J. Farm Sci., 33(4) : (435-440) 2020

RESEARCH PAPER

Heterosis for seed yield and it's component traits in sesame (*Sesamum indicum* L.)

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(Received: October, 2020 ; Accepted: December, 2020)

Abstract: Forty five hybrids of sesame developed by crossing 10 parents in half diallel fashion along with parents were evaluated in RBD with two replications during *kharif*, 2019 for heterosis. The analysis of variance (half diallel) revealed significant differences among genotypes for all the characters studied. Out of 45 crosses, high degree of significant desirable heterosis over mid parent, better parent and standard check was observed for the major traits, seed yield per plant, 1000 seed weight, oil content and number of capsules per plant. The cross JTS-8 x AKT-101 recorded highest positive heterosis over better parent and standard check (DS-5) for seed yield per plant, IC-204845 x AKT-101 over better parent and DS-5 x JLT-408 over standard check for oil content, MT-10-8-1 x AKT-101 over better parent and RMT-430 x AKT-101 over standard check for number of capsules per plant and JTS-8 x RMT-430over better parent and JTS-8 x AKT-101 over standard check for 1000 seed weight.

Keywords: Half diallel, Heterosis, Sesame, Yield attributes

Introduction

Sesame (*Sesamum indicum* L.) is probably the oldest known and used oilseed by man and its domestication is lost in the ancient mists (Weiss, 1983). It is a member of the Tubiflorae order and of the Pedaliaceae family. Sesame has many species of which most are native to sub-saharan Africa while *Sesamum indicum* is native to India. India has the highest area in the world followed by Myanmar, Sudan, China and Uganda but higher productivity in China. This is an important annual crop (with chromosome number 2n=26) in tropics and warm subtropics, where it is typically cultivated in small plots (Bedigian and Harlan, 1986).

Sesame is described as the "Queen of Oilseeds" due to its high oil content (38-54 per cent), protein (18-25 per cent), calcium, phosphorus, oxalic acid and excellent seed oil and meal quality. World sesame area was 105.70 lakh hectares with a production of 61.1 lakh tonne and a productivity of 535 kg / ha. India is a global leader in sesame production. Sesame is grown in India on an area of 15.66 lakh hectares with 7.43 lakh tonne of production (Anon, 2017-18).

In Karnataka, it is grown on an area of 0.35 lakh hectares with a production of 0.22 lakh tonne and an average yield of 629 kg / ha (Anon, 2017-18). In India, however, the productivity is poor compared with other countries that need improvement. Most of the varieties developed and commercialized for cultivation are under low management rates selections from local or closely related populations.

Hybrids must be produced exclusively by hand emasculation and pollination in the absence of a viable male sterility mechanism in sesame, as is done in other crops such as cotton. The commercial exploitation of heterosis is only feasible when methods of processing hybrid seeds are economically viable. It clearly shows the potential for enhancement of this crop's yield by commercial use of heterosis. Efforts have been under way in recent years to create sesame hybrids using various hybrid techniques such as (a) manual emasculation and pollination (b) the use ofchemical hybridizing agents (c) the development of genetic male sterile line and (d) the development of cytoplasmic genetic male sterile line (Ranganatha *et al*., 2012).

Heterosis or hybrid vigor or enhancement of outbreeding is the improved or increased role of a hybrid offspring of any biological quality. A number of workers for yield and yield components have already reported significantly high heterosis in sesame. In sesame it is possible because indeterminate plant with epipetalous nature of the flower facilitates simple emasculation, low seed rate, high seed multiplication ratio, nature of crossing, frequent visits by an insect such as honey bees and higher number of seeds set in a single pollination. Plant breeders are posed with a perpetual objective of evolving crop genotypes with higher productivity to address to the need of ever burgeoning population. Exploitation of heterosis in sesame has been recognized as a practical tool in providing breeders a means of improving yield and other important traits. The phenomenon of heterosis of F_1 hybrids can also reflect specific combining ability (*sca*) and general combining ability (*gca*) of parental lines. In the present study, ten parental lines and their forty five hybrids along with checks were evaluated to study the extent of heterosis for yield and yield attributes.

