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Heterosis for seed yield and its contributing attributes in sesame (*Sesamum indicum* L.)

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Abstract
A study was conducted in Sesame to estimate the magnitude of heterosis for yield and its nine yield components. 28 F_1 hybrids generated by half diallel crosses of eight pure diverse parent and these F_1s along with 8 parents were evaluated in a randomized block design with three replication at JNKVV, College of Agriculture Tikamgarh (MP) Appreciable heterosis was found over mid, better and standard parent for all the traits studied in desirable direction. In order of merit F_1 hybrids TKG-22 x SI-205-61(118.9%), TKG-22 x RMT-187(109.8%), SI-205-1 x EC-269 (95.6%), ES-230 x SI-205-61(86.2%), ES-230 x SI-205-61(75.8%), SI-1147 x EC-269 (63.2%), RMT-187 x SI-205-61(55.2%) and SI-983 x SI-1147(42.5%) were observed significant heterosis over mid parent while the maximum heterobeltiosis (better parent heterosis) for mean seed yield per plant (g) was exhibited by the hybrid RMT-187 x SI-205-61(108.2%) followed by ES-230 x SI-983(98.9%), ES-230 x SI-205-61(82.9%), SI-983 x SI-205-61(75.4%), TKG-22 x SI-205-1(63.5%), RMT-187 x SI-205-61(46.2%), TKG-22 x RMT-187(31.8%) and RMT-187 x SI-1147(28.6%). In case of standard heterosis, significant and positive heterosis over standard check TKG-22 for mean seed yield per plant(g) was observed in hybrid TKG-22 x SI-205-1(65.3%) followed by RMT-187 x SI-205-1(86.8%), TKG-22 x SI-983(78.9%), RMT-187 x SI-1147(62.6%), SI-205-1 x EC-269 (53.2%), SI-983 x SI-1147(38.5%), SI-205-61 x SI-1147(28.5%) and SI-205-1 x EC-269 (22.4%). The present study reveals good scope for isolation of pure lines from the progenies of heterotic F1s as well as commercial exploitation of heterosis in Sesame.

Keywords: Sesame, heterosis, mid parent, better parent and standard parent

Introduction
Sesame, although predominantly a self pollinated crop, its reproductive biology and making crosses offers a good scope for exploitation of heterosis. It is an important ancient oilseed crop whose oil is characterized for its stability and quality. Sesame contains about 50-60% seed oil (Uzun *et al.* 2002 and Arslan *et al.* 2007) [15, 2] with superior quality comparable to olive oil. The stability of its oil has been attributed to the presence of antioxidant like sesamin, sesaminol, sesamol, sesamolinol and squalene (Mohamed *et al.* 1998) [9]. Despite the nutritional value and oil quality of sesame seeds, research on this important crop plant has been scarce (Bedigian *et al.* 2003) [3], especially in India where funding was generally poor. The exploitation of hybrid vigour is one of the methods used in plant breeding to bring about cultivars development with high yielding potential. In some cases, the yields of F1 hybrids being considerably higher than those of the better parents have been reported (Murty *et al.* 1994 and Quijada *et al.* 1995) [11, 13]. Like in many other crops, the magnitude of heterosis in sesame is related to the degree of genetic divergence of the parents. In previous studies, significant negative relative heterosis, heterobeltiosis and standard heterosis for days to 50% flowering (less days to flowering) in three crosses and significant positive heterosis for number of primary branches per plant have been reported (Deepasankar *et al.* 2001) [4]. Also, there have been reports on significant positive heterosis for plant height (Navadiya *et al.* 1995 and Deepasankar *et al.* 2001) [12, 4]. The heterosis in sesame has not been exploited by developing high yielding heterotic hybrid to increase productivity. The present study was undertaken to study the extent of heterosis and heterobeltiosis for seed yield and its components to develop superior hybrids.

