbitaceae and originated in subtropical Asian Region particularly India (Kalloo, 1993). This is an annual plant, which produces fruits containing a fibrous vascular system. It is commonly grown for its tender fruits as well as for sponge which is used for scrubbing purposes. The dried fruits are used as a bath sponge, increase blood circulation and credited as a relief for rheumatic and arthritic

suffers. Tender fruits are rich in vitamin A, vitamin C and iron (Yawalker, 2004). It is highly cross pollinated due to monoecious nature. Various breeding techniques have been advocated considering the breeding behaviour of crop.

Out of these hybrid breeding is prominent and used in the improvement of vegetable crops, especially in out breeding species (Kalloo *et al.*, 2000). So a speedy improvement can be brought by exploiting heterosis for various yield contributing traits as well as earliness.

However, the information related to hybrid development in sponge gourd is very limited in India. Keeping above facts in consideration, the present investigation was carried out to estimate the extent of heterosis for different yield attributing traits.

Materials and Methods

Six genetically diverse parental lines of sponge gourd were used to develop 15 F₁s following a half diallel mating system, excluding reciprocals during Kharif season. The parental lines used were PSG-93 (P₁), PSG-82 (P₂), PSG-07-04 (P₃), PSG-115 (P₄), PSG-199 (P₅) and PSG-161 (P₆). The 15 F₁s along with their six parents were evaluated during summer season 2008 at the Vegetable Research Centre of the G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, Uttarakhand, India.

The experiment was laid out in a randomized block design (RBD) with three replications. Each genotype was grown in a single row of 8 m length with a spacing of 3×1 m. There were eight hills per entry with one plant at each hill. Observations for ten horticultural traits were recorded on five randomly selected plants.

The traits under study were days to anthesis of first male flower, node number of first male flower, days to anthesis of first female flower, node number of first female flower, fruit length, fruit weight, number of fruits per plant, number of primary branches per plant, main vine length and fruit yield per hectare. The mean data obtained for quantitative traits on per plant basis were analysed statistically for heterosis as suggested by Fonseca and Patterson (1968).

Results and Discussion

There were significant differences among the parental lines with respect to different

characters studied including total yield per hectare. The mean performance of six parental lines along with 15 F₁ hybrids is given in Table 1. The mean values of parents for days to first male flower anthesis ranged from 51.67 (P₄) to 67.67 days (P₁) and among crosses it ranged from 49.33 (P₁ × P₃) to 69.67 days (P₂ × P₆). Out of 15 F₁ hybrids, a total of 5 and 10 crosses showed negative heterosis over better parent and mid parent, respectively. The hybrid P₁ × P₂ exhibited maximum heterosis of -18.81% and -19.01% over better parent and mid parent, respectively. With respect to node number of first male flower, parental mean ranged from 4.33 (P₄) to 10.67 (P₂). Among the crosses it ranged from 3.67 (P₁ × P₃) to 12.67 (P₅ × P₆) node number.

The extent of heterosis varied from -19.23 to -53.84% over better parent and -12.00 to -54.71% over mid parent. Six F₁ hybrids showed heterosis over better parent, out of which F₁ hybrid P₁ × P₅ showed maximum heterosis over better parent (-53.84%) and mid parent (-54.71%) while F₁ hybrids P₂ × P₃, P₃ × P₆ and P₃ × P₄ showed maximum heterosis over standard parent (23.17%). The mean values of parents for days to first female flower anthesis ranged from 52.67 (P₃) to 77.33 days (P₁). Out of 15 F₁ hybrids, 5, crosses showed negative heterosis over better parent, 2 over standard parent and 9 over mid parent. The F₁ hybrid P₁ × P₂ showed maximum heterosis over better parent (-18.55%) and mid parent (-20.53%) while F₁ hybrid P₁ × P₃ showed maximum heterosis over standard parent (-11.23%). With respect to node number of first female flower, parental mean ranged from 12.00 (P₄) to 26.67 (P₂) node number. Among the crosses it ranged from 9 (P₄ × P₅) to 23.67 (P₅ × P₆). The extent of heterosis varied from -19.94 to -30.93% over better parent, -19.44 to -25.00% over standard parent and -9.48 to -37.93% over mid parent (Table 2 and 3).

