Studies on the Expression of Heterosis in Interspecific Hybrids of Sesame (*Sesamum indicum L.*)

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ABSTRACT

The present study was undertaken to develop superior hybrids for yield and its component traits in *Sesamum indicum* L. through interspecific hybridization by utilizing *S. malabaricum* as one of the parents. Direct and reciprocal crosses were attempted using eight cultivated varieties and *S. malabaricum*, which evaluated a total of fifteen interspecific hybrids. Highly significant and positive heterosis was observed in a few hybrids for the vegetative traits. For single plant yield, the number of seeds per capsule, 100 seed weight, highly significant and negative heterosis was observed. The hybrid SVPR 1 x *S. malabaricum* had expressed significantly negative relative heterosis for days to first flowering, days to maturity, and plant height. The cross *S. malabaricum* x TMV 3 had shown highly significant and positive relative heterosis for the number of primary and secondary branches the number of capsules on the main stem and branches.

Keywords: *Sesame; Interspecific hybridization; S. malabaricum; Heterosis; Yield*

Sesame (*Sesamum indicum* L., Pedaliaceae), commonly known as 'Til' is one of the oldest and earliest domesticated crops. It was a major oilseed in the ancient world because of its oil quality, medicinal value, ease of oil extraction, great stability, and drought resistance (Langham and Wiemers, 2002). It is a short-duration crop grown throughout the year. Since its oil is highly resistant to oxidative deterioration due to the presence of antioxidants such as sesamin and sesamolin (Yoshida and Takagi, 1997; Erbas *et al*., 2009) and also has a high percentage of unsaturated fatty acids (Yermanos *et al*., 1972), sesamum oil is having good market value for edible purpose in India. On the contrary of these benefits, sesame production is limited due to low seed yield (Ashri, 1989; Yol *et al.,* 2010: Pham *et al.,* 2010), susceptibility to diseases (El-Bramawy, 2006), stress factors (Sarwar*et al.,* 2007) shattering losses and cultivation in poor and low input conditions. Therefore, breeding efforts have mainly concentrated on developing high yielding and disease-resistant varieties. One important way to increase seed yield is the exploitation of heterosis. Despite its autogamous nature, several researchers have already reported the presence of significantly high heterosis for yield and yield components. Heterosis of a small amount for individual yield contributing characters may have an additive or synergistic effect on the end product (Sasikumar and Sardana, 1990). Utilization of few wild species for transfer of desirable characters like hardiness, profused flowering, resistance to phyllody, and drought tolerance into cultivated sesame, apart from exploiting heterosis is, remaining an untouched area of sesame research and the reports on this area of research is very limited. Therefore, the present study was undertaken to study the extent of heterosis for quantitative traits in the interspecific hybrids of sesame.

Materials and methods

The experiment was conducted at the Department of Oilseeds, Tamil Nadu Agricultural University, Coimbatore. Eight cultivated varieties of sesame viz., CO 1, PYR 1, SVPR 1, VRI 1, VRI(Sv) 2, TMV 3, TMV 4, and TMV 7 with the wild species *Sesamum malabaricum* (2n=26) were utilized for the present study. The wild species were collected from the Species Garden maintained at Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore, India. The genetically pure varietal seeds were obtained from the Department of Oilseeds, TNAU, Coimbatore. The parental seedlings were raised in earthen pots during Summer 2010 and then transferred to the field on 25 DAS. The crossing was done during flowering by utilizing the wild species as both male and female parents. The crossed seeds obtained with the parents were sown in pots and then transferred to the field in a randomized block design (RBD) with three replications. Each plot consisted of two rows of 5 m in length with a spacing of 30 cm between rows and 30 cm between plants. All need-based recommended practices were followed. Observations were recorded in ten randomly selected plants in each entry of two replications for ten quantitative traits *viz.*, days to first flowering, days to maturity, plant height at maturity, number of primaries, number of secondary branches, number of capsules on the main stem, number of capsules on branches, number of seeds per capsule, single plant yield and 100 seed weight. The mean values were used for the estimation of heterosis over the mid parent, cultivar parent, and wild parent since the ruling varieties were used as parents.

