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Study of *Per Se* Performance and Heterosis for Seed Yield and Component Traits In Sesame (*Sesamum indicum* L.)

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Abstract

The phenomenon of heterosis has provided the most important genetic tools in improving yield of crop plants. Identification of specific parental combination capable of producing the highest level of heterotic effects in F_1 has immense value for commercial exploitation of heterosis. The experimental material consisted of eight parents (including check G.TIL 4) and their 28 half-diallel crosses. The analysis of variance revealed highly significant differences due to genotypes for all the traits. On the basis of mean values, the parents G.TIL 10, G.TIL 4 and SKT 1607 recorded maximum seed yield per plant. G.TIL 10 was top ranking for number of effective branches per plant. This parental genotype also expressed good performance for various yield components, *viz.,* number of seed per capsule, harvest index (%) and oil content (%).The parent SKT 1608 found better for earliness, dwarfness and 1000 seed weight (g). While in case of hybrids, SKT 1608 × SKT 12-2, SKT 1608 × G.TIL 2 and SKT 1607 × G.TIL 2 were the best for seed yield per plant. Among the 28 F1 hybrids, SKT 1608 × SKT 12-2 and SKT 1608 × G.TIL 2 manifested significant positive heterosis for seed yield per plant over better parent and standard check (G.TIL 4) These two crosses also exhibited either of the significant positive heterosis for various component traits *viz.,* plant height (cm), capsule length (cm), number of seed per capsule, harvest index (%), 1000 seed weight (g), oil content (%) and leaf area per plant (cm^2).

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Introduction

Sesame (*Sesamum indicum* L.; 2n = 2x = 26) globally known as 'sesame', in India it is commonly known as 'Til' belongs to order Lamiales and family Pedaliaceae. A total 36 species have been identified in the genus, of which 22 species are from Africa, five from Asia, seven from both Africa and Asia and one species each from Crete and Brazil. There are three cytogenetic groups of which 2n = 26 consist of the cultivated *S. indicum* along with *S. alatum*, *S. capense, S. schenckii, S. malabaricum*; 2n = 32 consist of *S. prostrate, S. laciniatum, S. angolense, S. angustifolium*; while *S. radiatum, S. occidentale* and *S. schinzianum* belong to 2n = 64 group.[1] Among the cultivated group of species, the *S. indicum* is widely cultivated at globally. It is one of the oldest and most important traditional oilseed crops of the world. Sesame is called as the "Queen of oilseeds". Sesame seeds have nutritional as well as medicinal value due to rich in protein, carbohydrate, fat, fiber, vitamins E, A and B complex and minerals *viz*., calcium, phosphorus, iron, copper, magnesium, zinc and potassium with high-unsaturated fatty acid (linolenic and tochopherol). Sesame is an important source of high quality oil and protein.[2] The seeds are chemically composed of about 40-52 per cent oil, 20-27 per cent protein, 6-7 per cent moisture, 16 per cent carbohydrate and 6-8 per cent crude fiber. The oil consist of glycerides and fatty acid constituents chiefly oleic (40-48%), linolenic (30-45%), palmitic (8-10%) and stearic (4-8%). amino acids *viz*., argenine (12.5%), histidine (2.1%), lysine (2.9%), phenylalanine (6.2%), methionine (3.3%), leucine (8.9%), isolencine (3.9%), valine (3.5%) and threonine (3.6%) are commonly found in the sesame seed. In India, sesame is one of the most important oil seed crops grown after groundnut, rapeseed and mustard. It is cultivated in an area of 13.98 lakh hectares in India with an annual production of 4.18 lakh tonnes and productivity of 291 kg ha^{-1}, While in Gujarat an estimated area is 1.09 lakh ha with annual production of 0.78 lakh tonnes and productivity of 723 kg/ha.[3]

Heterosis breeding has been a potential method of increasing yield in most of the cross as well as self fertilizing crops. Heterosis study provides information about probable gene action and helps in sorting out desirable genotypes. Hybridization in sesame for creation of variability has been recognized as a practical tool for improving yield and other important traits. For developing promising varieties through hybridization, a careful choice of parents and breeding methodology are a matter of great concern to the plant breeder.

