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COMBINING ABILITY AND HETEROSIS IN SESAME UNDER UPPER EGYPT CONDITIONS

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ABSTRACT

The present investigation was carried out during summer 2017 and 2018 at El-Mattana Agricultural Research Station, Agricultural Research Center, Luxor, Egypt, to study combining ability and heterosis for yield and its components via line x tester analysis in sesame. Line × Tester mating design was applied using six lines and four testers and 24 F_1 crosses evaluated in three replications of randomized block design. Results indicated that genotypes and parents exhibited highly significant differences for all studied traits, except parents for number of capsule per plant indicating that variability did exist among all entries. Parental genotypes line 51 and line 43 were the best combiner for seed yield per plant and its attributes. Besides, parental cultivar sohag-1 was a good combiner for plant height, seed yield per plant and seed oil content. Results showed that mean squares due to both general (GCA) and specific (SCA) combining ability were highly significant for all characters, indicating the importance of both additive and non-additive gene effects in the inheritance of the studied traits. Results also suggested that several crosses exhibited significant positive heterosis relative to both mid and better parents for all studied traits. Generally, three crosses, namely line 51 x Line F10-25, line 51 x Sohag-1 and line 43 x Sohag-1 had significant positive SCA and exceeded their mid and better parents for seed yield per plant, number of capsule per plant and oil content. These crosses could be exploited for breeding program to improving this crop.

Key words: ***Combining ability, Heterosis, Sesame (Sesamum indicum L.).***

INTRODUCTION

Sesame (Sesamum indicum L.) is one of the most important oil seed crops grown in the tropical and sub-tropical regions. Sesame seeds contain 50-60% oil which has excellent stability due to the presence of natural antioxidants such as sesamolin, sesamin and sesamol. It has also super quality, nearly matching olive oil. Moreover, it also contains large levels of polyunsaturated fatty acids (Nzikou *et al* 2012). In Egypt, sesame is considered as a food crop rather than an oil seed crop because most of its seeds consumed directly, without oil extraction. Breeding works on sesame are, relatively, limited for increasing its yield in comparison to other crops. The total cultivated area in Egypt was 32,000 ha produced 45,000 tons (FAO 2016). Therefore, increasing seed yield is the main objective of sesame breeding programs. In order to increase the productivity of this crop, intensive efforts have been made by Egyptian breeders. Therefore, it is important to evaluate local and exotic germplasm aiming to improve seed yield.

Combining ability analysis aimed to understanding the nature and extent of types of gene action in the inheritance of yield and its components for obtaining better recombination. Attia *et al* (2004), Vidhyavati *et al* (2005), Gwade *et al* (2007), El-Shakhess and Khalifa (2007), Abd Elaziz *et* *al* (2010), Sedeck and Shafie (2013), Pawar and Monpara (2016), Priya *et al* (2016), Mungala *et al* (2017), and Abd -Elaziz and Ghareeb (2018) found that the non-additive type of gene action was predominant for plant height, number of branches per plant, length of fruiting zone, number of capsules per plant, seed yield per plant, 1000-seed weight and oil content. On the other hand, many researchers Manivannan and Ganesan, 2001, Banerjee and Kole, 2009, Abd Elaziz *et al* 2010, Sedeck and Shafie 2013 and Anyanga *et al* (2016) insured that the importance of additive and non-additive gene action for all the studied traits. But, the additive gene effects were greater than non-additive gene effects for plant height, length of fruiting zone, number of branches per plant, number of capsules per plant, 1000-seed weight, seed yield per plant and seed oil content.

Heterosis is considered as one of the most important tools that provide important information for improving seed yield and its components traits in sesame.

In the present investigation, attempts have been made using ten parents (sex lines, four testers) and 24 hybrids through line × tester analysis to bring out the best parents and cross combinations with good general and specific combining abilities for seed yield and its component characters.

MATERIALS AND METHODS

The experiments of the present study was carried out at El-Mattana Agricultural Research Station, in Luxor Governorate, Egypt, during two summer seasons (2017 and 2018) to study the inheritance of yield and its components in sesame. The materials used were six genotypes, used as lines {B4-2 (L1), M2A24 (L2), 66(L3), 56(L4), 43(L5), and 51(L6)} and four genotypes used as testers, viz., Shandaweel-3 (T1), Sohag - 1(T2), Line Zehre 18 (T3), and Line F10-25(T4) (Table1).