Results and Discussion

Although Sesame is largely a self-pollinated crop, high levels of heterosis have been reported by many scientists since 1945 (Pal, 1945) for the vegetative and economic traits in intervarietal hybridization. But the research on the exploitation of heterosis through interspecific hybridization is limited and only a few have been reported in sesame.

The mean performance of the parents for all the ten traits studied is given in table 1. With regard to attributes for earliness, like days to first flowering and days to maturity, significant heterosis in the negative direction is of practical value. In this study, significant negative heterosis(-12.60 and -26.52 percent) over the wild parent was observed in all the interspecific crosses while significant positive heterosis (13.65 to 40.87 percent) over the cultivar parent was expressed in all the fifteen crosses studied (Table 2). The relative heterosis ranged between -10.47 and 7.87 percent. The cross TMV 4 x *S. malabaricum* and VRI(Sv) 2 x *S. malabaricum* expressed highly significant negative heterosis over the male parent and to the mid parent. For days to maturity, heterosis over the wild parent was from -8.13 to -28.83 percent. Positive heterosis was observed from 22.92 to 43.23 percent, over the cultivar parent, indicating the longer duration of the hybrids over the popular varieties used as parents. The heterosis over mid-parental value ranged between -9.85 and 11.29 percent. SVPR 1 x *S. malabaricum* expressed highly significant and negative relative heterosis and heterosis over the wild parent for days to maturity, which has practical value for the development of short-duration hybrids. Heterosis for earliness in interspecific hybrids was reported by Prabakaran, (1992) and JayantaBhuyan (1996) in interspecific hybrids of sesame.

For plant height, relative heterosis ranged from -40.05 to 24.41 percent. The heterosis over the cultivar parent was found to be between -24.20 and 58.65 percent, and over the wild parent was from -50.42 to 97.74 percent. As the sesame crop has indeterminate growth type, highly significant, positive heterobeltiosis and relative heterosis were observed in the direct and reciprocal crosses of *S. malabaricumS. malabaricum* with CO 1, TMV 3, and TMV 7. Similarly, the hybrid SVPR 1 x *S. malabaricum* expressed highly significant, negative heterobeltiosis and relative heterosis for plant height due to its dwarfness. For the number of primary branches, heterosis over the mid parental value was ranged between 39.30 and -12.6 percent (Table 3). Heterosis over cultivar parent was positive, ranged from 94.17 to 5.45 percent. Heterosis over wild parent expressed was between -

42.63 to 67.83 percent indicating the huge variation in the hybrids derived from the interspecific cross for the number of primary branches. The direct and reciprocal hybrids of *S. malabaricum* with VRI(Sv) 2 were found to have significant and positive heterobeltiosis and relative heterosis since they possessed more primaries than both parents. For this trait, significant and positive heterosis was reported by Kavitha (1998) in the cross between *S. malabaricum* and *S.indicum*. For the number of secondary branches, all the 15 hybrids significantly excelled the cultivar parents since the hybrids possessed more secondaries than the cultivated genotypes, which was not observed over the wild parent because none of the hybrids had more secondaries than the wild parent *S. malabaricum* (Table 3). Heterosis over wild parents ranged from -62.81 to -26.92 percent and between 13.55 and 145.65 percent over the cultivar parents. The relative heterosis ranged between -41.62 to 12.65 percent. The hybrid *S. malabaricum* x TMV 3 expressed highly significant and positive relative heterosis and heterosis over the cultivar parent for the number of primary and secondary branches.

