COMBINING ABILITY ANALYSIS FOR SEED YIELD AND ITS COMPONENTS IN SUMMER SESAME *(Sesamum indicum* L.)

[1]*PARMAR, R.S.; [2]CHOVATIA, V. P.; [3]BARAD, H.R. AND [4]SAPARA, G. K.

DEPARTMENT OF GENETICS AND PLANT BREEDING
COLLEGE OF AGRICULTURE
JUNAGADH AGRICULTURAL UNIVERSITY
MOTABHANDARIYA (AMRELI) – 355 610, GUJARAT, INDIA

EMAIL: rakeshparmar@jau.in

[1]Assistant Professor, College of Agriculture, Junagadh Agricultural University, Motabhandariya (Amreli) – 355 610
[2]Director of Research and Dean PG Studies, Junagadh Agricultural University, Junagadh – 362 001
[3]Agricultural Officer, Office of the Registrar, Junagadh Agricultural University, Junagadh – 362 001
[4]Assistant Research Scientist, Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh – 362 001

ABSTRACT

The present investigation was conducted at the Agricultural Research Station, Junagadh Agricultural University, Motabhandariya (Amreli) with 14 parents and their 40 hybrids developed following line x tester mating design along with two checks, G.Til-2 and G.Til-3 during summer 2016. The female GT 10 and male AT 341 were good general combiners for seed yield per plant having high concentration of favourable genes as indicated by significant and positive gca effect. AT 285 for days to flowering, days to maturity and height to first capsule were good general combiners. The hybrids Khadkala-S x GT 1, AT 307 x AT 285, AT 322 x AT 285, AT 319 x GT 10 and AT 341 x GT 10 were high yielding along with desirable sca effects for seed yield per plant. These hybrids also had higher values for height to first capsule, number of branch per plant and number of capsule per plant. Therefore, these hybrids could profitably be exploited through heterosis breeding for general cultivation in order to increase the yield potentiality in summer sesame.

KEY WORDS: Combining ability, GCA, SCA, Sesame

INTRODUCTION

Sesame (*Sesamum indicum* L.), commonly known as gingelly, til, simsim, til or tal 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 (Bedigian and Harlan, 1986). Sesame is an important annual oilseed crop in the tropics and warm subtropics. At present, Myanmar is the largest producer of sesame seed in the world followed by India, China, Ethiopia, Nigeria and Uganda. 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, rapeseed 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 (Anon., 2016). This crop is generally cultivated as sole or mixed crop during *kharif*, semi-*rabi* and summer season.

The concept of general and specific combining ability as a measure of gene action was proposed by Sprague and Tatum (1942). 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 Kempthorne (1957) 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.

MATERIALS AND METHODS

The experimental material comprised of four females as testers *viz.*, AT 285, GT 1, GT 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 40 hybrids derived through line x tester mating design and were evaluated during summer 2016 under timely sowing condition (20th February) at Agricultural Research Station, Amreli. The parents and F_1's with checks were sown in single row (plot) of 2.25 m length with spacing 45 cm x 15 cm. 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). The combining ability analysis was carried out according to the method suggested by Kempthorne (1957).

RESULTS AND DISCUSION

Analysis of variance for combining ability (Table 1) revealed that mean squares due to lines and testers were significant for all the characters (except days to flowering and days to maturity in lines) 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 (except days to flowering and days to maturity) reflecting its significant contribution in favour of specific combining ability (sca) and towards non-additive genetic variance. The estimated variances due to testers (σ^2t) were higher than the corresponding variances due to lines (σ^2l) for all the characters except height to first capsule, length of capsule and number of capsules per leaf axils. This indicated that testers contributed more than lines towards $\hat{\sigma}^2$gca. The ratio of σ^2gca/σ^2sca was less than unity for 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.