Material and methods

In the present investigation, there are ten morphological diverse genotypes *viz*., DS-5 (check), DSS-9, JTS-8, RMT-430, TKG-22, IC-204845, JLT-408, MT-10-8-1RT-368 and AKT-101 were selected and crossed in half diallel mating design during 2018-19. Forty five hybrids along with parents and checks were raised during *kharif* season of 2019.The present study was conducted in randomized block design replicated twice at All

India Co-ordinated Research Project on Sesame and net work project on Niger, Main Agriculture Research Station, University of Agricultural Sciences, Dharwad (Karnataka).Seeds of each cross and their parents were sown in a row of 3m in 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 seven important characters *viz.*, Days to maturity, plant height (cm),number of brances per plant, number of capsules per plant, 1000 seed weight (g), oil content (%) and seed yield per plant (g). The data obtained for each character were analyzed by the usual standard statistical procedure (Panse and Sukhatme,1978). Magnitude of heterosis was estimated in relation to mid parent (average or relative heterosis), better parent (heterobeltiosis) and the best commercial check (standard heterosis) for each character using formulae (Turner, 1953 and Hayes *et al*, 1955). Variety DS-5 was used as the standard parental check.

Results and discussion

The ANOVA for the treatment mean sum of squares was significant for days to maturity, plant height, number of branches per plant, number of capsules per plant, 1000 seed weight, oil content and seed yield per plant. The variances due to parents and hybrids were highly significant for all the traits. Parents *vs* hybrids showed highly significant differences for days to maturity, plant height, number of branches per plant, number of capsules per plant, 1000 seed weight, oil content and seed yield per plant (Table 1).

Extent of heterosis

Heterosis was calculated as per cent increase and decrease over mid-parent, corresponding better parent and standard parent (Table 2).There were significant differences among hybrids and parents for all the characters studied. High degree of significant desirable heterosis over mid parent, better parent and standard check was observed for seven traits in forty five hybrids. For days to maturity, twenty six hybrids over mid parent, twenty nineover better parent and forty one over standard check showed significant negative heterosis with a range of -14.02 per cent (DSS-9 x RT-368) to -0.47 per cent (JTS-8 x RMT-430, JLT-408 x AKT-101).The F1s derived from crosses DSS-9 x RT-368, RMT-430 X IC-204845, DSS-9 X RMT-430 and RMT-430 X AKT-101 showed better performance for early maturity. All the 41 crosses showed significant negative heterosis over standard check displaying dominance for earliness.For plant height, twenty hybrids over mid parent, fourteen over better parent and forty one over standard check showed significant positive heterosis with a range of -14.02 per cent (DSS-9 x RT-368) to -0.47 per cent (JTS-8 x RMT-430, JLT-408 x AKT-101). For number of branches per plant twenty one hybrids over mid parent, fourteen over better parent and seven over standard check showed significant positive heterosis with a range of 2.33 per cent (DS-5 x DSS-9, DSS-9 x JLT-408) to 18.60 per cent (RMT-430 x AKT-101). For number of capsules per plant,twenty six hybrids over mid parent, sixteen over better parent and eleven over standard check showed significant positive heterosis which ranges from 0.31 per cent (JTS-8 x MT-10-8-1) to 37.56 per cent (RMT-430 x AKT-101).The F1 s derived from RMT-430 X AKT-101and RT-368 X AKT-101 for number of capsules per plant, For 1000 seed weight, eighteen hybrids over mid parent, twelve over better parent and fifteen over standard check showed significant positive heterosis which ranges from 1.67 per cent (MT-10-8-1 x RT-368) to 42.33 per cent (JTS-8 x AKT-101). For oil content, twenty hybrids over mid parent, sixteen over better parent and five over standard check showed significant positive heterosis with a range of 0.53 per cent (JTS-8 x AKT-101) to 4.12 per cent (DS-5 x JLT-408). For seed yield per plant, thirty one hybrids over mid parent, twenty eight over better parent and twenty two over standard check showed significant positive heterosis with a range of 0.69 per cent (DS-5 x RT-368) to 52.85 per cent (JTS-8 x AKT-101).

Heterosis for yield and yield components

Number of capsules per plant is known to directly contribute towards seed yield. Sixteen hybrids recorded positive significant heterobeltiosis while eleven hybrids exhibited significant positive standard heterosis over DS-5. The hybrid RMT-430 x AKT-101 (37.56 per cent) showed highest significant positive heterosis over standard check followed by DSS-9 x MT-10-8-1 (24.12 per cent) and DSS-9 x AKT-101 (17.86 per cent) (Table 2). Senthilkumar and Ganeshan (2001) showed similar results of significant and positive heterosis. Same results were reported by Vavdiya*et al.,*(2013), Saxena *et al*. (2017), Karande*et al*. (2018) and Karthikeyan *et al*. (2019).