With regard to economic attributes, *S. malabaricum* as a female with TMV 3, TMV 4, TMV 7, Paiyur 1 expressed significant and positive heterobeltiosis and relative heterosis for the number of capsules on the main stem (Table 2). This was also observed when TMV 7 and VRI 1 were used as females while crossed with *S. malabaricum* due to the presence of more capsules on the main stem than both the parents. The hybrids exhibited wide heterosis over the cultivated variety to the extent of -50.02 to 43.75 percent and over the wild parent between -20.08 and 74.55 percent. The heterosis over the mid parental value was from -38.50 to 57.27 percent for the number of capsules on main stem. The interspecific cross of *S. malabaricum* with TMV 7 exhibited highly significant and positive relative heterosis and heterosis in both the direct and reciprocal crosses. For the number of capsules on branches, all the hybrids expressed highly significant and positive heterosis over both the parents except *S. malabaricum* x Paiyur 1 and relative heterosis when *S. malabaricum* was used as female. (Table 3). The same result was observed when SVPR 1, TMV 7, and VRI 1 were used as females. Positive heterosis was expressed over the wild parent, ranged from 250.23 to 6.84 percent. The heterosis over cultivar parent was between 71.63 and -27.30 percent. Heterosis over the mid parental value was between -5.97 and 107.39 percent. Kavitha *et al*. (2000) reported that the heterosis for days to first flowering, number of primary and secondary branches, number of capsules per plant can be exploited through heterosis breeding in interspecific hybrids of sesame.

For the number of seeds per capsule and single plant yield, all the fifteen hybrids had expressed highly significant and negative heterobeltiosis and relative heterosis, due to the presence of very few seeds in the capsules of hybrids than in the parents. It was from -84.88 to -19.37 percent over the wild parent and between -86.47 and -28.73 percent over the cultivar parent and relative heterosis ranged from -24.34 to -85.72 for number of seeds per capsule (Table 3). For single plant yield, relative heterosis was between -53.16 and -16.58 percent (Table 4). The heterosis over the wild and cultivated parents ranged from -48.60 to -15.19 percent and -56.98 to -13.72 percent respectively. The hybrids showed highly significant and negative relative heterosis for 100 seed weight in all the fifteen hybrids, and positive heterobeltiosis expressed was also insignificant (Table 4).

Conclusion

Interspecific hybridization is a successful tool utilized in crop improvement to transfer desirable traits from the related species to the cultivated varieties. Sesame though having high value due to the edible and medicinal properties of the oil, and availability of genetic resources is low for further crop improvement. With the view of making hybridization between distantly related genotypes will produce more heterosis and substantial genetic diversity, this study was undertaken. From the present study, it can be concluded that the hybrid SVPR 1 x *S. malabaricum* expressed significantly negative relative heterosis for days to first flowering, days to maturity and plant height, which may be useful to develop short duration hybrids with short stature. The cross *S. malabaricum* x TMV 3 had highly significant and positive relative heterosis for the number of primary and secondary branches, number of capsules on the main stem and branches. For yield traits like the number of seeds per capsule, single plant yield, and 100 seed weight, negative heterosis was observed in all the interspecific crosses due to the presence of few and shriveled seeds in hybrids. However, promising varieties can be developed from these interspecific hybrids in further generations or by repeated backcrossing with the *S.indicum* parents followed by selection for yield and other desirable traits.

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Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

Originality and plagiarism

The author assures that the research work submitted here is original and not subjected to any plagiarized content.

Consent for publication

The author agreed to publish the content

Competing interests

There were no conflict of interest in the publication of this content

Data availability

All the data of this manuscript are included in the MS. No separate external data source is required.

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Table 1 . Mean Performance of Parents for various traits studied

Parents	Days to first flowering	Days to maturity	Plant height	No. of primary branches	No. of secondary branches	No. of capsules on main stem	No. of capsules on branches	No. of seeds / capsule	Single plant yield	100 seed weight
CO 1	46.69	94.69	133.33	6.50	3.49	29.00	94.19	74.33	30.47	0.346
SVPR 1	38.78	82.39	106.60	2.40	2.00	14.00	26.30	69.30	22.60	0.323
TMV 3	43.05	88.73	105.12	4.29	3.68	24.04	48.86	67.35	26.13	0.344
TMV 4	44.62	90.74	115.20	5.50	3.80	19.60	58.60	62.80	22.74	0.346
TMV 7	43.34	92.63	121.60	4.70	4.00	22.40	57.80	66.50	27.24	0.323
Paiyur 1	44.49	93.47	115.50	4.90	4.30	23.20	75.40	67.60	29.27	0.318
VRI 1	39.46	84.96	114.54	4.29	4.28	22.96	58.85	65.26	25.78	0.355
VRI(Sv) 2	42.60	91.77	127.84	5.39	5.93	30.41	93.05	67.33	29.03	0.347
S. malabaricum	68.66	142.29	162.98	7.67	12.37	19.02	32.01	59.53	24.30	0.224

