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GENE ACTION AND COMBINING ABILITY STUDY IN SESAME

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ABSTRACT

The study of gene action and combining ability have been conducted in 28 F_1 cross combinations along with eight parents in 8x8 half-diallel scheme following Griffing's Approach for 14 morphoeconomic traits including seed yield and oil content in sesame. The general combining ability (GCA) and specific combining ability (SCA) component of variation were significant for parents and crosses respectively for all characters except internode length for GCA indicating role of both additive and non-additive gene action. However, higher proportion of SCA variance (σ^2sca) than GCA variance (σ^2gca) revealed preponderance of non-additive gene action for all characters except capsule length and capsule width under study. Further, variance due to dominance played a significant role than additive variance in all traits except capsule width and 100-seed weight. Nirmala is considered as the best general combiner owing to its higher estimate of *gca* effects for yield per plant, for days to maturity, plant height, branches per plant, capsules per plant, seeds per capsule, capsule length and 100-seed weight. Among cross combinations; Rama × GT-10, AT-382 × Krishna, AT-382 × Nirmala, Krishna × Nirmala, Krishna × Uma, Nirmala × Prachi and Prachi × Uma showed significantly higher *sca* effect for seed yield per plant in the desired direction indicating their merit for recovery of transgressive segregants for higher productivity following reciprocal recurrent selection.

Keywords: Gene action, combining ability, diallel analysis, sesame (*Sesamum indicum* L.),

INTRODUCTION

Oilseeds crops serve as the second most economically important target group of the Indian agriculture next to cereals accounting for 19% of the global area with around 2.7% of global production (Thapa *et al*., 2019). India is the fourth largest oilseed producing country in the world after the USA, China and Brazil (DVVOF, 2017). There are nine oilseeds crops grown in India, out of which seven are of edible oilseed crops (soybean, groundnut, rapeseed mustard, sunflower, sesame, safflower, and niger) and two (castor and linseed) are of non-edible oilseed crops (Singh *et al.,* 2017). Among the minor oilseeds crop (castor, niger, safflower and sesame), sesame occupies the fifth position in terms of production after soybean, groundnut, sunflower and mustard (Pathak *et al*., 2014). Worldwide, it is cultivated in an area of 117 lakh ha with production of 60.16 lakh MT and productivity of 512 kg/ha (Myint *et al*., 2020). Asia and Africa contribute nearly 97% of the world's total production of sesame. In India, it is cultivated in an area of 17.30 lakh ha which occupied 26 states and 1 Union territory with the production of 7.46 lakh MT and productivity of 413 kg/ha (FAOSTAT, 2020) which is far below the world average. In India, Gujarat is the leading sesame producing state contributing 22.3% of total production, followed by West Bengal (19.2%), Karnataka (13.5%), Rajasthan (9.8%), Madhya Pradesh (9.06%), Tamil Nadu (4.7%), Andhra Pradesh (4.52%) and Maharashtra (4.52%) (Directorate of Economics and Statistics, Department of Agriculture and Cooperation, 2019). Its low productivity among the oilseed crops may be attributed to various factors like its cultivation in un-irrigated areas, cultivation of low yielding dehiscent varieties, lack of varietal replacement through the development of hybrids, lack of improved varieties with tolerant to biotic and abiotic stresses (Lakhanpaul *et al*., 2012). Furthermore, sesame is a typically neglected crop or an 'Orphan crop' or under-exploited oilseed crop since it is not mandated to any one of the international agricultural research centers till now and the paradigm of sesame parallels to many minor crops. Most of the varieties under cultivation are selections from local cultivars or closely related populations under low levels of management. Besides, less emphasis has given on researches related to yield structure as a basis for progress in sesame breeding which in turn yielded low productivity potential of cultivars grown in India. This indicates that there is a need to enhance the productivity of this crop by developing high yielding varieties and hybrids varieties. Study of nature of gene action helps to obtain information on the genetic systems governing the inheritance of characters to be improved and predict the performance in subsequent generations by assessing the potential of different crosses. Hence, an attempt was undertaken to study the mode of gene action for fourteen traits and combining ability in a 8 x 8 half-diallele crosses following

Griffing's numerical approach.