Materials and Methods
The experimental material comprised of eight pure diverse parents *viz;* TKG-22, ES-230, RMT-187, SI-983, SI-205-1, SI-205-61, SI-1147 and TKG-22 along with its 28 F1 hybrids

generated by half-diallel in all possible combinations excluding reciprocals during *kharif* 2016-17. TKG-22 used as standard check also. The experiment was laid out in randomized block design with three replications at JNKVV, College of Agriculture Tikamgarh, Madhya Pradesh (India) farm during *kharif* 2015-16. Each of the accessions and crosses was represented by a single row of two meters, plant to plant distance of 10cm and row to row spacing of 45cm. All the management practices were followed as per recommendations, so as to raise a normal crop. Observations were made on five randomly selected plants of each cross and parents for nine traits i.e. plant height(cm), number of branches per plant, number of capsule per plant, capsule length(cm), number of seed per capsule, days to flowering (50%), days to maturity, oil content (%) and mean seed yield/plant (g). Heterosis expressed as per cent increase or decrease in hybrid (F1) over its mid parental value, better parent (BP) and standard check (SC) values in the desirable direction was calculated using the following formula.

(i) Relative heterosis (RH); (Turner, 1953)

$$H_1 (\%) = \frac{\overline{F1} - \overline{MP}}{\overline{MP}} X 100$$

Where, MP = Mean performance of parent P_1 and P_2

F_1 = Mean performance of hybrid

(ii) Heterobeltiosis (BH); (Fonseca and Patterson, 1968)

$$BP = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} X 100$$

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

$\overline{F_1}$ = Mean performance of F_1 hybrid

(iii) Standard heterosis (SH)

$$SH = \frac{\overline{F_1} - \overline{SC}}{\overline{SC}} X 100$$

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

Results and Discussion

Wide range of variability exists among parents and their F1 hybrids for different traits under study. Out of the 28 hybrids, the significant desirable heterotic effects over their respective mid, better and standard parent were noticed in 13, 10 and 9 crosses for plant height (cm), 15, 10 and 8 crosses for number of branches per plant, 11, 9 and 6 crosses for number of capsule per plant, 10, 9 and 7 crosses for capsule length (cm), 14, 12 and 9 crosses for number of seed per capsule, 21, 5 and 15 crosses for days to flowering (50%), 18, 12 and 10 crosses for days to maturity, 21, 18 and 20 crosses for mean seed yield/plant (g), 18, 10 and 15crosses for oil content (%). The best significant hybrids for different traits with respect to heterosis over mid parent, better parent and standard check variety are presented in Table 1. An examination of performance of hybrids over better parent revealed that 18 hybrids manifested significant positive heterosis for mean seed yield/plant (g). The maximum heterobeltiosis for mean seed yield per plant was exhibited by the hybrid RMT-187 x SI-205-61(108.2%) followed by ES-230 x SI-983(98.9%), ES-230 x SI-205-61 (82.9%), SI-983 x SI-205-61(75.4%), TKG-22 x SI-205-1 (63.5%), RMT-187 x SI-205-61(46.2%), TKG-22 x RMT-187 (31.8%) and RMT-187 x SI-1147(28.6%). Among the above hybrids, RMT-187 x SI-205-61 also exhibited maximum heterobeltiosis for number of branches per plant, number of capsule per plant. Similar results were obtained by Dikshit and Swain (2000) [5], Dusane *et al.* (2002) [6] and Anuradha and Lakshmikantha (2005) [1]. Similarly, hybrid RMT-187 x SI-205-1(16.4%) also exhibited maximum heterobeltiosis for capsule length(cm) followed by RMT-187 x SI-205-1(16.4%), ES-230 x SI-205-1(13.9%), RMT-187 x SI-1147(10.9%), ES-230 x SI-1147(9.2%) and SI-205-1 x EC-269 (6.3%).Hybrid TKG-22 x RMT-187(89.8%) exhibited heterobeltiosis for oil content (%) followed by SI-1147 x TKG-22(43.2%), ES-230 x SI-205-61(62.9%), RMT-187 x SI-1147(42.6%), TKG-22 x SI-205-1(43.5%), SI-983 x SI-1147(22.5%) and TKG-22 x RMT-187(21.8%) Many number of hybrids exhibited significant heterosis over better parent in desirable direction for different component traits such as plant height(cm), number of branches per plant, number of capsule per plant, capsule length(cm), number of seed per capsule, days to flowering (50%), days to maturity, oil content (%) and mean seed yield/plant (g). Similar results were obtained by Dikshit and Swain, 2000 [5], Dusane *et al*., 2002 [6] and Mothilala and Ganesan, 2005 [10].