General combing ability estimates (Table 2) revealed that, parents AT 285 and AT 322 was found good general combiner for days to flowering. AT 285 was identified as good general combiner as it exhibited significant desirable (negative) gca effect for days to maturity. The male, AT 265 and female, GT 10 were identified as good general combiners, as they had significant and positive gca effect for taller traits plant height. The females, GT 1 and AT 285 were identified as good general combiner, as they exhibited significant and negative (desirable) gca effect for height to first capsule. The males, IS 209, AT 322, and AT 253 and the female, GT 10 were identified as good general combiners, as they had significant and positive gca effect for number of branches per plant. GT 10 was found good general combiners for number of internodes per plant and the males, AT 322 and AT 253 was found to be good general combiner for length of capsule by exhibiting highly significant and positive gca effects. The three males namely AT 253, AT 265 and IS 209 exhibited highly significant and positive gca effects and categorized as good general combiners. Female GT 10 and males, AT 341, AT 253 and Bhuva-2 were 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, female parent GT 1 and among the males, Khadkala-S, AT 265, Bhuva-2, AT 307 and IS 209 showed desirable gca effect and identified as good general combiners. Among the females, only GT 10 was identified as good general combiner, as it exhibited significant and positive gca effect for number of seeds per capsule. The male, AT 319 and AT 306 and female parent, GT 1 was found to be good general combiner for 1000 seed weight by exhibiting significant and positive gca effects. The perusal of results revealed that among female parents, GT 10 was found to be good general combiner for seed yield per plant by exhibiting highly significant and positive gca effects. Out of 10 males, AT 341, AT 253 and AT 319 exhibited significant and positive gca effect and categorized as good general combiners for seed yield per plant.

The female GT 10 and male AT 341 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 like GT 10 was also good general combiner for plant height, number of branches per plant, number of internodes per plant, number of capsules per plant and number of seeds per capsule. Likewise AT 341 was good general combiner for days to maturity, plant height, height to first capsule and number of seeds per capsule. The other females parents which had significant and desirable gca effect for various yield attributing characters included AT 285 for days to flowering, days to maturity and height to first capsule; GT 1 for days to flowering, height to first capsule, length of capsule and 1000-seed weight; RT 54 for days to flowering and days to maturity The other males parents included AT 253 for height to first capsule, number of branches per plant, length of capsule and number of seeds per capsule; AT 265 for days to flowering, days to maturity, length of capsule, and 1000-seed weight; AT 306 for plant height, height to first capsule, number of internodes per plant, AT 307 for height to first capsule; AT 319 for number of branch per plant, number of seeds per capsule and 1000 seed weight; AT 322 for height to first capsule, number of internodes per plant; Bhuva-2 for number of branch per plant; Khadkala-S for number of capsules per leaf axil; and IS 209 for length of capsule. The present results thus, suggested that these parents possessed high concentration of favourable genes for the respective traits and may be utilized in crossing programme to develop the varieties containing majority of desirable characteristics in sesame.

Specific combining ability estimates are presented in Table 3. The results showed that the crosses AT 253 x GT 10, Khadkala-S x AT 285, IS 209 x GT 1, AT 265 x GT 10 and AT 307 x AT 285 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 341 x GT 10, Khadkala-S x AT 285 and AT 322 x RT 54. For plant height, significant positive sca effects were displayed in 13 crosses. Five crosses exhibiting desirable positive sca effect for this trait were IS 209 x GT 10, AT 265 x RT 54, Bhuva-2 x AT 285, AT 253 x GT 1 and AT 319 x AT 285. Top five cross combinations *viz*., AT 319 x RT 54, AT 306 x AT 285, AT 265 x AT 285, Bhuva-2 x GT 1 and AT 307 x GT 10 showed negative and significant sca effects for height to first capsule. Three important crosses with maximum sca effect for number of branches per plant were AT-253 x GT 10, AT 306 x GT 10 and AT 319 x GT 10. Significant and positive sca effect for number of internodes per plant was observed for 11. Out of these, the best three crosses identified were Bhuva-2 x AT 285, AT 319 x GT 10 and IS 209 x GT 10. Sixteen crosses exhibited significant and positive sca effects for length of capsule, the most important crosses were Khadkala-S x GT 1, AT-253 x RT 54, Bhuva-2 x GT 10, AT 319 x AT 285 and AT 307 x GT 1. For number of capsules per plant, the best three cross combinations, out of fifteen desirable sca effects were AT 253 x RT 54, AT 306 x GT 10 and Khadkala-S x GT 1. Nine crosses exhibited significant and positive sca effects for number of capsules per leaf axil with five best cross combinations *viz*., IS 209 x RT 54, AT 265 x GT 1, Bhuva-2 x AT 285, AT 307 x RT 54 and AT-253 x GT 1. AT 306 x AT 285, AT-253 x GT 10 and AT 319 x GT 10 were the three best specific cross combination with respect to number of seed per capsule. The best three cross combinations; out of seventeen exhibited desirable sca effects for 1000 seed weight were AT 322 x AT 285, IS 209 x GT 1 and AT 341 x GT 1. Sixteen crosses possessed significant and positive sca effects for seed yield per plant. The top five crosses exhibiting desirable, significant and positive sca effects for seed yield per plant were AT-253 x RT 54, AT 307 x RT 54, Khadkala-S x GT 1, AT 319 x AT 285 and AT 322 x GT 10.