The main attribute which has a positive direct association with seed yield is the 1000 seed weight and for this trait hybrids have shared both positive and negative heterosis equally. Among hybrids JTS-8 x AKT-101 (42.33) recorded highest positive heterosis followed by RMT-430 x MT-10-8-1 (40.00 %), JTS-8 x MT-10-8-1 (37.00 %) and DS-5 x DSS-9

Table 1. Analysis of variance for seven characters in a set of 10 x10 diallel crosses in sesame

Source of variation	df	Days to maturity	Plant height (cm)	Number of branches per plant	Number of capsules per plant	1000 seed weight (g)	Oil content (%)	Seed yield per plant (g)
Replication	1	0.23	0.28	0.04	0.06	0.02	5.04	0.02
Genotypes	54	22.69**	130.98**	0.59**	198.97**	0.73**	21.75**	3.57**
Parents	9	31.92**	85.28**	0.42**	188.63**	0.48**	19.10**	2.89**
Hybrids	44	19.72**	141.90**	0.64**	205.52**	0.76**	22.56**	3.64**
Parents vs Hybrids	1	70.64**	61.27**	0.00018	3.36	1.68**	9.53	6.44**
Error	54	2.82	5.35	0.05	4.26	0.01	3.06	0.01

** -Significant at 1% level

Table 2. *Per cent* heterosis over mid parent (MPH), better parent (BPH) and standard check- DS-5(SH) for days to maturity, plant height (cm), number of branches per plant and number of capsules per plant in sesame (*Sesamum indicum* L.)

