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Manifestation of heterosis and combining ability for yield and its attributes in sesame (*Sesamum indicum* L.) using line x tester mating design

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Abstract

The present investigation was conducted in sesame to estimate heterosis and combining ability for yield and yield attributing traits using line x tester mating design. Four lines and three testers were crossed to produce 12 F_1 hybrids. The heterobeltiosis for seed yield per plant ranged from -16.51 to 24.57%, while the standard heterosis ranged from -12.74 to 33.58% over standard check variety DS-5. Analysis of variance for combining ability revealed that the mean squares due to lines x testers interaction showed significant for all characters. The significant variances due to lines, testers and line x tester showed the involvement of both additive and non-additive gene actions in controlling the traits. General and specific combining ability (GCA and SCA) variances showed major contribution of additive gene action for all the nine characters studied except number of seeds per capsule. AT 238 and JCS 2698 exhibited high gca effects and good *per se* performance for seed yield per plant and should be utilized in multiple crossing programmes. The sca effect of the crosses indicated that five hybrids manifested significant and positive sca effects for seed yield per plant. Among these, the best three specific combiners were AT 238 x DSS-9, AT 238 x DS-5 and TKG 506 x DSS-9.

Keywords: Heterosis, combining ability, line x tester, *per se* performance, seed yield

Introduction

Oilseed crops play an important role in agriculture and industrial economy of our country. India ranks first in respect of total hectarage and production of varieties of oilseed crops. Sesame is one of the most ancient and important oilseed crops grown next to groundnut and mustard in India. Sesame (*Sesamum indicum* L.) is a member of family *Pedaliaceae* with chromosome number 2n=2x=26. It is called as the" Queen of oil seeds" because of its excellent qualities of the seed, oil and meal. Sesame is highly nutritive (oil 50%, protein 25%) and its oil contains an antioxidant called sesamol which imparts a high degree of resistance against oxidative rancidity. The oil content in sesame ranges from 34 to 63% (Ashri, 1998) [1]. India contributes the highest sesame acreage of 17.73 lakh hectares with the production of eight lakh tonnes and productivity of 445 kg/hectare. The low productivity is attributed to poor crop management and exposure of the crop to a number of biotic and abiotic stresses (Madhuri and Karuna Sagar, 2018) [9]. The productivity of sesame is very low as compared to other oilseeds. Hence, it is necessary to increase productivity and thereby total oilseeds production to meet the edible oil requirement of the country. The crops, by virtue of its short duration, fits well into wide ranges of crop sequences and inter cropping systems. Development of short duration varieties in sesame is gaining importance due to their use as catch crop or relay crop and rice fallow crop. Apart from their wider use, they have several advantages like they require less crop management period, permit multiple cropping system, reduces overall production cost and allows escape from terminal drought. Nevertheless, the productivity of sesame in India is very low (445 kg/ha) in comparison with some other countries like China (705 kg/ha), Japan (700 kg/ha), Korea (635 kg/ha) and Thailand (575 kg/ha). There is an urgent need to augment the productivity levels. Unlike China, the hybrid technology so far, remained an untapped resource for raising sesame productivity in India. The development of commercial hybrids could improve the productivity and thereby the production to a level of exportable surplus of sesame in the country. For breaking the present yield barrier by evolving varieties with high yield potential, it is desirable to combine the genes from genetically diverse parents.

The success in identifying such parents mainly depends on the nature of gene action that controls the trait under improvement, combining ability and genetic makeup. There are several techniques for evaluating the varieties or strains in terms of their combining ability and genetic makeup. Of these, diallel, partial diallel and line x tester techniques are in common use. The line x tester analysis technique has been extensively used to assess the combining ability of parents and crosses for different quantitative characters as well as to study the extent of heterosis for yield and its attributing traits. Knowledge on combining ability is useful for selection of desirable parents for the exploitation of hybrid vigour. Selection based on phenotypic performance alone is not a sound procedure, particularly where metric traits are under the influence of epistatic genes. It is therefore, necessary to choose parents on their intrinsic genetic value. In the present study, four lines, three testers and their twelve hybrids were evaluated for combining ability and heterosis for yield and its attributes.

