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Research Note

Heterosis studies in sesame (*Sesamum indicum* L.)

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Abstract

Heterosis for seed yield and its components was studied in a set of line x tester crosses of 10 lines and 5 testers. The analysis of variance revealed highly significant differences among the genotypes for all the characters indicating that the genotypes exhibited significant differences for all the characters studied. The differences among the parents were highly significant for all the characters except days to 50% flowering, width of capsule and oil content. The differences among the hybrids were also found highly significant for all the characters suggesting the presence of sufficient diversity among hybrids themselves for all the characters. While, differences among the parents *vs* hybrids were also found significant for six characters *viz*., days to 50% flowering, days to maturity, number of internodes per plant, length of capsule, number of capsules per plant and seed yield per plant. High heterosis was observed for days to 50% flowering, days to maturity, number of branches per plant, number of internodes per plant, length of capsule, number of capsules per plant, number of seeds per capsule, 1000-seed weight and seed yield per plant. Whereas, the magnitude of heterosis was moderate for plant height, height to first capsule, width of capsule, number of capsules per leaf axil and oil content. The range of heterobeltiosis for seed yield per plant was from -44.14 to 50.9%, while the standard heterosis ranged from 42.01 to 54.9%. The cross Borda-2 x G.Til-1-9-4 had recorded the highest standard heterosis for seed yield per plant followed by ES-246 x G.Til-4, RMT-180 x G.Til-3 and ES-246 x G.Til-2. These crosses also exhibited desirable heterosis for important yield attributes suggested the heterosis for seed yield was associated with heterosis for component characters, which could be further exploited in sesame breeding.

Key words

Heterobeltiosis, standard heterosis, line x tester and sesame

Sesame (*Sesamum indicum* L.) is an important annual oilseed crop in the tropical and warm subtropics. Sesame has played a major role in the rich and diverse health and cosmetic traditions of India. It is called as the "Queen of oilseeds" because of its excellent quality of the seed, oil and meal. Choice of the parents for a breeding programme is important to improve quantitative characters like seed yield and its components. Exploitation of hybrid vigour is an important tool for making genetic improvement of yield and its attributing traits in sesame. The magnitude of heterosis for seed yield and its components provides a basis for determining genetic diversity and also serves as a guide for the choice of desirable parents for developing superior F_1 hybrids to exploit hybrid vigour and for building gene pools to be employed in breeding programme. The heterotic hybrids can also produce desirable transgressive segregants in advanced generations. Keeping this in view, the present investigation was carried out to know the extent of heterobeltiosis and standard heterosis for seed yield and its components in sesame crosses obtained from 10 lines x 5 testers mating method.

Ten diverse pure lines *viz*., EC-41, U-76-22, ES-246, UCS-76-1, ES-139, JLSL-8, RMT-180, IC-74188, Lalavadar-6 and Borda-2 were used as females and which were crossed with five male (tester) parents *viz*., G.Til-1-9-4, G.Til-2, G.Til-3, G.Til-4 and J-68-3 to develop 50 F_1 crosses using line x tester mating method during *kharif* season of 2015. The experimental material consisting of 66 entries including 15 parents (10 lines and 5 testers) and their resultant 50 hybrids along with one standard check variety (G. Til-4). These materials were evaluated in Randomized Block Design with two replications at Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh, Gujarat. Each genotype was accommodated in a single row plot of 3.0 m length with a spacing of 45 x 15 cm. The fertilizers in the experimental area were applied at the rate of 50.0 kg N_2 and 25.0 kg P_2O_5 per hectare. All the agronomic management practices and plant protection measures were adopted timely to raise healthy crop. The observations on five randomly selected competitive plants were recorded from each replication on fourteen characters (Table 1). The days to 50% flowering and days to maturity were recorded on plot basis. The oil content was analysed by using Nuclear Magnetic Resonance Spectro Photometer as suggested by Tiwari *et al.* (1974). The mean values of recorded observations were finally subject to statistical analysis. The analysis of variance was performed to test the significance of differences among the genotypes for all the characters following fixed effect model as suggested by Panse and Sukhatme (1985). The heterotic effects were computed as the percentage increase (+) or decrease (-) of F_1 mean values over better parent (heterobeltiosis) and standard check variety (standard heterosis) for all the characters and crosses following the standard formula.