Table.1 Mean performance of parents and F₁s for yield traits in sponge gourd

Genotype	Days to first male flower anthesis	Node number of first male flower	Days to first female flower anthesis	Node number of first female flower	Fruit length (cm)	Fruit weight (g)	Number of fruits per plant	Number of primary branches	Main vine length (m)	Total yield (q./ha.)
P ₁	67.67	8.67	77.33	19.00	19.06	164.33	13.25	7.35	8.93	66.29
P ₂	67.33	10.67	73.67	26.67	18.65	136.67	12.96	7.43	9.29	52.23
P ₃	52.67	4.67	54.67	15.33	21.99	255.0	12.16	7.79	9.41	95.86
P ₄	51.67	4.33	59.33	12.00	21.72	194.0	13.58	7.04	8.91	84.13
P ₅	65.00	9.00	70.67	14.67	19.44	125.0	14.14	8.32	10.66	58.62
P ₆	59.00	6.00	61.67	13.00	18.36	121.33	19.16	6.99	10.20	74.30
P ₁ × P ₂	54.67	7.00	60.00	20.67	22.30	225.67	16.74	6.87	9.97	120.68
P ₁ × P ₃	49.33	3.67	52.67	10.67	20.74	164.0	23.04	8.53	10.00	122.78
P ₁ × P ₄	54.33	4.00	58.67	16.00	19.51	159.33	20.67	8.04	9.52	107.80
P ₁ × P ₅	56.67	4.00	61.33	11.00	18.97	219.33	15.40	7.98	9.49	108.44
P ₁ × P ₆	55.33	8.67	56.00	17.33	21.65	113.33	19.34	8.04	9.46	70.99
P ₂ × P ₃	54.67	5.33	58.00	15.67	27.35	255.33	18.63	9.68	11.08	152.76
P ₂ × P ₄	53.33	4.00	54.33	12.00	21.57	200.67	19.00	7.72	10.39	126.68
P ₂ × P ₅	59.33	7.00	65.33	15.33	20.15	209.33	18.36	8.37	9.45	125.11
P ₂ × P ₆	69.67	7.33	77.33	18.00	20.65	150.67	15.37	8.06	9.32	73.71
P ₃ × P ₄	60.33	5.33	63.00	9.67	20.73	154.0	24.09	9.43	10.65	123.33
P ₃ × P ₅	52.33	4.33	56.33	11.00	21.76	169.0	24.82	7.36	9.91	137.90
P ₃ × P ₆	51.33	5.33	55.67	14.00	24.67	236.67	18.76	6.90	9.81	142.31
P ₄ × P ₅	56.33	5.00	60.67	9.00	20.60	145.33	21.54	8.65	10.64	101.85
P ₄ × P ₆	60.33	5.67	67.67	17.00	19.83	210.0	14.30	7.95	9.35	92.64
P ₅ × P ₆	59.67	12.67	66.00	23.67	20.82	199.33	22.39	8.95	9.45	137.59
Grand Mean	57.67	6.32	62.40	15.32	20.98	181.35	17.99	7.97	9.81	103.62
CD at 5%	3.09	0.73	4.32	2.14	1.57	19.74	3.51	0.74	0.79	12.55
CD at 1%	4.14	0.97	5.78	2.86	2.09	26.42	4.69	0.99	1.05	16.79
CV	3.25	6.98	4.20	8.46	4.52	6.60	11.81	5.61	4.86	7.34

P₁-PSG-93, P₂- PSG-82, P₃- PSG-07-04, P₄- PSG-115, P₅- PSG-199 and P₆- PSG-161

Table.2 Range of different yield traits, heterosis percentage and performance of top F₁ hybrids