Materials and Methods

In the current study four lines TKG-506, JCS 2698, AT-238 and AT-307 and three testers DS-5, RT-351 and DSS-9 with different agronomic and morphological characters were selected and crossed in Line x Tester mating design during 2017-18. Twelve hybrids along with seven parents were raised during *kharif* 2018. The present investigations were conducted in randomized block design replicated twice at Main Agriculture Research Station, University of Agricultural Sciences, Dharwad (Karnataka). Seeds of each cross and their parents were sown in a row of 3m length in each replication with a spacing of 30 cm between the rows and 15 cm between plants. Observations were recorded on five plants selected at random in each replication for nine important traits *viz.,* days to maturity, plant height, number of primary branches/plant, number of capsules on the main axis, number of capsules/plant, length of capsule, number of seeds/capsule, 1000-seed weight and seed yield/plant. Variety DS-5 was used as the standard parental check. DS-5 is one of the leading variety which matures in 90-95 days, more number of elongated capsules having white bold seeds and high oil content of 49 to 52%. The data obtained for each character were analyzed by the usual standard statistical procedure (Panse and Sukhatme, 1978) [14]. The variation among the hybrids was partitioned further into source attributed to general combining ability and specific combining ability components in accordance with the standard procedure suggested by (Kempthorne, 1957) [8]. Relative heterosis, heterobeltosis and standard heterosis were estimated suggested by (Hays *et al.*, 1955) [5].

Results and Discussion

The analysis of variance was performed to test the differences among parents and hybrids for all the nine characters. The variances due to crosses, lines, testers and line x tester were significant for all the characters except plant height and number of seeds / capsules for lines, number of seeds/capsules for testers and seed yield/plant for line x tester (Table 1). The significant variances due to lines, testers and line x tester showed the involvement of both additive and non-additive gene actions in controlling the traits. However, all these characters except number of seeds/capsules appeared to be controlled predominantly by additive gene action as judged from the high GCA variance compared to SCA variance. For number of seeds/capsules, the estimate of sca was higher than the gca indicating the predominance of non-additive gene action for this trait. The present investigation is in line with the reports of (Mishra and Yadav, 1996) [12], (Babu *et al.*, 2004) [3], (Patel *et al.*, 2005) [16], (Singh *et al.*, 2007) [24], (Bharathi and Vivekanandan, 2009) [4], (Azeez and Morakinyo, 2014) [2] and (Meena kumari *et al.*, 2015) [11] that the number of seeds/capsules has shown the predominance of non-additive gene action for realizing higher yields.

A perusal of gca effects revealed that among the lines, TKG-506 and AT-238 were good general combiners for seed yield and JCS 2698 were good general combiners for seed yield and its components with highly significant gca effects for these traits. Among the testers, DS-5 was good general combiner for seed yield/plant, number of capsules/plant and number of seeds/capsule while DSS-9 was good combiner for days to maturity, number of primary branches/plants, number of capsule on main axis, number of capsules/plant and length of capsule. As regards to earliness RT-351, DSS-9 and AT 307 were found to be the best general combiners (Table 2). The preponderance of additive gene action for days to maturity has been reported by (Kar *et al.*, 2002) [7] and (Parameshwarappa and Salimath, 2010) [15]. Therefore, it was noted as a good source of favorable genes for increasing seed yield through various yield contributing traits.

The performance of the F_1's derived from crosses JCS 2698 X RT 351, AT 307 X RT 351 and AT-238 X DSS-9 showed better performance for early maturity. The F_1's derived from AT-238 X DS-5 and AT 307 X DSS-9 for number of capsules on main axis and number of capsules/plants, F_1's derived from TKG-506 X DSS-9 for number of seeds/capsule and length of capsule, showed significant positive sca effects. Similarly crosses between JCS 2698 X DS-5 and TKG-506 X RT 351 for 1000-seed weight and JCS 2698 X DS-5 for seed yield/plant were good specific combiners. Therefore, the parents, whose *per se* performance was good, were not necessarily good general combiners. Thus, for selecting good parents, both *per se* performance and gca effects of the parents may be more realistic. Similarly, best F_1's on the basis of *per se* performance were not in accordance to F_1's with respect to sca effects. It is observed that all the parents were not good general combiners for all the traits but when they were crossed with good general combiners, their sca effects were high, e.g., JCS 2698 X DS-5 for number of capsules/plants. Similarly low x low combiners gave significant sca effects though they were not good general combiners, e.g., the performance of F_1's from the cross JCS 2698 X DSS-9 for number of capsules on the main axis.