MATERIALS AND METHODS

Eight sesame genotypes collected from different origin were used as parents to generate 28 hybrids by following diallel mating scheme (all combination without reciprocal). Hybridization was followed manually by fevicol method to obtained hybrid seeds and seeds of parental genotypes were obtained by selfing. Parents and F_1's were grown at EB-II section of department of Plant breeding and genetics, College of Agriculture, OUAT, BBSR. The experimental site is located at an altitude of 45 m above sea level (latitude 20.26°N and longitude 85.81°E) which is nearly 64 km west of the Bay of the Bengal, coming under the humid and subtropical climate zone of the state. Experimental materials were grown in Randomized Block Design (RBD) with three replications. Each net plot consisted of three rows of two-meter length with spacing of 30 cm × 10 cm. One border row on either side of each plot was laid to avoid the border effect. Observations on fourteen characters *viz*., days to 50% flowering, days to maturity, plant height, height up to first branching, plant height up to 1st capsule bearing node, branches per plant, internode length, capsules per plant, seeds per capsule, capsule length, capsule width,100-seed weight , yield per plant and oil percentage were recorded. The analysis of variance and combining ability (GCA and SCA) was estimated according method 2 (parents and one set of hybrids without reciprocals) of model –I (fixed model) of Griffing theory (Griffing, 1956) utilizing diallel procedure of R studio software. The same model was employed for the assessment of the *gca* effects associated with each parent (g_i), the *sca* effects associated with each cross (S_{ij}) as well as variance of the effects and the differences between effects.

RESULTS AND DISCUSSION

The analysis of variance disclosed a favorable condition for study of combining ability as significant difference was observed between parents, hybrid and parents vs hybrids except there was no significant difference among parents for the character branches per plant (Table 1). Estimates of combining ability variance components provides information about nature of gene action governing the character whereas estimates of *gca* effects and *sca* effects enables breeder for identification of better parents and potential crosses.

Combining Ability Variance

Analysis of variance for combining ability in respect of all the characters revealed significant differences in GCA and SCA variances for all the traits under study except for internode length there was no significant difference for GCA variance (Table 2). It was observed that GCA variance (σ^2gca) was lower than SCA variance (σ^2sca) for all characters indicating preponderance of non-additive gene action which is also confirmed from the ratio of additive genetic variance (σ^2A) to dominance genetic variance (σ^2D) was less than the unit. This report is in strongly agreed with the findings of Azeez and Morakiny (2014), Reddy *et al.,* (2015), Abdel-Rhman *et al* (2019) and Chauhan (2019). Involvement of both additive and non-additive gene action for various character was reported by Balla *et al.,* (2014), Sumathi and Muralidharan (2014),Hassan and Sedeck (2015), Anyanga *et al.,* (2016), Tripathy *et al.,* (2016) and Suganthi *et al.,* (2018). This contradictory finding with present research was due to composition of materials handled and the presence of genotype × environment interactions.

The predictability factor calculated from GCA and SCA variances reflects the degree to which character is transmitted to the progeny (Banerjee and Kole, 2009). The large predictability ratio suggests the importance of additive gene effects, while a low ratio signifies the presence of dominant and/or epistatic gene effects. In this present findings PF value is low for all the character under study further confirming the predominance of non-additive gene action in the expression of these characters. This is in agreement with the findings of Azeez and Morakinyo (2014) and Tripathy *et al.,* (2016).

General combing ability effect of parents

The estimates of *gca* effects of parents for fourteen characters are shown in Table 4.The high value of g_i are due to the fact that in the cross combinations one parent is much better or worse than the other. For example, Nirmala is considered as the best parent for yield per plant as it exihibited highest *gca* effect, whereas for days to 50% flowering GT-10 considered as worst parent despite of highest *gca* effect value because negative *gca* effect is desirable for this character. Based on *gca* effect value and its desirable direction, genotypes were ranked for fourteen character under study (Table 5) and parents were assessed as high (1-2), medium (3-6) and low (7-8) based on gca rank for all the characters (Table 6). Nirmala was the best general combiner days to maturity, plant height, branches per plant, capsules per plant, seeds per capsule, capsule length, 100-seed weight and yield per plant. AT-382 was good general combiner for days to 50% flowering, days to maturity, plant height up to 1st branching, plant height up to 1st capsule bearing node, capsule width and 100-seed weight. Uma was good general combiner for days to 50% flowering, internode length, seeds per capsule, capsule length, capsule width and oil percentage. Rama exhibited good general combining ability for internode length and capsules per plant. VRI-1 was good general combiner for plant height and oil percent. GT-10 was good general combiner for plant height up to 1st branching and yield per plant. Parents with high and favorable *gca* effect will merit selection for use in the hybridization program. Nirmala and GT-10 could be used as parents in the

Table 1. Analysis of variance of parents and hybrids (F_1) for fourteen characters in sesame

Character	Genotype(35)	Parent (7)	Hybrid (27)	Parent vs Hybrid (1)	Error (70)	CV (%)
DF	33.75**	38.52**	26.11**	206.67**	3.39	5.93
DM	150.94**	107.79**	167.95**	20.50**	2.72	1.99
PH	888.27**	909.02**	179.40	19882.3**	81.70	6.64
PHB	134.44**	146.24**	110.33**	702.84**	44.10	23.53
PHC	243.18**	238.40**	82.89**	4604.49**	31.69	9.32
B/P	3.32**	1.19	2.63**	36.83**	1.033	23.49
IL	5.65**	6.59*	5.02*	15.80***	2.90	29.53
C/P	1409.84**	665.12**	1293.42**	9766.07**	92.97	11.37
S/C	126.46**	58.82*	95.64**	1432.039	28.12	7.54
CL	0.126**	0.165**	0.081**	1.060**	0.016	4.91
CW	0.015**	0.015**	0.014**	0.025**	0.003	7.94
HSW	0.002**	0.003**	0.001**	0.012**	0.001	5.20
Y/P	28.96**	16.63**	23.45**	264.035**	2.85	13.14
OP	190.98**	136.67**	211.26**	23.43**	3.008	4.78