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Analysis of variance showed significant differences among the genotypes for all the characters studied indicating the presence of sufficient variability among the genotypes. Further, partitioning of mean sum of squares for parents and hybrids, the differences among the parents were also found significant for all the characters except days to 50% flowering, width of capsule and oil content. The differences among the hybrids were also found significant for all the characters suggesting the presence of sufficient diversity among hybrids themselves for all the characters. The mean squares due to parents *vs* hybrids were also found significant for the six characters *viz*., days to 50% flowering, days to maturity, number of internodes per plant, length of capsule, number of capsules per plant and seed yield per plant indicated that performance of parents was different than that of hybrids as well as presence of overall heterosis (Tabe 1).

The experimental results indicated that the magnitude of heterosis over better parent as well as standard check varied from cross to cross and character to character. This depicted the existence of potential heterosis in sesame. The range of heterosis in hybrids over their better parent and standard check variety G. Til-4, number of crosses showing significant and desirable heterosis over better parent and standard check are presented in Table 2).

Manifestations of heterosis for different characters are summarised as below; For days to 50% flowering, out of 50 crosses, 8 and 7 hybrids exhibited significant negative heterobeltiosis and standard heterosis, respectively. The best standard heterotic cross was UCS-76-1 x G.Til-1-9-4 followed by Lalavadar-6 x G. Til-2 and Lalavadar-6 x G. Til-4. Standard heterosis for earliness in sesame has been reported by Shekhawat *et al.* (2014).

With respect to days to maturity, out of 50 hybrids, 9 hybrids showed significant negative heterobeltiosis for days to maturity, on the other hand, 7 hybrids showed significant negative standard heterosis for days to maturity. The best standard heterotic cross was Lalavadar-6 x G.Til-2 followed by EC-41 x G.Til-4 and Lalavadar-6 x G.Til-4. Significant negative heterosis for days to maturity has been reported by Rao (2011) and Shekhawat *et al.* (2014). For plant height, 4 and 3 hybrids exhibited significant positive heterobeltiosis and standard heterosis for plant height, respectively. The best standard heterotic cross was ES-246 x G.Til-1-9-4 followed by U-76-22 x G. Til-4 and ES-246 x G.Til-2. Jadhav and Mohrir (2013), Parimala *et al.* (2013) and Shekhawat *et al.* (2014) also observed significant positive heterosis for plant height in sesame. Tall plant with shorter internodes plays an important role in increasing the yield as capsules takes places at each node.

When respect to height to first capsule, significant negative heterobeltiosis was recorded by 4 crosses, while none of the crosses displayed significant negative standard heterosis. The cross combinations JLSL-8 x G.Til-3, Lalavadar-6 x G.Til-3 and JLSL-8 x G.Til-4 showed the highest magnitude of desirable heterosis. Two out of four heterotic crosses for height to first capsule involved G.Til-3 as one of the parents indicating the potentiality and usefulness of this parent in the reduction of height up to first capsule. Significant negative heterosis for height to first capsule has also been reported by Jadhav and Mohrir (2013). In case of number of branches per plant, the number of crosses which significantly excelled the better parent and standard check for number of branches per plant were 13 and 23, respectively. The highest value of standard heterotic crosses for this trait was expressed by the cross ES-246 x G.Til-1-9-4 followed by Borda-2 x G.Til-1-9-4 and Lalavadar-6 x G.Til-1-9-4. All these three crosses involved common tester G.Til-1-9-4. These hybrids hold promise since they are likely to yield desirable transgressive segregants. Significant positive heterosis for number of branches per plant in sesame has been reported by several workers; Rao (2011), Padmasundari and Kamala (2012), Parimala *et al.* (2013) and Shekhawat *et al.* (2014). An examination of performance of hybrids for number of internodes per plant, significant positive estimates of heterobeltiosis and standard heterosis for this trait were observed in 13 and 25 cross combinations, respectively. The highest value of standard heterotic crosses for this trait was exhibited by the cross ES-246 x G.Til-1-9-4 followed by ES-41 x G.Til-4 and ES-246 x G.Til-4. All the three best crosses for this trait involved ES-246 as one of the parents indicating the potentiality and usefulness of this parent in the increase in number of internodes per plant in sesame. Jadhav and Mohrir (2013) also reported significant positive heterosis for number of internodes per plant in sesame.