Table 2. Expression of heterosis in interspecific crosses for days to flowering, days to maturity and plant height

Crosses	Days to first flowering				Days to maturity				Plant height			
	Mean	Heterosis over			Mean	Heterosis over			Mean (cm)	Heterosis over		
		Female parent	Male parent	Mid-parent		Female parent	Male parent	Mid-parent		Female parent	Male parent	Mid-parent
S. malabaricum x CO 1	57.39	-16.41**	22.92**	-0.49^{NS}	122.82	-13.68**	29.71**	3.65**	167.09	2.52**	25.32**	12.78**
CO 1 x *S. malabaricum*	55.53	18.93**	-19.12**	-3.72**	124.92	31.93**	-12.21**	5.43**	175.60	31.70**	97.74**	18.52**
SVPR 1 x *S. malabaricum*	52.46	35.28**	-23.59**	-2.35*	101.27	22.92**	-28.83**	-9.85**	80.80	-24.20**	-50.42**	-40.05**
S. malabaricum x TMV 3	54.46	-20.68**	26.50**	-2.50**	122.26	-14.08**	37.79**	5.84**	166.77	2.33**	58.65**	24.41**
TMV 3 x *S. malabaricum*	54.47	26.53**	-20.67**	-2.48**	117.83	32.80**	-17.19**	2.01**	143.60	36.61**	-11.89**	7.12**
S. malabaricum x TMV 4	58.83	-14.32**	31.85**	3.87**	124.58	-12.45**	37.29**	6.92**	153.00	-6.12**	32.81**	10.00**
TMV 4 x *S. malabaricum*	50.71	13.65**	-26.14**	-10.47**	118.25	30.32**	-16.90**	1.49**	144.40	25.35**	-11.40**	3.82*
S. malabaricum x TMV 7	58.26	-15.15**	34.43**	4.04**	130.72	-8.13**	41.12**	11.29**	167.80	2.96**	37.99**	17.93**
TMV 7 x *S. malabaricum*	56.31	29.93**	-17.99**	0.55^{NS}	123.51	33.34**	-13.20**	5.15**	139.20	14.47**	-14.59**	-2.17^{NS}

S. malabaricum x Paiyur 1	53.52	-22.05**	20.30**	-5.40**	121.85	-14.37**	30.36**	3.37**	153.20	-6.00**	32.64**	10.03**
Paiyur 1 x *S. malabaricum*	54.15	21.71**	-21.13**	-4.29**	123.46	32.09**	-13.23**	4.73**	112.20	-2.86**	-31.16**	-19.42**
S. malabaricum x VRI 1	54.65	-20.40**	38.49**	1.09^{NS}	121.69	-14.48**	43.23**	7.10**	137.35	-15.73**	19.91**	-1.02 ^{NS}
VRI 1 x *S. malabaricum*	54.73	38.70**	-20.29**	1.24^{NS}	121.00	42.42**	-14.96**	6.49**	142.20	24.15**	-12.75**	2.48^{NS}
S. malabaricum x VRI(Sv) 2	60.01	-12.60**	40.87**	7.87**	120.20	-15.52**	30.98**	2.71**	143.28	-12.09**	12.08**	-1.46^{NS}
VRI(Sv) 2 x *S. malabaricum*	50.44	18.40**	-26.54**	-9.33**	117.89	28.46**	-17.15**	0.73^{NS}	146.20	14.36**	-10.30**	0.54^{NS}

Table 3. Expression of heterosis in interspecific crosses for number of primary and secondary branches, number of capsules on main stem

