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STUDY OF GENE ACTION AND COMBINING ABILITY FOR SEED YIELD AND ITS ATTRIBUTING TRAITS IN SESAME (*Sesamum indicum* L.)

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ABSTRACT

The present experiment was carried out using line x tester analysis at the Department of Seed Science and Technology, Sagadividi Farm, J.A.U., Junagadh with fourteen parents and forty hybrids along with a two checks, G.Til-2 and G.Til-3 were evaluated during summer 2016-17. The female G.Til-10 and male AT-319 were good general combiners for seed yield per plant having high concentration of favourable genes as indicated by highly significant and positive gca effect. Also AT-341 and AT-265 for days to flowering, days to maturity and height to first capsule were good general combiners. The hybrids Khadkala-S x G.Til-1, AT-307 x AT-285, AT-322 x AT-285, AT-319 x G.Til-10 and AT-341 x G.Til-10 were high yielding along with positive desirable sca effect for seed yield per plant. These hybrids also had higher values for height to first capsule, number of branch per plant, number of capsules per plant, number of seeds per capsule, number of capsules per leaf axils and 1000-seed weight could profitably be exploited through heterosis breeding for general cultivation in order to increase the yield potentiality in sesame.

Key words : *Sesame, seed yield, GCA, SCA and combining ability.*

Sesame (*Sesamum indicum* L.) is a very ancient oilseed crop of the tropic and warm sub-tropics regions with is a member of the order Tubiflorae and family Pedaliaceae. Sesame is predominantly annual self-pollinated (85-95%) diploid (2n=2x=26) crop. It is referred as 'Queen of Oilseeds' due to its regard by the users and owing to its oil quality (1). Sesame contains about 45-52% oil, 20-27% protein, 6-7% moisture, 16% carbohydrate and 6-8% crude fiber in its small oblong seeds. In India, during 2015-16, sesame is cultivated in an area of 17.46 lakh ha with a production of 9.11 lakh tones annually and productivity of 474 kg/ha (Anon., 2016). Being the fourth important oilseed crop in Indian agriculture after groundnut, rape seed and mustard, it is widely cultivated in the states of Uttar Pradesh, Rajasthan, Orissa, Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, West Bengal, Bihar and Assam. In Gujarat, during 2015-16, sesame is cultivated in an area of 2.56 lakh ha with a production of 1.52 lakh tones and productivity of 530 kg/ha (2). The average productivity is very low as compare to other growing countries China, Japan and Korea. Hence, there is an urgent need to increase the productivity by breaking the present yield barrier and developing hybrids with high yield potential.

The concept of general and specific combining ability as a measure of gene action was proposed by (3). The resulting total genetic variance is partitioned into the variance due to general combining ability and specific combining ability. The general combining ability is an average performance of a line in hybrid combinations and can be recognized as a measure of additive gene action and specific combining ability is the deviation from expectation on the basis of average performance of lines involved and can be regarded as a measure of non-additive gene action. The line x tester analysis proposed by (4) is powerful tool to discriminate good as well as poor combiners and choose appropriate parental material in breeding programme. Therefore, combining ability analysis was carried-out in the present study with a view to obtain useful information for selection of better parents and crosses for their further use in breeding programme. The information regarding nature and magnitude of gene action could also be obtained, which is useful in deciding breeding methodology aiming at exploitable fixable (additive) and non-fixable (non-additive) genetic variances.

An estimate of combining ability is known to be greatly influenced by the environment. The results of combining ability analysis based on single environment do not take into account genotype by environment interaction and so results obtained might be highly biased. Hence, the results based on several environments would be more realistic, which take into account the stability of gene action. Increasing the number of environments reduces the contribution of both the pooled error and the additive by environment interaction to the phenotypic variances, whereas increasing replications only reduces the pooled error. So, the present study was undertaken to study the combining ability estimates, combining ability x environment interaction and nature and extent of gene action in sesame. Combining ability analysis has been utilized to know the nature and extent of gene action controlling expression of different characters including seed yield and would help in proper planning of a successful breeding programme.