Traits	Days to first male flower anthesis	Node number of first male flower	Days to first female flower anthesis	Node number of first female flower	Fruit length (cm)
Range of mean values					
Parents	51.67 to 67.67	4.33 to 10.67	54.67 to 77.33	12.00 to 26.67	18.36 to 21.99
F ₁	49.33 to 69.67	3.67 to 12.67	52.67 to 77.33	9.00 to 23.67	18.97 to 27.35
Range of heterosis percentage					
BP	-6.21 to -18.81	-19.23 to -53.84	-7.54 to -18.55	-19.44 to -30.43	12.15 to 24.37
SP	0	0	-8.42 to -11.23	-19.44 to -25.00	13.56 to 25.93
MP	-8.06 to -19.01	-12.00 to -54.71	-6.60 to -20.53	-9.48 to -37.93	6.87 to 34.61
Number of heterotic crosses over					
BP	5	6	5	5	6
SP	0	0	2	2	3
MP	10	10	9	9	7
Three top parents	P ₄ (51.67) P ₃ (52.67) P ₆ (59.00)	P ₄ (4.33) P ₃ (4.67) P ₆ (6.00)	P ₃ (54.67) P ₄ (59.33) P ₆ (61.67)	P ₄ (12.00) P ₆ (13.00) P ₅ (14.67)	P ₃ (21.99) P ₄ (21.72) P ₅ (19.44)
Three top F ₁ s with heterosis percentage					
BP	P ₁ × P ₂ (-18.81) P ₁ × P ₅ (-12.82) P ₂ × P ₅ (-8.72)	P ₁ × P ₅ (-53.85) P ₃ × P ₅ (-51.85) P ₄ × P ₅ (-44.44)	P ₁ × P ₂ (-18.55) P ₁ × P ₅ (-13.21) P ₁ × P ₆ (-9.19)	P ₁ × P ₃ (-30.44) P ₁ × P ₅ , P ₃ × P ₅ and P ₄ × P ₅ (-25.00) P ₃ × P ₄ (-19.44)	P ₂ × P ₃ (24.37) P ₁ × P ₆ (17.92) P ₁ × P ₂ (17.00)
SP	- - -	- - -	P ₁ × P ₃ (-11.23) P ₂ × P ₄ (-8.42) P ₂ × P ₅ (-10.11)	P ₄ × P ₅ (-25.00) P ₃ × P ₄ (-19.44) P ₁ × P ₃ (-11.11)	P ₂ × P ₃ (25.94) P ₁ × P ₂ (22.65) P ₃ × P ₆ (13.57)
MP	P ₁ × P ₂ (-19.01) P ₁ × P ₃ (-18.01) P ₁ × P ₅ (14.57)	P ₁ × P ₅ (-54.72) P ₂ × P ₄ (-46.67) P ₁ × P ₄ (-38.46)	P ₁ × P ₂ (-20.53) P ₁ × P ₃ (-20.20) P ₁ × P ₆ (-19.42)	P ₂ × P ₄ (-37.93) P ₁ × P ₃ (-37.86) P ₁ × P ₅ (-34.65)	P ₂ × P ₃ (34.61) P ₃ × P ₆ (22.24) P ₁ × P ₂ (18.27)

BP- Better Parent, SP -Standard Parent and MP -Mid parent

Table.3 Range of different yield traits, heterosis percentage and performance of top F₁ hybrids

Traits	Fruit weight (g)	Number of fruits per plant	Number of primary branches	Main vine length (m)	Total yield (q./ha.)
Range of mean values					
Parents	121.33 to 255.00	12.16 to 19.16	6.99 to 8.32	8.91 to 10.66	52.23 to 95.86
F ₁	113.33 to 255.33	14.30 to 24.82	6.87 to 9.68	9.32 to 11.08	70.99 to 152.76
Range of heterosis percentage					
BP	24.17 to 67.46	29.85 to 104.08	9.58 to 28.14	11.68 to 19.41	21.05 to 113.43
SP	13.05 to 31.61	35.17 to 82.79	12.87 to 37.54	10.10 to 24.35	21.05 to 81.58
MP	16.79 to 61.84	19.35 to 88.77	11.77 to 27.27	8.73 to 18.46	16.94 to 125.74
Number of heterotic crosses over					
BP	5	9	9	5	12
SP	4	11	11	8	12
TP	9	12	9	6	12
Three top parents	P3 (255.00) P4 (194.00) P1 (164.33)	P6 (19.16) P5 (14.14) P4 (13.58)	P5 (8.32) P3 (7.79) P2 (7.43)	P5 (10.66) P6 (10.20) P3 (9.41)	P3 (95.86) P4 (84.13) P6 (74.30)
Three top F ₁ s with heterosis percentage					
BP	P ₂ × P ₅ (67.47) P ₅ × P ₆ (64.29) P ₁ × P ₂ (37.32)	P ₃ × P ₅ (104.08) P ₃ × P ₄ (98.03) P ₁ × P ₃ (89.39)	P ₅ × P ₆ (28.14) P ₂ × P ₃ (24.36) P ₄ × P ₅ (22.92)	P ₄ × P ₅ (19.42) P ₂ × P ₃ (17.71) P ₂ × P ₄ (16.61)	P ₂ × P ₅ (113.43) P ₅ × P ₆ (85.18) P ₁ × P ₂ (82.04)
SP	P ₂ × P ₃ (31.62) P ₃ × P ₆ (21.09) P ₁ × P ₂ (16.32)	P ₃ × P ₅ (82.79) P ₃ × P ₄ (77.37) P ₁ × P ₃ (69.64)	P ₂ × P ₃ (37.55) P ₃ × P ₄ (33.99) P ₅ × P ₆ (27.18)	P ₂ × P ₃ (24.36) P ₃ × P ₄ (19.53) P ₄ × P ₅ (19.42)	P ₂ × P ₃ (81.58) P ₃ × P ₆ (69.16) P ₃ × P ₅ (63.91)
MP	P ₅ × P ₆ (61.84) P ₂ × P ₅ (60.00) P ₁ × P ₅ (51.61)	P ₃ × P ₅ (88.77) P ₃ × P ₄ (87.15) P ₁ × P ₃ (81.32)	P ₃ × P ₄ (27.28) P ₂ × P ₃ (27.25) P ₅ × P ₆ (16.96)	P ₂ × P ₃ (18.46) P ₃ × P ₄ (16.25) P ₂ × P ₄ (14.15)	P ₂ × P ₅ (125.74) P ₅ × P ₆ (107.03) P ₂ × P ₃ (106.31)