Overall, the estimate of sca effects revealed that none of the crosses was superior simultaneously for all the characters (Table 4). However, the best hybrids on the basis of significant and positive sca effect for seed yield per plant were Khadkala-S x GT 1, AT 307 x RT 54, AT 307 x AT 285, AT 322 x AT 285 and AT 319 x GT 10. All of these hybrids recorded significant and 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 GT 1 recorded significant and desirable sca effect for number of branch per plant, length of capsule, number of capsules per plant, number of seeds per capsule; second ranking hybrid AT 307 x RT 54 recorded significant and desirable sca effect for number of capsules per leaf axils; third ranking hybrid AT 307 x AT 285 recorded significant and desirable sca effect for width of capsule and number of capsules per plant; fourth ranking hybrid AT 322 x AT 285 only 1000-seed weight; and fifth ranking hybrid AT 319 x GT 10 number of branch per plant and number of seeds per capsule. 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 Saxena and Bisen (2017), Ram *et al*. (2018) and Virani *et al*. (2018). Cross combination AT 319 x GT 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.

In the present study, the gca effects of parent were more or less associated with their *per se* performance for all the characters (Table 4). For instance, male AT 341 which exhibited highly significant and positive gca effect for seed yield per plant, days to flowering, days to maturity, plant height, number of capsules per plant, also expressed high *per se* performance for the respective characters. GT 10 exhibited highly significant and positive gca effect for seed yield per plant, plant height, number of branch per plant, number of internodes per plant, number of capsules per plant, number of seeds per capsule, also expressed high *per se* performance for the respective characters. Similarly, AT 253, AT 265, AT 306, AT 307, AT 319, Bhuva-2, Khadkala-S, AT 285 and GT 1 parents showing significant gca effect in desired direction for different traits also showed good *per se* performance for the respective characters Saxena and Bisen (2017), Ram *et al*. (2018) and Virani *et al*. (2018) have also suggested that parental selection can be done on the basis of *per se* performance, which supported the present findings.

CONCLUSION

The foregoing discussion and information, clearly indicated the female GT 10 and male AT 341 were good general combiners for seed yield per plant having high concentration of favourable genes as indicated by significant and positive gca effects. Crosses Khadkala-S x GT 1, AT 307 x AT 285, AT 322 x AT 285, AT 319 x GT 10 and AT 341 x GT 10 were high yielding along with desirable sca effects for seed yield per plant. These hybrids also had higher values for height to first capsule, number of branch per plant and number of capsule per plant. Therefore, these hybrids could profitably be exploited through heterosis breeding for general cultivation in order to increase the yield potentiality in sesame.

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Table 1: Analysis of variance (mean squares) and variance estimates for combining ability in summer sesame

Source of Variation	df	Days to Flowering	Days to Maturity	Plant Height (cm)	Height to First Capsule	Number of Branches / Plant	NO. of Capsules / Plant	No. of Internodes / Plant	No. of Capsules / Leaf Axil	Length of Capsule (cm)	No. of Seeds / Capsule	1000 Seed Weight (g)	Seed Yield / Plant (g)
Lines (L)	9	2.36	9.28	424.50**	202.83**	0.60**	201.10**	27.33**	0.42**	0.26**	61.12**	0.11**	6.04**
Testers (T)	3	42.36**	159.90**	1014.20**	181.81**	16.45**	2239.30**	193.14**	0.17**	0.10**	225.18**	0.12**	86.50**
L x T	27	2.29	7.96	178.10**	72.34**	0.54**	179.90**	16.29**	0.10**	0.07**	54.15**	0.19**	6.97**
Error	78	1.94	5.55	5.17	2.85	0.05	8.81	3.07	0.02	0.01	5.18	0.00	0.31
Variance components													
Lines ($\hat{\sigma}^2$l)		0.01	0.11	20.54	10.87	0.00	1.76	0.92	0.03	0.02	0.58	-0.01	-0.08
Testers ($\hat{\sigma}^2$t)		1.34	5.07	27.98	3.65	0.53	68.64	5.90	0.00	0.00	5.70	-0.00	2.65
$\hat{\sigma}^2_{GCA}$		1.91	7.30	51.55	11.43	0.76	99.07	8.95	0.02	0.01	8.48	-0.01	3.74
$\hat{\sigma}^2_{SCA}$		0.12	0.80	57.63	23.16	0.16	57.03	4.41	0.03	0.02	16.24	0.06	2.22
$\hat{\sigma}^2_{GCA}/\hat{\sigma}^2_{SCA}$		16.56	9.09	0.89	0.49	4.65	1.74	2.03	0.66	0.55	0.52	-0.12	1.69

