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# General and Specific Combining Ability in Sesame (*Sesamum indicum* L.) for Seed Yield and Related Traits

**S. H. Prakash[1] and Tapash Dasgupta[2*]**

*[1]Department of Genetics and Plant Breeding, Institute of Agricultural Science, University of Calcutta, Kolkata 700019, West Bengal, India.*
*[2]School of Agriculture and Rural Development, Ramakrishna Mission Vivekananda Educational and Research Institute, Narendrapur, Kolkata 700103, India.*

### *Authors' contributions*

*This work was carried out in collaboration between both authors. Author SHP done the data collection, wrote the protocol and wrote the first draft of the manuscript. Author TD designed the study and performed the statistical analysis of the study. Both authors read and approved the final manuscript.*

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## ABSTRACT

Combining ability study on seed yield per plant from a 7x 7 half-diallel cross of sesame over two years showed that both general combining ability (gca) and specific combining ability (sca) variances important for controlling the traits. Thus, the objectives of this study were to evaluate the gene action and select appropriate parents/crosses using combining ability analysis. Both additive and non additive was of greater significance for seed yield per plant, capsules per plant, days to flowering and oil content. Non additive genetic variances were in the genetic for 1000 seed weight and branches per plant. On the contrary preponderance of additive genetic was found in the inheritance of capsule length and seeds per capsule. The relative magnitude non-additive year interaction was larger than additive x year interaction. The variety Suprava was the best general combiner for seed yield and its major components except oil content. The cross combinations Suprava x Savitri, Suprava x JLT 408 and EC 90 x Savitri would be the best choices for obtaining

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**Corresponding author: E-mail: tapashdg@rediffmail.com;*

desirable recombinants. Suprava x Savitri having additive gene control emerged as the best specific combiner for yield and its components except oil content. For improving seed yield and oil content simultaneously, the specific combiner IC 59 x Savitri was identified to be ideal as this cross mostly controlled by additive gene action and hence desirable recombinants can be obtained in early segregating generation. Breeding strategy for different crosses has been discussed in details. The information could help sesame breeders for appropriate selection of parents with high yield potential and oil content to develop future hybridization programs.

*Keywords: Sesame; half-diallel cross; hybrids; gca; sca.*

## 1. INTRODUCTION

*Sesamum indicum* L. is an important oilseed crop in India, but its productivity is low compared to other oilseed crop. The Seed contains around 50-60% oil [1]. Apart from cooking oil which is PUFA saturated oil, sesame is used in several other purposes like in manufacturing of soaps, perfumery, cosmetics, pharmaceuticals, insecticides, paints and varnishes [2]. Further, sesame seed is popularly utilized in confectioneries, cookies, cake and in bread making. India, though is considered as a one of the major sesame growing countries in the world [3], but it occupies low position in genetic improvement for productivity. The major reason is unavailability of high yielding varieties in India. There exists a large variability of sesame germplasm in India, as India is considered as one of the centres of origin in addition to Africa [2]. Presence of variability and selection of appropriate types from variable types are considered as backbone of plant breeding program. In sesame few wild characters like, non- synchronous maturity get mixed up in the cultivated accessions make the varieties to produce poor or moderate yield. Breaking the linkage and generate desirable recombinants obviously lead to development of promising types. Combining ability is a significant tool for the selection of desirable parents along with the knowledge regarding nature and magnitude of gene effects on seed yield. For successful implementation of breeding program, diallel analysis is considered as an important technique [4] which has two main objectives (i) identification of superior combining parents and crosses for investigated traits, and (ii) to understand the inheritance of the characters through combining ability estimates. Moreover, breeding methodology to be followed for developing varieties mainly depends upon nature of gene action controlling the traits. Hence, knowledge about inheritance pattern of sesame characters, along with general and specific combining ability is important for genetic improvement of sesame. Diallele analysis for yield and related characters has been reported by many earlier research workers in sesame [5], Banerjee and Kole [6], Tripathy et al. [7] Pandey et al. [8]. Yield is a complex quantitative character which interacts with multiple environments. But information of genetic effect of yield over environment is limited. In the present investigation, a 7 x 7 diallel cross is tested over two years to estimate combining ability of parents and crosses along with combining ability x year interaction for yield and its attributes in sesame.