For length of capsule, 7 and 8 crosses showed significant positive heterobeltiosis and standard heterosis, respectively for this character. The highest value of standard heterosis was exhibited by the cross Lalavadar-6 x J-68-3 followed by JLSL-8 x G.Til-4 and UCS-76-1 x G.Til-3. Heterosis observed in most of the crosses was in low magnitude. This indicated that simple additive genetic effect might be acting in expression of heterosis for length of capsule. Jadhav and Mohrir (2013), Jatothu *et al.* (2013) and Shekhawat *et al.* (2014) reported significant positive heterosis for length of capsule in sesame.
In case of width of capsule, out of 50 crosses, none of the crosses showed significant positive

heterobeltiosis and standard heterosis for width of capsule. Number of capsules per plant is an important yield attribute in sesame. The number of crosses which significantly excelled the better parent and standard check variety for this trait were 7 and 5, respectively. The highest value of standard heterosis for this trait was expressed by the cross Borda-2 x G.Til-1-9-4 followed by ES-246 x G.Til-1-4-9 and ES-246 x G.Til-2. Among last two crosses involved common line *i.e.* ES-246, indicated the potentiality and usefulness of this parent in increasing number of capsules per plant. Significant positive heterosis for number of capsules per plant in sesame has been reported by Prajapati *et al.* (2010), Parimala *et al.* (2013) and Shekhawat *et al.* (2014).

With respect to number of capsules per axil, the number of crosses which significantly excelled the better parent and standard check variety for number of capsules per leaf axil was 4 and 1, respectively. The highest value of standard heterosis for this trait was expressed by the cross ES-139 x G.Til-1-9-4. For number of seeds per capsule, significant positive estimates of heterobeltiosis and standard heterosis were observed in 4 and 11 cross combinations, respectively. The highest value of significant standard heterosis for this trait was exhibited by the cross IC-74188 x G.Til-2 followed by ES-246 x G.Til-2 and JLSL-8 x G.Til-3. Two out of three best crosses involved common testers *viz*., G.Til-2 indicating that this parent can be used in breeding programme to increase number of seeds per capsule. Higher estimates of heterosis for number of seeds per capsule in sesame have been reported earlier by Prajapati *et al.* (2010), Jatothu *et al.* (2013) and Shekhawat *et al.* (2014).

With respect to 1000-seed weight, out of 50 crosses, 7 and 5 crosses expressed significant positive heterobeltiosis and standard heterosis, respectively for 1000-seed weight. The cross Lalavadar-6 x J-68-3 exhibited the highest positive standard heterosis followed by ES-246 x G.Til-4 and UCS-76-1 x G.Til-2. Significant estimates of heterosis for l000-seed weight in sesame have been reported by Padmasundari and Kamala (2012), Jadhav and Mohrir (2013) and Shekhawat *et al.* (2014). In case of oil content, none of the crosses exhibited significant positive heterobeltiosis or standard heterosis. Seed yield is the attribute of economic importance, for seed yield per plant, a total of 4 and 5 cross combinations displayed significant positive heterobeltiosis and standard heterosis, respectively. High estimates of standard heterosis were recorded in the crosses Borda-2 x G.Til-1-9-4, ES-246 x G.Til-4 and RMT-180 x G.Til-3. It is interesting to note that in the most of the heterotic crosses involved G.Til-4 as one of the parents. Further, these crosses also showed desirable heterobeltiosis and/or standard heterosis for yield components like number of days to maturity, number of branches per plant, number of internodes per plant, length of capsule, number of seeds per capsule and number of capsules per plant. In this context, these crosses hold promise for further exploitation since they are expected to yield desirable transgressive segregants in the segregating generations. Significant positive heterobeltiosis for seed yield per plant in sesame has been reported by Jadhav and Mohrir (2013), Jatothu *et al.* (2013), Salunke *et al.* (2013), Vavadiya *et al.* (2013), Parimala *et al.* (2013), Shekhawat *et al.* (2014) and Chaudhari *et al.* (2015).