BP- Better Parent, SP -Standard Parent and MP -Mid parent

Five hybrids showed negative heterosis over better parent, out of which $P_1 \times P_3$ exhibited highest significant negative heterosis over better parent, two hybrids showed negative heterosis over standard parent, out of which $P_4 \times P_5$ exhibited highest significant negative heterosis over standard parent (-25.00%) and nine hybrids showed negative heterosis over mid parent, out of which $P_2 \times P_4$ exhibited highest significant negative heterosis over mid parent (-37.93%). Earliness (indicated by negative estimates of heterosis) is a well-recognized and prime objective of any breeding programme as it helps the grower to reap a high market price earlier. The best crosses $P_1 \times P_2$, $P_1 \times P_3$, $P_1 \times P_4$, $P_1 \times P_5$, $P_1 \times P_6$, $P_2 \times P_3$, $P_2 \times P_4$, $P_2 \times P_5$, $P_3 \times P_4$, $P_3 \times P_5$, $P_3 \times P_6$ and $P_4 \times P_5$ were found to be the most promising for earliness. In accordance with the present findings, Abusaleha and Dutta (1995) found in sponge gourd and Mole *et al.*, (2001); Shaha and Kale (2003) and Rao *et al.*, (2000) also observed earliness in heterotic combinations of ridge gourd.

The estimates of parental mean value for fruit length ranged from 18.38 cm (P_6) to 21.99 cm (P_3) while for F_1 hybrids it varied from 18.97cm ($P_1 \times P_5$) to 27.35cm ($P_2 \times P_3$). The range of heterosis varied from 12.15 to 24.37%, 13.56 to 25.93% and 6.87 to 34.61% over better parent, standard parent and mid parent, respectively. Six hybrids showed highly significant heterosis over better parent. The hybrid $P_2 \times P_3$ exhibited maximum heterosis 24.37%, 25.94% and 34.61% over better parent, standard parent and mid parent, respectively. A perusal of average data for fruit weight varied from 121.36g (P_6) to 255.00g (P_3), whereas in crosses it ranged from 113.33g ($P_1 \times P_6$) to 255.33g ($P_2 \times P_3$). The extent of heterosis varied from 24.84 to 57.46% over better parent, 13.05 to 31.61% over standard parent and 16.79 to 61.84% over mid parent. The highly significant heterosis was noted in 5, 4 and 9 hybrids over