Sl.	Crosses	Days to maturity			Plant height (cm)			Number of branches per plant			Number of capsules per plant		
No.		MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH
1	DS-5 x DSS-9	-4.29 **	-6.07 **	-6.07 **	-3.43 *	-4.06 *	-3.05	4.76	-4.35	2.33	-4.72	-13.20 **	-10.69 **
2	DS-5 X JTS-8	4.35 **	0.93	0.93	2.36	2.24	3.32	8.43	-2.17	4.65	-7.05 *	-8.01 *	-5.34
3	DS -5X RMT-430	0.00	-4.21**	-4.21**	-0.12	-5.18 **	-4.18 *	5.75	0.00	6.98	-12.22 **	-24.33 **	-22.14 **
4	DS-5 X TKG-22	-3.55 *	-4.67**	-4.67**	3.75 *	0.46	1.52	12.94 *	4.35	11.63*	-11.33 **	-14.69 **	-12.21 **
5	DS-5 X IC 204845	-6.41 **	-7.94**	-7.94**	-0.88	-4.18 *	-3.17	3.80	-10.87 *	-4.65	14.98 **	-2.08	0.76
6	DS-5 X JLT-408	-4.08 **	-6.54**	-6.54**	6.72 **	4.41 *	5.51 **	14.29 **	4.35	11.63*	12.78 **	-5.04	-2.29
7	DS-5 X MT-10-8-1	-7.69 **	-10.28 **	-10.28**	3.03	1.16	2.23	17.07 **	4.35	11.63*	-8.85 **	-22.11 **	-19.85 **
8	DS-5 X RT-368	-6.70 **	-8.88**	-8.88 **	8.27 **	7.39 **	8.52 **	11.90 *	2.17	9.30	3.05	-4.75	-1.98
9	DS-5 X AKT-101	-4.31 **	-6.54**	-6.54 **	10.22 **	5.49 **	6.60 **	4.65	-2.17	4.65	28.47 **	12.46 **	15.73 **
10	DSS-9 X JTS-8	-3.45 *	-4.85**	-8.41 **	6.00 **	5.43 **	6.29 **	20.00 **	18.42 **	4.65	-1.81	-9.70 **	-9.01 **
11	DSS-9 X RMT-430	-4.98 **	-7.28**	-10.75 **	4.96 **	0.27	0.00	3.80	0.00	-4.65	2.30	-3.79	-18.63 **
12	DSS-9 X TKG-22	-1.69	-2.39	-4.67 **	1.97	-0.63	-0.90	16.88 **	15.38 *	4.65	5.86	0.00	-4.89
13	DSS-9 X IC 204845	-4.60 **	-4.83 *	-7.94 **	-0.44	-3.13	-3.40	21.13 **	13.16 *	0.00	0.19	-7.04	-21.37 **
14	DSS-9 X JLT-408	-5.62 **	-6.31**	-9.81 **	-6.29 **	-7.72 **	-7.97 **	15.79 **	15.79 *	2.33	25.12 **	14.62 **	-3.05
15	DSS-9 X MT-10-8-1	-3.92 **	-4.85**	-8.41 **	9.67 **	8.39 **	8.09 **	16.22 **	13.16 *	0.00	57.56 **	46.75 **	24.12 **
16	DSS-9 X RT-368	-10.24 **	-10.68 **	-14.02**	-5.61 **	-5.76 **	-6.02 **	13.16 *	13.16 *	0.00	10.83 **	9.09 *	-4.73
17	DSS-9 X AKT-101	-5.85 **	-6.31**	-9.81 **	-3.50 *	-7.05 **	-7.31 **	15.38 **	12.50 *	4.65	45.66 **	39.35 **	17.86 **
18	JTS-8 X RMT-430	7.58 **	6.50**	-0.47	5.38 **	0.16	0.98	5.13	0.00	-4.65	10.28 **	-4.09	-3.36
19	JTS-8 X TKG-22	0.73	-1.44	-3.74 *	-0.84	-3.88 *	-3.09	-13.16 *	-15.38 *	-23.26**	-5.53	-8.18 *	-7.48 *
20	JTS-8 X IC 204845	-5.16 **	-6.76 **	-9.81 **	-3.08	-6.20 **	-5.43 **	-5.71	-10.81	-23.26**	-1.59	-15.45 **	-14.81 **
21	JTS-8 X JLT-408	0.74	0.00	-5.14 **	-5.26 **	-7.21 **	-6.45 **	-12.00 *	-13.16 *	-23.26**	13.11 **	-3.94	-3.21
22	JTS-8 X MT-10-8-1	-1.49	-1.98	-7.48 **	-3.86 *	-5.50 **	-4.73 *	6.85	5.41	-9.30	15.47 **	-0.45	0.31
23	JTS-8 X RT-368	-2.97 *	-3.92 *	-8.41 **	-1.64	-2.33	-1.52	20.00 **	18.42 **	4.65	9.42 **	2.12	2.90
24	JTS-8 X AKT-101	-1.98	-2.94	-7.48 **	12.06 **	7.36 **	8.25 **	24.68 **	20.00 **	11.63*	18.52 **	4.70	5.50
25	RMT-430 X TKG-22	-1.73	-4.78 **	-7.01 **	4.30 *	2.19	-3.28	-7.50	-9.76	-13.95*	-10.35 **	-20.06 **	-23.97 **
26	RMT-430 X IC-204845	-5.71 **	-8.21 **	-11.21 **	7.13 **	5.14 **	-0.82	-5.41	-14.63 *	-18.60**	7.28	5.74	-21.22 **
27	RMT-430 X JLT-408	2.26	0.49	-4.67 **	2.38	-0.73	-4.03 *	-16.46 **	-19.51 **	-23.26**	-10.64 **	-13.11 **	-35.27 **
28	RMT-430 X MT-10-8-1	8.54 **	6.93 **	0.93	15.66 **	11.76 **	8.83 **	16.88 **	9.76	4.65	53.62 **	52.05 **	13.28 **
29	RMT-430 X RT-368	-2.50	-4.41 **	-8.88 **	-9.37 **	-13.29 **	-13.79 **	-21.52 **	-24.39 **	-27.91**	-13.96 **	-20.28 **	-30.38 **
30	RMT-430 X AKT-101	-4.50 **	-6.37 **	-10.75 **	11.18 **	10.24 **	1.84	25.93 **	24.39 **	18.60**	81.29 **	78.06 **	37.56 **
31	TKG-22 X IC 204845	-1.44	-1.91	-4.21 **	-5.62 **	-5.78 **	-10.82 **	-2.78	-10.26	-18.60**	12.67 **	-0.80	-5.65
32	TKG-22 X JLT-408	-5.34 **	-6.70 **	-8.88 **	-5.23 **	-6.22 **	-9.34 **	-16.88 **	-17.95 **	-25.58**	-1.48	-14.29 **	-18.47 **
33	TKG-22 X MT-10-8-1	-4.62 **	-6.22 **	-8.41 **	3.30 *	1.85	-0.82	6.67	2.56	-6.98	17.17 **	3.53	-1.53
34	TKG-22 X RT-368	-3.15 *	-4.31 **	-6.54 **	-7.69 **	-9.91 **	-10.43 **	11.69 *	10.26	0.00	13.81 **	9.15 **	3.82
35	TKG-22 X AKT-101	-2.18	-3.35 *	-5.61 **	1.63	0.41	-4.96 **	18.99 **	17.50 **	9.30	31.80 **	19.42 **	13.59 **
36	IC 204845 X JLT-408	-4.88 **	-5.80 **	-8.88 **	-9.49 **	-10.59 **	-13.56 **	-12.68 *	-18.42 **	-27.91	45.88 **	43.88 **	4.12
37	IC 204845 X MT-10-8-1	-5.13 **	-6.28 **	-9.35 **	-3.38 *	-4.90 *	-7.39 **	-4.35	-8.33	-23.26**	-2.31	-2.72	-29.01 **
38	IC 204845 X RT-368	-5.11 **	-5.80 **	-8.88 **	4.84 **	2.16	1.56	32.39 **	23.68 **	9.30	16.63 **	6.64	-6.87 *
39	IC 204845 X AKT-101	-3.16 *	-3.86 *	-7.01 **	11.97 **	10.81 **	4.53 *	36.99 **	25.00 **	16.28**	45.51 **	40.91 **	8.85 **
40	JLT-408 X MT-10-8-1	-2.22	-2.46	-7.48 **	14.22 **	13.80 **	10.82 **	27.03 **	23.68 **	9.30	12.67 **	10.67 *	-19.24 **
41	JLT-408 X RT-368	0.25	0.00	-4.67 **	-6.90 **	-8.18 **	-8.71 **	0.00	0.00	-11.63*	35.33 **	22.20 **	6.72 *
42	JLT-408 X AKT-101	4.67 **	4.41 **	-0.47	15.67 **	13.10 **	9.34 **	2.56	0.00	-6.98	26.99 **	21.34 **	-6.26
43	MT-10-8-1 X RT-368	0.99	0.49	-4.21 **	-7.86 **	-8.81 **	-9.34 **	0.00	-2.63	-13.95*	38.86 **	27.45 **	11.30 **
44	MT-10-8-1 X AKT-101	-0.99	-1.47	-6.07**	6.92**	4.17*	1.45	13.16*	7.50	0.00	42.68**	98.74**	7.18 *
45	RT-368 X AKT-101	-2.94*	-2.94	-7.48**	17.20**	13.05**	2.39**	-5.13	-7.50	13.95*	-5.94	-11.36**	22.60**