MATERIALS AND METHODS

The experimental material was comprised of four females as testers *viz.,* AT-285, G.Til-1, G.Til-10 and RT-54 and ten males as lines namely AT-253, AT-265, AT-306, AT-307, AT-319, AT-322, AT-341, Bhuva-2, Khadkala-S and IS-209 and their forty hybrids derived from line x tester mating design. Location for sowing during summer 2016-17 i.e., Timely sowing 3rd week of February at Junagadh (20th February) the parents and F_1's with checks were sown in single row (plot) of 2.25m length with spacing 45cm x 15cm. All the agronomical practices and plant protection measures were followed as and when required to raise a good crop of sesame. The observations were recorded on five randomly selected plants from parents and crosses for all characters *viz.,* days to flowering, days to maturity, plant height (cm), height to first capsule (cm), number of branches per plant, number of internodes per plant, length of capsule (cm), number of capsules per plant, number of capsules per leaf axil, number of seeds per capsule, 1000-seed weight (g) and seed yield per plant (g). Department of Seed Science and Technology, Sagadividi Farm, J.A.U., Junagadh is located in South Saurashtra Agro-climatic zone of Gujarat state. The combining ability analysis was carried-out according to the method suggested by (4). This design is related to North-Carolina Design II (Comstock and Robinson, 1952) in terms of covariance of half-sibs and full-sibs. The model for this design is as under: $Y_{ijk} = + g_i + g_j + s_{ij} + r_k + _{ijk}$.

RESULTS AND DISCUSSION

In E_2 Junagadh environment, analysis of variance for combining ability revealed (table-1) that mean squares due to lines and testers were significant for all the characters suggesting that both lines and testers had considerable general combining ability (GCA) and contributed towards additive genetic variance. Highly significant mean squares due to lines x testers were manifested by all the characters reflecting its significant contribution in favor of specific combining ability (sca) and towards non-additive genetic variance. The estimated variances due to testers (ó^{2}t) were higher than the corresponding variances due to lines (ó^{2}l) for all the characters except height to first capsule, width of capsule and number of capsules per leaf axils. This indicated that testers contributed more than lines towards ^{2}gca.

The estimates of ó^{2}gca were higher than the corresponding ó^{2}sca for days to maturity, number of branches per plant, number of internodes per plant, width of capsule, number of capsules per plant and seed yield per plant. While, in case of remaining characters *viz*., days to flowering, plant height, height to first capsule, length of capsule, number of capsules per leaf axil, number of seeds per capsule and1000-seed weight the magnitude of ó^{2}sca was higher than ó^{2}gca.The ratio of ó^{2}gca/ó^{2}sca was less than unity for days to flowering, plant height, height to first capsule, length of capsule, number of capsules per leaf axil, number of seeds per capsule and 1000-seed weight which indicated that non-additive gene action, while for remaining character it was more than unity which indicated that additive gene action.

For general combing ability (table-2), parents the AT-265 and AT-306 was found positive good general combiner for days to flowering. AT-341 and RT-54 was identified as good general combiner as it exhibited significant desirable (negative) gca effect for days to maturity. The male, AT-341 and female, G.Til-10 were identified as good general combiners as they had significant and positive gca effect for taller traits plant height. The females, G.Til-10 and AT-306 were identified as good general combiner as it exhibited significant and negative (desirable) direction in gca effect for height to first capsule. The males, AT-319, AT-253, Khadkala-S and Bhuva-2 and the females, G.Til-10 were identified as good general combiners as they had significant and positive gca effect for number of branches per plant.

G.Til-10 was found good general combiners and the males namely, AT-306 and AT-307 was found to be good general combiner for number of internodes per plant by exhibiting highly significant and positive direction of gca effects. The males namely, IS-209 and AT-253 and female G.Til-1 was found to be good general combiner for length of capsule by exhibiting highly significant and positive direction of gca effects. The four males namely AT-341, AT-322, AT-253 and AT-307 exhibited highly significant and positive gca effects and categorized as good general combiners. Female G.Til-10 was identified as good general combiners as they had significant and positive gca effect for number of capsules per plant.

In number of capsules per leaf axil, females parent RT-54 and G.Til-1 and among the males, AT-265, AT-307 and G.Til-1 indicated desirable gca effect and identified as good general combiners as it exhibited significant and positive gca effect. Among the females, only G.Til-10 was identified as good general combiner in Junagadh environments as it exhibited significant and positive gca effect for number of seeds per capsule. The males, AT-265 and AT-319 and female parents, only G.Til-1 was found to be good general combiner for 1000-seed weight by exhibiting significant and positive direction in gca effects. Two males AT-319 & AT-253 exhibited highly significant and positive gca effects and categorized as good general combiners. The perusal of results revealed that among female parents, only G.Til-10 was found to be

Table-1 : Analysis of Variance (mean squares) and variance estimates for combining ability for E_2 Junagadh environment.