Table 2: General combining ability effects for lines and testers in summer sesame

Parents	Days to Flowering	Days to Maturity	Plant Height (cm)	Height to First Capsule	Number of Branches / Plant	Number of Capsules / Plant	Number of Internodes / Plant	Number of Capsules / Leaf Axil	Length of Capsule (cm)	Number of Seeds / Capsule	1000 Seed Weight (g)	Seed Yield / Plant (g)
Females (Testers)												
AT 285	-0.94*	-1.86**	0.29	-0.72	-0.52**	-1.44	0.10	0.00	**-0.05**	-1.02	0.03	-0.35*
GT 1	-0.58	-0.72	-6.42**	-2.89**	-0.55**	-5.99**	-2.02**	0.10*	**0.07***	-1.48*	0.07**	-1.10**
GT 10	1.72**	3.38**	7.61**	2.99**	1.04**	12.61**	3.55**	-0.08*	**-0.04***	4.09**	-0.02	2.49**
RT 54	-0.21	-0.79	-1.48*	0.62	0.04	-5.19**	-1.63**	-0.02	**0.03**	-1.59*	-0.08**	-1.05**
SEg$_i$ ±	**0.25**	**0.41**	**0.42**	**0.31**	**0.04**	**0.54**	**0.32**	**0.02**	**0.01**	**0.42**	**0.01**	**0.10**
Males (Lines)												
AT 253	0.13	-0.54	-2.60**	-3.47**	0.29**	2.51**	1.52**	-0.02	0.21**	0.95	0.04*	0.72**
AT 265	-0.54	-1.46*	3.67**	2.34**	-0.13*	-2.23*	-0.80	0.23**	0.20**	0.33	0.16**	-0.08
AT 306	0.04	0.21	4.46**	3.67**	-0.04	-0.92	-0.70	-0.17**	-0.07**	2.86**	-0.03	-0.17
AT 307	0.04	0.13	4.16**	4.71**	-0.15*	-2.36**	-1.20*	-0.12**	-0.14**	-0.70	-0.04	-0.63**
AT 319	-0.63	-0.29	-6.04**	-1.69**	0.34**	0.28	-2.49**	-0.16**	0.00	4.17**	0.11**	0.70**
AT 322	0.96*	0.29	-8.64**	-5.70**	-0.19**	-3.98**	2.25**	-0.09*	-0.13**	-2.08**	-0.09**	-0.76**
AT 341	-0.29	-0.71	10.85**	6.26**	-0.25**	9.30**	1.29*	-0.17**	-0.07**	-1.04	-0.06**	1.25**
Bhuva-2	-0.04	-0.29	-2.45**	-2.54**	0.30**	3.32**	1.07*	0.24**	-0.20**	0.57	-0.16**	0.24
Khadkala-S	0.21	1.04	1.49*	0.61	-0.15*	-4.01**	-1.23*	0.31**	0.05*	-2.80**	0.04*	-0.85**
IS 209	0.13	1.63*	-4.90**	-4.20**	-0.01	-1.92*	0.28	-0.04	0.16**	-2.27**	0.02	-0.43**
SEg$_i$ ±	**0.40**	**0.65**	**0.66**	**0.48**	**0.06**	**0.86**	**0.50**	**0.04**	**0.02**	**0.66**	**0.02**	**0.16**

