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

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Abstract
A study was conducted in sesame to assess the extent of heterosis for fourteen quantitative traits including seed yield per plant. Two lines and ten testers were crossed in a line x tester fashion to develop 20 F_1 hybrids. The analysis of variance revealed that highly significant differences among hybrids for all characters except length of capsule, weight of capsule and oil content and significant differences among parents for all characters except for days to 50% flowering, days to maturity, plant height, height to first capsule and number of capsules per leaf axil, indicating the presence of sufficient amount of genetic diversity for these traits. Heterosis was worked-out over better parent and standard variety, GJT-5. The standard heterosis for seed yield per plant ranged from -35.34 to 17.71 %. The cross G.Til-3 x DS 21 were good heterotic combinations for seed yield per plant, which recorded 17.71 % standard heterosis and 25.69% heterobeltiosis respectively. The heterosis for seed yield per plant was associated with the heterosis expressed by its component characters.

Keywords: Sesame, heterobeltiosis, standard heterosis

Introduction
Sesame (*Sesamum indicum* L.) is one of the most ancient and important oilseed crops. It is called as the "Queen of Oilseeds" because of its excellent qualities of the seed, oil and meal. Its seed contains 50 % oil and 25 % protein. It is sixth most important oilseed crop in India and has 18.40 lakh ha area with 6.23 lakh tones production and productivity of 338 kg/ha. The yield improvement achieved through conventional hybridization followed by selection has been only marginal. Although sesame is largely a self-pollinated crop, high level of heterosis for yield and its components has been reported by Fateh *et al*. (1995) [3], Padmavathi (1998) [7], Jadhav and Mohrir (2013) [4] and chaudhari *et al*. (2017) [3]. But, Commercial exploitation of heterosis is feasible only if the means of producing hybrid seeds economically viable. It is possible in sesame because indeterminate plant with epipetalous nature of the flower facilitating easy emasculation, low seed rate, high seed multiplication ratio, natural out crossing, frequent visit by a large number of insects including honey bees and higher number of seeds set in a single pollination. In an often cross-pollinated crop like sesame there is a good scope for exploitation of heterosis because out crossing reached up to 68% which indicates the potentiality of the crop for improvement in yields. Further, with convincing reports on availability of heterosis and possibility of commercial hybrids, generation of cytoplasmic male sterility system in sesame using the possible wild donors can enable the production of hybrids. The sesame plant has distinct features favourable for hybrid seed production. Heterosis of small amount for individual yield contributing characters may have an additive or synergistic effect on the end product (Sasikumar and Sardana, 1990) [8]. Therefore, the present study was undertaken to study the extent of heterosis for quantitative traits in sesame.

Material and Methods
The present study on sesame was conducted at Cotton Research Station, Junagadh Agricultural University, Junagadh, Gujarat. Two diverse lines *viz*., G. Til -2, G.Til -3 and ten testers *viz*., DS 10, DS 21, RT 127, RMT 166, RT 346, HT 2, JLS 408-2, RMT 186, RMT 175 and NIC 17274 were crossed in a line x tester design during *summer* 2016 to produce 20 hybrids. The resulting 20 hybrids along with 12 parents and a check variety, GJT-5 were evaluated during *summer* 2017 in a Randomized Block Design with three replications. Each plot with a spacing of 30 x 10 cm^2. All need based agronomic practices were followed during the crop growth period to raise a good crop. Observations were recorded on randomly selected five plants in each entry for 14 quantitative traits including seed yield per plant for each replication. The mean values were used for the analysis of variance for experimental design. The estimation of heterosis over better parent and standard check was carried-out as per the standard procedure.

Results and Discussion

Analysis of variance (Table 1) revealed that genotypes found significant for all the characters except weight of capsule which was showed only significant differences. Differences among hybrids were also found highly significant for all characters except length of capsule, weight of capsule and oil content. Differences among parents were also found significant for all characters except for days to 50% flowering, days to maturity, plant height, height to first capsule and number of capsules per leaf axil. This indicated that with exception of few traits heterosis could be exploited for most of the traits.

The details on range of heterobeltiosis and standard heterosis as well as number of hybrids having significant heterosis are presented in Table 2. The maximum range of heterobeltiosis and standard heterosis were observed for seed yield per plant, 1000-seed weight, number of capsules per leaf axil, number of capsules per plant and number of branches per plant. Days to 50% flowering, days to maturity and oil content showed minimum range of heterobeltiosis and standard heterosis. The extent of standard heterosis for days to 50 % flowering varied from -5.22 to 1.74% where eight crosses exceeded the standard parent in desirable direction. In case of days to maturity extent of standard heterosis varied from 0.32 to 3.82% where none of the crosses exceeded the standard heterosis in desirable direction.

The characters contributing towards vegetative growth such as plant height and number of branches per plant exhibited heterosis upto 24.12 and 45.45% respectively. The results are in concurrence with the findings of chaudhari *et al.* (2017) [2]. A desirable degree of vegetative growth is essential for realizing high yield as total dry matter production is one of the components deciding high seed yield in crop plants. Out of 20 crosses, 2, 2 and 15 crosses showed significant positive standard heterosis for the characters length of capsule, weight of capsule and number of capsules per leaf axil, in which heterosis ranged from -6.40 to 33.54, -3.91 to 20.44 and -34.29 to 17.14% respectively. Similar results have been reported by chaudhari *et al.* (2017) [2]. A total of 15 hybrids for number of capsules per plant, 3 hybrids for number of seeds per capsule, 16 hybrids for 1000-seed weight, and 7 hybrids for oil content showed significant positive standard heterosis. Similar results have been reported for this characters by jatothu *et al.* (2013) [5] and chaudhari *et al.* (2017) [2].