Source	d.f.	Days to flower-ing	Days to maturity	Plant height (cm)	Height to first capsule	Numbe r of branch es per plant	Number of internod es per plant	Length capsule (cm)	Number of capsules per plant	Number of capsules per leaf axil	Numbe r of seeds/ capsule	1000-se ed weight (g)	Seed yield per plant (g)
Lines (L)	9	6.39**	10.97**	72.79**	64.29**	0.58**	20.40**	0.18**	240.90**	0.29**	190.23**	0.07**	14.98**
Testers (T)	3	27.69**	102.40**	857.24**	509.49**	14.44**	201.07**	0.23**	3779.80**	0.22**	628.69**	0.09**	197.27**
L x T	27	6.33**	7.23**	72.22**	45.64**	1.02**	15.59**	0.06**	330.40**	0.09**	51.71**	0.21**	15.36**
Error	78	1.25	3.17	9.00	5.66	0.048	3.85	0.01	9.82	0.02	9.02	0.00	0.51
Variance components													
Lines (2l)		0.00	0.31	0.02	1.55	-0.04	0.40	0.01	-7.46	0.02	11.54	-0.01	-0.03
Testers (2t)		0.72	3.20	26.17	15.46	0.45	6.18	0.01	114.98	0.00	19.23	-0.00	6.06
2GCA		1.02	4.75	37.41	22.98	0.62	9.06	0.02	160.00	0.02	34.10	-0.01	8.64
2SCA		1.69	1.35	21.07	13.32	0.32	3.91	0.02	106.89	0.03	14.20	0.07	4.96

Table-2 : General combining ability effect for lines and testers under Junagadh environments in sesame for E_2 environment.

Parents	Days to flower-ing	Days to maturity	Plant height (cm)	Height to first capsule	Number of branches per plant	Number of internod es per plant	Length of capsule (cm)	Number of capsule s per plant	Number of capsule s per leaf axil	Number of seeds per capsule	1000-se ed weight (g)	Seed yield per plant (g)
Females (Testers)												
AT-285	-0.22	-0.61	-2.53**	-2.32**	-0.60**	-1.12*	-0.04	-1.51	0.00	-1.80*	0.00	-0.55**
G.Til-1	-0.65	-0.94	-4.07**	-2.58**	-0.42**	-0.73	0.12**	-6.51**	0.09*	-1.82*	0.07**	-1.25**
G.Til-10	1.42**	2.76**	7.83**	6.12**	0.95**	3.81**	-0.09**	16.28**	-0.11**	6.80**	-0.01	3.75**
RT-54	-0.55	-1.21*	-1.23	-1.21	0.07	-1.96**	0.01	-8.26**	0.02	-3.18**	-0.06**	-1.96**
SEgi +	0.21	0.33	0.53	0.44	0.04	0.35	0.01	0.57	0.02	0.55	0.01	0.13
Males (Lines)												
AT-253	0.33	0.58	-5.15**	-5.47**	0.31**	-0.11	0.16**	3.37**	-0.01	4.83**	0.02	1.13**
AT-265	-1.00**	-0.67	0.81	-0.8	-0.04	0.39	0.12**	-3.14**	0.19**	1.87*	0.13**	0.03
AT-306	-0.92**	-0.26	1.22	3.62**	-0.11	2.61**	-0.03	-3.12**	-0.14**	2.90**	-0.02	-0.27
AT-307	0.25	-0.09	-0.13	1.14	-0.05	1.04	-0.09**	2.77**	0.12**	1.09	0.06**	0.45*
AT-319	-0.50	-0.67	-0.96	-0.38	0.33**	-1.51**	-0.04	2.69**	-0.19**	5.81**	0.09**	1.65**
AT-322	0.42	-0.42	-1.98*	-0.97	-0.28**	0.82	-0.14**	3.79**	-0.11**	0.12	-0.04*	0.85**
AT-341	-0.75*	-1.59**	4.32**	0.51	-0.23**	0.14	-0.08**	7.15**	-0.06	-4.34**	-0.01	0.38
Bhuva-2	0.67*	1.66**	1.28	0.80	0.08	-0.91	-0.15**	-2.40**	-0.01	-4.57**	-0.12**	-1.40**
Khadkala-S	0.42	0.33	0.85	0.56	0.18**	-1.66**	0.08**	-4.61**	0.29**	-2.63**	-0.05**	-1.12**
IS-209	1.08**	1.16*	-0.25	1.01	-0.19**	-0.80	0.18**	-6.50**	-0.08*	-5.08**	-0.05**	-1.70**
SEgi +	0.33	0.51	0.84	0.69	0.06	0.56	0.02	0.90	0.04	0.87	0.02	0.21