* - Significant at 5 % level   ** - Significant at 1 % level

(23.00 %) (Table 2). Senthilkumar and Ganesan (2001) reported heterosis with a range of -34.80 to 47.10 per cent over better parents and -34.80 to 8.70 per cent over standard check, respectively. Significant positive heterosis was also noticed by Mothilal and Manoharan (2004), Singh *et al*. (2007), Jawahar *et al*. (2013) and Chaudhari *et al*. (2015), Patel *et al*. (20l7), Rajput *et al.* (2017) and Karthikeyan *et al*. (2019).

Oil content is an important character for higher yield. Sixteen hybrids could manifest significant positive heterobeltiosis ranging from -14.36 per cent (DSS-9 x IC-204845) to 21.05 per cent. However, these hybrids also exhibited positive heterosis for seed yield per plant (Table 2). Similar results related to positive heterosis was recorded by Jawahar *et al.,* (2013) and Vavdiya *et al,* (2013). Chaudhari *et al*. (2014), Rajput *et al.* (2017), Virani *et al*. (20.l7), Raikwar (20l8) and Daba *et al*. (20l9) observed similar results related to positive heterosis.

The present investigation revealed a high order of heterosis for seed yield per plant. Twenty eight hybrids manifested significant

Contd…Table 2. *Per cent* heterosis over mid parent (MPH), better parent (BPH) and standard check- DS-5 (SH) for 1000 seed weight (g), oil content (%) and seed yield per plant (g) in sesame (*Sesamum indicum* L.)