In case of standard heterosis, 20 hybrids showed significant values for mean seed yield/plant (g). The maximum significant and positive heterosis over standard check TKG-22 for mean seed yield/plant (g) was observed in hybrid TKG-22 x SI-205-1(65.3%) followed by, RMT-187 x SI-205-1(86.8%), TKG-22 x SI-983(78.9%), RMT-187 x SI-1147(62.6%), SI-205-1 x EC-269 (53.2%), SI-983 x SI-1147(38.5%), SI-205-61 x SI-1147(28.5%) and SI-205-1 x EC-269 (22.4%). Among thes crosses, TKG-22 x SI-205-1 also exhibited significant and desirable heterosis for plant height (cm). Likewise, hybrid RMT-187 x SI-205-1 also exhibited significant and desirable heterosis for plant height (cm) and number of capsule per plant The heterotic response over the standard check in sesame were also reported by Krishnaiah *et al.* (2003) [8], Dikshit and Swain (2000) [5] and Dusane *et al*. (2002) [6].

The hybrids exhibited heterobeltiosis and economic heterosis for mean seed yield/plant (g), oil content (%) and other characters were found to be most promising for mean seed yield/plant (g), oil content (%) and other desirable traits, hence could be further evaluated to exploit the heterosis or utilized in future breeding programme to obtain desirable segregants for the development of superior genotypes. The present study reveals ample variability among the parents and high scope for the exploitation of heterosis for advancement of mean seed yield/plant (g) and oil content (%) in sesame.

The crosses exhibited highly significant positive heterosis over mid parent were TKG-22 x SI-205-61(118.9%), TKG-22 x RMT-187(109.8%), SI-205-1 x EC-269 (95.6%), ES-230 x SI-205-61(86.2%), ES-230 x SI-205-61(75.8%), SI-1147 x EC-269 (63.2%), RMT-187 x SI-205-61(55.2%), SI-983 x SI-1147(42.5%), beter parent were TKG-22 x RMT-187(21.8%), RMT-187 x SI-205-61(108.2%), ES-230 x SI-983(98.9%), ES-230 x SI-205-61(82.9%), SI-983 x SI-205-61(75.4%), TKG-22 x SI-205-1(63.5%), RMT-187 x SI-205-61(46.2%), TKG-22 x RMT-187(31.8%), RMT-187 x SI-1147(28.6%) and over standerd check TKG-22 were TKG-22 x SI-205-1(65.3%), RMT-187 x SI-205-1(86.8%), TKG-22 x SI-983(78.9%), RMT-187 x SI-1147(62.6%), SI-205-1 x EC-269 (53.2,%), SI-983 x SI-1147(38.5%), SI-205-61 x SI-1147(28.5%), SI-205-1 x EC-269 (22.4%). These crosses were recognized as the best heterotic crosses for mean seed yield/plant (g), oil content (%) and these crosses can be further evaluated and used in hybrid breeding programme to boost up the sesame yield.