## 2. MATERIALS AND METHODS

Seven genetically divergent varieties of sesame (*Sesamum indicum* L.) viz., Suprava, EC90, JLT408, RT351, Savitri and GT10 were crossed in all possible combinations excluding reciprocals. The 21 $F_1$ tested along with their parents in randomized block design with 3 replications at Agricultural Experiment Station, University of Calcutta, Baruipur, south 24 Proganas (22°51′ latitude north and 88°25′ longitude east)West Bengal, in 2018 and 2019 during pre-kharif season. Each plot consisted of a single row of 3 m long with the spacing of 30 cm and 10 cm, between rows and plants respectively. Normal recommended cultural practices were followed to raise the crop. Ten competitive plant excluding the border plants from each plot were selected randomly for data recording of each replication for number of branches per plant, days to flowering, number of capsules per plant, capsule length (cm), number of seeds per capsule, 1000 seed weight (cm), seed yield per plant(g), oil content(%). To record data of capsule length and number of seeds per capsule, ten capsules were taken from middle portion of each plant to measure capsule length (cm) and number of seeds per capsule and were averaged. Statistical analyses were done following Griffing method 2, model I. The software PB Tools Version 1.4 of International

Rice Research Institute, Philippines, was used to analyse the data combined over two years. The estimates of components of variance were done according to Singh [9].

## 3. RESULTS AND DISCUSSION

The analysis of variance for combining ability (Table 1) for the data combined over two years revealed that mean squares due to general combining ability (gca) and specific combining ability (sca) were significant for seed yield per pant and seven other yield related traits. This indicates the involvement of both additive and non additive genetic control, as revealed by components of GCA and SCA mean squares which were highly significant for all the variables. The relative importance of additive and non-additive genetic effects is usually determined by predictability ratio as suggested by Sokol and Baker [10] and if the ratio exceeds 0.5, then additive genetic effect is emphasized to be major determining factor for the inheritance of the trait and low ratio suggests non-additive genetic variance to be more important.

In the present study, the predictability ratio turned out to be around 0.5, for seed yield, capsules per plant, days to flowering and oil content, indicating almost equal importance of additive and non- additive genes in the genetic control of the four traits. On the contrary, the traits like, capsule per plant and seeds per capsule were mainly controlled by additive gene effect with larger additive genetic variance than non-additive component and having predictability ratio more than 0.5 (Table 1). Out of eight traits, the remaining two traits, namely, 1000 seed weight and branches per plant exhibited, non-additive genetic control demonstrated low predictability ratio and higher magnitude of non-additive genetic component than additive component as disclosed from analysis of variance. The present findings are in agreement of the earlier reported results of Sajjanar et al. [11], Chakraborty and Basu [12], Solanki and Gupta [13] and Banerjee and Kole [6] for seed yield per plant, capsules per plant, days to flowering and oil content. Similarly, Djigma [14] and Rajaravindran et al. [15] found greater importance of additive gene effect for capsule length and seeds per capsule respectively corroborating the present findings. While, Kamala [16] and Das and Dasgupta [5] reported that 1000 seed weight and branches per plant were predominantly controlled by non-additive genetic effect confirming similarity to the present results. However, some contradictory reports have been documented by earlier researchers like Arulmozhi et al. [17], Kar et al. [18], and Kumar et al. [19] where non-additive gene action was found to control seed yield, capsules per plant, seeds per capsule and other traits. Such discrepancies may be obtained due to differences in parental materials or environments.

The greater inheritance of $\sigma_a^2$ for capsule length and seeds per capsule proposes the use of breeding system utilizing mainly $\sigma_a^2$ like simply pedigree system and selection in the early generation will be rewarding for their up-gradation. On the other hand, improvement for the traits such as seed yield per plant, capsules per plant, days to flowering and oil content that are genetically controlled both by additive and non-additive genes, may be pursued by recurrent selection with deferred selection in later generations which would allow a decrease in dominance, additive x dominance and dominance x dominance as suggested by Solanki and Gupta [13]. Similarly, for the traits like 1000 seed weight and branches per plant which are controlled by non-additive gene action, the magnitude of additive x additive epistatic variance being not known, simple pedigree method with selection at later generations would help to exploit dominance and epistatic variance apart from additive x additive genetic component [20].