The six genotypes (lines) and the four tester were crossed (line x tester mating scheme) in summer of 2017. The seeds of the 24 F_1 crosses and their parents were grown in a randomized complete block design with three replications on 15th May in 2018. Each genotype was grown in a plot of 3 rows, 4 meter long and 50 cm width and 20 cm between hills. Plants were thinned to two plants/hill. The recommended cultural practices were adopted throughout the growing season. The following traits were measured on a random sample of ten guarded plants of each type in each plot, plant height, length of fruiting zone, number of branches/plant, number of capsules/plant, seed yield/plant, 1000-seed weight. Besides seed oil percentage was determined by using petroleum either (Bp 40-60°) as solvent in soxhalet apparatus according to the method of A.O.A.C 1980.

Table 1. The origin and main descriptions of the studied sesame genotypes.

No.	Genotype	Origin	Main description	
			No. of capsule/ leaf axel	Branching habit
1	Line B4-2	Egypt	Single	Branched
2	Line M2A24	Egypt	Three	Branched
3	Line 66	Egypt	Single	Branched
4	Line 56	Egypt	Single	Non branched
5	Line 43	Egypt	Single	Branched
6	Line 51	Egypt	Single	Non branched
7	Shandweel-3	Local cultivar	Three	Non branched
8	Sohag-1	Egypt	Three	Branched
9	Line zehre 18	Egypt	Three	Non branched
10	Line F10-25	Egypt	Single	Non branched

Analysis of variance:

Data of the experiment was subjected to proper statistical analysis of variance according to Snedecor and Cochran (1994). The combining ability effects were estimated using line x tester analysis according to Kempthorne (1957).

Heterosis of all possible 24 F_1 was estimated for both mid-parent and better-parent using the following formulas:

1- Heterosis for mid- parent: $\frac{F1-M.P}{M.P}$ x 100

2- Heterosis for better parent: $\frac{F1-B.P}{B.P}$ x 100

where:

F_1 = Mean of F_1 cross.

M.P.= Mean of the respective parents.
B.P. = Mean of the better parent.
Significance of heterosis was measured via L.S.D. (least significant differences) using the following formula:
L.S.D. = $t_{0.05}$ x S.E.

Where: S.E. for mid-parent = $\sqrt{\frac{3Mse}{2r}}$

S.E. for better parent = $\sqrt{\frac{2Mse}{r}}$

t = tabulated value at the degree of freedom for the error.,
Mse = Mean squares for pooled error.,
r = number of replications.,

RESULTS AND DISCUSSION

Analysis of variance

Main square for line x testers analysis of lines, testers and their interactions for all studied traits are presented in Table (2). Results revealed that genotypes and parents exhibited highly significant differences for all the studied traits except parents for number of capsules per plant. It could be recommended that parents selected were quite variable and should adequate amount of variability among the crosses for all of the studied traits. Results revealed that crosses were highly significantly different for all studied traits. Mean squares due to parents vs crosses were significant for all studied traits, showing the presence of heterotic effects due to the action of non-additive genetic variance in the crosses. Meanwhile, the lines and testers revealed significant differences for all the studied traits except number of branches per plant for lines. The interaction between lines x testers exhibited significant differences for all the studied traits. These results agreed with those of El-Shakhess and Khalifa (2007), Jawahar *et al* (2013), Meenakaumari *et al* (2015), Abd El-Rhman and Shafi (2016), Aye *et al* (2018) and Deshmukh *et al* (2019).

Table 2. Mean squares for the genotypes and combining ability for all the studied traits of sesame genotypes.

SOV	df	Plant height (cm)	Fruiting zone length (cm)	No. of branches/ plant	No. of capsules/ plant	Seed weight/ plant (g)	1000-seed weight (g)	Oil content %
Replicate	2	110.49	178.89	0.30	1844.49	50.97	0.08	1.189
Genotypes	33	3728.52**	1916.21**	5.29**	11298.15**	137.86**	1.03**	42.015**
Parents	9	749.51**	410.64*	4.87**	222.02	21.90*	0.46**	14.259**
Crosses	23	2817.41**	2222.32**	2.64**	8382.40**	166.17**	0.82**	54.209**
P Vs C	1	51495.30**	8425.94**	69.89**	178045.55**	530.35**	10.88**	11.338**
Lines	5	2792.91**	2639.99**	4.73**	15656.19**	405.75**	0.42**	77.515**
Testers	3	8080.75**	2826.83**	0.91	2538.76*	270.82**	0.46**	38.710**
L x T	15	1772.90**	1962.19**	2.30**	7126.54**	65.38**	1.02**	48.541**
Error	66	179.82	194.76	0.39	890.44	22.14	0.03	1.011
GCA		105.367	26.241	0.035	126.688	10.167	-0.021	0.118
SCA		531.026	589.142	0.634	2078.700	14.412	0.331	16.177
GCA/SCA		0.198	0.045	0.055	0.061	0.705	-0.063	0.007