Table 1: The best significant hybrids for different traits with respect to heterosis over mid parent, better parent and check variety

Characters	Heterosis over MP	Heterosis over BP	Heterosis over SC
Plant height (cm)	TKG-22 x ES-230 (-16.8%)	ES-230 x RMT-187 (-12.3%)	RMT-187 x SI-983 (-11.32%)
	SI-983 x SI-205-61 (-12.6%)	SI-205-1 x SI-205-61(-11.6%)	RMT-187 x SI-205-1(-9.68%)
	TKG-22 x SI-983(-12.8)	ES-230 x SI-205-1(-10.8%)	SI-205-1 x EC-269 (-8.69%)
	SI-983 x SI-1147 (-10.8)	RMT-187 x SI-1147(-8.2%)	RMT-187 x SI-1147 (-7.21%)
	TKG-22 x SI-1147(-11.6%)	RMT-187 x EC-269 (-10.5%)	RMT-187 x EC-269 (-8.23%)
	TKG-22 x EC-269 (-10.6%)	ES-230 x TKG-22 (-9.23%)	TKG-22 x SI-205-1(-8.69%)
Number of branches per plant	SI-983 x SI-205-1 (44.8%)	RMT-187 x SI-205-61(36.2%)	SI-205-61 x SI-1147(40.6%)
	SI-983 x SI-205-61 (35.2%)	SI-205-1 x SI-1147(34.7%)	SI-205-61 x EC-269 (30.2%)
	SI-983 x SI-1147 (33.8%)	SI-205-1 x EC-269(32.4%)	SI-1147 x EC-269 (28.3%)
	SI-983 x EC-269 (31.5%)	TKG-22 x SI-205-61(28.4%)	ES-230 x SI-1147(18.2%)
	ES-230 x SI-205-1(30.4%)	SI-205-1 x SI-205-61(43.5%)	ES-230 x SI-205-61(20.3%)
	RMT-187 x SI-205-61(28.9%)	TKG-22 x SI-205-1(24.8%)	RMT-187 x SI-205-61(18.3%)
Number of capsule per plant	TKG-22 x SI-205-1 (68.3%)	RMT-187 x SI-205-61(56.2%)	RMT-187 x SI-205-1(48.3%)
	RMT-187 x SI-1147(56.3%)	TKG-22 x SI-205-61(39.3%)	RMT-187 x SI-205-61(34.5%)
	TKG-22 x SI-1147(50.3%)	ES-230 x SI-205-1(31.7%)	ES-230 x SI-983(28.9%)
	RMT-187 x SI-205-61(36.2%)	RMT-187 x SI-205-61(30.4%)	TKG-22 x SI-205-61(28.3%)
	TKG-22 x SI-983(18.3%)	SI-205-1 x EC-269 (12.9%)	SI-205-1 x EC-269 (10.5%)
Capsule length (cm)	ES-230 x SI-205-1(18.9%)	RMT-187 x SI-205-1(16.4%)	SI-983 x SI-205-61(12.3%)
	ES-230 x SI-205-61(15.2%)	ES-230 x SI-205-1(13.9%)	TKG-22 x SI-1147(10.3%)
	RMT-187 x SI-205-61(13.5%)	RMT-187 x SI-1147(10.9%)	ES-230 x SI-1147(9.3%)
	SI-205-1 xSI-205-61(10.8%)	ES-230 x SI-1147(9.2%)	RMT-187 x SI-205-61(7.3%)
	ES-230 x SI-1147(9.8%)	SI-205-1 x EC-269 (6.3%)	SI-205-1 x EC-269 (5.6%)
Number of seed per capsule	SI-983 x SI-205-61(35.6%)	ES-230 x SI-205-1(32.4%)	RMT-187 x SI-205-61(28.6%)
	SI-983 x SI-1147(32.4%)	SI-205-1 x EC-269 (28.6%)	SI-205-1 x SI-1147(27.3%)
	RMT-187 x SI-205-61(30.4%)	SI-983 x SI-205-61(24.6%)	RMT-187 x SI-205-61(20.6%)
	SI-1147 x EC-269(12.6%)	RMT-187 x SI-205-61(10.4%)	SI-205-1 x EC-269 (8.3%)