The testing year interacted significantly with gca for all characters except capsule length. However, the magnitude of gca variance was much higher than those gca x year interaction for all traits except capsules per plant as was clearly revealed from $\frac{\sigma_g^2}{\sigma_{gy}^2}$ ratio (Table 1) indicating either of the year was effective in providing the gca estimates. The interactions between sca with year were significant for seed yield and all other seven traits. The magnitude of sca variances were higher than sca x year interactions as were also evident from $\frac{\sigma_g^2}{\sigma_{gy}^2}$ ratios which were more than unity, except for days to flowering describing gca x year role was less in the genetic control of the characters compared to gca. However, the interaction component appeared to be important for days to flowering. Comparison of the interaction component between sca and gca revealed higher contribution of sca x year than gca x year for all traits signifying dominance and epistatic component of variance varied more with years than the additive genetic component.

**Table 1. Analysis of Variance (mean squares) for combining ability (Griffing' Method2, Model I, ) in 7x7 half diallel crosses pooled over two years**

| Source of variation | d.f. | No. of branches per plant | Days to flowering | No. of capsules per plant | Capsule Length | No. of seeds per capsules | 1000 Seed Weight | Seed yield per plant | Oil content |
|---|---|---|---|---|---|---|---|---|---|
| Gca | 6 | 12.67** | 39.37** | 1873.79** | 3.07** | 3540.58** | 1.09** | 90.23** | 243.18** |
| Sca | 21 | 9.20** | 9.36** | 597.54** | 0.42** | 579.39** | 0.80** | 34.54** | 88.62** |
| Gca x year | 6 | 0.38** | 10.92** | 1499.45** | 0.006ns | 56.22** | 0.04** | 5.84** | 79.37** |
| Sca x year | 21 | 0.99** | 5.37** | 270.97** | 0.02** | 112.50** | 0.07** | 7.99** | 25.47** |
| Error | 108 | 0.13 | 0.29 | 9.01 | 0.003 | 4.83 | 0.003 | 0.30 | 0.14 |
| $\sigma_a^2$ | | 1.39 | 4.34 | 207.20 | 0.34 | 392.86 | 0.12 | 9.99 | 27.00 |
| $\sigma_{na}^2$ | | 4.54 | 4.53 | 294.27 | 0.21 | 287.28 | 0.40 | 17.12 | 44.24 |
| $\frac{\sigma_a^2}{\sigma_a^2 + \sigma_{na}^2}$ | | 0.23 | 0.49 | 0.41 | 0.62 | 0.58 | 0.23 | 0.37 | 0.38 |
| $h_n^2$ (%) | | 22.93 | 47.37 | 40.58 | 61.48 | 57.35 | 22.94 | 36.44 | 37.82 |
| $\sigma_{gy}^2$ | | 0.03 | 1.18 | 165.60 | 0.0003 | 5.71 | 0.0004 | 0.62 | 8.80 |
| $\sigma_{sy}^2$ | | 0.86 | 5.08 | 261.96 | 0.017 | 107.67 | 0.067 | 7.69 | 25.33 |
| $\frac{\sigma_g^2}{\sigma_{gy}^2}$ | | 46.33 | 3.68 | 1.25 | 1133.33 | 68.80 | 300.00 | 16.11 | 3.07 |