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

good general combiner for seed yield per plant E_2 Junagadh environments by exhibiting highly significant and positive gca effects. Out of 10 males, AT-319, AT-253, AT-322 and AT-307 exhibited significant and positive gca effect and categorized as good general combiner.

For specific combining ability (Table-3), the crosses AT-307 x G.Til-10, Khadkala-S x AT-285, AT-306 x G.Til-1, AT-253 x G.Til-10 and AT-322 x RT-54 exhibited significant and negative sca effect for days to flowering. Significant and desirable (negative) sca effect for days to maturity was displayed by seven Crosses. The three top crosses with maximum desirable sca effect included AT-253 x G.Til-10, AT-306 x AT-285, and AT-307 x G.Til-1. In Plant height significant positive sca effects were displayed in 17 crosses. Five crosses exhibiting desirable positive sca effect for this trait were AT-265 x RT-54, AT-253 x G.Til-10, AT-306 x RT-54, AT-341 x AT-285 and AT-319 x G.Til-1. Likewise, best five crosses *viz.,* Bhuva-2 x RT-54, IS-209 x RT-54, AT-265 x AT-285,

Table-3 : Specific combining ability effect of hybrids under E_2 Junagadh environments in sesame.

Sr. No.	Crosses	Days to flowering	Days to maturity	Plant height	Height to first capsule	Number of branches per plant	Number of internodes per plant	Length of capsule (cm)	Number of capsules per plant	Number of capsules / leaf axil	Number of seeds per capsule	1000-seed weight	Seed yield per plant
1	AT-253 x AT-285	0.30	2.36**	-0.01	-0.27	0.03	-1.43*	-0.02	1.03	-0.22**	-2.50**	0.11**	0.15
2	AT-253 x G.Til-1	1.73**	0.02	1.62	0.29	-0.72**	0.94	-0.04	5.67**	0.16**	0.15	0.01	1.19**
3	AT-253 x G.Til-10	-1.67**	-3.01**	4.96**	3.69**	1.38**	2.08**	-0.09**	6.28**	0.16**	3.57**	-0.44**	0.39
4	AT-253 x RT-54	-0.37	0.63	-6.57**	-3.72**	-0.68**	-1.59**	0.15**	-12.98**	-0.10**	-1.22	0.32**	-1.74**
5	AT-265 x AT-285	0.63	-0.06	-1.54	-5.47**	0.21**	-0.84	-0.22**	-8.56**	-0.02	-0.08	-0.24**	-1.98**
6	AT-265 x G.Til-1	-0.93**	-0.06	-1.77*	0.82	0.03	-0.03	0.18**	-9.46**	0.09*	-0.93	0.07**	-1.81**
7	AT-265 x G.Til-10	0.33	-1.09*	-7.16**	-4.18**	0.09	-2.66**	0.08**	10.92**	0.03	-0.47	0.03	2.33**
8	AT-265 x RT-54	-0.03	1.21*	10.47**	8.82**	-0.33**	3.54**	-0.05*	7.10**	-0.10**	1.47	0.13**	1.46**
9	AT-306 x AT-285	-0.12	-2.48**	-1.95*	-0.35	-0.06	1.98**	0.12**	-3.47**	0.12**	1.79*	0.20**	0.05
10	AT-306 x G.Til-1	-2.02**	0.52	-6.18**	-0.26	0.13*	-2.68**	-0.09**	-1.27	-0.04	0.21	0.25**	0.12
11	AT-306 x G.Til-10	1.92**	1.82**	3.30**	-1.99**	0.52**	0.12	-0.04	8.90**	0.03	2.29**	-0.29**	0.96**
12	AT-306 x RT-54	0.22	0.12	4.83**	2.60**	-0.60**	0.59	0.01	-4.15**	-0.10**	-4.29**	-0.16**	-1.14**
13	AT-307 x AT-285	0.38	2.69**	0.44	1.52*	0.58**	-1.32*	-0.07**	13.13**	0.25**	3.23**	0.01	2.83**
14	AT-307 x G.Til-1	0.82*	-1.97**	1.67*	-0.18	0.17**	1.99**	0.13**	-2.7**	-0.11**	1.62	0.04	-0.07