In general, it can be concluded that the magnitude of heterosis was higher for days to 50% flowering, days to maturity, number of branches per plant, number of internodes per plant, length of capsule, number of capsules per plant, number of seeds per capsule, 1000-seed weight and seed yield per plant and moderate for plant height, height to first capsule and number of capsules per leaf axil. In case of width of capsule and oil content, none of the crosses reported significant heterosis (Table 3). The crosses which showed high heterosis for seed yield per plant also had high heterosis for plant height, number of branches per plant, 1000-seed weight, number of capsules per plant and number of internodes per plant. The results thus, revealed that the heterosis for seed yield per plant was associated with the heterosis expressed by its component characters (Table 3). Such a situation of combinational heterosis has been reported in sesame by several workers *viz*., Padmasundari and Kamala (2012), Parimala *et al.* (2013) and Shekhawat *et al.* (2014).

Findings of the present investigation revealed that Borda-2 x G. Til1-1-9-4, ES-246 x G. Til-4 and RMT-180 x G. Til-3 were found to be the more heterotic cross combinations for seed yield and yield attributing traits on the basis of *per se* performance and heterosis over standard check. Therefore, these crosses may be advanced and exploited in future breeding programmes for improving yield and its components in sesame.

References

Chaudhari, G.B., Naik, M.R., Anarase, S.A. and Ban, Y.G. 2015. Heterosis studies for quantitative traits in sesame (*Sesamum indicum* L.). *Electron. J. Pl. Breed.*, **6**(1):218-224.

Jadhav, R.S. and Mohrir, M.N. 2013. Heterosis studies for quantitative traits in sesame (S*esamum indicum* L.). *Electron. J. Pl. Breed.*, **4**(1):1056-1060.

Jatothu, J.L., Dangi, K.S. and Kumar, S.S. 2013. Evaluation of sesame crosses for heterosis of yield and yield attributing traits. *J. Trop. Agric*., **51** (1-2):84-91.

Padmasundari, M. and Kamala, T. 2012. Heterosis in sesame (*Sesamum indicum* L.). *Asian J. Agric. Sci.*, **4** (4):287-290.

Panse, V.G. and Sukhatme, P.V. 1985. *Statistical Methods for Agricultural Workers.* ICAR, New Delhi.

Parimala, K., Swarnalatha, I., Bharathi, D.V., Raghu, B., Srikrishnalatha, K. and Reddy, A. V. 2013. Heterosis for yield and its component traits in sesame (*Sesamum indicum* L.). *Int. J. Applied Bio. and Pharmaceutical Technology (IJABPT)*. **4(**4**)**:65-68.

Prajapati, N.N., Patel, C.G., Bhatt, A.B., Prajapati, K.P. and Patel, K. M. 2010. Heterosis in sesame (*Sesamum indicum* L.). *Internat. J. agri. Sci*., **6**(1): 91-93.

Rao, S.V.S.G. 2011. Heterosis and *per se* performance in *kharif* sesame (*Sesamum indicum* L.). *Res. on Crops*, **12**(1):185-187.

Salunke, D.P., Lokesha, R. and Banakar, C.K. 2013. Heterosis for yield and its components in sesame, (*Sesamum indicum* L.). *Bioinfolet*., **10**(1A):68-71.

Shekhawat, N.R., Macwana, S.S., Choudhary, R. and Patel, B. R. 2014. Line x Tester analysis in sesame (*Sesamum indicum* L.*). Intern. Quarterly J. of Life Sci., The Bioscan,* **9**(4):1657-1660, 2014 (Suplmnt. on Gen. and Pl. Breed.).

Tiwari, P.N., Gambhir, P.N. and Rajan, T.S. 1974. Rapid and non destructive determination of seed oil by pulsed NMR technique. *J. American Oil Chem. Soc*., **51**:104-109.