*, **- indicate significance at $P_{0.05}$ and $P_{0.01}$ respectively. Figure in the parentheses indicate degrees of freedom for the corresponding source of variation.

Table 2. Analysis of variance for combining ability for 14 characters in 8 × 8 half diallel crosses in sesame

Character	Mean sum of square			
	Genotype (35)	GCA (7)	SCA (27)	Error (70)
DF	11.21**	25.20**	7.77**	1.13
DM	50.32**	147.52**	26.01**	0.908
PH	296.27**	258.01**	305.83**	27.24
PHB	44.80**	92.32**	32.93*	14.70
PHC	81.05**	118.83**	71.62**	10.57
NBP	1.11**	0.758*	1.20**	0.345
IL	1.89*	1.64	1.95*	0.967
C/P	469.94**	537.76**	452.99**	30.99
S/C	42.17**	72.58**	34.56**	9.37
CL	0.042**	0.089**	0.030**	0.005
CW	0.005**	0.008**	0.004**	0.0010
HSW	0.001**	0.001**	0.001**	0.0001
Y/P	9.65**	19.107**	7.30**	0.95
OP	63.65**	111.70**	51.64**	1.002

*, **- indicate significance at $P_{0.05}$ and $P_{0.01}$ respectively. Figure in the parentheses indicate degrees of freedom for the corresponding source of variation.

hybridization program to obtain desirable recombinants for yield. Further, the parents showing good general combining ability for particular component trait may be used in component breeding for bringing improvement of particular component trait, thereby effecting improvement in yield. As the traits capsules per plant and branches per plant are important yield components, cross involving Rama, Nirmala and VRI-1, Nirmala respectively would likely to produce good hybrids and create desirable segregants having higher yield coupled with more number of branches and capsules per plant. Parents with good general combining ability was also reported for different

Table 3. Combining ability variance components for fourteen characters in 8 × 8 half diallel crosses in sesame

Parameter / Character	σ^2gca	σ^2sca	σ^2e	σ^2g	σ^2p	σ^2A/ σ^2D	PF	h^2 (bs)	h^2 (ns)
DF	1.75	6.64	1.13	10.13	11.25	0.53	0.35	89.96	30.99
DM	12.15	25.11	0.90	49.41	50.32	0.97	0.49	98.20	48.30
PH	0.00	278.60	27.23	278.60	305.83	0	0	91.10	0.00
PHB	5.94	18.23	14.70	30.11	44.81	0.66	0.39	67.19	26.51
PHC	4.73	61.05	10.57	70.50	81.05	0.16	0.13	86.98	11.65
B/P	0.00	0.85	0.34	0.85	1.202	0	0	71.16	0.00
IL	0.00	0.98	0.96	0.164	1.95	0	0	50.20	0.00
C/P	8.48	421.99	30.99	438.95	469.94	0.04	0.04	93.41	3.61
S/C	3.80	25.20	9.37	32.80	42.17	0.30	0.23	77.78	18.03
CL	0.06	0.03	0.05	0.037	0.0417	0.40	0.80	88.00	28.48
CW	0.04	0.03	0.01	0.0038	0.0048	3.34	0.73	79.32	16.67
HSW	0	0.05	0.01	0.0005	0.006	2.00	0	82.96	0.15
Y/P	1.19	6.34	0.95	8.70	9.65	0.38	0.27	90.17	24.52
OP	6.06	50.64	1.02	0.17	62.65	0.24	0.19	98.43	18.87

σ^2gca = variance due to GCA, σ^2sca = variance due to SCA, σ^2e= variance due to environment, σ^2g=Variance due to genotype, σ^2p=Variance due to phenotype, σ^2A=Additive variance, σ^2D= Dominance variance. h^2 (bs)= heritability broad sense, h^2 (ns)=heritability narrowsense.PF (Predictability Factor) =2 σ^2gca/2 σ^2gca + σ^2sca)

Table 5. Scoring of parents in respect of rank in gca effects for fourteen characters