Table 1: Analysis of variance (mean squares) for combining ability in Sesame

Source	**d.f.**	**Mean sum of squares**								
		Days to maturity	**Plant height (cm)**	**No. of primary branches/plant**	**No. of capsules on the main axis**	**No. of capsules / plant**	**Length of capsule (cm)**	**No. of seeds / capsule**	**1000 seed weight (g)**	**Seed yield / plant (g)**
Crosses	11	21.23**	532.19**	0.726**	83.20**	175.31**	0.298**	51.98**	0.189**	11.82**
Lines	3	34.56*	629.12	1.25*	142.80**	326.89**	0.26*	76.19	0.29*	24.83**

Testers	2	39.35*	1297.39*	1.79*	176.59**	419.476**	0.86**	104.49	0.431**	19.88**
Line x Tester	6	4.12*	187.21**	0.201*	8.13**	19.38**	0.051**	23.39**	0.031**	1.09
Error	36	0.49	29.30	0.09	1.52	1.46	0.017	2.62	0.013	0.43
GCA variance	-	2.95	76.0	0.08	12.84	31.36	0.07	6.59	0.05	1.97
SCA variance	-	1.12	51.2	0.039	1.87	6.89	0.018	5.96	0.02	0.28
Add. variance	-	5.96	151.0	0.18	25.93	69.61	0.089	11.89	0.07	3.87
Dom. variance	-	1.12	51.2	0.039	1.87	6.89	0.018	5.96	0.02	0.28
Dom. variance/ Add. variance	-	0.14	0.28	0.36	0.07	0.19	0.13	0.49	0.161	0.08

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

Table 2: Estimates of general combining ability (GCA) and specific combining ability (sca) effects for yield and its components in sesame

Parents	**Days to maturity**	**Plant height (cm)**	**No. of pri. branches/plant**	**No. of caps. on main axis**	**No. of capsules/plant**	**Length of capsule (cm)**	**No. of seeds / capsule**	**1000 seed weight (g)**	**Seed yield / plant (g)**
Lines									
TKG 506	0.73**	9.89**	-0.33**	1.26**	1.70**	0.32**	4.12**	0.23**	3.12**
JCS 2698	2.65**	-13.52**	0.13	-1.39**	-1.90**	-0.08*	-0.88	-0.08**	-1.89**
AT 307	-3.10**	5.60*	-0.42**	-4.53**	-5.28**	-0.19**	-2.89**	0.03	-0.89**
AT 238	-0.91**	-0.88	0.54**	4.96**	8.89**	-0.17**	1.89**	-0.24**	0.47*
SE(gi)	0.36	1.89	0.10	0.38	0.42	0.08	0.63	0.04	0.24
SE(gi-gi)	0.45	2.59	0.19	0.48	0.61	0.06	0.12	0.05	0.27
Testers									
DS-5	1.89**	-10.39**	0.43**	4.30**	5.98**	0.45**	-3.49**	0.17**	1.43**
RT-351	-1.93**	10.26*	-0.08	-2.98**	-5.01**	0.06	0.98	0.19**	-0.29
DSS-9	0.22	1.79	0.48**	0.19	0.98**	-0.18**	4.32**	0.03	7.95**
SE(gi)	0.29	1.93	0.08	0.42	0.37	0.021	0.50	0.05	0.28
SE(gi-gi)	0.32	2.64	0.14	0.53	0.49	0.039	0.74	0.06	0.32
Crosses									
TKG 506 x DS-5	0.46	-2.01	0.011	1.90*	4.23**	0.10	-2.26*	-0.04	-0.12
TKG 506 x RT-351	-0.62*	-0.85	-0.09	-1.35	-2.21**	-0.09	1.66	-0.09	0.08
TKG 506 x DSS-9	0.42	3.80	0.07	-0.52	-1.80*	-0.04	0.74	0.14*	0.07
JCS 2698 x DS-5	-0.57	-0.74	0.23	-1.59*	-6.15**	0.10	1.93	-0.08	-0.19
JCS 2698 x RT-351	0.54	1.41	0.15	-0.36	0.38	0.07	1.67	0.26**	0.69
JCS 2698 x DSS-9	0.61	-0.73	-0.23	2.13*	3.26**	-0.18**	-3.64**	-0.14*	-0.53
AT 307 x DS-5	2.60**	13.62**	0.22	-1.14	-1.59**	-0.04	0.53	0.09	0.04
AT 307 x RT-351	-1.14**	-5.89	-0.29	1.19	0.64	-0.09	-0.47	-0.15**	-0.89*
AT 307 x DSS-9	-0.39	-7.23	0.027	-0.12	1.18	0.08	-0.07	0.05	0.84*
AT 238 x DS-5	2.26**	6.13	0.41	0.91	3.89**	-0.19**	3.16**	-0.02	0.79*
AT 238 x RT-351	-0.98**	-8.23**	-0.19	0.85	0.99	0.08	-2.81**	0.08	0.14
AT 238 x DSS-9	-0.38	5.21	0.19	-1.32	-1.87**	2.08**	3.24**	-0.051	-0.34
SE (Sij)	0.47	3.19	0.17	0.72	0.74	0.06	0.93	0.05	0.29
SE (Sij-Sij)	0.63	5.17	0.24	0.89	0.84	0.09	1.42	0.07	0.34

