



## Research Article

# Deciphering combining ability and gene action study in elite genotypes of sesame (*Sesamum indicum* L.) using diallel mating design

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## Abstract

To study the nature of gene action and to isolate better parents for the breeding program; combining ability for important parameters was examined in sesame. Seven diverse parents of sesame and their twenty-one  $F_1$ s (half diallel) were grown in *Kharif* 2019, in a randomized complete block design with three replications. Method-2, Model-I of Griffing method was used to analyze combining ability and gene action. Variances due to general combining ability (GCA) and specific combining ability (SCA) for all the traits were highly significant indicating the importance of both additive and non-additive gene actions for the inheritance of all the characters except days to maturity where the additive type of gene action is more important than non-additive type. Connotation among GCA effects and mean performance of the parents proposed that the performance per se could be a good indicator of its ability to transmit the desired traits to its off-springs. The hybrids, GT 03 x AT 307, AT 413 x AT 307, and GT 03 x AT 345 were found superior hybrids for days to flowering, number of capsules per plant, 1000 seed weight, and oil content. AT 413 x AT 307 hybrid having best per se performance for seed yield per plant.

**Keywords** gene action, GCA, half- diallel, SCA, variance

## Introduction

Sesame (*Sesamum indicum* L.;  $2n = 2x = 26$ ) is one of the oldest oilseed crops grown throughout the tropical and sub-tropical regions of the world. It is also known as Gingelly, Til, Simsin, Beni and Gergelim. The genus *Sesamum* has 36 species among which twenty-two species are from Africa, five from Asia, seven from both Africa and Asia, and one species each from Crete and Brazil. High-quality vegetable oil of sesame is considered the queen of oils for human consumption, as it contains a high amount of unsaturated fatty acids and antioxidants e.g., sesamin, sesaminol, sesamol and sesamolol [1]. It is an erect herbaceous annual plant and both indeterminate and determinate type growth habits are observed but most of the varieties show an indeterminate growth habit, which continuously bears new leaves, flowers and capsules as long as the environment remains suitable for growth which helps sesame plants to attain a height of 200 cm [2]. Sesame plants require 70 to 150 days to complete their life cycle based on environmental conditions and the nature of variety [3]. Sesame seeds contain a high amount of linoleic acid, vitamins (E, A, B<sub>1</sub> and B<sub>2</sub>) and minerals (Ca and P) whereas sesame cake can be used to feed dairy cattle and also be used as fertilizer [3]. India is the second-largest

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**Table 1. Analysis of variance (mean sum of square) for eleven characters in sesame**

Sources of variation	d. f.	Days to flowering	Days to maturity	Plant height (cm)	Number of primary branches /plant	Number of capsules/ plant	Number of seeds/ capsule	Capsule length (cm)	1000 seed weight (g)	Seed yield/ plant (g)	Harvest index (%)	Oil content (%)
Replications	2	32.42*	11.62*	55.20	1.00**	160.69**	37.99	0.01	0.01	8.94**	5.54	5.72
Genotypes	28	19.37**	11.56**	187.28**	0.35**	373.00**	93.84**	0.18**	0.52**	26.81**	35.79**	20.51**
Parents	6	28.93**	19.60**	105.46	0.09	217.27**	15.33	0.04	0.50**	7.40**	4.22	31.19**
Hybrids	20	17.99**	10.17**	225.27**	0.46**	451.10**	126.16**	0.21**	0.57**	34.7**	47.55**	18.75**
Parents Vs Hybrids	1	8.76	0.89	97.00	0.01	145.76*	11.61	0.47**	0.02	11.56*	3.59	0.01
Error	56	5.31	3.39	52.55	0.13	29.20	14.32	0.05	0.06	1.70	11.46	7.55