Sl.	Crosses	1000 seed weight (g)			Oil content (%)			Seed yield per plant (g)		
No.		MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH
1	DS-5 x DSS-9	29.02**	19.03*	23.00*	-0.25	-0.92	-1.59	9.69**	7.36**	10.42**
2	DS-5 X JTS-8	48.00**	33.55**	38.00**	9.72**	2.83	0.75	40.94**	21.81**	25.28**
3	DS -5X RMT-430	-14.43	-20.65*	-18.00	3.70	-3.51*	-5.46**	-7.81**	-19.92**	-17.64**
4	DS-5 X TKG-22	-22.36*	-26.99**	-14.33	-6.53*	-7.45**	-7.6**	-0.54	-0.74	2.08
5	DS-5 X IC 204845	28.57**	16.13	20.00*	-1.86	-9.86**	-11.67**	30.96**	10.53**	13.68**
6	DS-5 X JLT-408	3.45	-3.23	0.00	14.08**	6.26**	4.12*	20.01**	8.10**	11.18**
7	DS-5 X MT-10-8-1	18.92*	17.24	24.67**	1.81	-2.52	-4.48*	7.49**	1.22	4.10*
8	DS-5 X RT-368	-3.47	-5.81	-2.67	11.25**	4.55**	2.44	4.92**	-2.09	0.69
9	DS-5 X AKT-101	33.44**	33.23**	38.33**	10.95**	2.89	0.81	26.76**	22.01**	25.49**
10	DSS-9 X JTS-8	0.19	-1.10	-14.33	-3.38	-10.67**	-11.27**	-8.05**	-19.04**	-20.28**
11	DSS-9 X RMT-430	8.54	7.92	-4.67	2.05	-5.64**	-6.28**	18.09**	4.51*	2.92
12	DSS-9 X TKG-22	4.56	-8.81	7.00	-1.33	-2.35	-2.61	7.16**	5.08**	7.64**
13	DSS-9 X IC 204845	-3.52	-5.7	-17.67*	-6.18*	-14.36**	-14.93**	-19.00**	-30.39**	-31.46**
14	DSS-9 X JLT-408	3.70	-1.93	-9.24**	2.18	-5.42**	-6.05**	2.57	-5.78**	-7.22**
15	DSS-9 X MT-10-8-1	34.25**	18.21*	30.00**	5.04	-0.08	-0.75	16.51**	11.99**	10.28**
16	DSS-9 X RT-368	0.54	-5.08	-6.67	0.38	-6.26**	-6.89**	5.37**	0.35	-1.18
17	DSS-9 X AKT-101	-8.71	-16.03	-12.67	-5.18	-12.62**	-13.20**	-10.47**	-11.99**	-13.33**
18	JTS-8 X RMT-430	48.84**	44.91**	28.00**	16.21**	14.77**	-0.73	46.38**	45.51**	10.35**
19	JTS-8 X TKG-22	-15.75	-27.84**	-15.33*	-11.16**	-17.06**	-17.28**	-9.55**	-21.69**	-19.79**
20	JTS-8 X IC 204845	11.78	11.55	-6.67	2.54	-0.12	-13.61**	21.07**	17.70**	-11.81**
21	JTS-8 X JLT-408	19.39*	15.19	3.67	13.40**	12.18**	-2.97	30.63**	24.68**	2.78
22	JTS-8 X MT-10-8-1	32.73**	28.84**	37.00**	9.54**	7.61**	-3.52*	62.97**	48.70**	35.07**
23	JTS-8 X RT-368	-1.47	-8.8	-10.33	10.91**	10.72**	-4.24*	1.52	-6.55**	-16.74**
24	JTS-8 X AKT-101	51.69**	36.86**	42.33**	18.11**	16.23**	0.53	79.75**	60.66**	52.85**
25	RMT-430 X TKG-22	26.42**	10.80	30.00**	3.00	-4.98**	-5.24**	29.33**	12.54**	15.28**
26	RMT-430 X IC-204845	-0.58	-3.40	-14.67	22.31**	20.17**	1.37	15.77**	11.90**	-15.14**
27	RMT-430 X JLT-408	4.67	3.70	-6.67	7.75*	7.23**	-9.33**	15.14**	10.53**	-8.89**
28	RMT-430 X MT-10-8-1	43.84**	31.66**	40.00**	15.04**	11.25**	-0.26	53.83**	41.13**	28.19**
29	RMT-430 X RT-368	-4.29	-9.15	-10.67	-1.92	-3.31	-16.67**	-10.32**	-16.99**	-26.04**
30	RMT-430 X AKT-101	43.85**	44.23**	38.33**	0.73	0.00	-15.65**	39.40**	25.26**	19.17**
31	TKG-22 X IC 204845	7.31	-8.24	7.67	9.64**	-0.10	-0.37	28.39**	854**	11.18**
32	TKG-22 X JLT-408	28.62**	13.64	33.33**	6.00	-2.03	-2.34	28.47**	15.93**	18.75**
33	TKG-22 X MT-10-8-1	-4.32	-8.81	7.00	3.28	-1.94	-2.2	10.03**	3.80*	6.32**
34	TKG-22 X RT-368	-14.68	-21.6*	-8.00	-4.11	-10.62**	-10.86**	-11.97**	-17.69**	-15.69**
35	TKG-22 X AKT-101	24.7*	17.61	38.00**	11.94**	2.96	2.69	43.97**	38.85**	42.22**
36	IC 204845 X JLT-408	-6.15	-9.63	-18.67*	0.80	-0.72	-16.06**	-5.08**	-11.79**	-27.29**
37	IC 204845 X MT-10-8-1	-12.48	-13.35**	-1.13	-1.72	-5.90*	-15.65**	-4.94**	-15.44**	-23.19**
38	IC 204845 X RT-368	44.95**	33.90**	31.67**	21.38**	18.44**	2.08	43.70**	28.92**	14.86**
39	IC 204845 X AKT-101	37.01**	23.40**	28.33**	22.31**	21.05**	1.37	37.04**	19.49**	13.68**
40	JLT-408 X MT-10-8-1	-16.47	-22.89*	-18.00*	10.46**	7.32**	-3.79*	9.34**	4.28*	-5.28**
41	JLT-408 X RT-368	22.12*	16.95*	15.00	12.72**	11.65**	-3.77*	25.59**	20.89**	7.71**
42	JLT-408 X AKT-101	-14.43	-19.69*	-17.00	0.24	-0.24	-15.67**	-7.24**	-13.43**	-17.64**
43	MT-10-8-1 X RT-368	-0.65	-4.39	1.67	11.77**	9.61**	-1.73	21.34**	20.18**	9.17**
44	MT-10-8-1 X AKT-101	-17.91	-18.81*	-13.67	1.30	-2.05	-12.18**	-2.76	-4.96**	-9.58**
45	RT-368 X AKT-101	-5.77	-8.33	-4.67	20.46**	18.75**	2.34	10.59**	7.08**	1.88