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

Heterosis was calculated as *per cent* increase and decrease over mid-parent, corresponding better parent and standard parent (Table 3). Five crosses *viz*., JCS 2698 X RT 351, JCS 2698 X DSS-9, AT 307 X RT 351, TKG 506 X DSS-9 and AT-238 X RT 351 recorded significant negative heterosis for maturity. Similar results were reported by (Sankar and Kumar, 2001) [20], (Jatothu *et al*., 2013) [6], (Reddy *et al*., 2015) [19] and (Virani *et al*., 2017) [27]. All the twelve crosses showed significant negative heterosis over standard check displaying dominance for earliness. The range of standard heterosis for seed yield/plant was -12.74 to 33.58% and found maximum in the cross AT 238 X DS-5 (33.58%). The same cross had a high heterotic value for four other traits *viz.*, Plant height, number of capsules on the main axis, number of capsule/plant and number of primary branches/plant. Heterotic behavior of crosses with respect to yield component traits differs from character to character. However, a few crosses such as TKG-506 X DSS-9, TKG-506 X DS-5, TKG-506 X RT-351 and AT-238 X DSS-9 showed appreciable level of promising hybrid vigour for seed yield as well as over other major component traits. These findings got support from the views of earlier workers (Solanki and Gupta, 2000) [25], (Manivannan and Ganeshan, 2001) [10], (Senthil *et al.*, 2003) [22], (Vidyavathi *et al*., 2005) [26], (Singh *et al*., 2007) [23], (Ranjith *et al*., 2011) [18], (Padma Sundari and Kamala, 2012) [13], (Ramesh *et al*., 2014) [17] and (Saxena and Bisen, 2017) [21] regarding the heterosis in Sesame.

Best three parents on the basis of *per se* performance and gca effect and best three crosses with respect to their *per se* performance, sca effects and standard heterosis have been presented in (Table 4). The crosses showed significant sca and heterosis for yield / plant, in which both the parents were good general combiners that produced high sca effects indicating the predominance of additive gene interactions e.g., the performance of the cross AT 238 X DS-5. Whereas other superior crosses, where both the parents were not good general combiners, showed the involvement of non-additive types of gene action. The crosses that exhibited high heterosis for seed yield and its contributing traits (AT 238 X RT-351, AT 307 X RT-351, JCS 2698 X DS-5, TKG 506 X DSS-9 and AT 238 X DS 5) could be used for commercial exploitation in sesame. The hybrids of the parental line having desirable gca effects for various attributes may be advanced to get desirable segregants. The hybrids, which exhibited high sca effect, did not always involve both good general combiner parents with high gca effect, there by suggesting importance of intra and inter-allelic interactions. Therefore, while selecting hybrids for future breeding work, one has to consider all the aspects independently. The hybrids, which exhibited high sca effects for seed yield per plant, had also registered desirable sca effect for other yield attributing characters, which suggested cumulative effect of various yield contributing attributes resulting in high sca effect for seed yield and thereby high heterotic effects as well.

Table 3: Heterosis (in *per cent*) over mid parent (MP), better parent (BP) and standard variety DS-5 (SC) for different characters