producer of sesame in the world but suffers a serious setback in terms of productivity (368 kg/ha) as compared to the world's average (489 kg/ha) [4]. It is cultivated in an area of 13.98 lakh ha in India with an annual production of 4.18 lakh tonnes and productivity of 291 kg/ha [4]. In Gujarat, it has an estimated area of 1.09 lakh ha with an annual production of 0.78 lakh tonnes and productivity of 723 kg/ha [4]. Sesame is highly drought tolerant which adapt and produce sufficient seeds well under fairly high temperatures [3]. However, moisture levels before planting and flowering have a great impact on the seed yield [5]. Sesame is normally self-pollinated but depending upon insect populations, out crossing also takes place up to 10-50 per-cent under field conditions [6]. Due to the differences in chromosomal numbers across the cyt-taxonomic groups, there is limited cross-compatibility among the species which leads to difficulty in the transfer of desirable traits from crop wild relatives to cultivated ones [2].

Source identification and its evaluation is the major technique in the development of crop varieties to enhance their efficiency [7]. The success of the breeding program is determined by the useful gene combinations, organized in the form of good combining lines and isolation of valuable germplasms. For deciding the selection procedure of the sesame improvement program, knowledge of the combining ability effects and their subsequent variances has a vital significance [8]. Combining ability is helpful to identify the desirable parents for producing better recombinants [9]. Hence, the investigation of general and specific combining ability would yield very useful information; which is required to form an efficient breeding plan leading to rapid improvement. The objectives of the present study were to estimate general combining ability (GCA) and specific combining ability (SCA), assess the nature and magnitude of gene action controlling the inheritance of seed yield and some of its components traits in sesame elite lines.

## Methodology

Seven Morphologically diverse genotypes of sesame (excluding check GT 04), representing different sesame growing regions of Gujarat were crossed in a half diallel mating system (excluding reciprocals) during summer 2019 to produce 21 F<sub>1</sub> hybrids at Agronomy Instructional Farm, S. D. Agricultural University, Sardarkrushinagar by manual crossing. The selfing was ensured by protecting plants from out-crossing using red-colored kite paper bags. A set of 29 genotypes comprising of seven parents, one check GT 04 and 21 F<sub>1</sub> hybrids were sown in Randomized Block Design (RBD) with three replications, during *Khariif*-2019. Each entry was sown in 3.0 m length in two rows with 45 × 15 cm spacing. Agronomical practices and plant protection measures were adopted as per the recommendations for raising a good crop. The observations were recorded both as visual assessment (days to flowering and days to maturity) and measurement on randomly selected five competitive individual plants [plant height, number of primary branches per plant, number of capsules per plant, capsule length, number of seeds per capsule, 1000 seed weight, seed yield per plant, harvest index (%) and oil content (%)]. The replication wise progeny means of each entry for the eleven traits were used for statistical analysis as suggested by Sukhatme and Amble [10]. Moreover, the half diallel analysis was performed as per the method suggested by Griffing [11] Model-I and method-2 using the software WINDOSTAT version 8.1.



**Table 2. Analysis of variance for combining ability of eleven traits in sesame**

Sources of Variation	d. f.	Days to flowering	Days to maturity	Plant height (cm)	Number of primary branches / plant	Number of capsules/plant	Number of seeds/capsule	Capsule length (cm)	1000 Seed weight (g)	Seed yield/plant (g)	Harvest index (%)	Oil content (%)
GCA	6	18.76**	12.69**	104.46**	0.24**	309.96**	27.3**	0.04*	0.18**	16.13**	17.51**	10.05**
SCA	21	3.24*	1.48	53.24**	0.08*	77.64**	33.89**	0.06**	0.17**	7.29**	10.55**	6.05**
Error	54	1.81	1.16	18.01	0.04	10.32	4.94	0.01	0.02	0.55	3.87	2.39
$\sigma^2_{gca}$		1.88	1.28	9.60	0.02	33.29	2.48	0.002	0.01	1.73	1.51	0.85
$\sigma^2_{sca}$		1.43	0.31	35.22	0.03	67.32	28.95	0.04	0.15	6.74	6.67	3.66
$\sigma^2_{gca}/\sigma^2_{sca}$		1.31	4.05	0.27	0.57	0.49	0.08	0.06	0.11	0.25	0.22	0.23