The crosses which showed high heterosis for seed yield per plant also had high heterosis for plant height, number of branches per plant, weight of capsule, number of capsules per plant, number of seeds per capsule and 1000-seed weight. 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 Singh *et al.* (2005) [9], Thiyagu *et al.* (2007) [10], Khan *et al.* (2009) [6] and Banerjee and Kole, (2010) [1] and Tripathy *et al.* (2016). The negative heterosis was observed in some of the crosses may be attributed to non-allelic interaction with the large number of decreasing alleles. The cross G.Til-3 x DS 21 showed desirable standard heterosis for seed yield per plant along with other trait *viz.*, plant height, weight of capsule, number of capsules per plant, number of seeds per capsule and 1000-seed weight and cross G.Til-3 x RT 127 also Showed significant heterosis for seed yield per plant and 1000-seed weight. These two crosses showed good in heterosis so it can be used further for hybridization programme.

Table 1: Analysis of variance for experimental design for different 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	3.13*	3.63	41.73*	4.75*	1.6**	2.10*	0.23*
Genotypes	31	1.94**	3.40**	37.41**	3.46**	0.19**	3.98**	0.16**
Parents	11	0.81	2.08	9.38	2.21	0.17**	2.49**	0.22**
Hybrids	19	2.29**	4.31**	40.08**	4.34**	0.20**	4.75**	0.14
P. vs H.	1	7.80**	0.36	294.91**	0.39	0.03	6.40**	0.006
Error	62	0.65	1.19	12.24	1.37	0.06	0.66	0.06

Source	d. f.	Weight of capsule (g)	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	1.46*	13.45*	0.20	106.90**	0.27**	10.08	0.18*
Genotypes	31	0.72*	50.84**	0.25**	49.31**	0.77**	26.95**	0.10**
Parents	11	0.94*	7.44*	0.09	39.41**	0.54**	22.70**	0.14**
Hybrids	19	0.56	37.60**	0.33**	29.05**	0.82**	20.74**	0.07
P. vs H.	1	1.43	779.76**	0.52**	543.144**	2.37**	191.50**	0.22*
Error	62	0.38	3.66	0.06	12.91	0.04	3.20	0.04

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

Table 2: Range of heterobeltiosis (H_1) and standard heterosis (H_2) as well as number of crosses with specific heterotic effects for various traits in sesame

S. No.	Characters	Range of heterosis (%)						Number of crosses with significant heterosis			
		Heterobeltiosis (H_1) (%)			Standard heterosis (H_2) (%)			H_1 (%)		H_2 (%)	
								+Ve	-Ve	+Ve	-Ve
1	Days to 50% flowering	-0.91	to	7.41	-5.22	to	1.74	12	0	0	8
2	Days to maturity	-1.56	to	2.84	0.32	to	3.82	5	0	14	0
3	Plant height (cm)	-5.47	to	20.89	1.34	to	24.12	4	0	6	0
4	Height to first capsule (cm)	-7.48	to	17.53	-6.25	to	16.47	2	0	2	0
5	Number of branches per plant	-37.70	to	47.62	-15.91	to	45.45	2	1	3	0
6	Number of internodes per plant	-38.71	to	6.45	-44.44	to	-4.68	0	14	0	17
7	Length of capsule (cm)	-23.82	to	8.68	-6.40	to	33.54	0	1	2	0
8	Weight of capsule (g)	-19.59	to	21.51	-3.91	to	20.44	1	2	2	0
9	Number of capsules per plant	-12.85	to	44.90	-2.38	to	42.18	14	1	15	0
10	Number of capsules per leaf axil	-20.00	to	46.43	-34.29	to	17.14	2	0	0	15
11	Number of seeds per capsule	-3.55	to	18.69	-6.27	to	15.35	2	0	3	0
12	1000-seed weight (g)	-21.11	to	39.73	-2.75	to	49.44	8	3	16	0
13	Seed yield per plant (g)	-30.95	to	25.69	-35.34	to	17.71	2	3	1	5
14	Oil content (%)	-1.24	to	1.08	0.00	to	1.50	1	4	7	02

+ve = Positive and -ve = Negative

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

S. No.	Crosses	Seed yield per plant (g)	Plant height (cm)	Number of branches per plant	Number of internodes per plant	Length of capsule (cm)	Weight of capsule (g)	Number of capsules per plant	Number of seeds per capsule	1000seed weight (g)	*Per se* seed yield per plant (g)
1	G.Til 3 × DS 21	25.69**	20.89**	14.29	6.45	-11.41	21.51*	38.28**	18.69**	6.84*	20.87
2	G.Til 3 × RT 127	23.56**	4.02	-1.82	-20.65**	-15.26	-3.14	1.30	1.75	30.89**	20.52
3	G.Til 3 × RT 346	12.48	3.73	-37.70**	2.58	-9.93	-19.59*	39.34**	6.67	-5.86	18.68
4	G.Til 2 × DS 10	5.70	1.24	-3.57	-9.68**	-3.87	-12.18	3.68	9.34*	14.43**	19.05

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