15	AT-307 x G.Til-10	-3.25**	-0.67	-4.92**	-3.65**	-0.97**	-1.35*	0.05*	-24.56**	-0.30**	-1.36	-0.24**	-4.97**
16	AT-307 x RT-54	2.05**	-0.04	2.81**	2.31**	0.21**	0.69	-0.10**	14.12**	0.16**	-3.48**	0.19**	2.21**
17	AT-319 x AT-285	1.47**	-0.39	-0.24	2.22**	-0.20**	-0.93	0.22**	8.52**	-0.03	-4.98**	0.28**	1.1**
18	AT-319 x G.Til-1	-1.43**	0.94	4.33**	1.44*	-0.28**	3.18**	0.07**	-3.02**	-0.19**	-2.93**	-0.37**	-2.03**
19	AT-319 x G.Til-10	-0.50	0.24	-5.83**	-4.99**	0.52**	0.21	-0.19**	1.96*	0.08*	9.25**	0.04*	2.74**
20	AT-319 x RT-54	0.47	-0.79	1.73*	1.34	-0.04	-2.46**	-0.09**	-7.46**	0.15**	-1.33	0.05**	-1.82**
21	AT-322 x AT-285	-0.78*	0.69	3.09**	1.80*	0.45**	0.60	-0.04	9.08**	-0.12**	-0.03	0.26**	1.74**
22	AT-322 x G.Til-1	1.65**	-0.64	-1.24	-0.48	-0.53**	1.51**	0.04	-13.76**	0.32**	-6.21**	-0.34**	-3.46**
23	AT-322 x G.Til-10	0.58	-0.34	-4.20**	-2.91**	0.23**	-2.46**	0.02	6.02**	-0.07	1.01	0.32**	2.24**
24	AT-322 x RT-54	-1.45**	0.29	2.36**	1.59*	-0.15*	0.34	-0.02	-1.34	-0.14**	5.22**	-0.24**	-0.52*
25	AT-341 x AT-285	1.38**	-0.81	4.79**	2.59**	-0.17**	1.95**	0.06**	-5.98**	0.03	0.20	-0.32**	-1.53**
26	AT-341 x G.Til-1	-0.18	0.19	-4.31**	-0.55	0.55**	-3.17**	0.03	-1.88*	0.01	0.68	-0.12**	-0.33
27	AT-341 x G.Til-10	-0.92**	-0.51	2.76**	-1.12	-0.85**	-0.77	-0.10**	5.03**	-0.05	-5.90**	0.34**	0.64**
28	AT-341 x RT-54	-0.28	1.13*	-3.24**	-0.92	0.46**	1.99**	0.00	2.84**	0.01	5.02**	0.10**	1.21**
29	Bhuva-2 x AT-285	-1.03**	-1.72**	1.22	2.40**	0.05	3.07**	-0.03	3.70**	0.05	0.93	0.07**	0.75**
30	Bhuva-2 x G.Til-1	1.07**	0.28	1.42	-1.51*	0.04	-0.79	-0.28**	1.90*	0.09*	-0.92	-0.04*	0.35
31	Bhuva-2 x G.Til-10	0.67*	1.91**	3.93**	5.26**	-0.37**	2.01**	0.25**	-11.56**	0.16**	-3.70**	0.09**	-2.42**
32	Bhuva-2 x RT-54	-0.70*	-0.46	-6.57**	-6.15**	0.28**	-4.29**	0.06*	5.95**	-0.30**	3.68**	-0.12**	1.32**
33	Khadkala-S x AT-285	-2.12**	0.61	-4.75**	-3.53**	-0.32**	-1.38*	-0.12**	-6.52**	0.02	2.06*	-0.20**	-1.23**
34	Khadkala-S x G.Til-1	0.32	0.61	2.16*	-0.83	0.7**	-1.54**	0.09**	17.62**	-0.14**	6.94**	0.15**	4.11**
35	Khadkala-S x G.Til-10	1.58**	-1.09*	2.93**	4.73**	-0.57**	1.36*	0.01	-3.87**	-0.07	-2.47**	0.02	-1.49**
36	Khadkala-S x RT-54	0.22	-0.13	-0.34	-0.37	0.18**	1.56**	0.02	-7.23**	0.20**	-6.53**	0.03	-1.39**
37	IS-209 x AT-285	-0.12	-0.89	-1.05	-0.91	-0.57**	-1.68**	0.11**	-10.93**	-0.08*	-0.63	-0.18**	-1.88**
38	IS-209 x G.Til-1	-1.02**	0.11	2.29**	1.25	-0.09	0.59	-0.13**	6.90**	-0.18**	1.39	0.36**	1.92**
39	IS-209 x G.Til-10	1.25**	2.74**	4.23**	5.15**	0.01	1.46**	0.01	0.88	0.03	-2.22*	0.13**	-0.44*
40	IS-209 x RT-54	-0.12	-1.96**	-5.47**	-5.49**	0.66**	-0.37	0.02	3.15**	0.23**	1.46	-0.31**	0.40
Min.		-3.25	-3.01	-7.16	-6.15	-0.97	-4.29	-0.28	-24.56	-0.30	-6.53	-0.44	-4.97
Max.		2.05	2.74	10.47	8.82	1.38	3.54	0.25	17.62	0.32	9.25	0.36	4.11
S.E. (Sij)		0.67	1.03	1.67	1.38	0.12	1.11	0.04	1.81	0.07	1.73	0.04	0.41
Number of cross with desirable sca effect		12	7	17	11	16	13	13	19	13	10	19	16