*** and ** indicate significance at 0.05 and 0.01, respectively**

Mean performance of parents and their crosses

The mean performance of ten parental genotypes and twenty four F_1 crosses for all the studied traits is in presented in Table (3). Significant differences were detected among all genotypes for studied traits. Lines showed wide differences with a range of 156.33-207.67 cm, 95.67-129.33 cm, 1-4.33, 120.00-140.00, 15.00-19.70g, 3.86-5.24g, 38.55-45.62% for plant height, length of fruiting zone, number of branches per plant, number of capsule per plant, seed yield per plant, 1000- seed weight and seed oil content, respectively.

Table 3. Mean performance of the ten parents and the twenty four crosses for all studied traits of sesame.

Genotypes		Plant height cm	Fruit zone cm	No. of branches/ plant	No. of capsules/ plant	Seed yield/ plant, g	1000-seed weight, g	Seed oil content
Lines	Line B4-2	207.67	122.00	4.33	126.00	17.83	4.10	40.71
	Line M2A24	167.00	104.33	1.00	140.00	19.70	4.87	45.31
	Line 66	190.00	110.00	3.00	122.67	18.33	5.24	45.62
	Line 56	156.33	95.67	1.00	120.00	15.00	3.86	38.55
	Line 43	163.67	109.67	3.33	130.00	17.33	4.68	44.68
	Line 51	181.00	129.33	1.00	139.73	16.50	4.67	42.90
sters	Sh. 3	163.00	118.00	1.00	124.00	23.80	4.81	42.92
	So. 1	166.74	97.58	2.67	113.05	20.53	4.71	41.70
	Zeher18	188.00	128.00	1.00	121.67	19.28	4.60	42.74
	Line F10/25	173.33	114.00	1.00	120.67	14.80	4.42	41.61
Crosses	L1 x T1	200.00	116.70	5.00	183.33	18.26	3.64	51.88
	L1 X T2	236.67	98.33	2.67	195.00	24.67	3.71	43.79
	L1 X T3	303.33	186.67	4.00	203.33	20.33	4.20	41.29
	L1 X T4	229.33	142.67	2.33	179.00	12.90	3.72	44.79
	L2 x T1	216.67	150.00	3.00	238.00	24.33	4.22	39.98
	L2 X T2	248.00	181.33	3.00	191.00	23.00	3.72	36.5
	L2X T3	183.00	106.33	2.67	285.33	21.67	3.31	41.29
	L2 X T4	177.33	113.67	3.00	184.00	11.33	4.22	47.36
	L3 x T1	238.33	128.33	4.33	193.33	19.27	3.96	37.69
	L3 X T2	260.00	145.00	4.00	338.33	33.83	3.19	44.93
	L3X T3	240.00	150.33	3.33	203.33	23.00	3.67	47.16
	L3 X T4	198.33	120.00	5.00	213.33	28.83	5.07	41.89
	L4 x T1	191.67	105.00	3.00	181.00	16.36	4.11	39.37
	L4 X T2	262.00	130.33	3.67	156.33	24.07	3.52	44.60
	L4X T3	246.67	145.33	2.00	150.00	12.33	3.78	35.76
	L4 X T4	210.00	108.33	4.67	151.00	10.33	3.21	40.92
	L5 x T1	241.67	153.33	4.00	196.67	27.00	3.96	44.79
	L5 X T2	236.67	140.00	4.33	198.33	34.00	4.19	44.20
	L5X T3	253.33	171.33	4.33	244.33	26.33	4.37	41.29
	L5 X T4	201.67	151.67	3.00	300.00	27.00	4.26	43.79
	L6 x T1	181.67	102.67	5.00	210.00	21.00	4.46	35.76
	L6 X T2	216.67	80.00	5.00	242.67	35.00	3.76	35.76
	L6X T3	230.00	148.33	5.00	241.67	28.50	4.32	36.50
	L6 X T4	196.67	111.67	3.67	340.00	36.23	2.51	45.30
LSD 5%		21.90	22.79	1.03	48.73	7.68	0.28	4.39

The results showed that tester T_3 had the highest mean of plant height (188 cm), and fruiting zone length on the main stem (128 cm), while tester T_2 possessed the highest values of number of branches per plant (2.67) . However, tester T_1 possessed highest number of capsules per plant (124.00 capsules), 1000-seed weight (4.81g) and seed yield per plant (23.80 g) and seed oil content (42.92%).