Vavdiya, P.A., Dobariya, K.L., Babariya, C.A. and Sapovadiya, M.V. 2013. Heterosis for seed yield and its components in sesame (*Sesamum indicum* L.). *Electron. J. Pl. Breed.*, **4** (3):1246-1250.

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Table 1. Analysis of variance for the experimental design in respect of fourteen characters in sesame

Source	d. f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Height to first capsule (cm)	Number of branches per plant	Number of internodes per plant	Length of capsule (cm)
		1	**2**	**3**	**4**	**5**	**6**	**7**
Replications	2	9.521	41.651	11.356	58.027	1.875*	1.427	0.055
Genotypes	64	45.713**	118.164**	664.607**	205.289**	30.200**	29.211**	0.773**
Parents	14	19.210	69.694**	613.557**	227.543**	14.402**	23.418**	0.378**
Hybrids	49	52.47**	131.955**	689.541**	202.980**	35.330**	30.449**	0.887**
P. *vs* H.	1	85.572*	120.986*	157.492	6.829	0.002	49.665**	0.722**
Error	128	13.863	20.327	148.80	31.124	0.061	1.951	0.082

Source	d. f.	Width of capsule (cm)	Number of capsules per plant	Number of capsules per leaf axil	Number of seeds per capsule	1000-seed weight (g)	Seed yield per plant (g)	Oil content (%)
		8	**9**	**10**	**11**	**12**	**13**	**14**
Replications	2	0.004	111.27	0.056	18.776	0.057	2.607	2.790
Genotypes	64	0.018**	1203.175**	0.693**	214.608**	0.511**	36.185**	10.408**
Parents	14	0.011	321.610**	0.667**	155.052**	0.619**	12.164**	9.923
Hybrids	49	0.022**	1452.020**	0.714**	235.234**	0.490**	42.158**	10.470**
P. *vs* H.	1	0.017	1351.682**	0.045	37.712	0.047	79.806**	14.149
Error	128	0.008	53.949	0.038	27.583	0.062	2.232	5.694

Table 2. Range of heterobeltiosis (HB), standard heterosis (SH), number of crosses with significant heterosis and crosses showing the highest heterosis in desired direction for various traits in sesame

Sl. No.	Characters	Range of heterosis (%)		Number of crosses with significant heterosis				Crosses showing the highest heterosis (%) in desired direction over	
		HB (%)	SH (%)	HB (%)		SH (%)		HB	SH
				+Ve	-Ve	+Ve	-Ve		
1	Days to 50% flowering	-28.90 to 23.05	-23.96 to 14.67	3	8	0	7	Lalavadar-6 x G.Til-2	UCS-76-1 x G.T-1-9-4
2	Days to maturity	-18.66 to 16.60	-12.88 to 17.99	7	9	10	7	EC-41 x G.Til-1-9-4	Lalavadar-6 x G.Til-2
3	Plant height (cm)	-43.74 to 45.37	-35.16 to 58.78	4	10	3	4	ES-246 x G.Til-1-9-4	ES-246 xG.Til-1-9-4
4	Height to first capsule (cm)	-24.54 to 64.05	-19.87 to 61.21	15	4	17	0	JLSL-8 x G. Til-3	JLSL-8 x G. Til-4
5	No. of branches/plant	-84.56 to 166.67	-73.13 to 234.33	13	24	23	15	ES-246 x G.Til-2	ES-246 x G.Til-1-9-4
6	No. of internodes/plant	-44.44 to 56.31	-22.69 to 56.69	13	16	25	3	ES-139 x G.Til-2	ES-246 x G.Til-1-9-4
7	Length of capsule (cm)	-42.77 to 33.99	-38.95 to 30.63	7	15	8	7	JLSL-8 x G.Til-4	Lalavadar-6 x J-68-3
8	Width of capsule (cm)	-28.84 to 13.98	-19.48 to 16.43	0	8	0	2	UCS-76-1 x G.Til-4	ES-246 x G.Til-1-9-4
9	No. of capsules/plant	-65.89 to 133.69	-73.27 to 108.80	7	33	5	28	Borda-2 x G.Til-1-9-4	Borda-2 x G.Til-1-9-4
10	No. of capsules/leaf axil	-50.00 to 87.50	-50.00 to 50.00	4	19	1	31	ES-139 x G.Til-1-9-4	ES-139 x G.Til-1-9-4
11	No. of seeds/capsule	-43.90 to 22.14	-34.50 to 30.99	4	15	11	8	ES-246 x J-68-3	IC-74188 x G.Til-2
12	1000-seed weight (g)	-31.33 to 28.13	-26.32 to 23.04	7	18	5	11	UCS-76-1 x G.Til-2	Lalavadar-6 x J-68-3
13	Oil content (%)	-13.05 to 5.70	-6.18 to 7.60	0	10	0	0	UCS-76-1 x J-68-3	ES-139 x G.Til-3
14	Seed yield/plant (g)	-44.14 to 50.90	-42.01 to 54.90	4	27	5	26	Borda-2 x G.Til-1-9-4	Borda-2 x G.Til-1-9-4