\*  $P \leq 0.05$ , \*\*  $P \leq 0.01$

**Table 3. General Combining Ability (GCA) effects and correlation with mean performance for eleven traits in sesame**

Characters	Parents						
	GT 03	SKT 1501	AT 413	AT 383	AT 338	AT 307	AT 345
Days to flowering	-2.29** (G)	0.97* (P)	-0.47 (A)	-0.43 (A)	1.97** (P)	1.12** (P)	-0.88* (G)
Days to maturity	-1.43** (G)	1.53** (P)	-0.32 (A)	-0.54 (A)	1.50** (P)	0.38 (P)	-1.13** (G)
Plant height (cm)	-5.42** (G)	2.61* (P)	2.83* (P)	0.18 (P)	1.23 (P)	-4.10** (G)	2.67* (P)
Number of primary branches/plant	0.16* (G)	-0.04 (P)	-0.06 (P)	-0.16* (P)	-0.19** (P)	0.26** (G)	0.04 (A)
Number of capsules/plant	7.69** (G)	-1.52 (P)	-2.93** (P)	-3.31** (P)	-7.70** (P)	8.14** (G)	-0.38 (P)
Number of seeds/capsule	-1.00 (P)	-1.44* (P)	2.66** (G)	0.34 (A)	0.50 (A)	-2.42** (P)	1.35 (A)
Capsule length (cm)	-0.07 (P)	-0.01 (P)	0.02 (A)	0.10* (G)	-0.02 (P)	-0.09* (P)	0.08 (A)
1000 seed weight (g)	0.08 (A)	0.14** (G)	-0.27** (P)	0.00 (P)	-0.06 (P)	0.14** (G)	-0.04 (P)
Seed yield per plant (g)	0.79** (G)	0.37 (A)	-0.65** (P)	-1.61** (P)	-1.60** (P)	1.97** (G)	0.72** (G)
Harvest index (%)	1.28* (G)	-0.89 (P)	0.12 (A)	-0.17 (P)	-2.57** (P)	1.34* (G)	0.90 (A)
Oil content (%)	-0.35 (P)	0.80 (A)	-0.06 (P)	-0.49 (P)	-0.96* (P)	-0.92 (P)	1.98** (G)

\*  $P \leq 0.05$ , \*\*  $P \leq 0.01$ , G = Good general combiner (significant and desirable for particular trait),

A = Average general combiner (non-significant negative and positive is poor) and

P = Poor general combiner (significant and negative for particular trait)

## Results and Discussion

The analysis of variance (Table 1) showed highly significant variances between the sesame genotypes and  $F_1$ 's for all the traits under study. This indicated that both additive and non-additive type of gene action played a significant role in determining various traits so the importance of these two components of genetic variance cannot be underestimated for the improvement of sesame. The presence of a fair amount of genetic variability is considered adequate for further biometrical assessment.

The analysis of variance for combining ability (Table 2) showed that the mean square due to GCA was significant for all the characters except for the days to maturity. Significant GCA and SCA variances for all the traits suggested the importance of both additive and non-additive types of gene action in the inheritance of traits. While in the case of days to maturity, additive type of gene action is more important than non-additive type. In the improvement of all the traits evaluated here, breeding methods like recurrent selection and diallel selective mating might be effective as both additive and non-additive gene effects were important for the genetic control of these characters whereas in the case of days to maturity pedigree method can be more beneficial. The higher magnitude of SCA variance as compared to GCA variance for



all the traits (except days to flowering and days to maturity) indicated that non-additive gene effect is greater than additive effect. The ratio of  $\sigma^2_{gca}$  variance to  $\sigma^2_{sca}$  variance was greater than unity for days

**Table 4. Top three ranking parents with respect to mean performance and GCA effects; hybrids with respect to mean performance and SCA effects; heterosis over better parent and standard check – GT 04**