Crosses data showed that, The best cross combinations were (L_1 x T_3) for plant height (303.33cm), and the fruiting zone length (186.67cm), (L_1 x T_1), (L_3 x T_4), (L_6 x T_1), (L_6 x T_2), and (L_6 x T_3) for number of branches per plant (5.00 branches), (L_6 x T_4) for number of capsules plant and seed yield per plant (340.00 capsules), (L_3 x T_4) for thousand seed weight (5.07 g), (L_1 x T_1) for seed oil content (51.88%). These crosses revealed the superior values across all their respective parents.

The present results confirm the findings of Mungala *et al* (2017) and Abd Elaziz and Ghareeb (2018). Consequently, it should own the genetic factors for high yield potential, revealing their importance in sesame improving programs.

General and specific combining ability

The analysis of combining ability has been utilized to know the nature and extent of gene action controlling expression of different characters including seed yield and its attributes would help in proper planning of a successful breeding programme, these results are in agreement with Saravanan *et al.* (2000). Results in Table (4) represented mean squares for general (GCA) and specific combining ability (SCA) as well as GCA/SCA ratio.

Mean squares due to GCA and SCA were highly significant for all studied characters, suggesting that both additive and non-additive gene actions were importance in the inheritance of all studied characters.

The GCA/SCA ratio was lower than 1, meaning that non-additive component was more important than additive for all the traits studied. The present results confirm the findings of Kar *et al* (2002), Preveenkumar *et al* (2012), Pawar and Monpara (2016) and Priya *et al* (2016).

General combining ability effects

The general combining ability (GCA) effects of line x tester for studied characters are listed in Table (4). Based on general combining ability (GCA) effects, the female lines L_1 had significant positive GCA effects for plant height and seed oil content. Meanwhile, L_5 had significant positive GCA for GCA effects for length of fruiting zone, 1000-seed weight, seed yield per plant and seed oil content. Moreover, L_6 had significant positive GCA effects for number of branches per plant, number of capsules per plant and seed yield per plant.

Table 4. Estimates of general combining ability effects of the ten sesame parents for all the studied traits.

Genotype		Plant height cm	Fruit zone cm	No. of branches /plant	No.of capsules/ plant	Seed yield/plant g	1000-seed weight g	Seed oil content
Line	L1	17.347**	3.278	-0.250	-27.306*	-4.277**	-0.060	3.496**
	L2	-18.736**	5.028	-0.833**	7.111	-3.233*	-0.012	-0.659
	L3	9.181	3.111	0.417	19.611	2.918*	0.095	0.976**
	L4	2.597	-10.556	-0.417	-57.889**	-7.543**	-0.224**	-1.779**
	L5	8.347	21.278**	0.167	17.361	5.268**	0.317**	1.576**
	L6	-18.736**	-22.139**	0.917**	41.111**	6.868**	-0.116	-3.611**
LSD 5%		10.952	11.395	0.513	24.364	2.584	0.138	0.821
Tester	T1	-13.319**	-6.806	0.306	-17.083	-2.280*	0.180**	-0.364
	T2	18.347**	-3.639	0.028	2.806	5.779**	-0.197**	-0.311
	T3	17.736**	18.583**	-0.194	3.861	-1.288	0.062	-1.394**
	T4	-22.764**	-8.139	-0.139	10.417	-2.210*	-0.045	2.069**
LSD 5%		8.940	9.304	0.419	19.893	2.110	0.113	0.670

*** and ** indicate significance at 0.05 and 0.01, respectively**

For testers the results suggested that the genotype T_1 was a good combiner for 1000-seed weight and seed oil content. Also, T_2 was a good combiner for plant height and seed yield per plant . Whereas, T_3 was a good combiner for plant height and length of fruiting zone and T_4 for oil content. The results of GCA effects of parental lines showed that the female lines L_5 and L_6 were the best general combiners for increasing seed yield per plant. Among male parents, T_2 was good general combiners. From the results obtained here, it can be concluded that L_5 and L_6 among lines and T_2 among testers were good general combiners for improvement of most studied traits. Similar trends were obtained by Mishra and Sikarwar (2001), El-Shakhess (2003), Attia *et al* (2004),Taher and El-Samanody (2006), El-Shakhess and Khalifa (2007), Abd Elaziz *et al* (2010), Hassan and Sedeck (2015), Aye *et al* (2018) and Deshmukh *et al* (2019). They found that significant general combining ability effects in some parental lines for some studied traits.