Parent / Characters	Rama	AT-382	VRI-1	GT-10	Krishna	Nirmala	Prachi	Uma
DF	6	1	4	8	5	7	3	2
DM	5	1	6	7	4	2	3	8
PH	3	7	2	6	4	1	8	5
PHB	8	1	4	2	5	6	7	3
PHC	6	1	8	4	5	7	2	3
B/P	7	5	2	3	6	1	8	4
IL	1	4	5	3	8	7	6	2
C/P	2	7	8	4	3	1	5	6
S/C	3	5	8	7	6	1	4	2
CL	6	3	8	7	5	2	4	1
CW	6	1	5	3	8	4	7	2
HSW	6	1	7	5	4	2	8	3
Y/P	4	6	8	2	7	1	3	5
OP	7	3	1	8	6	5	4	2
Average score	**5**	**3.28**	**5.42**	**4.92**	**5.42**	**3.35**	**5.14**	**3.42**
Rank	**8**	**1**	**6**	**4**	**7**	**2**	**5**	**3**

Table 6: Frequency of *gca* effect ranking of parental lines for fourteen characters

Parents	Frequency of character in GCA ranking		
	High(1-2)	Medium(3-6)	Low(7-8)
Rama	2	9	3
AT-382	6	6	2
VRI-1	2	4	6
GT-10	2	7	5
Krishna	0	11	3
Nirmala	8	3	3
Prachi	1	8	5
Uma	6	7	1

characters by Rajput and Kute (2012), Hassan and Sedeck (2015), Reddy (2015), Shobha Rani *et al.,* (2015), Tripathy *et al.,* (2016), Rajput *et al.,* (2017), Aye *et al.,* (2018) and Yarasi and Reddy (2018).

Specific combing ability effect of parents

Specific combining ability is the deviation from the performance predicted based on general combining ability. It is an important criterion for the choice of the parent for the hybridization program because it reveals best cross combination which can be used for developing heterotic hybrids with high vigor. In the present study, it was observed that none of the cross combination was consistently good for all the characters considering the *sca* effects for yield and yield components (Table 7). However, some of the crosses exhibited significant *sca* effects for more than one character. Earlier many scientists such as Hassan and Sedeck (2015), Shobha Rani *et al.,* (2015), Reddy (2015), Anyanga *et al.,* (2016), Azeez and Morakiny (2014), Rajput *et al.,* (2017) and Yarasi and Reddy (2018) reported crosses with good *sca* effect for different characters under study.

Specific combining ability effects represent dominance and epistasis components of genetic variation which are not fixable in self-pollinated crops like sesame which can be exploited through heterosis breeding programs. The performance of a cross for *sca* effect is the result of the *gca* effect of the parental combination (Table 8). The crosses were derived from parents with positive significant *gca* effects (H), positive but non-significant *gca* effects (M), negative *gca* effects (L) in various combinations (H × H, H × M, M × H, M × M, H × L, M × L, L × M, L × H and L × L).

It appeared that cross combination did not exhibit a specific trend for all characters with respect to *sca* effects. Only a few cross combinations showed consistently, positive or negative *sca* effects for many characters. Good number of crosses with significant *sca* effects in desirable direction for yield and yield contributing characters was observed in this present investigation. For seed yield per plant, Rama × GT-10 (M × M), AT-382 × Krishna (L × M), AT-382 × Nirmala (L × H), Krishna × Nirmala (M × H), Krishna × Uma (M× M), Nirmala × Prachi (H × M) and Prachi × Uma (M × M) showed significant *sca* effect in the desired direction. Out of these seven crosses, five crosses (AT-382 × Krishna, AT-382 × Nirmala, Krishna × Nirmala, Nirmala × Prachi and Prachi × Uma) also showed desirable *sca* effect for capsules per plant and seeds per capsule, whereas Rama × GT-10 for only capsules per plant. For branches per plant, Krishna × Nirmala and Nirmala × Prachi showed *sca* effect in the desired direction from the parental combination of M × H and H × L respectively. Among the parents involved in these seven cross combinations for yield, three parents namely, Nirmala, GT-10 and Prachi were predominantly controlled by additive genetic effects as *gca* effects of these three parents were top-ranked for seed yield/ plant. Thus, the cross combinations Rama × GT-10, AT-382 × Nirmala, Krishna × Nirmala, Nirmala × Prachi and Prachi × Uma constituted of at least one parent having high *gca* effect and thus additive effect was preponderant in the genetic control of these five combinations. Nirmala × Prachi would be the best cross as both parents having good *gca* effect. This would lead to be useful ramification of these five combinations for desirable segregants of fixable nature in the early generation and might lead to the isolation of high yielding genotypes. The importance of general combining ability was thereby, reflected in the high specific combinations also. On the other hand, the cross combinations AT-382 × Krishna (L × M) and Krishna × Uma (M× M) were transcended by non- additive genetic effect for seed yield/plant as no good general combiner was involved in these crosses. Therefore, delayed selection in segregating generation might be advocated for these combinations.