	TKG-22 x SI-205-61(9.3%)	SI-205-1 x SI-205-61(8.3%)	ES-230 x SI-1147(6.5%)
	SI-205-1 x EC-269 (8.3%)	ES-230 x EC-269 (7.3%)	TKG-22 x ES-230(5.6%)
Days to flowering (50%)	TKG-22 x SI-205-61(-17.8%)	ES-230 x SI-1147(-14.5%)	ES-230 x SI-1147(-10.4%)
	SI-983 x SI-205-1(-12.5%)	SI-205-1 xSI-205-61(-11.2%)	SI-205-61 x SI-1147(-9.8%)
	ES-230 x SI-1147(-10.2%)	SI-205-1 x SI-1147(-9.2%)	SI-205-61 x EC-269 (-7.5%)
	SI-983 x SI-1147(-8.2%)	SI-205-1 x EC-269 (-7.2%)	SI-1147 x EC-269 (-5.1%)
	SI-983 x EC-269 (-7.6%)	TKG-22 x SI-205-61(-4.6%)	RMT-187 x SI-205-61(-3.2%)
	SI-205-1 x EC-269 (-5.6%)	-	SI-983 x SI-205-61(-3.2%)
Days to maturity	TKG-22 x SI-205-61(-20.7%)	RMT-187 x SI-205-61(-16.2%)	TKG-22 x RMT-187(-12.4%)
	ES-230 x SI-1147(-18.9%)	SI-205-1 x SI-1147(-14.2%)	ES-230 x SI-1147(-10.2%)
	SI-983 x SI-205-1(-14.2%)	SI-205-1 x SI-205-61(-12.3%)	SI-205-61 x SI-1147(-9.2%)
	SI-983 x SI-1147(-10.8%)	SI-205-1 x EC-269 (-9.2%)	SI-1147 x EC-269 (-7.8%)
	SI-983 x EC-269 (-9.2%)	TKG-22 x SI-205-61(-8.1%)	RMT-187 x SI-205-61(-6.7%)
Oil content (%)	SI-983 x SI-205-61(55.4%)	TKG-22 x RMT-187(89.8%)	ES-230 x SI-205-61(55.8%)
	RMT-187 x SI-205-1(66.8%)	SI-1147 x EC-269 (43.2%)	SI-205-1 x EC-269 (35.6%)
	RMT-187 x SI-205-61(26.2%)	ES-230 x SI-205-61(62.9%)	TKG-22 x SI-983(48.9%)
	ES-230 x SI-205-61(66.2%)	RMT-187 x SI-1147(42.6%)	RMT-187 x SI-205-61(35.2%)
	ES-230 x SI-983(78.9%)	TKG-22 x SI-205-1(43.5%)	RMT-187 x SI-1147(28.7%)
	SI-205-1 x EC-269 (33.2%)	SI-983 x SI-1147(22.5%)	SI-983 x SI-1147(18.5%)
	SI-205-1 x EC-269 (12.4%)	TKG-22 x RMT-187(21.8%)	SI-205-61 x SI-1147(12.5%)
Mean seed yield/plant (g)	TKG-22 x SI-205-61(118.9%)	RMT-187 x SI-205-61(108.2%)	TKG-22 x SI-205-1(65.3%)
	TKG-22 x RMT-187(109.8%)	ES-230 x SI-983(98.9%)	RMT-187 x SI-205-1(86.8%)
	SI-205-1 x EC-269 (95.6%)	ES-230 x SI-205-61(82.9%)	TKG-22 x SI-983(78.9%)
	ES-230 x SI-205-61(86.2%)	SI-983 x SI-205-61(75.4%)	RMT-187 x SI-1147(62.6%)
	ES-230 x SI-205-61(75.8%)	TKG-22 x SI-205-1(63.5%)	SI-205-1 x EC-269 (53.2%)
	SI-1147 x EC-269 (63.2%)	RMT-187 x SI-205-61(46.2%)	SI-983 x SI-1147(38.5%)
	RMT-187 x SI-205-61(55.2%)	TKG-22 x RMT-187(31.8%)	SI-205-61 x SI-1147(28.5%)
	SI-983 x SI-1147(42.5%)	RMT-187 x SI-1147(28.6%)	SI-205-1 x EC-269 (22.4%)

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