Specific combining ability effects (SCA)

Effects of specific combining ability (SCA) for studied characters are presented in Table (5). With regard to plant height, the maximum positive significant SCA value was obtained by crosses (L_1 x T_3) as the tallest cross. However, cross (L_2 x T_2) and (L_1 x T_3) sca estimate affects for length of fruiting zone revealed highly significant positive effects among two crosses, indicating the possibility for breeding a long length of fruiting zone which could led directly to increase number of capsules per plant. For number of branches per plant, two crosses (L_4 x T_4) and (L_1 x T_1) had highly significant and positive SCA effect. Moreover, with respect to number of capsules per plant, (L_6 x T_4), (L_3 x T_1) and (L_4 x T_2) showed highly significant and positive sca effect. Concerning with seed yield per plant, two crosses (L_6 x T_4) and (L_2 x T_1) had highly significant and positive sca effect. As for 1000-seed weight, three crosses (L_3 x T_4), (L_6 x T_1) and (L_6 x T_3) showed highly significant and positive sca effect.

Moreover, with respect to seed oil content, eight crosses exhibited highly significant and positive sca effects. Similar conclusion are in contrast with those reported by Ammar (2004), Taher and El-Samanody (2006) and Aye *et al* (2018). Consequently, it suggested that sca performance might be considered as criterion for selecting the best crosses. A perusal of F1's hybrids revealed that (L_6 x T_4) for seed yield per plant and (L_1 x T_1) for seed oil content were identified as the best crosses since they possessed desirable SCA effects.

Table 5. Specific combining ability effects of crosses

Genotype	Plant height (cm)	Fruit zone (cm)	No.of branches/ plant	No.of capsules/ plant	Seed yield/plant (g)	1000-seed weight (g)	Seed oil content
L1 x T1	-29.014*	-12.611	1.194**	14.411	1.498	-0.358*	6.809**
L1 x T2	-24.014*	-34.111**	-0.861	34.667	-0.151	0.092	-1.334
L1 x T3	43.264**	32.000**	0.694	-22.500	2.582	0.316*	-2.754**
L1 x T4	9.764	14.722	-1.028*	42.667	-3.929	-0.050	-2.720**
L2 x T1	23.764	18.972	-0.222	-16.917	6.530*	0.175	-0.940
L2 x T2	23.403	47.139**	0.056	-52.333*	-2.862	0.047	-4.472**
L2 x T3	40.986**	-50.083**	-0.056	6.194	2.871	-0.622**	1.401
L2 x T4	-6.153	-16.028	0.222	-32.222	-6.540*	0.400**	4.011**
L3 x T1	17.486	-0.778	-0.139	102.611**	-4.686	-0.193	-4.865**
L3 x T2	7.486	12.722	-0.194	-1.889	1.821	-0.584**	2.326**
L3 x T3	-11.903	-4.167	-0.639	-35.139	-1.945	-0.369**	5.632**
L3 x T4	-13.069	-7.778	0.972	-39.556	4.810	1.145**	-3.094**
L4 x T1	-22.597*	-10.444	-0.639	13.472	2.864	0.273	-0.430
L4 x T2	16.069	11.722	-0.306	61.056*	2.516	0.062	4.748**
L4 x T3	1.347	4.500	-1.139*	-33.444	-1.151	0.064	-3.009**
L4 x T4	5.181	-5.778	1.472**	-9.278	-3.229	-0.399**	-1.309
L5 x T1	21.658	6.056	-0.222	9.806	0.697	-0.411**	1.633
L5 x T2	-15.014	-10.444	0.389	-41.611	-0.362	0.192	0.993
L5 x T3	2.264	-1.333	-0.611	-34.083	-0.962	0.113	-0.833
L5 x T4	-8.903	5.722	-0.778	-63.500*	0.627	0.107	-1.793*
L6 x T1	-11.264	-1.194	0.028	-46.667	-6.903**	0.515**	-2.207**
L6 x T2	-7.931	-27.028*	0.306	-31.500	-0.962	0.191	-2.260**
L6 x T3	6.014	19.083	0.528	42.250	-0.395	0.499**	-0.437*
L6 x T4	13.181	9.1	-0.861	133.500**	8.260**	-1.204**	4.904**
LSD 5%	21.898	22.790	1.026	48.729	5.168	0.276	1.642