,** Significant at 5 and 1 per cent levels, respectively

Table 3: Specific combining ability effect of hybrids in summer sesame

Sr. No.	Crosses	Days to Flowering	Days to Maturity	Plant Height (cm)	Height to First Capsule	Number of Branches / Plant	Number of Capsules / Plant	Number of Internodes / Plant	Number of Capsules / Leaf Axil	Length of Capsule (cm)	Number of Seeds / Capsule	1000 Seed Weight (g)	Seed Yield / Plant (g)
1	AT 253 x AT 285	1.11**	2.28**	-4.11**	-4.52**	-0.27**	-5.33**	0.15	-0.17**	0.00	-8.71**	0.05*	-1.71**
2	AT 253 x GT 1	0.74	0.14	8.80**	4.95**	-0.50**	-7.48**	-1.03*	0.20**	-0.06**	-6.51**	0.01	-1.86**
3	AT 253 x GT 10	-1.56**	-2.29**	-2.06**	-0.03	1.05**	-4.41**	-1.77**	0.12**	-0.15**	8.72**	-0.20**	-0.05
4	AT 253 x RT 54	-0.29	-0.12	-2.63**	-0.40	-0.29**	17.22**	2.64**	-0.15**	0.22**	6.50**	0.14**	3.62**
5	AT 265 x AT 285	1.11**	1.19	-9.45**	-5.39**	0.22**	-4.56**	0.24	0.05	-0.17**	1.65*	-0.04*	-0.79**
6	AT 265 x GT 1	-0.26	0.39	0.83	0.27	0.05	2.08*	-0.22	0.35**	0.12**	0.68	0.01	0.37*
7	AT 265 x GT 10	-0.89*	-2.04**	-4.90**	-2.54**	-0.47**	4.32**	-2.98**	-0.13**	0.14**	-0.26	-0.02	0.81**
8	AT 265 x RT 54	0.04	0.46	13.53**	7.66**	0.20**	-1.84*	2.96**	-0.27**	-0.09**	-2.07**	0.05*	-0.39*
9	AT 306 x AT 285	-0.47	-0.81	-7.07**	-6.86**	-0.20**	-0.14	0.28	0.11**	0.11**	7.88**	0.12**	1.14**
10	AT 306 x GT 1	-0.51	0.72	0.37	5.44**	-0.10	-5.65**	1.13*	-0.18**	-0.12**	2.38**	0.30**	-0.44**
11	AT 306 x GT 10	1.19**	0.63	-0.20	-3.94**	0.65**	12.08**	-0.04	0.07	-0.09**	-7.59**	-0.11**	0.7**
12	AT 306 x RT 54	-0.21	-0.54	6.90**	5.36**	-0.35**	-6.29**	-1.37**	0.00	0.09**	-2.67**	-0.30**	-1.40**
13	AT 307 x AT 285	-0.81*	-0.72	-1.01	0.66	0.34**	2.97**	0.40	-0.07	-0.08**	-3.62**	0.01	0.26
14	AT 307 x GT 1	0.83*	-0.19	6.33**	1.60**	0.28**	-0.51	-0.68	-0.10*	0.16**	1.74**	0.12**	0.45**
15	AT 307 x GT 10	-0.14	0.38	-10.53**	-4.72**	-0.61**	-12.85**	-0.65	-0.05	-0.10**	0.57	-0.34**	-2.78**
16	AT 307 x RT 54	0.13	0.54	5.20**	2.46**	-0.01	10.39**	0.93	0.22**	0.03	1.32*	0.22**	2.06**
17	AT 319 x AT 285	0.86*	0.36	8.26**	6.90**	0.09	8.90**	-3.40**	-0.04	0.17**	-0.19	0.02	1.57**
18	AT 319 x GT 1	-0.51	-1.11	-3.03**	-4.34**	0.12	-6.59**	0.21	0.00	0.05*	3.14**	-0.31**	-1.47**
19	AT 319 x GT 10	0.19	0.79	4.94**	4.42**	0.53**	4.98**	3.21**	-0.02	-0.07**	-0.37	0.13**	1.30**
20	AT 319 x RT 54	-0.54	-0.04	-10.17**	-6.98**	-0.74**	-7.29**	-0.02	0.05	-0.15**	-2.58**	0.16**	-1.40**
21	AT 322 x AT 285	-0.72	-0.89	-1.07	1.01*	-0.06	-2.21*	-0.60	-0.17**	0.10**	-0.94	0.44**	-0.07
22	AT 322 x GT 1	-0.76	0.31	5.13**	1.80**	-0.22**	-3.33**	3.08**	0.07	0.02	-0.88	-0.37**	-0.81**
23	AT 322 x GT 10	1.28**	2.88**	-0.80	0.53	-0.24**	5.47**	-3.56**	0.18**	0.05*	2.85**	0.22**	1.39**
24	AT 322 x RT 54	0.21	-2.29**	-3.27**	-3.34**	0.52**	0.07	1.08*	-0.08*	-0.17**	-1.03	-0.29**	-0.50**

Table 3: Contd….