Further, it was observed that AT-382 × VRI-1 showed significant *sca* effect in desirable direction for six traits *viz*., days to flowering (L × M), days to maturity (L × H), plant height (M ×H), branches per plant (M × H), seed per capsule (M × L) and capsule length (M × L) followed

Table 7: Estimates of specific combining ability *(sca)* effects of crosses for fourteen characters in 8 x 8 half diallel cross in sesame

Character / **Cross**	**DF**	**DM**	**PH**	**PHB**	**PHC**	**B/P**	**IL**	**C/P**	**S/C**	**CL**	**CW**	**HSW**	**Y/P**	**OP**
Rama × AT-382	-3.07**	-4.79**	0.93	2.82	2.48	-0.92	2.36**	-11.99*	1.56**	-0.05	0.02	-0.010	-1.15	-7.88**
Rama × VRI-1	0.46	-0.42	-8..50**	1.59	3.25	-0.11	-0.76	0.95	-2.80**	0.08	0.08**	-0.016	-0.48	-5.58**
Rama × GT-10	-2.80**	0.52	6.09	6.08	4.06	-0.22	-0.86	22.18**	-0.06	-0.09	-0.06**	-0.003	2.59**	4.85**
Rama × Krishna	-2.04**	-1.99**	-0.545	-4.34	-3.89	-0.20	-1.53	-3.68	-4.27**	-0.05	0.05	-0.016	0.19	-3.32**
Rama × Nirmala	-0.74	-0.92	-0.85	2.01	4.88	0.19	-1.79*	2.19	0.95*	0.15*	0.04	-0.028**	-0.81	0.32
Rama × Prachi	-2.60**	-2.59**	16.08**	1.83	8.72**	1.17**	0.11	2.35	4.53**	0.05	0.06**	0.032**	1.63	1.42
Rama × Uma	-1.40	7.22**	0.58	0.15	2.93	-0.42	-0.43	-19.89**	8.89**	0.26*	-0.08**	0.026**	0.45	-3.88**
AT-382 × VRI-1	-2.70**	-7.69**	10.33**	2.58	8.76**	1.44**	-1.46	6.014	6.69**	0.37**	0.19	0.012	1.63	-6.64**
AT-382 × GT-10	4.03**	-4.42**	14.46**	1.35	6.14*	0.66	-1.36	-4.09	-0.56**	0.24**	0.10	-0.003	-0.78	-1.01
AT-382 × Krishna	0.18*	-1.25	10.56**	0.03	-4.12	1.08	-1.99*	33.96**	0.56**	0.06	0.07*	-0.005	2.92**	11.87**
AT-382 × Nirmala	-1.90	-2.19**	4.60	0.87	6.66*	0.28	-0.59	11.52*	7.12**	0.03	0.04	-0.015	2.66**	-6.64**
AT-382 × Prachi	-1.44	1.15	9.36*	0.76	3.02	-0.03	-1.29	-4.59	1.36**	-0.04	-0.05	0.026	1.62	-1.51
AT-382 × Uma	-0.57	15.29**	6.22	4.88	-0.01	0.06	-0.72	1.04	-0.28**	0.03	0.03	0.008	0.55	1.37
VRI-1 × GT-10	0.57	1.95*	25.72**	4.14	0.56	-0.53	-1.27	-11.77*	3.41**	0.07	-0.04	0.001	0.38	-8.06**
VRI-1 × Krishna	1.34	-4.89**	14.36**	-8.09*	5.70	0.22	-0.72	2.57	1.87**	0.24**	0.05	-0.020*	0.59	0.08
VRI-1 × Nirmala	-2.37*	-1.49	1.41	9.57**	6.45*	-0.32	-0.88	-12.28**	-6.23**	-0.20**	-0.03	-0.023*	-3.08**	10.27**
VRI-1 × Prachi	-1.90	0.52	5.03	7.57*	4.83	-0.36	0.26	-12.05*	1.34**	-0.11	-0.04	0.022*	-0.26	11.59**
VRI-1 × Uma	-1.04	8.65**	21.49**	-9.96**	3.71	2.09**	1.79*	42.31**	-0.31**	0.07	0.01	-0.034**	2.25	-6.65**
GT-10 × Krishna	-4.94**	2.38**	17.30**	-5.85	2.57	2.26**	-0.49	10.80*	7.27**	0.13*	-0.02	-0.022*	1.49	-1.59
GT-10 × Nirmala	0.36	-2.55**	7.89	-1.44	1.54	0.85	-0.14	0.77	1.17**	0.05	0.045	-0.011	0.19	-6.23**
GT-10 × Prachi	3.50**	-0.22	10.99**	1.64	7.29*	-0.12	0.63	23.25**	-2.59**	0.07	-0.03	-0.023*	1.74	0.118
GT-10 × Uma	-3.30**	-4.08**	13.59**	2.62	0.54	0.49	1.49	17.29**	3.16**	-0.17*	-0.01	-0.028**	0.34	-0.45
Krishna × Nirmala	-0.87	-0.38	0.67	-0.08	-1.92	0.36	2.32*	33.75**	7.64**	0.16*	-0.04	0.002	4.14**	-6.55**
Krishna × Prachi	3.59**	1.95*	6.32	6.60	4.19	-0.37	0.22	-27.56**	6.54**	0.05	-0.04	-0.005	-4.17**	-10.73**
Krishna × Uma	-0.87	1.08	8.56	9.72**	3.06	-0.15	0.32	8.85	-4.43**	0.06	0.01	-0.001	2.06*	15.68**
Nirmala × Prachi	-1.10	2.01*	16.90**	-2.50	3.09	1.96**	0.06	34.09**	5.77**	0.09	-0.06**	-0.026**	4.08**	8.37**
Nirmala × Uma	-0.24	-3.85**	2.26	2.41	5.30	-0.49	0.99	16.77**	0.53**	-0.06	0.01	0.004	-0.87	0.37
Prachi × Uma	1.23	-5.52**	4.45	6.37	7.89**	0.02	0.05	13.05*	5.70**	-0.01	0.02	0.002	3.50**	3.366**
SE (ĩj)	**0.96**	**0.864**	**4.73**	**3.47**	**2.95**	**0.53**	**0.89**	**5.05**	**0.064**	**0.06**	**0.03**	**0.009**	**0.883**	**0.908**
SE (ĩj-ik)	**1.43**	**1.278**	**7.001**	**5.14**	**4.36**	**0.78**	**1.32**	**7.47**	**0.095**	**0.095**	**0.05**	**0.013**	**1.306**	**1.343**
SE (ĩj-kl)	**1.35**	**1.205**	**6.601**	**4.85**	**4.11**	**0.72**	**1.244**	**7.042**	**0.089**	**0.089**	**0.04**	**0.013**	**1.232**	**1.266**