*** and ** indicate significance at 0.05 and 0.01, respectively**

Estimation of Heterosis:

Estimates of heterosis of the crosses over mid and better parent for all studied traits are shown in Tables (6 and 7). Mean squares for parents vs. crosses as an indication to average heterosis across all crosses were significant for all studied traits Table (2).

Table 6. Estimates of heterosis relative to the mid (MP) and better parent (BP) for plant height, fruiting zone length, number of branches and capsules /plant traits in 2018 season.

Crosses		Plant height(cm)		L. fruiting zone (cm)		N. branches		N. of capsules/ plant	
		MP	BP	MP	BP	MP	BP	MP	BP
1	L1 x T1	7.91	-3.69	-2.78	-4.37	87.50**	15.38**	46.67*	45.50
2	L1 x T2	26.42**	13.96	-10.44	-19.40	-23.81**	-38.46**	63.14**	54.76*
3	L1 x T3	53.33**	46.07**	49.33**	45.83**	50.00**	-7.69**	64.20**	61.38*
4	L1 x T4	20.38*	10.43	20.90*	16.94	-12.50**	-46.15**	45.14*	42.06
5	L2 x T1	31.31**	29.74**	34.93**	27.12	200.00**	200.00**	80.30**	70.00**
6	L2 x T2	48.62**	48.50**	79.61**	73.80**	63.64**	12.50**	50.96*	36.43
7	L2 x T3	3.10	-2.66	-8.46	-16.93	166.67**	166.67**	118.09**	103.81**
8	L2 x T4	4.21	2.31	4.12	-0.29	200.00**	200.00**	41.18	31.43
9	L3 x T1	35.03**	25.44*	12.57	8.76	116.67**	44.44**	56.76**	55.91*
10	L3 x T2	45.77**	36.84**	39.70**	31.82**	41.18**	33.33**	187.06**	175.82**
11	L3 x T3	26.98**	26.32*	26.33**	17.45	66.67**	11.11**	66.44**	65.76**
12	L3 x T4	9.17	4.39	7.14	5.26	150.00**	66.67**	75.34**	73.91**
13	L4 x T1	20.04*	17.59	-1.72	-11.02	200.00**	200.00**	48.36*	45.97
14	L4 x T2	62.19**	57.13**	34.89**	33.56**	100.00**	37.50**	34.16	30.28
15	L4 x T3	43.27**	31.21**	29.96**	13.54	100.00**	100.00**	24.14	23.29
16	L4 x T4	27.40**	21.15	3.34	-4.97	366.67**	366.67**	25.48	25.14
17	L5 x T1	47.96**	47.66**	34.70**	29.94*	84.62**	20.00**	54.86*	51.28*
18	L5 x T2	43.26**	41.94**	35.10**	27.66*	44.44**	30.00**	63.20**	52.56*
19	L5 x T3	44.08**	34.75**	44.18**	33.85**	100.00**	30.00**	94.17**	87.95**
20	L5 x T4	19.68*	16.35	35.62**	33.04**	38.46**	-10.00**	139.36**	130.77**
21	L6 x T1	5.62	0.37	-16.98	-20.62*	400.00**	400.00**	59.25**	50.29*
22	L6 x T2	24.62*	19.71	-29.49**	-38.14**	172.73**	87.50**	91.99**	73.66**
23	L6 x T3	24.66*	22.34*	15.28**	14.69	400.00**	400.00**	84.90**	72.95**
24	L6 x T4	11.01	8.66	-8.22	-13.66	266.67**	266.67**	161.14**	143.32**
LSD 5%		18.96	21.90	19.74	22.79	0.889	1.026	42.20	48.73

*** and ** indicate significance at 0.05 and 0.01, respectively**

Table 7. Estimates of heterosis relative to the mid (MP) and better parent (BP) for seed yield/plant, 1000-seed weight, and seed oil content traits in 2018 season.