Characters	Best performing Parents	Best General Combiners	Best Performing Hybrids	Hybrids with high SCA Effect	Type of GCA	sca effects
Days to flowering	AT 345	GT 03	GT 03 x AT 383	SKT 1501 x AT 413	P x A	(-2.99**)
	GT 03	AT 345	GT 03 x AT 413	AT 413 x AT 307	A x P	(-2.81**)
	AT 383	AT 413	GT 03 x AT 307	GT 03 x AT 383	G x A	(-2.44**)
Days to Maturity	AT 345	GT 03	GT 03 x AT 383	GT 03 x AT 383	G x P	(-1.81**)
	GT 03	AT 383	GT 03 x AT 345	SKT 1501 x AT 413	P x A	(-1.66**)
	AT 338	AT 345	GT 03 x AT 413	AT 413 x AT 338	A x P	(-1.62**)
Plant height (cm)	GT 03	GT 03	GT 03 x AT 307	AT 383 x AT 338	P x P	(-10.6**)
	AT 307	AT 307	GT 03 x SKT 1501	AT 383 x AT 345	P x P	(-10.02**)
	AT 338	-	AT 383 x AT 338	GT 03 x SKT 1501	G x P	(-9.25**)
Number of primary branches/plant	AT 307	AT 307	GT 03 x AT 307	GT 03 x SKT 1501	G x P	(0.40**)
	GT 03	GT 03	SKT 1501 x AT 307	SKT 1501 x AT 307	P x G	(0.32**)
	AT 413	-	AT 307 x AT 345	AT 307 x AT 345	G x A	(0.24**)
Number of capsules/plant	GT 03	AT 307	GT 03 x SKT 1501	AT 383 x AT 345	P x P	(15.92**)
	AT 307	GT 03	GT 03 x AT 307	GT 03 x SKT 1501	G x P	(12.00**)
	AT 345	-	AT 413 x AT 307	AT 413 x AT 307	P x G	(10.51**)
Number of seeds/capsule	AT 413	AT 413	SKT 1501 x AT 383	SKT 1501 x AT 383	P x A	(8.76**)
	AT 383	-	AT 413 x AT 345	AT 338 x AT 307	A x P	(8.05**)
	AT 345	-	AT 413 x AT 338	SKT 1501 x AT 345	P x A	(4.50**)
Capsule length (cm)	AT 383	AT 383	SKT 1501 x AT 383	SKT 1501 x AT 383	P x G	(0.32**)
	AT 413	-	AT 383 x AT 345	AT 413 x AT 338	A x P	(0.29**)
	AT 338	-	GT 03 x AT 345	GT 03 x SKT 1501	P x P	(0.26**)
1000 seed weight (g)	GT 03	SKT 1501	AT 383 x AT 345	AT 413 x AT 383	P x P	(0.65**)
	AT 307	AT 307	AT 307 x AT 345	AT 383 x AT 345	P x P	(0.63**)
	AT 338	-	SKT 1501 x AT 307	AT 307 x AT 345	G x P	(0.41**)
Seed yield per plant (g)	AT 307	AT 307	SKT 1501 x AT 307	AT 413 x AT 307	P x G	(3.97**)
	AT 345	GT 03	AT 413 x AT 307	SKT 1501 x AT 307	A x G	(3.65**)
	GT 03	AT 345	GT 03 x AT 307	GT 03 x SKT 1501	G x A	(3.08**)
Harvest index (%)	AT 307	AT 307	AT 413 x AT 307	AT 413 x AT 383	A x P	(4.94**)
	GT 03	GT 03	GT 03 x AT 345	GT 03 x SKT 1501	G x P	(4.88**)
	AT 345	-	GT 03 x SKT 1501	AT 413 x AT 307	A x G	(4.76**)
Oil content (%)	AT 345	AT 345	SKT 1501 x AT 345	AT 338 x AT 307	P x P	(3.39**)
	SKT 1501	-	AT 413 x AT 345	GT 03 x AT 413	P x P	(3.31**)
	AT 307	-	GT 03 x AT 413	AT 383 x AT 338	P x P	(3.23**)