Material and Methods

The experimental material comprised of eight parents (including check G.TIL 4) and their 28 half-diallel crosses. The 8 × 7 half diallel crosses were made during *kharif*-2017 at Castor-Mustard Research Station, S. D. Agricultural University, Sardarkrushinagar by manual crossing. The seeds of parental lines were maintained through selfing. A set of 36 genotypes comprising of eight parents (including check G.TIL 4) and their 28 F_1 hybrids were sown in Randomized Block Design (RBD) with three replications, during *kharif*-2018. Each entry was sown in two rows of 3.0 m in length 45 × 15 cm spacing. The recommended agronomical practices and plant protection measures were adopted for raising a good crop. The observations were recorded both as visual assessment (days to flowering and days to maturity) and measurement on randomly selected five competitive individual plants (plant height, number of effective branch per plant, number of capsule per plant, capsule length, number of seed per capsule, 1000 seed weight, seed yield per plant, harvest index (%) and oil content (%). The replication wise mean values of each entry for the twelve traits were analyzed according to Randomized Block Design (RBD) 4 and estimation of heterobeltiosis[5] and economic heterosis.[6] The replicated mean data were analyzed statistically using the software WINDOSTAT version 8.1.

Results and Discussion

The analysis of variance from the mean data (Table 1) revealed highly significant differences due to genotypes for all the traits. This suggest that parents and their hybrids under study possessed a sufficiently high amount of genetic variability. Further, partitioning of mean sum of square due to genotypes implied that the differences among parents were significant for all the traits excluding harvest index (%). The significant differences among parents showed greater diversity in the parental lines. In case of hybrids, significant differences were found for all the traits except days to maturity indicating varying performance of cross combinations. Mean sum of

squares due to parents Vs hybrids were significant for all the traits exclusive of days to maturity, number of capsule per plant and seed yield per plant (g), which explained sufficient amount of heterosis was reflected in crosses for many of the yield attributing traits.

Table 1: Analysis of variance (mean sum of square) for the experimental design of twelve traits in sesame

Sources of variation	d.f.	Days to flowering	Days to maturity	Plant height	Number of effective branch per plant	Number of capsule per plant	Capsule length	Number of seed per capsule	1000 seed weight	Seed yield per plant	Harvest index	oil content
Replications	2	0.56	1.44	143.59	0.56	37.39	0.03*	2.06	0.00	5.90	9.41	0.05
Genotypes	35	14.28**	3.99**	246.26**	0.95**	223.06**	0.10**	165.19**	0.42**	17.59**	25.11**	32.43**
Parents	7	26.99**	11.23**	343.21**	1.31**	290.68**	0.23**	234.32**	0.48**	8.35*	3.02	63.09**
Hybrids	27	8.11**	2.18	221.54**	0.78**	211.20**	0.07**	147.38**	0.39**	20.38**	31.15**	24.62**
Parents Vs Hybrids	1	92.02**	2.15	234.93*	2.97**	70.03	0.13**	162.00**	0.68**	7.08	16.74*	28.45**
Error	**70**	**1.74**	**1.59**	**57.24**	**0.25**	**53.13**	**0.01**	0.80	0.00	3.06	3.69	0.26

*** P ≤ 0.05, ** P ≤ 0.01t**

The mean performance of parents revealed that the parent G.TIL 10 was top ranking for seed yield per plant (g) and the number of effective branch per plant. This parental genotype also expressed good performance for various yield components, *viz*., number of seed per capsule, harvest index (%) and oil content (%). The parent SKT 1608 was found better for earliness, dwarfness and 1000 seed weight (g) (Table 2). The mean performance of hybrids disclosed that none of the hybrids were found superior for all the traits. The hybrid SKT 1608 × SKT 12-2, SKT 1608 × G.TIL 2 and SKT 1607 × G.TIL 2 recorded maximum seed yield per plant. (Table 2).

Table 2: Mean performance of the parents and their F_1 hybrids for twelve traits in sesame for various traits