Table 8: Classification of F_1s (crosses) on the basis of *gca* effect for 14 characters in sesame

Character / Crosss	DF	DM	PH	PHB	PHC	B/P	IL	C/P	S/C	CL	CW	HSW	Y/P	OP
Rama ×AT-382	M × L	M × L	M × L	H × L	M × L	L × M	L × M	M × L	M × M	L × M	L × H	L × H	M × L	L × H
Rama ×VRI-1	M × M	M × H	M × H	H × M	M × H	L × H	L × M	M × L	M × L	L × L	L × L	L × L	M × L	L × H
Rama ×GT-10	M × H	M × H	M × M	H × L	M × M	L × M	L × L	M × M	M × L	L × L	L × M	L × M	M × M	L × L
Rama ×Krishna	M × M	M × L	M × M	H × M	M × M	L × M	L × M	M × M	M × L	L × L	L × L	L × M	M × M	L × L
Rama × Nirmala	M × H	M × L	M × H	H × M	M × H	L × H	L × M	M × H	M × H	L × H	L × M	L × M	M × H	L × L
Rama × Prachi	M × L	M × L	M × L	H × H	M × L	L × L	L × M	M × L	M × M	L × H	L × L	L × L	M × M	L × M
Rama ×Uma	M × L	M × H	M × M	H × L	M × M	L × M	L × L	M × L	M × H	L × H	L × L	L × M	M × M	L × H
AT-382×VRI-1	L × M	L × H	L × H	L × M	L × H	M × H	M × M	L × L	M × L	M × L	H × L	H × L	L × L	H × H
AT-382 ×GT-10	L × H	L × H	L × M	L × L	L × M	M × M	M × L	L × M	M × L	M × L	H × M	H × M	L × M	H × L
AT-382 ×Krishna	L × M	L × L	L × M	L × M	L × M	M × M	M × M	L × M	M × L	M × L	H × L	H × M	L × M	H × L
AT-382 ×Nirmala	L × H	L × L	L × H	L × M	L × H	M × H	M × M	L × H	M × H	M × H	H × M	H × M	L × H	H × L
AT-382 × Prachi	L × L	L × L	L × L	L × H	L × L	M × L	M × M	L × L	M × M	M × H	H × L	H × L	L × M	H × M
AT-382 × Uma	L × L	L × H	L × M	L × L	L × M	M × M	M × L	L × L	M × H	M × H	H × L	H × M	L × M	H × H
VRI-1×GT-10	M × H	H × H	H × M	L × L	H × M	H × M	M × L	L × M	L × L	L × L	L × M	L × M	L × M	H × L
VRI-1 ×Krishna	M × M	H × L	H × M	L × M	H × M	H × M	M × M	L × M	L × L	L × L	L × L	L × M	L × M	H × L
VRI-1 × Nirmala	M × H	H × L	H × H	L × M	H × H	H × H	M × M	L × H	L × H	L × H	L × M	L × M	L × H	H × L
VRI-1 × Prachi	M × L	H × L	H × L	L × H	H × L	H × L	M × M	L × L	L × M	L × H	L × L	L × L	L × M	H × M
VRI-1 ×Uma	M × L	H × H	M × M	L × L	H × M	H × M	M × L	L × L	L × H	L × H	L × L	L × M	L × M	L × H
GT-10× Krishna	H × M	H × L	M × M	L × M	M × M	M × M	L × M	M × M	L × L	L × L	M × L	M × M	M × M	L × L
GT-10 ×Nirmala	H × H	H × L	M × H	L × M	M × H	M × H	L × M	M × H	L × H	L × H	M × M	M × M	M × H	L × L
GT-10 ×Prachi	H × L	H × L	M × L	L × H	M × L	M × L	L × M	M × L	L × M	L × H	M × L	M × L	M × M	L × M
GT-10 ×Uma	H × L	H × H	M × M	L × L	M × M	M × M	L × L	M × L	L × H	L × H	M × L	M × M	M × M	L × H
Krishna × Nirmala	M × H	L × L	M × H	M × M	M × H	M × H	M × M	M × H	L × H	L × H	L × M	M × M	M × H	L × L
Krishna × Prachi	M × L	L × L	M × L	M × H	M × L	M × L	M × M	M × L	L × M	L × H	L × L	M × L	M × M	L × M
Krishna × Uma	M × L	L × H	M × M	M × L	M × M	M × M	M × L	M × L	L × H	L × H	L × L	M × M	M × M	L × H
Nirmala × Prachi	H × M	L × L	H × L	M × H	H × L	H × L	M × M	H × L	H × M	L × H	M × L	M × L	H × M	L × M
Nirmala × Uma	H × L	L × H	H × M	M × L	H × M	H × M	M × L	H × L	H × H	H × H	M × L	M × M	H × M	L × H
Prachi × Uma	L × L	L × H	L × M	H × L	L × M	L×M	M × L	L × L	M × H	H × H	L × L	L × M	M × M	M × H