AT-319 x G.Til-10 and AT-265 x G.Til-10 exhibited significant and negative sca effects for height to first capsule in E_2.The significant cross combinations identified for number of branches per plant were 16. Three important crosses with maximum sca effect for this trait were AT-253 x G.Til-10, Khadkala-S x G.Til-1 and IS-209 x RT-54. Significant and positive sca effect for number of internodes per plant was observed for 13. Out of these, the best three crosses identified were; AT-265 x RT-54, AT-319 x G.Til-1 and Bhuva-2 x AT-285.

Similarly, thirteen crosses recorded significant and positive sca effect for length of capsule character in E_2, some crosses with maximum sca effect included Bhuva-2 x G.Til-10, AT-319 x AT-285, AT-265 x G.Til-1, AT-253 x

Table-4 : Best five parents in per se, gca effect sca effects for various characters in sesame for E_2 Junagadh environment.

Characters	Best performing parents	Good general combiners	Best specific combiners	Characters	Best performing parents	Good general combiners	Best specific combiners
Days to flowering	G.Til-1	AT-265	AT-307 x G.Til-10	Length of capsule (cm)	AT-265	IS-209	Bhuva-2 x G.Til-10
	AT-319	AT-306	Khadkala-S x AT-285		AT-319	AT-253	AT-319 x AT-285
	AT-341	AT-341	AT-306 x G.Til-1		G.Til-10	G.Til-1	AT-265 x G.Til-1
	AT-253	G.Til-1	AT-253 x G.Til-10		RT-54	AT-265	AT-253 x RT-54
	Bhuva-2	RT-54	AT-322 x RT-54		AT-341	Khadkala-S	AT-307 x G.Til-1
Days to maturity	AT-285	AT-341	AT-253 x G.Til-10	Number of capsules per plant	G.Til-10	G.Til-10	Khadkala-S x G.Til-1
	IS-209	RT-54	AT-306 x AT-285		RT-54	AT-341	AT-307 x RT-54
	AT-307	G.Til-1	and AT-307 x G.Til-1		AT-341	AT-322	AT-307 x AT-285
	AT-341	AT-265	IS-209 x RT-54		Khadkala-S	AT-253	AT-265 x G.Til-10
	G.Til-1	AT-319	Bhuva-2 x AT-285		G.Til-1	AT-307	AT-322 x AT-285
Plant height (cm)	AT-253	G.Til-10	AT-265 x RT-54	Number of capsules per leaf axil	Khadkala-S	Khadkala-S	AT-322 x G.Til-1
	AT-319	AT-341	AT-253 x G.Til-10		AT-253	AT-265	AT-307 x AT-285
	AT-265	Bhuva-2	AT-306 x RT-54		G.Til-1	AT-307	IS-209 x RT-54
	G.Til-1	AT-306	AT-341 x AT-285		AT-265	G.Til-1	Khadkala-S x RT-54
	AT-307	Khadkala-S	AT-319 x G.Til-1		AT-307	RT-54	Bhuva-2 x G.Til-10
Height to first capsule (cm)	AT-341	G.Til-10	Bhuva-2 x RT-54	Number of seeds per capsule	G.Til-10	G.Til-10	AT-319 x G.Til-10
	G.Til-10	AT-306	IS-209 x RT-54		RT-54	AT-319	Khadkala-S x G.Til-1
	Khadkala-S	AT-307	AT-265 x AT-285		AT-253	AT-253	AT-322 x RT-54
	RT-54	IS-209	AT-319 x G.Til-10		G.Til-1	AT-306	AT-341 x RT-54
	AT-285	Bhuva-2	AT-265 x G.Til-10		AT-319	AT-265	Bhuva-2 x RT-54
Number of branch per plant	G.Til-10	G.Til-10	AT-253 x G.Til-10	1000-seed weight (g)	AT-253	AT-265	IS-209 x G.Til-1
	RT-54	AT-319	Khadkala-S x G.Til-1		AT-307	AT-319	AT-341 x G.Til-1
	Khadkala-S	AT-253	IS-209 x RT-54		AT-319	G.Til-1	AT-253 x RT-54
	AT-341	Khadkala-S	AT-307 x AT-285		AT-341	AT-307	AT-322 x G.Til-10
	AT-253	Bhuva-2	AT-341 x G.Til-1		AT-306	AT-253	AT-319 x AT-285
Number of inter-nodes per plant	R-T-54	G.Til-10	AT-265 x RT-54	Seed yield per plant (g)	G.Til-10	G.Til-10	Khadkala-S x G.Til-1
	G.Til-10	AT-306	AT-319 x G.Til-1		RT-54	AT-319	AT-307 x AT-285
	AT-341	AT-307	Bhuva-2 x AT-285		AT-341	AT-253	AT-319 x G.Til-10
	IS-209	AT-322	AT-253 x G.Til-1		G.Til-1	AT-322	AT-265 x G.Til-10
	Khadkala-S	AT-265	Bhuva-2 x G.Til-10		AT-253	AT-307	AT-322 x G.Til-10