P= Poor combiner, A= Average combiner and G= Good combiner  
\* P ≤ 0.05, \*\* P ≤ 0.01

to flowering (1.31) and days to maturity (4.05) which suggested additive gene effect whereas the ratio of less than unity for plant height (0.27), number of primary branches per plant (0.57), number of capsules per plant (0.49), number of seeds per capsule (0.08), length of capsule (0.06), 1000 seed weight (0.11), seed yield per plant (0.25), harvest index (0.22) and oil content (0.23) showed non-additive gene effect. Similar importance of both additive and non-additive types of gene action for the inheritance of all these traits was reported by Abd El-Bramawy and Shaban [12], Kumar et al. [13], Azeez and Morakinyo [14] and Joshi et al. [15]. In the case of days to maturity, the predominant role of additive gene action was also observed by Pushpa et al. [16], Saravanan and Nadarajan [17], Abd El-Bramawy and Shaban [12], Mishra et al. [18], Kumar et al. [13] and Abd El Kader et al. [19].

It is very important to identify parents with high GCA values for the trait to be improved. The GCA-effects of the seven parents for eleven physiological traits estimated in F<sub>1</sub> generations are presented in Table 3. The GCA effects of parents indicated that none of the parents were consistently good for all the characters under study. Parents GT 03, AT 307 and AT 345 were found good general combiners with positive correlation to performance per se and a highly significant GCA effect for seed yield per plant. The parent GT 03 is good general combiner for almost all the traits under study viz. days to flowering, days to maturity, plant height (cm), number of primary branches per plant, number of capsules per plant, seed yield per plant (g) and harvest index (%). The parent AT 307 was a good general combiner for plant height (cm), number of primary branches per plant, number of capsules per plant, 1000 seed weight (g) and harvest index whereas AT 345 was a good general combiner for days to flowering, days to maturity and oil content (%). While the parent, SKT 1501 and AT 307 was found good general combiner for 1000 seed weight. The



parent, AT 383 was found good general combiner for capsule length. While parents, AT 413 was found good general combiner for the number of seed per capsule. These three parents were observed to be the best combiners due to their good general combining ability effects and their ability to transmit traits to their progenies for seed yield and other yield and quality-related attributes. When the parents with the desirable combining ability for the important characters are not available, multiple crosses would be desirable for the development of hybrid and/or selection of superior recombinants in the segregating generations. These three parents could be considered in the future breeding program for improving a particular trait through the selection of transgressive segregants for seed yield and its component traits.

Unlike GCA-effects, the SCA-effects (Table 4) are the result of non-additive gene action. Analysis of data expressed that none of the crosses had high-ranking SCA effects for all the traits under study. The crosses AT 383 x AT 345 recorded the highest SCA effect which was also high in per se performance of the number of capsules per plant. The hybrid combination with high per se performance, high SCA effects along with at least one parent having high GCA effects would tend to increase the frequency of favorable alleles. Cross AT 413 x AT 307 showing highest SCA for seed yield/plant with one parent (AT 307) having high GCA effects and high per se performance suggested its bright future for developing the varieties high yield potential.

## Conclusion

The nature and magnitude of gene action, which was a predominantly non-additive type for the expression of the majority of the physiological traits, indicated that hybrid breeding might be effective for the improvement of such traits. However, reciprocal recurrent selection or diallel selective mating system could be applied for the utilization of both additive and non-additive types of gene actions. Performance per se could be a good indicator of a parent's ability to transmit the desirable traits to its progenies attributable to the association between GCA effects and the mean performance of the parents. When the parents with the desirable combining ability for the important characters are not available, multiple crosses would be desirable for the development of hybrid and/or selection of superior recombinants in the segregating generations. Commercial exploitation of hybrid vigor could be achieved through hybrids with high performance per se along with high SCA for yield and yield attributes. In the present study, based on the mean performance of parents, GT 03 and AT 307 were found superior parents for most of the characters. The hybrids, GT 03 x AT 307, AT 413 x AT 307 and GT 03 x AT 345 were found superior hybrids for days to flowering, number of capsules per plant, 1000 seed weight, and oil content. AT 413 x AT 307 hybrid having best per se performance for seed yield per plant.

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