*** significant at 1% level*

**Table 2. Estimates of general combining ability (gca) effects of parents for ten traits in 7 x 7 half-diallel crosses**

| Parents | Number of branches per plant | Days to flower | Number of capsules per plant | Capsule length | Number of seeds Per capsule | 1000 Seed weight | Seed yield per plant | Oil content |
|---|---|---|---|---|---|---|---|---|
| Suprava | -0.017 | -1.206** | 10.912** | 0.301** | 16.175** | 0.186** | 2.418** | 1.704** |
| EC90 | -0.576** | 0.164 | -1.376 | 0.361** | 3.563** | -0.218** | -1.264** | -2.997** |
| RT351 | -0.709** | -0.892** | -4.147** | -0.045* | -5.577** | -0.058* | 0.129 | 1.170** |
| JLT408 | 0.266* | 0.386* | -3.071** | -0.136** | -2.480** | -0.036 | -0.527** | 0.102 |
| IC59 | 0.476** | 1.034** | -1.901* | -0.282** | -8.789** | 0.170** | 0.166 | -2.898** |
| Savitri | 0.038 | -0.355* | -3.642** | -0.079** | -1.896** | 0.023 | 0.498** | 0.717** |
| GT10 | 0.523** | 0.868** | 3.225** | -0.120** | -0.995 | -0.067** | -1.418** | 2.201** |
| S.E.(gi) | 0.112 | 0.165 | 0.926 | 0.018 | 0.678 | 0.019 | 0.169 | 0.082 |

*** and * significant at 1% and 5% level respectively*

The perusal of data of gca estimates revealed that no parent exhibited good gca effect uniformly for all characters (Table 2) However, the parent Suprava showed significantly positive gca effect for seed yield per plant, oil content and four other traits viz. Number of capsules per plant, capsule length, seeds per capsule and 1000 seed weight (Table 2). For days to flowering, it is known that significantly negative gca effect is the desired criteria for selection, as plant breeders always look for early days to flowering in the genetic improvement of any crop and Suprava also demonstrated significantly negative gca effect for days to flowering. Next to Suprava, Savitri was identified as a good general combiner for seed yield, oil content and days to flowering. Some parents though did not show significantly positive gca effect for seed yield, but were good parents for genetic improvement for component traits. The parent GT10 ranked top with significantly positive gca effects for oil content and also was a good general combiner for capsules per plant length along with branches per plant. Similarly, the parent EC90 was a good general combiner for capsule length and seeds per capsule. Over all the parents, Suprava and Savitri were identified as the good general combiner for seed yield, oil content and some traits. Obviously, incorporation of suprava and savitri in the crossing program would help to produce desirable recombinants with additive gene effect.

**Table 3. Five top crosses with significant SCA effects (descending order) with *per se* performance, and gcastatus in $F_1$ generation pooled per over two years**

| Characters | Cross combinations | Sca effects | Per se performance | Gca effects |
|---|---|---|---|---|
| Branches per plant | Savitri x GT10 | 1.68** | 8.73 | Medium x High |
| | Suprava x Savitri | 1.64** | 8.15 | Low x Medium |
| | EC90 x JLT408 | 1.48** | 7.67 | Low x High |
| | IC59 x Savitri | 1.47** | 8.48 | High x Medium |
| | IC59 x GT10 | 1.26** | 8.75 | High x High |
| Days to flowering | Suprava x JLT408 | -2.12** | 34.50 | High x Low |
| | Savitri x GT10 | -2.11** | 35.80 | High x Low |
| | Suprava x Savitri | -1.55** | 34.33 | High x High |
| | Suprava x GT10 | 1.27** | 35.80 | High x Low |
| | EC90 x GT10 | -1.14** | 37.33 | Low x Low |
| Capsules per plant | Suprava x JLT408 | 17.07** | 132.00 | High x Low |
| | Savitri x GT10 | 16.23** | 123.43 | Low x High |
| | RT351 x GT10 | 15.18** | 121.88 | Low x High |
| | EC90 x Savitri | 10.86** | 113.47 | High x Low |
| | EC90 x JLT408 | 7.93** | 111.10 | High x Low |
| Capsule length (cm) | EC90 x IC59 | 0.46** | 3.83 | High x Low |
| | Suprava x GT10 | 0.34** | 3.81 | High x Low |
| | Suprava x JLT408 | 0.22** | 3.68 | High x Low |
| | Suprava x IC59 | 0.21** | 3.52 | High x Low |
| | EC90 x Savitri | 0.20** | 3.78 | High x Low |
| Seeds per capsule | Suprava x JLT408 | 20.91** | 137.06 | High x Low |
| | Suprava x Savitri | 13.98** | 130.72 | High x Low |
| | EC90 x JLT408 | 12.65** | 116.18 | High x Low |
| | EC90 x Savitri | 11.15** | 115.27 | High x Low |
| | RT351 x GT10 | 10.72** | 106.60 | Low x Medium |
| 1000 seed weight (g) | Suprava x Savitri | 0.60** | 4.23 | High x Medium |
| | EC90 x JLT408 | 0.52** | 3.69 | Low x Low |
| | RT351 x GT10 | 0.37** | 3.67 | Low x Low |
| | Suprava x RT351 | 0.31** | 3.87 | High x Low |
| | Suprava x JLT408 | 0.30** | 3.88 | High x Low |
| Seed yield per plant (g) | RT351 x GT10 | 3.91** | 16.87 | Low x Low |
| | EC90 x Savitri | 3.87** | 17.35 | Low x High |
| | Suprava x Savitri | 3.61** | 20.77 | High x High |
| | IC59 x Savitri | 3.04** | 17.94 | Medium x High |
| | Suprava x JLT408 | 2.54** | 18.67 | High x Low |
| Oil content (%) | RT 351 x JLT408 | 6.174** | 51.48 | High x Medium |
| | RT351 x IC59 | 6.025** | 48.33 | High x Low |
| | IC59 x Savitri | 4.336** | 47.09 | Low x High |
| | Suprava x GT10 | 4.200** | 52.14 | High x High |
| | Suprava x RT351 | 3.655** | 50.57 | High x High |