Sr. No.	Parents/hybrids	Days to flowering	Days to maturity	Plant height (cm)	Number of effective branch per plant	Number of capsule per plant	Capsule ength (cm)
Parent:							
1.	SKT 1602	46.33	92.67	110.67	3.07	36.53	3.39
2.	SKT 1604	45.67	90.67	111.00	3.33	46.73	2.88
3.	SKT 1607	48.00	93.33	137.67	4.20	57.67	2.71
4.	SKT 1608	42.67	90.00	111.33	3.53	56.53	2.58
5.	SKT 12-2	48.33	93.67	121.33	4.27	67.27	2.91
6.	G.TIL 2	44.67	91.33	110.33	4.33	65.07	2.64
7.	G.TIL 4	43.00	90.00	112.67	3.13	52.47	3.17
8.	G.TIL 10	51.67	95.33	131.00	4.87	53.00	2.80
	Parental mean	**46.29**	**92.13**	**118.25**	**3.84**	**54.41**	**2.88**
Hybrids:							
9.	SKT 1602 × SKT 1604	45.33	91.33	117.67	2.93	42.40	3.11
10.	SKT 1602 × SKT 1607	44.00	92.00	104.67	3.00	34.13	3.12
11.	SKT 1602 × SKT 1608	42.33	92.33	106.00	3.13	63.53	3.24
12.	SKT 1602 × SKT 12-2	45.00	93.00	117.00	3.20	45.73	3.01
13.	SKT 1602 × G.TIL 2	44.00	91.67	113.33	2.87	44.27	2.80
14.	SKT 1602 × G.TIL 4	42.67	91.33	115.00	3.20	47.93	3.20
15.	SKT 1602 × G.TIL 10	44.33	92.67	129.00	4.27	56.60	3.05
16.	SKT 1604 × SKT 1607	43.67	91.00	117.67	4.20	64.07	2.99
17.	SKT 1604 × SKT 1608	42.67	92.00	125.33	3.53	56.47	2.95
18.	SKT 1604 × SKT 12-2	45.00	92.67	127.33	2.73	35.40	3.06
19.	SKT 1604 × G.TIL 2	44.33	91.33	119.33	3.00	44.47	3.05
20.	SKT 1604 × G.TIL 4	46.00	93.00	121.33	3.20	57.93	2.89
21.	SKT 1604 × G.TIL 10	48.00	92.67	137.67	4.20	67.07	2.59
22.	SKT 1607 × SKT 1608	41.67	92.67	123.00	3.40	53.07	2.99
23.	SKT 1607 × SKT 12-2	43.00	92.00	119.67	2.73	41.67	2.82
24.	SKT 1607 × G.TIL 2	42.33	92.00	132.67	3.47	57.73	3.02
25.	SKT 1607 × G.TIL 4	44.33	93.00	138.67	2.93	54.07	3.17
26.	SKT 1607 × G.TIL 10	45.67	93.00	123.33	3.60	56.40	2.82
27.	SKT 1608 × SKT 12-2	43.00	92.33	118.00	4.20	60.27	3.13
28.	SKT 1608 × G.TIL 2	41.67	91.33	123.33	3.93	57.07	2.94

29.	SKT 1608 × G.TIL 4	42.67	92.00	112.33	3.47	49.47	2.87
30.	SKT 1608 × G.TIL 10	43.00	92.67	118.67	3.67	56.60	2.87
31.	SKT 12-2 × G.TIL 2	46.00	94.00	121.33	2.93	45.27	2.90
32.	SKT 12-2 × G.TIL 4	45.33	93.33	115.33	3.47	50.47	2.89
33.	SKT 12-2 × G.TIL 10	47.33	94.33	134.67	4.47	57.40	2.91
34.	G.TIL 2 × G.TIL 4	44.00	93.00	118.33	3.07	53.27	3.03
35.	G.TIL 2 × G.TIL 10	42.00	92.33	125.00	3.67	54.80	2.92
36.	G.TIL 4 × G.TIL 10	44.67	94.00	134.67	3.93	61.67	2.72
	Hybrid mean	**44.07**	**92.46**	**121.80**	**3.44**	**52.47**	**2.97**
	General mean	**44.56**	**92.38**	**121.00**	**3.53**	**52.90**	**2.95**
	Range	**41.67 to 51.67**	**90.00 to 95.33**	**104.67 to 138.67**	**2.73 to 4.87**	**34.13 to 67.27**	**2.58 to 3.39**
	S.Em±	0.76	0.73	4.37	0.29	4.21	0.05
	CD at 5%	2.15	2.05	12.32	0.81	11.87	0.15
	CV %	2.96	1.36	6.25	14.03	13.78	3.11