Crosses		Seed yield/plant (g)		1000-seed weight (g)		Seed oil content	
		MP	BP	MP	BP	MP	BP
1	L1 x T1	-12.30**	-23.29**	-18.31**	-24.35**	24.07**	20.88**
2	L1 x T2	28.58**	20.12**	-15.66**	-21.08**	6.27**	5.01**
3	L1 x T3	9.57**	5.46	-3.52**	-8.77**	-1.04	-3.39**
4	L1 x T4	-20.94**	-27.66**	-12.56**	-15.70**	8.82**	7.64**
5	L2 x T1	11.88**	2.24	-12.79**	-13.29**	-9.37**	-11.76**
6	L2 x T2	14.33**	12.01**	-22.34**	-23.62**	-16.1**	-19.44**
7	L2 x T3	11.17**	9.98*	-30.14**	-32.05**	-6.21**	-8.87**
8	L2 x T4	-34.3**	-42.47**	-9.08**	-13.29**	8.97**	4.52**
9	L3 x T1	-8.54*	-19.05**	-21.21**	-24.44**	-14.86**	-17.38**
10	L3 x T2	74.1**	64.77**	-35.79**	-39.07**	2.91**	-1.51
11	L3 x T3	22.3**	19.29**	-25.48**	-30.03**	6.75**	3.38**
12	L3 x T4	74.04**	57.27**	5.07**	-3.19**	-3.96**	-8.18**
13	L4 x T1	-15.69**	-31.27**	-5.31**	-14.65**	-3.35**	-8.27**
14	L4 x T2	35.46**	17.2**	-17.83**	-25.19**	11.15**	6.95**
15	L4 x T3	-28.04**	-36.03**	-10.66**	-17.83**	-12.02**	-16.33**
16	L4 x T4	-30.65**	-31.11**	-22.46**	-27.32**	2.1**	-1.66*
17	L5 x T1	31.28**	13.45**	-16.51**	-17.63**	2.26**	0.25
18	L5 x T2	79.57**	65.58**	-10.73**	-10.95**	2.34**	-1.07
19	L5 x T3	43.85**	36.58**	-5.84**	-6.67**	-5.54**	-7.59**
20	L5 x T4	68.05**	55.77**	-6.44**	-9.09**	1.49*	-1.99*
21	L6 x T1	4.22	-11.76**	-5.95**	-7.37**	-16.66**	-16.68**
22	L6 x T2	89.01**	70.45**	-19.82**	-20.16**	-15.46**	-16.64**
23	L6 x T3	59.31**	47.82**	-6.68**	-7.33**	-14.76**	-14.92**
24	L6 x T4	131.52**	119.6**	-44.65**	-46.13**	7.21**	5.59**
LSD 5%		6.65	7.68	0.239	0.276	1.42	1.64

*** and ** indicate significance at 0.05 and 0.01, respectively**

Heterosis expressed as the percentage deviation of F_1 means performance from the mid parent and better parent values for all the studied traits are presented in Tables (6 and 7). Studies on the magnitude of heterosis in F_1 helps in assess the ability of the lines (test genotypes) to transmit the desirable characters to the F_1s upon hybridization.

For plant height, highest positive heterosis over mid parent was recorded in the cross L_4xT_2 (62.19%) followed by L_1xT_3 (53.33%) while maximum positive heterosis over better parent was observed for L_4 x T_2 (57.13%) followed by L_2 x T_2 (48.62%). However, the maximum and highly significant heterosis estimates were observed for length of fruit zone, highest positive heterosis over mid parent was recorded in the cross L_2 x T_2 (79.61%) followed by L_1 x T_3 (49.33%) while maximum positive heterosis over better parent was observed in L_2 x T_2 (73.80%) followed by L_1 x T_3 (45.83%). The cross L_2 x T_2 exhibited highest positive heterosis over both mid and better parent. The tester line, T_2 involved in the above cross is a low performer (Table 3). The poor performing parent resulting in heterotic test cross indicate its good nicking ability.

With respect to number of branches/plant the cross L_6 x T_1 and L_6 x T_3 expressed highest positive heterosis over both mid and better parent. Relatively lower *per se* performance of the line, L_6 (Table 3) involved in the above heterotic cross indicate its good combining ability with the tester T_1 and T_3.