Crosses	Heterosis (in percent) over	Days to maturity	Plant height (cm)	No. of primary branches / plant	No. of capsules on the main axis	No. of capsules / plant	Length of capsule (cm)	No. of seeds / capsule	1000 seed weight (g)	Seed yield/ plant (g)
TKG 506 x DS-5	MP	5.01*	-0.68	2.57	16.30**	8121**	9.40**	-5.43*	1.50	5.98
	BP	1.65-	-6.53	0.01	3.89	2.10*	7.54**	-12.96**	-5.62**	-9.40**
	SC	2.80**	-9.94	9.10	27.09**	16.44**	29.27**	5.13	2.6	13.55**
TKG 506 x RT-351	MP	0.62	9.58**	-14.43*	3.51	-0.71	0.53**	3.86*	12.94**	15.51**
	BP	-5.59**	7.73**	-15.62*	-6.76	-6.76	-4.87*	0..80	6.15**	-3.82
	SC	-8.28**	4.08	-6.93	-8.89*	-8.81*	13.09**	18.10**	15.40**	21.40**
TKG 506 x DSS-9	MP	2.62**	2.84	-21.10**	11.63**	5.95**	-1.05	5.03**	2.16	10.23**
	BP	-0.50*	1.94	-23.66*	10.34**	4.02**	-12.15**	1.03	0.0	5.63*
	SC	-4.92**	0.19	-10.98	7.85*	4.78**	3.30	17.02**	13.60**	29.78**
JCS 2698 x DS-5	MP	4.84**	-5.98*	28.48**	-9.43**	-7.31**	9.51**	3.28	-7.61**	-11.90**
	BP	0.50*	-5.25*	19.14**	-10.92**	-9.44**	5.81**	2.04	-11.67**	-16.51**
	SC	-2.53*	-18.85**	25.74**	9.85*	5.67**	19.05**	5.55	-8.6**	-12.74**
JCS 2698 x RT-351	MP	3.67**	-5.81**	9.42	-13.48**	-8.58**	6.84*	6.55*	18.23**	5.96
	BP	-2.87**	0.40	3.80	-23.23**	-13.93**	5.84*	2.95	14.07**	-3.48
	SC	-4.89**	-8.87**	9.90	-12.48	-7.89**	12.99*	10.96**	15.40**	-0.50
JCS 2698 x DS- 9	MP	4.21**	-4.89	-10.04*	2.09	2.43	-8.32**	-0.93	-9.52**	-6.44*
	BP	0.02	-12.27**	-1.12**	-8.75**	-4.74**	-13.80**	-3.93	-13.79**	-9.86**
	SC	-2.01**	-13.79**	-9.01	7.74*	6.04*	-8.70**	4.88	-4.2	3.65
AT 307 x DS-5	MP	-3.80**	-8.26**	-4.97	-4.06*	-4.46**	-5.29*	-5.30*	-0.82	-3.03
	BP	-7.89**	-13.84**	-6.71	-12.76**	-11.10**	-12.00**	-6.30	-6.4*	-6.16
	SC	-5.90**	-12.84**	-3.15	8.59	5.93**	3.20**	-6.30	-5.4*	-6.18
AT 307 x RT-351	MP	-3.04**	9.25*	-3.88	-15.59**	-7.84*8	2.42	-6.54**	17.75**	8.51*
	BP	-7.52**	5.58	-6.60	-20.37**	-8.93**	-2.38	-8.98**	13.20**	-0.18
	SC	-7.53**	5.89	0.03	-21.37**	-9.93**	4.40	-2.82**	12.20**	-0.16
AT 307 x DSS- 9	MP	-5.38**	-0.20	-14.07*	-10.56**	-4.36**	2.68	2.61**	-5.49*	2.15
	BP	-6.05**	-0.92	-20.12**	-12.38**	-5.79**	-7.96**	3.81	11.21**	-5.52
	SC	-7.05**	-0.98	-9.01	-13.21**	-5.79**	-6.89**	11.01**	3.0	8.46*
AT 238 x DS-5	MP	3.01**	8.91**	23.83**	13.64**	8.06**	6.95*	1.90	-3.19	13.58
	BP	2.92**	7.89**	21.43**	6.64*	3.27*	-3.19	-2.91	-4.46	24.57**
	SC	3.78**	5.89**	35.42**	31.33**	16.81**	9.80**	6.17*	10.80**	33.58**
AT 238 x RT-351	MP	-4.67*	8.50**	1.01	19.68**	7.67**	0.28	3.40	4.31	7.51*
	BP	-7.26**	3.25	-0.91	4.10	0.90	-6.54	-0.90	1.26	-2.21
	SC	-8.57**	-5.58	7.90	15.34**	6.00	0.03	12.12**	-4.2	3.56
AT 238 X DSS-9	MP	-2.80**	-2.89	5.85	19.69**	14.10**	0.80	6.83**	-6.70**	15.20**
	BP	-6.80**	-8.25	-8.64	12.35**	9.75**	-1.27	4.72**	-13.50**	12.20**
	SC	-6.82**	-12.12**	8.72	20.34**	13.34**	28.33**	12.35**	-5.0	23.95**
CD(P=0.05)	MP	0.99	7.20	0.39	1.61	1.84	0.14	2.49	0.09	0.89
CD(P=0.01)	MP	1.38	9.57	0.62	2.40	2.39	0.19	3.29	0.12	1.27
CD(P=0.05)	BP& SC	2.12	9.16	0.54	1.89	1.94	0.11	3.92	0.19	1.22
CD(P=0.01)	BP& SC	2.50	12.3	0.89	2.53	2.59	0.19	4.78	0.29	1.66