Sr. No.	**Parents/hybrids**	**Number of seed per capsule**	**1000 seed weight (g)**	**Seed yield per plant (g)**	**Harvest index (%)**	**Oil Content (%)**
Parent:						
1.	SKT 1602	63.58	4.70	12.25	21.49	40.35
2.	SKT 1604	79.29	3.86	15.33	21.09	43.16
3.	SKT 1607	72.12	3.71	15.41	21.98	37.01
4.	SKT 1608	60.40	3.53	12.04	20.10	39.59
5.	SKT 12-2	51.82	4.16	14.80	21.22	47.30
6.	G.TIL 2	69.77	3.85	15.66	20.98	42.64
7.	G.TIL 4	70.08	3.54	13.03	23.57	39.11
8.	G.TIL 10	75.49	3.59	16.35	21.68	31.81
	Parental mean	**67.82**	**3.87**	**14.36**	**21.51**	**40.12**
Hybrids:						
9.	SKT 1602 × SKT 1604	71.93	4.59	13.99	20.57	42.69
10.	SKT 1602 × SKT 1607	69.44	4.56	11.15	17.27	40.32
11.	SKT 1602 × SKT 1608	81.47	4.51	16.31	21.14	38.08
12.	SKT 1602 × SKT 12-2	63.51	3.75	11.84	19.72	37.25
13.	SKT 1602 × G.TIL 2	87.76	3.65	14.41	23.02	41.80
14.	SKT 1602 × G.TIL 4	60.42	4.10	11.90	20.84	42.89
15.	SKT 1602 × G.TIL 10	70.49	3.99	16.76	23.41	44.84
16.	SKT 1604 × SKT 1607	62.79	4.00	17.93	21.14	45.98
17.	SKT 1604 × SKT 1608	68.98	4.14	16.09	25.65	39.05
18.	SKT 1604 × SKT 12-2	81.61	3.97	11.79	21.34	40.49
19.	SKT 1604 × G.TIL 2	65.83	3.74	10.93	19.30	45.06
20.	SKT 1604 × G.TIL 4	71.35	3.73	14.55	20.90	41.03
21.	SKT 1604 × G.TIL 10	75.92	3.52	17.90	26.05	41.48
22.	SKT 1607 × SKT 1608	71.56	4.19	15.90	26.10	43.32
23.	SKT 1607 × SKT 12-2	60.53	4.36	10.11	13.17	38.66

24.	SKT 1607 × G.TIL 2	68.95	4.53	18.03	24.83	37.27
25.	SKT 1607 × G.TIL 4	78.38	4.48	17.81	21.10	36.40
26.	SKT 1607 × G.TIL 10	69.82	3.83	15.10	23.55	43.16
27.	SKT 1608 × SKT 12-2	69.51	4.74	20.54	26.83	41.34
28.	SKT 1608 × G.TIL 2	77.71	4.31	19.11	27.61	42.27
29.	SKT 1608 × G.TIL 4	58.88	4.53	13.88	18.55	40.10
30.	SKT 1608 × G.TIL 10	75.06	3.59	15.26	23.29	38.24
31.	SKT 12-2 × G.TIL 2	76.08	3.75	14.53	23.19	43.64
32.	SKT 12-2 × G.TIL 4	63.28	4.03	13.73	22.87	38.23
33.	SKT 12-2 × G.TIL 10	76.15	3.63	15.88	22.91	46.10
34.	G.TIL 2 × G.TIL 4	69.33	3.88	14.31	25.85	40.67
35.	G.TIL 2 × G.TIL 10	65.24	3.75	13.41	22.21	46.75
36.	G.TIL 4 × G.TIL 10	69.49	3.76	16.11	26.47	40.88
	Hybrid mean	**70.77**	**4.06**	**14.97**	**22.46**	**41.36**
	General mean	**70.11**	**4.01**	**14.84**	**22.25**	**41.08**
	Range	**51.82 to 87.76**	**3.52 to 4.74**	**10.11 to 20.54**	**13.17 to 27.61**	**31.81 to 47.30**
	S.Em±	0.52	0.02	1.01	1.11	0.29
	CD at 5%	1.46	0.05	2.85	3.13	0.83
	CV %	1.27	0.74	11.78	8.63	1.24

Table 3: Number of hybrids having significant heterotic effect in sesame for various traits