RT-54 and AT-307 x G.Til-1. Sixteen crosses exhibited significant and positive sca effects out of which three best cross combinations *viz.,* Khadkala-S x G.Til-1, AT-307 x RT-54 and AT-307 x AT-285 were identified for number of capsules per plant showed positive and significant sca effects. Thirteen crosses exhibited significant and positive sca effects from which the most important crosses included AT-322 x G.Til-1, AT-307 x AT-285, IS-209 x RT-54, Khadkala-S x RT-54, Bhuva-2 x G.Til-10, AT-307 x RT-54, AT-253 x G.Til-1 and AT-253 x G.Til-10 which exhibited significant and positive sca effect under E_2. Likewise, best five crosses *viz.,* AT-319 x G.Til-10, Khadkala-S x G.Til-1, AT-322 x RT-54, AT-341 x RT-54 and Bhuva-2 x RT-54 exhibited significant and positive sca effects for number of seed per capsule and positive crosses were recorded 20. Best three cross combinations, out of nineteen crosses exhibited significant and positive sca effects viz., IS-209 x G.Til-1, AT-341 x G.Til-1, AT-253 x RT-54, AT-322 x G.Til-10 and AT-319 x AT-285 showed positive and significant sca effects for 1000-seed weight. Sixteen crosses possessed significant and positive sca effect for seed yield per plant (g). The top five crosses exhibiting desirable, significant and positive sca effect for this trait were Khadkala-S x G.Til-1, AT-307 x AT-285, AT-319 x G.Til-10, AT-265 x G.Til-10 and AT-322 x G.Til-10.

The female G.Til-10 and male AT-319 were good general combiners for seed yield per plant having high concentration of favourable genes as indicated by significant and positive gca effect for these parents (Table-4). Besides having good combining ability effect for seed yield per plant, these parents were also observed to be good combiners for yield contributing characters. For example, G.Til-10 was also good general combiner for plant height, height to first capsule, number of branches per plant, number of internodes per plant, number of capsules per plant and number of seeds per capsule. Likewise has good general combiner AT-265 for days to flowering, days to maturity, number of internodes per plant, number of capsules per leaf axil and number of seeds per capsule.