On the other side, number of capsules per plant, exhibited highest positive heterosis over mid and over better parent in the cross L_3 x T_2 (187.06 and 175.82%) followed by L_6 x T_4 (161.14 and 143.32%) respectively. The cross L6xT4 expressed highest positive heterosis over both mid and better parent. Though the *per se* performance of the line (L_6) involved in the above heterotic cross (L_6 x T_4) is slightly lower than other lines, its good combining ability might be reason for its heterotic performance and such lines can be utilized as parents for hybridization programmes in different breeding methods.

With respect to 1000- seed weight one hybrid displayed significant and positive heterosis over mid parent and it was maximum in the cross L_3 x T_4 (5.07%). All crosses were negative and significant.

For seed yield per plant, the cross L_6 x T_4 (131.52 and 119.6 %) showed the highest positive heterosis over both mid and better parent followed by L_6 x T_2 (89.01 and 70.45 %), respectively. The cross L_6 x T_4 exhibited the highest positive heterosis over both mid and better parent. Though the *per se* performance of the line L_6 is least compared to other lines in the study (Table 3) it resulted in maximum heterosis against the common tester T_4 for seed yield per plant. This indicates its good combining ability and such lines can be used in hybridization programmes either to develop heterotic hybrids or to generate good transgressive segregants.

With respect to oil content (%), highest positive heterosis over mid and better parent were observed in the cross L_1 x T_1 (24.07 and 20.88%) followed by L_4 x T_2 (11.15 and 6.95%). Highest positive heterosis for both mid parent and better parent was recorded by the cross L_1 x T_1. Good combining ability of the line L_1 might have resulted in heterotic performance in the above cross. These results are in line with those obtained by Shabana *et al* (1996), El-Shakhess (2003), El-Shakhess and Khalifa (2007), Abd Elaziz *et al* (2010) and Sedeck and Shafie (2013), Jawahar *et al* (2013), Meenakaumari *et al* (2015) Abd El-Rhman and Shafi (2016), Raikwar (2018) and Dela and Sharma (2019).

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القدره على الأئتلاف و قوه الهجين فى السمسم تحت ظروف مصر العليا

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أجريت هذه الدراسة بمزرعة محطة البحوث الزراعية بالمطاعنة - محافظة الاقصر خلال الموسمين ٢٠١٧، ٢٠١٨ و قد اشتملت الدراسة على ٦ تراكيب وراثية من السمسم (أمهات) (Line B4-2، Line M2A24، Line66، Line 56، Line 43، Line 51) و ٤ أباء اختباريه (كشافات) و هي شندويل٣ ، سوهاج ١، Line zehre18، Line F10-25 مختلفة في القدرة المحصولية و بعض الصفات الأخرى باستخدام تحليل السلالة x الكشاف. تم تقييم سلوك الآباء و هجنها القمية في الجيل الأول بالإضافة لتقدير تأثيرات قوة الهجين على أساس متوسط الأبوين و الأب الأعلى و كذلك تقدير القدرة العامة و الخاصة على الائتلاف وبعض المقاييس الاحصائية الأخرى. أظهرت النتائج وجود اختلافات معنوية بين التراكيب الوراثية و كذلك الآباء في كل الصفات تحت الدراسة فيما عدا عدد الكبسولات للآباء فقط و عدد الفروع للكشاف مما يشير إلى وجود اختلافات وراثية بين تلك التراكيب. كما أظهرت النتائج أن Line 43، Line 51 كانت الأفضل في قدرتها على التالف للمحصول و مكوناته بالإضافة إلى أن الأب الأختبارى سوهاج١ أظهر قدرة عامة على التآلف لصفات طول النبات، محصول النبات و نسبة الزيت. وتشير النتائج الى أن تأثير تباين السيادة كان هو الأكثر أهمية بالمقارنة بالتباين المضيف فى توريث جميع الصفات. كما أوضحت النتائج إلى وجود العديد من الهجن ذات قوة هجين موجبة و مرغوبة بالمقارنة بمتوسط الأبوين أو الأب الأفضل. وقد أوضحت النتائج وجود اقتران بين القدرة الخاصة على الائتلاف مع قوة الهجين. و تخلص النتائج إلى وجود ثلاثة هجن تجاوزت متوسط آبائهم و كذلك الأب الأفضل هما Line 51 x Line F10-25، line 51 x Sohag-1، Line 43 x Sohag1K فى صفات محصول البذور للنبات و كذلك عدد الكبسولات للنبات و نسبة الزيت و بالتالي يمكن الاستفادة من هذه الهجن في برنامج التربية لاستنباط أصناف جديدة لهذا المحصول الهام.

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