* - Significant at 5 % level   ** - Significant at 1 % level

Table 3. Top three crosses exhibiting maximum heterosis and their mean performance with respect to seven characters in sesame

Characters	Crosses	*Per se* performance	*Per cent* heterosis over standard check (DS-5)
Days to maturity	DSS-9 X RT-368	92.00	-14.02**
	RMT-430 X IC-204845	95.00	-11.21 **
	DSS-9 X RMT-430	95.50	-10.75**
Plant height (cm)	JLT-408 X MT-10-8-1	141.80	10.82 **
	JLT-408 X AKT-101	139.90	9.34 **
	RMT-430 X MT-10-8-1	139.30	8.83 **
Number of branches per plant	RMT-430 X AKT-101	5.10	18.60**
	IC 204845 X AKT-101	5.00	16.28**
	RT-368 X AKT-101	3.70	13.95*
Number of capsules per plant	RMT-430 X AKT-101	90.10	37.56*
	DSS-9 X MT-10-8-1	81.30	24.12**
	RT-368 X AKT-101	50.70	22.60**
1000 seed weight (g)	JTS-8 X AKT-101	4.27	42.33**
	RMT-430 X MT-10-8-1	4.20	40.00**
	DS-5 X AKT-101	4.15	38.33**
Oil content (%)	DS-5 X JLT-408	51.10	4.12*
	TKG-22 X AKT-101	50.40	2.69
	DS-5 X RT-368	50.28	2.44
Seed yield per plant (g)	JTS-8 X AKT-101	11.00	52.85**
	TKG-22 X AKT-101	10.24	42.22**
	JTS-8 X MT-10-8-1	9.73	35.07**