Traits	Over better parent				Over standard check			
	+ve	-ve	Total	Range	+ve	-ve	Total	Range
Days to flowering	03	05	08	-10.42 to 6.98	07	00	07	-3.10 to 11.63
Days to maturity	10	00	10	-1.43 to 4.44	17	00	17	1.11 to 4.81
Plant height	10	00	10	-5.85 to 24.02	07	00	07	-7.10 to 23.08
Number of effective branch per plant to 42.55	00	14	14	-35.94 to 2.13	05	00	05	-12.77
Number of capsule per plant to 27.83	01	08	09	-47.37 to 26.54	01	02	03	-34.94
Capsule length	05	11	16	-17.32 to 11.70	00	17	17	-18.38 to 2.21
Number of seed per plant	07	16	23	-20.82 to 28.13	10	08	18	-15.98 to 25.23
1000 seed weight	11	15	26	-22.47 to 27.97	27	00	27	-0.66 to 33.90
Seed yield per plant	03	06	09	-34.39 to 38.76	10	00	10	-22.39 to 57.65
Harvest index	05	03	08	-40.07 to 31.64	02	05	07	-44.12 to 17.14
Oil content	08	15	23	-21.26 to 16.60	20	06	26	-6.94 to 19.53

The data furnished in Table 3 implied that out of 28 F_1 hybrids, 3 and 10 F_1 hybrids registered significant and positive heterosis over better parent and standard check (G.TIL 4) for seed yield per plant (g). The cross SKT 1608 × SKT 12-2 recorded top ranking heterosis over better parent (38.76%) and standard parent (57.65 %). The range of heterobeltiosis and standard heterosis varied

from -34.39 per cent (SKT 1607 × SKT 12-2) to 38.76 per cent (SKT 1608 × SKT 12-2) and -22.39 per cent (SKT 1607 × SKT 12-2) to 57.65 per cent(SKT 1608 × SKT 12-2), respectively. Previous workers also reported low to moderate estimates of heterobeltiosis and standard heterosis.[7,8,9,10,11,12,13,14,15,16,17 and18] A comparative study of best heterotic hybrids showed that for seed yield per plant (Table 4), F1 hybrids SKT 1608 × SKT 12-2 and SKT 1608 × G.TIL 2 manifested significant positive heterosis over both better parent and standard check or alone better or standard parent for various component traits *viz*., plant height (cm), capsule length, number of seed per capsule, harvest index, 1000 seed weight and oil content. The significant and desirable useful heterosis (Heterobeltiosis) and standard heterosis for components were also reported for different traits in sesame.[19, 20, 21, 22, 23,24,25,26 and 27]

Table 4: Comparision of top five heterotic crosses in sesame

Sr. No.	Hybrids	Heterosis over Standard parent	Heterosis over Better parent	Useful and significant heterobeltiosis/standard heterosis for components
1.	SKT 1608 × SKT 12-2	57.65** (20.54)	38.76**	NEB, CL, NSC, TEST, HI, OIL
2.	SKT 1608 × G.TIL 2	46.67**(19.11)	20.04**	PH, CL, NSC, TEST, HI, OIL
3.	SKT 1602 × SKT 1608	25.23**(16.31)	33.13**	NSC, TEST
4.	SKT 1607 × G.TIL 2	38.43**(18.03)	15.18	DAF, NEB, CL, TEST
5.	SKT 1604 × SKT 1607	37.62**(17.93)	16.33	NEB, TEST, OIL

Figure in the parentheses indicated mean performance for seed yield per plant.
*** P ≤ 0.05, ** P ≤ 0.01**

Where:

DAF	:	Days to flowering	PH	:	Plant height (cm)
NEB	:	Number of effective branch per plant	CL	:	Capsule length (cm)
NSC	:	Number of seed per capsule	TEST	:	1000 seed weight (g)
HI	:	Harvest index (%)	OIL	:	Oil content (%)

Conclusion

The F_1 hybrids SKT 1608 × SKT 12-2 and SKT 1608 × G.TIL 2 manifested significant and desirable heterosis for seed yield and other component traits over better parent and standard check (G.TIL 4). The hybrid SKT 1602 × SKT 1608 showed desirable heterosis for component traitslike number of seed per capsuleand 1000 seed weight; SKT 1607 × G.TIL 2 for days to flowering, number of effective branch per plant, capsule length and 1000 seed weight and SKT 1604 × SKT 1607 for number of effective branch per plant, 1000 seed weight and oil content. Heterosis and *Per Se* performance indicated that F1 hybrids SKT 1608 × SKT 12-2 and SKT 1608 × G.TIL 2 were found promising for commercial exploitation.

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Conflict of Interest

The authors do not have any conflict of interest.

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