Crosses	No. of primary branches				No. of secondary branches				No. of capsules on main stem			
	Mean	Heterosis over			Mean	Heterosis over			Mean	Heterosis over		
		Female parent	Male parent	Mid-parent		Female parent	Male parent	Mid-parent		Female parent	Male parent	Mid-parent
S. malabaricum x CO 1	8.38	9.26^{NS}	28.92**	18.28**	8.47	-31.53**	142.69**	6.81^{NS}	28.19	48.21**	-2.79 ^{NS}	17.41**
CO 1 x *S. malabaricum*	7.80	20.00**	1.69^{NS}	10.09^{NS}	7.00	100.57**	-43.41**	-11.73*	15.20	-47.59**	-20.08**	-36.69**
SVPR 1 x *S. malabaricum*	4.40	83.33**	-42.63**	-12.61^{NS}	4.60	130.00**	-62.81**	-35.98**	17.40	24.29**	-8.52*	5.39^{NS}
S. malabaricum x TMV 3	8.33	8.60^{NS}	94.17**	39.30**	9.04	-26.92**	145.65**	12.65**	26.34	38.49**	9.57**	22.34**
TMV 3 x *S. malabaricum*	7.20	67.83**	-6.13^{NS}	20.40**	8.20	122.83**	-33.71**	2.18^{NS}	19.00	-20.97**	-0.11 ^{NS}	-11.75 ^{NS}
S. malabaricum x TMV 4	5.80	-24.38**	5.45^{NS}	-11.92 ^{NS}	8.20	-33.71**	115.79**	1.42^{NS}	26.40	38.80**	34.69**	36.72**
TMV 4 x *S. malabaricum*	6.40	16.36*	-16.56**	-2.81^{NS}	7.60	100.00**	-38.56**	-6.00 ^{NS}	18.40	-6.12^{NS}	-3.26 ^{NS}	-4.71^{NS}
S. malabaricum x TMV 7	6.60	-13.95**	40.43**	6.71^{NS}	8.20	-33.71**	105.00**	0.18^{NS}	32.20	69.30**	43.75**	55.48**
TMV 7 x *S. malabaricum*	6.40	36.17**	-16.56**	3.48^{NS}	9.00	125.00**	-27.24**	9.96*	29.20	30.36**	53.52**	40.99**

S. malabaricum x Paiyur 1	7.60	-0.91NS	55.10**	20.92**	7.20	-41.79**	67.44**	-13.62**	33.20	74.55**	43.10**	57.27**
Paiyur 1 x *S. malabaricum*	7.80	59.18**	1.69NS	24.11**	7.60	76.74**	-38.56**	-8.82NS	21.20	-8.62**	11.46**	0.43NS
S. malabaricum x VRI 1	6.27	-18.25**	46.15**	4.85NS	4.86	-60.71**	13.55NS	-41.62**	18.36	-3.47 NS	-20.03**	-12.53*
VRI 1 x *S. malabaricum*	7.20	67.83**	-6.13 NS	20.40**	6.80	58.88**	-45.03**	-18.32**	24.40	6.27*	28.29**	16.25*
S. malabaricum x VRI(Sv)2	8.60	12.13*	59.55**	31.70**	7.28	-41.15**	22.77**	-20.44**	25.28	32.91**	-16.87**	2.29NS
VRI(Sv)2 x *S. malabaricum*	8.80	63.27**	14.73**	34.76**	8.60	45.03**	-30.48**	-6.01 NS	15.20	-50.02**	-20.08**	-38.50**

Table 4. Expression of heterosis in interspecific crosses for number of capsules in branches and number of seeds per capsule