H: Parents with positive significant *gca* effects, M: Parents with positive but insignificant *gca* effects, L: Parents with negative *gca* effects by Krishna × Nirmala for five traits *viz*., internode length (L× L),capsules per plant (M × H), seeds per capsule (M× H), capsule length (M × L) and yield per plant (L × L). Although specific combining ability effects *per se* would not contribute to segregation and selection potential of a cross, the observed pattern of *sca* effects did reflect differences among the crosses with regard to certain genetic properties.

The parents involving H × H *gca* effects in cross combinations are desirable in self-pollinated crops like sesame as they involve additive and additive × additive types of interaction which is fixable in early generation. The result revealed that very few cross combinations had shown good *sca* effect from H × H combination. Best *sca* effect from L × L parental combination for characters *viz.,* days to 50% flowering, days to maturity, plant height up to 1st branching, plant height up to 1st capsule bearing node and internode length is expected due to the negative *gca* effect of the parent is desirable. For internode length, capsule per plant, capsule width, 100-seed weight and yield per plant none of cross showed desirable *sca* effect from H × H combination.

Babu *et al.,* (2004) also reported frequent heterotic hybrids for seed yield/plant involving H × L *gca* effects of parents. Solanki and Gupta (2003) reported that crosses expressing high *sca* effects for seed yield and its components had parental combinations of H × L, H × L, M × L, L × M and L × L *gca* effects. Possible complementary epistatic gene action in poor combiners and predominance of additive gene action in good combiners worked in combination to maximize expression in M × H, H × M, L × M, H × H, L × H and L × H type of combinations.

CONCLUSION

The diallel analysis by Griffing's method for gene action study helps in identification of parents and crosses through estimation of *gca* effect and *sca* effect. It also provides useful information about types of gene action governing a character. In the present study, it is asserted that high yielding plant types can be recovered as few parents and crosses showed good *gca* effects and *sca* effects for most of the character. Further it was confirmed that from most of the character expression was governed by non-additive gene action including seed yield. In the situation of fixing favorable genes in the homozygous condition only through the pedigree method of breeding would not be effective which can be resorted by some form of recurrent selection, inter se crossing in the inbred generation followed by pedigree selection for breaking tight linkage and bringing desirable recombination in homozygous condition.

REFERENCES

Abd El-Kader MTM, Fahmy RM, El-Shaer HFA and Abd El-Rahman MA.2017. Genetic analysis of six parental sesame genotypes for yield and its attributes in F_1crosses, *Journal of Basic and Environmental Science*, x (xxxx) xx-xx.

Anyanga WO, Rubaihayo P, Gibson P and Okori P.2016. Combining ability and gene action in sesame (*Sesamumindicum*L.) in elite genotypes by diallel mating design,*Journal of Plant Breeding and CropScience*,8(11): 250-256.