positive heterobeltiosis ranging from -30.39 per cent (DSS-9 x IC-204845) to 60.66 per cent (JTS-8 x AKT-101).Twenty two hybrids registered significant positive standard heterosis over DS-5 ranging from -31.46 per cent (DSS-9 x IC-204845) to 52.85 percent (JTS-8 x AKT-101).The study indicated that JTS-8 x AKT-101 had the highest heterosis (52.85 per cent) followed by TKG 22 x AKT 101 (42.22 %), JTS-8 x MT-10-8-1 (35.07), RMT-430 x MT-10-8-1 (28.19 %) and IC-204845 x AKT-101 (13.68 %) (Table 3). These hybrids also expressed significant positive heterosis for1000 seed weight, number of capsules per plant, plant height and negative heterosis for days to maturity. Heterosis percentage to a extent of 58.11 per cent over better parent and 52.67 over standard check observed by Jawahar *et al*. (2013) and Vavdiya *et al.* (2013). Chaudhari *et al.* (2014), Shobha *et al.* (2015), Patel *et al*. (20l7), Raikwar *et al*. (2018) and Daba *et al*. (20l9) also reported similar results indicating positive heterosis.

Top three heterotic crosses exhibiting maximum heterosis percentage over standard check (DS-5) and their mean performance with respect to seven characters (Table 3). For days to maturity, per cent standard heterosis and mean performance for three crosses *viz.,* DSS-9 x RT-368, RMT-430 x IC-204845 and DSS-9 x RMT-430 were-14.02, -11.21 and -10.75 and 92.00, 95.00 and 95.50. For Plant height, percent standard heterosis and mean performance for three crosses *viz.,* JLT-408 x MT-10-8-1, JLT-408 x AKT-101 and RMT-430 x MT-10-8-1 were 10.82, 9.34 and 8.83 and 141.80, 139.90 and 139.30. For number of branches per plant, percent standard heterosis and mean performance for three crosses *viz.,*RMT-430 x AKT-101, IC-204845 x AKT-101 and RT-368 x AKT-101 were 18.60, 16.25 and 13.95 and 5.10, 5.00 and 3.70. For number of capsules per plant, per cent standard heterosis and mean performance for three crosses *viz.,* RMT-430 x AKT-101, DSS-9 x MT-10-8-1 and RT-368 xAKT-101 were 37.56, 24.12 and 22.60 and 90.10, 81.30 and 50.70. For 1000 seed weight, percent standard heterosis and mean performance for three crosses *viz.,* JTS-8 x AKT-101, RMT-430 x MT-10-8-1 and DS-5 x AKT-101 were 42.33, 40.00 and 38.33 and 4.27, 4.20 and 4.15. For oil content, per cent standard heterosis and mean performance for three crosses *viz.,* DS-5 x JLT-408, TKG-22 x AKT-101 and DS-5 X RT-368 were 4.12, 2.69 and 2.44 and 51.10, 50.40 and 50.28. For seed yield per plant, per cent standard heterosis and mean performance for three crosses *viz.,* JTS-8x AKT-101, TKG-22 X AKT-101 and JTS-8 X MT-10-8-1 were 52.85, 42.22 and 35.07 and 11.00, 10.24 and 9.73, respectively (Table 3).

Conclusion

In the present study, where the *per se* performance of the parents and the *per cent* heterosis of the resultant hybrids were considered with best three crosses for all traits mentioned. From the foregoing discussion it can be clearly brought out that the cross combinations *viz*., JTS-8 X AKT-101, TKG-22 X AKT-101, JTS-8 X MT-10-8-1, RMT-430 X MT-10-8-1 and DS-5 X JTS-8 for seed yield and TKG-22 X AKT-101, DS-5 X RT-368, IC-204845 X AKT-101, TKG-22 x RT-368 and DSS-9 x JTS-8 for oil content with higher standard heterosis for seed yield over high yielding commercial check DS-5. The selected crosses for each trait have high potential to be used for recombination breeding to develop high potential pure lines. All parents in the selected crosses can be used for future breeding program of this crop.The crosses that exhibited high heterosis for seed yield and its contributing traits could be used for commercial exploitation in sesame.

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