Crosses	No. of capsules on branches				No. of seeds / capsule			
	Mean	Heterosis over			Mean	Heterosis over		
		Female parent	Male parent	Mid-parent		Female parent	Male parent	Mid-parent
S. malabaricum x CO 1	112.11	250.23**	19.03**	77.67**	10.98	-81.56**	-85.23**	-83.59*
CO 1 x *S. malabaricum*	68.80	-26.96**	114.93**	9.03**	28.00	-62.33**	-52.96**	-58.17 NS
SVPR 1 x *S. malabaricum*	34.20	30.04**	6.84**	17.30**	35.60	-48.63**	-40.20**	-44.73 NS
S. malabaricum x TMV 3	83.86	161.98**	71.63**	107.39**	9.94	-83.30**	-85.24**	-84.33*
TMV 3 x *S. malabaricum*	48.40	-0.94 NS	51.20**	19.70**	48.00	-28.73**	-19.37**	-24.34 NS
S. malabaricum x TMV 4	92.00	187.41**	57.00**	103.07**	10.80	-81.86**	-82.80**	-82.34*
TMV 4 x *S. malabaricum*	42.60	-27.30**	33.08**	-5.97 NS	38.40	-38.85**	-35.49**	-37.22NS
S. malabaricum x TMV 7	82.60	158.04**	42.91**	83.94**	9.00	-84.88**	-86.47**	-85.72*
TMV 7 x *S. malabaricum*	88.20	52.60**	175.54**	96.41**	45.60	-31.43**	-23.40**	-27.64NS
S. malabaricum x Paiyur 1	70.80	121.18**	-6.10**	31.83**	11.80	-80.18**	-82.54**	-81.44*
Paiyur 1 x *S. malabaricum*	55.20	-26.79**	72.45**	2.78NS	26.40	-60.95**	-55.65**	-58.47NS
S. malabaricum x VRI 1	92.68	189.53**	57.49**	104.01**	13.68	-77.02**	-79.04**	-78.08*
VRI 1 x *S. malabaricum*	84.60	43.76**	164.29**	86.22**	30.40	-53.42**	-48.93**	-51.28NS
*S. malabaricum*xVRI(Sv)2	96.35	201.00**	3.55**	54.09**	12.68	-78.70**	-81.17**	-80.01*
VRI(Sv)2 x*S. malabaricum*	78.40	-15.74**	144.92**	25.38**	33.60	-50.10*	-43.56**	-47.03NS

Table 5. Expression of heterosis in interspecific crosses for single plant yield and 100 seed weight

Crosses	Single plant yield				100 seed weight			
	Mean (g.)	Heterosis over Female parent	Heterosis over Male parent	Heterosis over Mid-parent	Mean (g.)	Heterosis over Female parent	Heterosis over Male parent	Heterosis over Mid-parent
S. malabaricum x CO 1	17.23	-81.56**	-85.23**	-83.59*	0.239	6.70^{NS}	-30.92**	-16.14**
CO 1 x *S. malabaricum*	19.61	-62.33**	-52.96**	-58.17^{NS}	0.244	-29.48**	8.93^{NS}	-14.39**
SVPR 1 x *S. malabaricum*	14.53	-48.63**	-40.20**	-44.73^{NS}	0.204	-36.84**	-8.93^{NS}	-25.41**
S. malabaricum x TMV 3	15.32	-83.30**	-85.24**	-84.33*	0.206	-8.04^{NS}	-40.12**	-27.46**
TMV 3 x *S. malabaricum*	17.46	-28.73**	-19.37**	-24.34^{NS}	0.216	-37.21**	-3.57^{NS}	-23.94**
S. malabaricum x TMV 4	19.62	-81.86**	-82.80**	-82.34*	0.232	3.57^{NS}	-32.95**	-18.60**
TMV 4 x *S. malabaricum*	15.36	-38.85**	-35.49**	-37.22^{NS}	0.196	-43.35**	-12.50^{NS}	-31.23**
S. malabaricum x TMV 7	17.66	-84.88**	-86.47**	-85.72*	0.182	-18.75^{NS}	-43.65**	-33.46**
TMV 7 x *S. malabaricum*	18.82	-31.43**	-23.40**	-27.64^{NS}	0.209	-35.29**	-6.70^{NS}	-23.58**
S. malabaricum x Paiyur 1	19.46	-80.18**	-82.54**	-81.44*	0.217	-3.13^{NS}	-31.76**	-19.93**
Paiyur 1 x *S. malabaricum*	20.61	-60.95**	-55.65**	-58.47^{NS}	0.189	-40.57**	-15.63^{NS}	-30.26**
S. malabaricum x VRI 1	19.66	-77.02**	-79.04**	-78.08*	0.245	9.38^{NS}	-30.99**	-15.37**
VRI 1 x *S. malabaricum*	18.32	-53.42**	-48.93**	-51.28^{NS}	0.196	-44.79**	-12.50^{NS}	-32.30**
*S. malabaricum*xVRI(Sv)2	15.00	-78.70**	-81.17**	-80.01*	0.250	11.61^{NS}	-27.95**	-12.43**
VRI(Sv)2 x*S. malabaricum*	12.49	-50.10*	-43.56**	-47.03^{NS}	0.225	-35.16**	0.45^{NS}	-21.19**