*** significant at 1% level*

Specific combining ability estimates revealed that like gca estimates, no cross combination was superior with significant sca effects for all traits (Table 3). But three best specific combiner for all traits disclosed that the cross combinations Suprava x Savitri, Suprava x JLT408 and E90 X Savitri were characterised with significantly positive sca effects for seed yield with at least three yield component traits with high per se performance for seed yield were very desirable as they involve parents with high x high/medium/low combiners. In other words additive genetic mostly control the inheritance of these crosses.

For oil content two crosses namely, RT 351 combining with JLT 408 and IC 59 showed significantly positive sca effects with per se performance. But performance of these two crosses for seed yield per plant was not satisfactory, Next to those two superior cross for oil content, the cross combination IC 59 x Savitri may be considered as an ideal cross which demonstrated significant posive sca effect for oil and seed yield as well. This cross combination involved at least one parent with significantly positive gca effect. So, additive gene effect mainly controlled cross. It is to be mentioned that from the analysis of gca estimates Suprava and Savitri were identified as parents mainly controlled by additive gene effect. In self-pollinated crop like sesame additive, additive x additive interaction can be exploited easily following pedigree method of breeding. Hence, three cross combinations namely, Suprava x Savitri, Suprava x JLT 408 and EC 90 x Savitri would be better choice to get desirable recombinants of fixable nature with high yield and yield related traits. Since, sesame is an oilseed crop and so along with seed yield, genetic improvement of oil content is also important. Under this situation, the cross combination IC 59 x Savitri exhibiting significantly positive sca effects both for oil content and seed yield (Table 3) appeared to be ideal choice for getting desirable segregants. This cross also having significantly positive gca estimates in at least one of two parents would offer the cross to be desirable choice.

## 4. CONCLUSION

The present finding revealed importance of additive and non- additive genes in the genetic control of seed yield, capsules per plant, days to flowering and oil content. Among parental lines Suprava and Savitri were identified as the preferable general combiners for seed yield, oil content and some yield attributing traits. Incorporation of suprava and savitri in the crossing program would help to produce desirable recombinants with additive gene effect. However, the crosses Suprava x Savitri, Suprava x JLT 408 and EC 90 x Savitri had the most desirable specific combining abilities (sca effects) to get desirable recombinants of fixable nature with high yield and yield related traits. All these crosses would like to produce desirable segregants or transgreesive segregants and selection can be made in early generation to exploit additive gene effect for genetic improvement of seed yield per plant and seed yield combined oil content.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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