better parent, standard parent and mid parent, respectively. The F_1 hybrid $P_2 \times P_5$ showed maximum heterosis over better parent (67.47%), $P_2 \times P_3$ showed maximum heterosis over standard parent (31.62%) and $P_5 \times P_6$ showed maximum heterosis over mid parent (61.84%). The mean value for number of fruit per plant of parent varied from 12.16 (P_3) to 19.16 (P_6) and for F_1 hybrids it ranged from 14.30 ($P_4 \times P_6$) to 24.82 ($P_3 \times P_5$). Heterosis ranged from 29.85 to 104.08% over better parent, 35.17 to 82.79% over standard parent and 19.35 to 88.77% over mid parent. Nine crosses were possessing significant heterosis over better parent. The cross $P_3 \times P_5$ exhibited maximum heterosis 104.08, 82.79 and 88.77% over better parent, standard parent and mid parent, respectively. The findings are similar to the result obtained by Ahmed *et al.*, (2006); Singh *et al.*, (2009) and Hedau and Sirohi (2004) reported that yield attributing characters and fruit yield showed positive heterosis, while vine length and flowering showed negative heterosis. The three best performing F_1 hybrids for yield were DRG-1 \times P.N., DRG-1 \times PRG-7 and DRG-1 \times AAUJ-3 and manifested 93.09, 68.51 and 66.50 percent heterosis over top parent (DRG-1), respectively. These hybrids also recorded the maximum fruit weight, fruit length and highest number of fruit per plant in ridge gourd and similar result found by Patel and Desai (2008) in sponge gourd. The result for number of primary branches of parental mean ranged from 6.99 (P_6) to 8.32 (P_5) and mean of the crosses varied from 6.87 ($P_1 \times P_2$) to 9.68 ($P_2 \times P_3$). Range of heterosis was estimated from 9.58 to 28.14% over better parent, 12.87 to 37.54% over standard parent and 11.77 to 27.27% over mid parent. Nine crosses were significant superior to the better parent. The hybrid $P_5 \times P_6$ showed maximum heterosis (28.15%) over better parent, hybrid $P_2 \times P_3$ showed maximum heterosis (37.55%) over mid parent. The estimates of parental mean value for main vine length ranged from

8.91m (P₄) to 10.66m (P₅) while for F₁ hybrid it varied from 9.32m (P₂ × P₆) to 11.08m (P₂ × P₃). The range of heterosis varied from 11.68 to 19.41%, 10.10 to 24.35% and 8.73 to 18.46% over better parent, standard parent and mid parent, respectively. Five hybrids showed highly significant heterosis over better parent. The F₁ hybrid P₄ × P₅ exhibited maximum heterosis (19.42%) over better parent while F₁ hybrid P₂ × P₃ showed maximum heterosis over standard parent (24.36%) and mid parent (18.46%). The mean value for total yield per hectare ranged from 52.23 q/ha (P₂) to 95.86q/ha (P₃), whereas for crosses it ranged from 70.99q/ha (P₁ × P₆) to 152.86q/ha (P₂ × P₃). The extent of heterosis for this foremost trait ranged from 21.05 to 113.43% over better parent, 21.05 to 81.58% over standard parent and 16.95 to 125.74% over mid parent. The twelve crosses performed better parent heterosis. The maximum heterosis estimate over better parent was recorded in crosses like P₂ × P₅ (113.43%) followed by P₅ × P₆ (85.18%) and P₁ × P₂ (82.04%). Based on the result on standard parent heterosis, it was evident that cross P₂ × P₃ exhibited maximum heterosis (81.58%) followed by P₃ × P₆ (69.16%) and P₃ × P₅ (63.91%). The maximum heterosis estimate over mid parent was recorded in crosses like P₂ × P₅ (125.74%), followed by P₅ × P₆ (107.03%) and P₂ × P₃ (106.31%). Heterotic effect for these fruit characters were also reported by Narasannavar *et al.*, (2014) and Rao *et al.*, (2000) for yield, the F₁s LA-46 × LA-99, LA-12 × LA-76 and LA-32 × LA-37 proved the best and manifested 51.8 and 125.9, 81.8 and 121.1 and 99.1 and 200.1% heterosis, respectively, in both kharif and summer seasons over the better parent in ridge gourd and similar result also found in sponge gourd by Patel and Desai (2008). Naliyadhara *et al.*, (2007) revealed that the cross combination CHSG-1 × JSGL-70 depicted highest heterobeltiosis (69.10%), whereas the cross combination NSG-28 ×

CHSG-1 exhibited highest economic heterosis (53.56%) with maximum fruit yield (1.69 kg/vine) in sponge gourd.

The crosses P₂ × P₃, P₃ × P₆ and P₃ × P₅ were found to be best heterotic combinations as they exhibited significant heterosis percentage for yield per hectare over the standard check parent. The high yielding F₁ hybrid P₂ × P₃ (PSG-82 × PSG-07-04) was showed 81.58% heterosis for yield over standard check may be recommended for commercial exploitation.

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