+ve = Positive and -ve = Negative

Table 3. Comparative study of ten most standard heterotic crosses for seed yield per plant along with *per se* performance and their heterotic effects for component characters in sesame

Sl. No.	Crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	Height to first capsule (cm)	No. of branches per plant	No. of internodes per plant	Length of capsule (cm)	Width of capsule (cm)
		1	2	3	4	5	6	7	8
1	Borda-2 x G.Til-1-9-4	14.67	7.96	17.18	30.49**	189.55**	15.13*	-7.88	-6.32
2	ES-246 x G.Til-4	2.76	-0.15	10.28	31.13**	143.28**	49.21**	-10.94	12.12
3	RMT-180 x G.Til-3	-0.23	1.75	-21.09	-16.60	61.19**	31.75**	-15.54	2.23
4	ES-246 x G.Til-2	0.77	8.72	26.94*	4.15	162.69**	36.33**	17.07*	12.57
5	U-76-22 x G.Til-4	-0.65	2.51	30.98*	53.71**	94.78**	-4.41	5.91	7.73
6	Lalavadar-6 x J-68-3	9.29	7.61	-1.41	21.42	114.93**	31.34**	30.63**	9.74
7	ES-246 x G.Til-1-9-4	-8.74	-1.29	58.78**	61.21**	234.33**	56.69**	16.41*	16.43
8	IC-74188 x G.Til-2	-3.77	-5.17	2.58	6.07	1.49	28.84**	21.23*	8.77
9	Lalavadar-6 x G.Til-2	-23.80**	-12.88**	-16.71	11.01	116.42**	24.27**	-6.13	-15.17
10	ES-139 x G.Til-2	12.99	13.45**	8.44	26.42*	85.07*	33.83**	-18.60*	3.94

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Table 3. Contd.,

Sl. No.	Crosses	No. of capsules per plant	No. of capsules per leaf axil	No. of seeds per capsule	1000-seed weight (g)	Oil content (%)	Seed yield per plant (g)	*Per se* seed yield per plant (g)
		9	10	11	12	13	14	15
1	Borda-2 x G.Til-1-9-4	108.80**	0.00	0.34	-25.69**	-6.02	54.90**	25.02
2	ES-246 x G.Til-4	31.01**	0.00	4.29	19.03**	3.76	32.04**	21.33
3	RMT-180 x G.Til-3	16.44	-16.67	11.24	-2.75	-0.84	30.06**	21.01
4	ES-246 x G.Til-2	71.83**	0.00	27.16**	16.38*	4.47	29.85**	20.97
5	U-76-22 x G.Til-4	53.89**	0.00	6.33	-6.45	-0.20	18.17*	19.09
6	Lalavadar-6 x J-68-3	4.28	-50.00**	22.49**	23.04**	6.38	17.80*	19.03
7	ES-246 x G.Til-1-9-4	90.26**	0.00	2.74	14.38	6.58	12.27	18.13
8	IC-74188 x G.Til-2	14.15	0.00	30.99**	11.10	5.16	10.62	17.87
9	Lalavadar-6 x G.Til-2	-2.46	-50.00**	3.45	-26.32**	-2.47	10.22	17.80
10	ES-139 x G.Til-2	25.35*	0.00	-1.93	-8.14	-0.84	8.80	17.57

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