Sr. No.	Crosses	Days to Flowering	Days to Maturity	Plant Height (cm)	Height to First Capsule	Number of Branches	Number of Capsules	Number of Internodes	Number of Capsules	Length of Capsule (cm)	Number of Seeds / Capsule	1000 Seed Weight	Seed Yield / Plant (g)
25	AT 341 x AT 285	-0.47	-1.23	3.18**	-0.12	-0.19**	0.05	1.26*	0.05	0.03	-1.08	-0.18**	-0.35*
26	AT 341 x GT 1	0.83*	1.64*	-0.92	1.01*	0.28**	4.43**	-0.80	-0.11**	-0.06**	-2.02**	-0.13**	0.28
27	AT 341 x GT 10	-0.47	-2.46**	-1.28	-0.13	-0.14*	-1.31	2.40**	0.07	0.02	0.84	0.40**	0.81**
28	AT 341 x RT 54	0.13	2.04**	-0.98	-0.76	0.06	-3.17**	-2.86**	0.00	0.01	2.26**	-0.10**	-0.75**
29	Bhuva-2 x AT 285	-0.39	0.69	11.74**	5.68**	-0.24**	8.96**	3.84**	0.23**	-0.10**	-0.46	-0.05*	1.26**
30	Bhuva-2 x GT 1	0.58	-1.44*	-8.78**	-5.02**	0.16*	3.14**	-2.32**	0.07	-0.16**	0.64	-0.07**	0.52**
31	Bhuva-2 x GT 10	-0.06	0.46	4.29**	3.84**	-0.16*	-6.10**	-0.45	-0.15**	0.19**	-0.53	0.06**	-1.01**
32	Bhuva-2 x RT 54	-0.12	0.29	-7.25**	-4.50**	0.24**	-6.0**	-1.08*	-0.15**	0.07**	0.35	0.06**	-0.77**
33	Khadkala-S x AT 285	-1.31**	-2.31**	0.00	2.33**	0.07	-2.94**	-2.70**	0.16**	-0.24**	5.75**	-0.07**	-0.15
34	Khadkala-S x GT 1	0.33	-0.78	-3.32**	-3.24**	-0.03	11.47**	1.52**	-0.06	0.24**	0.25	0.03	2.04**
35	Khadkala-S x GT 10	0.36	1.13	-3.75**	-3.75**	-0.19**	-5.73**	0.65	-0.08*	0.06*	-3.36**	-0.19**	-1.65**
36	Khadkala-S x RT 54	0.63	1.96**	7.08**	4.65**	0.15*	-2.80**	0.53	-0.02	-0.05*	-2.64**	0.23**	-0.25
37	IS 209 x AT 285	1.11**	1.44*	-0.48	0.31	0.24**	-5.70**	0.53	-0.15**	0.18**	-0.28	-0.3**	-1.17**
38	IS 209 x GT 1	-1.26**	0.31	-5.41**	-2.46**	-0.03	2.45**	-0.89	-0.25**	-0.19**	0.58	0.41**	0.92**
39	IS 209 x GT 10	0.11	0.54	14.30**	6.33**	-0.42**	3.54**	3.18**	0.00	-0.04	-0.86	0.06**	0.49**
40	IS 209 x RT 54	0.04	-2.29**	-8.41**	-4.17**	0.22**	-0.29	-2.82**	0.40**	0.05*	0.56	-0.17**	-0.24
	Min.	-1.56	-2.46	-10.53	-6.98	-0.74	-12.85	-3.56	-0.27	-0.24	-8.71	-0.37	-2.78
	Max.	1.28	2.88	14.30	7.66	1.05	17.22	3.84	0.40	0.24	8.72	0.44	3.62
	S.E. (S_{ij})	0.79	1.19	1.35	0.97	0.12	1.71	1.00	0.08	0.05	1.31	0.04	0.32
	Number of cross with desirable sca effect	5	7	13	15	14	15	11	9	16	11	17	16