Aye M, Win S andHom NH. 2018.Combining ability and heterosis studies in sesame (*Sesamumindicum* L.) genotypes,*International Journalof Advance Research,*6(2):1220-1229.

Azeez MA and Morakinyo AJ.2014.Combining ability studies and potential for oil quality improvementin sesame (*Sesamumindicum* L.), *Journalof Agroalimentary Processes and Technologies*, 20(1):1-8.

Balla MS and Adam SI.2017. Combining ability for yield and yield components in six parents and their 15 F_1 hybrids of sesame (*Sesamumindicum*L.) in half diallel mating design,*Journal of Plant breeding and crop Science*,6(12):179-184.

Babu DR, Kumar PVR, Rani CVD and Reddy AV.2004. Studies on combining ability for yield and yield components in sesame, *Sesamumindicum* L., *Journal Oilseeds Research*,21: 260-262.

Banerjee PP and Kole PC.2009. Combining ability analysis for seed yield and its component traits in sesame (*Sesamumindicum*L.),*International journal of plant breeding and genetics,* 3(1):11-21.

Chauhan BB, Gami RA, Prajapati KP, Patel JR and Patel PJ.2019a. Diallel analysis through griffing's approach for seed yield and its attributing traits in sesame (*Sesamumindicum* L.),*International journal of advanced biological research*,9(3): 229-233.

Directorate of Vanaspati, Vegetable oil and Fats and Department of Commerce (DVVOF),2017.

Directorate of Economics and Statistics. 2019. Department of Agriculture and Cooperation. http://www.dacnet.nic.in/eands/APY_96_To_06.htm.

Food and Agriculturre Organization Statistical Databases (FAOSTAT),2020.

Griffing B. 1956b. Concept of general and specific combining ability in relation to diallel crossing systems, *Australian Journal of Biological Science,* 9(4): 463–493.

Hassan MS and Sedeck FS.2015. Combining Ability and Heterosis Estimates in Sesame,*World Applied Sciences Journal,* 33(5): 690-698.

Myint D, Gilani SA, Kawase M and Watanabe KN. 2020. Sustainable Sesame (*Sesamumindicum* **L.)** Production through Improved Technology: An Overview of Production, Challenges and Opportunities in Myanmar,*Sustainability*, 12(9): 3515.

Pathak N, Rai AK, Kumari R, Thapa A and Bhat KV.2014. Sesame Crop: An Underexploited Oilseed Holds Tremendous

Potential for Enhanced Food Value,*Agricultural Sciences*, 5: 519-529.

Rajput SD and Kute NS. 2012. Combining ability for yield and its contributing characters in sesame (*S. indicum* L), *Bioinfolet*, 9: 831-833.

Rajput SD, Harer PN and Kute NS.2017.Combining ability analysis for yield and its component traits in sesame (*Sesamumindicum*L),*Electronic Journal of Plant Breeding*, 8(4): 1307-1309.

Reddy AV, Parimala K and Rao PVR.2015.Exploitation of hybrid vigour in sesame (*Sesamumindicum*L.),*Electronic Journal of Plant Breeding*, 6(1): 125-129.

Shobha Rani T, Babu TK, Rao PM, Thippeswamy S, Reddy K andSoujanya G.2015.Heterosis studies in sesame (*Sesamumindicum). International Journal of Plant, Animal and Environmental Sciences,*3(5).

Singh AK, Singh AK, Choudhary AK, Kumari A and Kumar R.2017.Towards oilseeds sufficiency in India: Present status and way forward,*Journal of Agri Search*, 4(2):80-84.

Solanki ZS and Gupta D.2003.Inheritance study for seed yield in sesame,*Sesame and Safflower newsletters*, 18:25-28.

Suganthi S. 2018. Estimation of genetic parameters in sesame (*Sesamumindicum*L.) through diallel analysis,*Journal of Pharmacognosy and Photochemistry*, 2665-2667.

Sumathi P and Muralidharan V.2014.Gene effects and inheritance of branching and other yield attributing characteristics in sesame (*Sesamumindicum*). *Tropical Agricultural Research and Extension,*16(3).

Thapa S andBaral R.2019. Status, challenges and solutions of oil-seed production in India. research& reviews. *Journal of Agriculture and Allied Sciences.*

Tripathy SK, Mishra D, Mohapatra PM, Pradhan KC, Mishra D, Mohanty SK, Dash S, Reshmi Raj KR, Swain D, Mohanty MR and Panda S.2016. Genetic analysis of seed yield in sesame (*Sesamumindicum*L.),*International Journal of Agricultural Sciences,*6(9) :1128-1132.

Yarasi B and Reddy KH.2018.Combining ability studies through diallele analysis for yield and its component traits in Sesame (*Sesamumindicum* L.),*International Journal of Agriculture Innovations and Research,* 7(1):