Likewise for the other parents which had significant and desirable gca effect for various yield attributing characters included AT-341 for days to flowering, days to maturity, plant height and number of capsules per plant; G.Til-1 for days to flowering, days to maturity, length of capsule, number of capsules per leaf axil and 1000-seed weight; RT-54 for days to flowering, days to maturity and number of capsules per leaf axil. The other males parents included AT-253 for number of branches per plant, number of internodes per plant, length of capsule, number of capsules per plant, number of capsules per leaf axil, number of seeds per capsule and 1000-seed weight ; AT-265 for days to flowering, days to maturity, length of capsule, and 1000-seed weight; AT-306 for days to flowering, plant height, height to first capsule, number of internodes per plant and number of seeds per capsule; AT-307 for height to first capsule, number of internodes per plant, number of capsules per plant, number of capsules per leaf axil and 1000-seed weight ; AT-319 for days to maturity, number of branch per plant, number of seeds per capsule and 1000-seed weight; AT-322 for number of internodes per plant and number of capsules per plant; Bhuva-2 for plant height, height to first capsule, number of branch per plant; Khadkala-S for plant height, number of branch per plant, length of capsule and number of capsules per leaf axil; and IS-209 for height to first capsule and length of capsule. The present results revealed and suggested that these male and female parents possessed high concentration of desirable accumulation genes for the respective traits and may be utilized in crossing programme block to develop new the varieties containing majority of desirable characteristics in sesame.

In the present study, the gca effects of parent were more or less associated with their *per se* performance for all the characters. For instance, male AT-253 which exhibited highly significant and positive gca effect for seed yield per plant, number of branches per plant, number of internodes per plant, length of capsule, number of capsules per plant, number of capsules per leaf axil, number of seeds per capsule and 1000-seed weight, also expressed high *per se* performance for the respective characters. G.Til-10 exhibited highly significant and positive gca effect for seed yield per plant, plant height, height to first capsule, number of branches per plant, number of internodes per plant, number of capsules per plant and number of seeds per capsule, also expressed high *per se* performance for the respective characters. Likewise, AT-319, AT-322, AT-306, AT-307, AT-265, RT-54, AT-341 and G.Til-1 parents showing significant gca effect in desired direction for different traits also showed good *per se* performance for the respective characters (5, 6, 7) have also suggested that parental selection can be done on the basis of *per se* performance, which supported the present findings.

The estimate of sca effects found that none of the hybrid was superior simultaneously for all the characters. However, the best hybrids on the basis of significant and positive sca effect for seed yield per plant were Khadkala-S x G.Til-1, AT-307 x AT-285, AT-319 x G.Til-10, AT-265 x G.Til-10 and AT-322 x G.Til-10. All of these hybrids observed significant and positive desirable sca effect for one or more component traits of seed yield. In general, results revealed that as component traits of

seed yield with significant and desirable effect increased, the value of sca effect of hybrids for seed yield also increased, e.g., the top ranking hybrid Khadkala-S x G.Til-1 recorded positive significant and desirable sca effect for number of branch per plant, number of capsules per plant and number of seeds per capsule; second ranking hybrid AT-307 x AT-285 found significant and desirable sca effect for number of branch per plant, number of capsules per plant and number of capsules per leaf axils; third ranking hybrid AT-319 x G.Til-10 recorded significant and desirable sca effect for only height to first capsule; fourth ranking hybrid AT-265 x G.Til-10 observed significant and desirable sca effect for only height to first capsule; and fifth ranking hybrid AT-322 x G.Til-10 for 1000- seed weight. In general, the hybrids with significant and desirable sca effect for seed yield also recorded significant and desirable sca effect for one or more of its component traits. Similar findings, as observed in present study, were also reported (8, 9, 10). Cross combination AT-319 x G.Til-10 involving both good general combiners offers still better possibilities of exploitation as it is expected to yield stable segregants in the advanced generations and needs further exploitation in the breeding programme.

The foregoing discussion and information given explicitly indicated the female G.Til-10 and male AT-253 were good general combiners for seed yield per plant having high accumulation of superior genes as indicated by significant and positive gca effect and that hybrids Khadkala-S x G.Til-1, AT-307 x AT-285, AT-319 x G.Til-10, AT-265 x G.Til-10 and AT-322 x G.Til-10 were high yielding along with desirable sca effect for seed yield per plant. These hybrids also had higher values for height to first capsule, number of branch per plant, number of capsules per plant, number of seeds per capsule, number of capsules per leaf axils and 1000-seed weight could profitably be exploited through heterosis breeding for general cultivation in order to increase the yield potentiality in sesame.

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