Table 4: Best five parents in *per se and good general and specific combiners* for various characters in summer sesame

Characters	Best performing parents	Good general combiners	Best specific combiners	Characters	Best performing parents	Good general combiners	Best specific combiners
Days to Flowering	Khadkala-S	AT 265	Khadkala-S x AT	**Length of Capsule (cm)**	AT 319	AT-253	Bhuva-2 x GT 10
	AT 319	AT 285	Bhuva-2 x AT 285		AT 265	IS 209	AT 319 x AT 285
	GT 1	GT 1	AT 306 x GT 1		GT 10	AT 265	AT 265 x GT 1
	Bhuva-2	RT 54	IS 209 x GT 1		Bhuva-2	GT 1	AT-253 x RT 54
	AT 341	AT 341	AT 307 x GT 10		AT-253	Khadkala-S	Khadkala-S x GT
Days to Maturity	AT 285	AT 285	AT 306 x AT 285	**Number of Capsules / Plant**	AT 341	GT 10	AT 306 x GT 10
	IS 209	AT 265	AT-253 x GT 10		GT 10	AT 341	Khadkala-S x GT
	AT 307	AT 341	AT 265 x GT 10		RT 54	AT 322	AT 307 x RT 54
	AT 341	RT 54	AT 322 x RT 54		Khadkala-S	AT-253	AT 319 x AT 285
	Khadkala-S	GT 1	Bhuva-2 x AT 285		Bhuva-2	Bhuva-2	AT 307 x AT 285
Plant Height (cm)	GT 10	GT 10	AT 265 x RT 54	**Number of Capsules / Leaf Axil**	Khadkala-S	Khadkala-S	IS 209 x RT 54
	AT 341	AT 341	IS 209 x GT 10		AT-253	AT 265	AT 307 x RT 54
	Khadkala-S	AT 306	Bhuva-2 x AT 285		IS 209	GT 1	AT 265 x GT 1
	RT 54	AT 307	AT-253 x GT 1		RT 54	Bhuva-2	AT 322 x GT 1
	AT 285	Bhuva-2	AT 341 x AT 285		GT 1	RT 54	Bhuva-2 x GT 1
Height to First Capsule (cm)	IS 209	AT-253	AT 265 x AT 285	**Number of Seeds / Capsule**	GT 10	GT 10	AT 306 x AT 285
	AT-253	AT 322	Bhuva-2 x RT 54		AT-253	AT 319	AT-253 x GT 10
	AT 307	AT 285	IS 209 x RT 54		RT 54	AT-253	AT 319 x GT 10
	AT 306	GT 1	AT 307 x GT 10		AT 319	AT 306	Khadkala-S x GT
	AT 265	AT 319	AT 265 x GT 10		IS 209	AT 265	AT-253 x RT 54
Number of Branches / Plant	RT 54	GT 10	AT-253 x GT 10	**1000 Seed Weight (g)**	AT 307	AT 265	AT 341 x GT 10
	GT 10	AT 319	AT 319 x GT 10		AT 319	AT 319	IS 209 x GT 1
	Bhuva-2	Bhuva-2	AT 306 x GT 10		AT 341	GT 1	AT 322 x AT 285
	Khadkala-S	AT-253	Khadkala-S x GT 1		AT-253	AT 285	AT 322 x GT 10
	AT-253	AT 306	AT 341 x GT 1		AT 322	AT-253	AT 306 x GT 1
Number of Internodes / Plant	GT 10	GT 10	Bhuva-2 x AT 285	**Seed Yield / Plant (g)**	AT 341	GT 10	Khadkala-S x GT
	RT 54	AT 306	AT 265 x RT 54		GT 10	AT 341	AT 307 x RT 54
	Khadkala-S	AT 322	AT 319 x GT 1		RT 54	AT-253	AT 307 x AT 285
	AT 341	IS 209	AT 322 x GT 1		GT 1	AT 319	AT 322 x AT 285
	AT 285	Bhuva-2	Khadkala-S x RT		Bhuva-2	AT 322	AT 319 x GT 10

[MS received : September 19 , 2018] ***[MS accepted : September 25, 2018]***