*, ** = significant at 5% and 1% respectively

Table 4: Three best parents, F$_1$'s, general combiners and specific combiners for yield and component traits in Sesame in line x tester experiment

Traits		Best parent (*per se* performance)	Best general combiners (gca)	Best F$_1$'s with respect of sca	Best F$_1$'s w.r.t *per se* performance and standard heterosis
Days to maturity	Early	AT 307	TKG 506	AT 307 x RT-351	AT 238 x RT-351
		RT-351	DS-5	TKG 506 x RT-351	AT 238 x DSS- 9
		AT 238	DSS-9	AT 238 x RT-351	AT 307 x RT-351
	Late	JCS 2698	JCS 2698	AT 307 x DS-5	AT 238 x DS-5
		DS-5	AT 307	AT 238 x DS-5	TKG 506 x DS-5
		TKG 506	TKG 506	JCS 2698 x DSS-9	JCS 2698 x DS-5
Plant height (cm)	Tall	TKG 506	DS-5	AT 307 x DS-5	AT 307 x RT-351
		AT 238	AT 238	TKG 506 x DSS-9	AT 238 x DS-5
		DS-5	TKG 506	AT 238 x DSS-9	JCS 2698 x DS-5
	Dwarf	JCS 2698	DSS-9	AT 238 x RT-351	AT 307 x DS-5
		RT-351	RT-351	AT 307 x DSS-9	JCS 2698 x RT-351

	DSS-9	AT 238	AT 307 x RT-351	JCS 2698 x DS-5
No. of primary branches / plant	AT 238	DSS-9	AT 238 x DS-5	JCS 2698 x DS-5
	DSS-9	AT 238	JCS 2698 x DS-5	AT 238 x DS-5
	DS-5	DS-5	AT 307 x DS-5	JCS 2698 x RT-351
No. of capsules on the Main axis	TKG 506	JCS 2698	JCS 2698 x DSS-9	AT 238 x DSS-9
	AT 238	RT-351	TKG 506 x DS-5	AT 238 x DS-5
	DS-5	DS-5	AT 307 x RT-351	TKG 506 x DS-5
No. of Capsules/ plant	AT 238	TKG 506	TKG 506 x DS-5	AT 238 x DS-5
	DS-5	RT-351	AT 238 x DS-5	AT 238 x DSS-9
	DSS-9	DS-5	JCS 2698 x DSS-9	TKG 506 x DS-5
Length of capsule (cm)	TKG 506	DSS-9	AT 238 x DSS- 9	TKG 506 x DS-5
	DS-5	RT-351	TKG 506 x DS-5	JCS 2698 x DS-5
	RT-351	JCS 2698	JCS 2698 x DS-5	JCS 2698 x RT-351
No. of seeds / capsule	DSS-9	DS-5	AT 238 x DSS-9	AT 238 x DSS 9
	AT 238	AT 238	AT 238 x DS-5	JCS 2698 x RT-351
	TKG 506	TKG 506	JCS 2698 x DS-5	TKG 506 x DSS 9
1000- seed weight (g)	RT-351	AT 307	TKG 506 x DSS-9	JCS 2698 x RT-351
	DS-5	DSS-9	TKG 506 x RT-351	AT 307 x RT-351
	DSS-9	DS-5	AT 307 x DS-5	TKG 506 x RT-351
Seed yield /plant (g)	DS-5	DSS-9	AT 307 x DSS-9	AT 238 x DSS-9
	TKG 506	JCS 2698	AT 238 x DS-5	AT 238 x DS-5
	AT 238	DS-5	JCS 2698 x RT-351	TKG 506 x DSS-9

Conclusion

From the present investigation, two lines AT 238 and JCS 2698 exhibited high gca effects and good *per se* performance for seed yield per plant and should be utilized in multiple crossing programmes. The sca effect of the twelve crosses indicated that five hybrids manifested significant and positive sca effects for seed yield per plant. Among these, the best three specific combiners were AT 238 x DS-5, AT 238 x DSS-9 and TKG 506 x DSS-9 for seed yield per plant. The results suggest that heterosis coupled with high sca effects may be considered as a criterion for selecting the best cross combination for further improvement of seed yield per plant in Sesame.

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