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PM Salunke
Department of Genetics and Plant Breeding, College of Agriculture, Latur, Maharashtra, India

PB Wadikar
Associate Professor, Department of Genetics and Plant Breeding, College of Agriculture, Latur, Maharashtra, India

VA Dhengle
Department of Genetics and Plant Breeding, College of Agriculture, Latur, Maharashtra, India

SS Sonne
Department of Genetics and Plant Breeding, College of Agriculture, Latur, Maharashtra, India

SN Band
Department of Horticulture, College of Agriculture, Latur, Maharashtra, India

Corresponding Author:
PM Salunke
Department of Genetics and Plant Breeding, College of Agriculture, Latur, Maharashtra, India

Assessment of combining ability in sesame (*Sesamum indicum* L.) by using L x T analysis for seed yield and its attributing traits

PM Salunke, PB Wadikar, VA Dhengle, SS Sonne and SN Band

Abstract
The present investigation entitled "Assessment of combining ability in sesame (*Sesamum indicum* L.) by using L x T analysis for seed yield and its attributing traits." to estimate general and specific combining ability effects in 21 crosses obtained by crossing 7 x 3 genotypes in L x T fashion and their 7 lines, 3 testers and 1 standard check were evaluated in RBD with 2 replications during *Rabi* 2022-23 at ATS, Latur. Among the lines, TS-11 was the best general combiner for Plant height, number of branches per plant, number of capsules per plant, 1000 seed weight and seed yield per plant. The line, TBS-06 was best general combiner for number of capsules per plant, 1000 seed weight and seed yield per plant. Among the testers, V-22 showed positive GCA effects for Plant height, number of capsules per plant and seed yield per plant. These parents could be utilized in the breeding programme for further improvement of these specific traits. The cross TS-14 x V-18 (1.419) expressed highest significantly desirable positive SCA effects for seed yield per plant (g).

Keywords: Sesame, combining ability, GCA, SCA

Introduction
Sesame is commonly known as Til (Marathi), Tili (Punjab), Nuvulu (Telegu), Tai (Gujarat), Rassi (Orissa), Ellu (Tamil) beside this gingelly, simsim, sesamum, benniseed. India ranks first in sesame production followed by China, Myanmar, Sudan, Uganda. Sesame belongs to order Tubiflorae and family Pedaliaceae. Sesame is self-pollinated crop. The somatic chromosome number of sesamum species is on the basis of cytogenetically into three distinct groups. First group has 2n=26 chromosome number comparing of *S. indicum* and *S. malabricum* spp. While the second group has 2n=32 consist of sesame *S. prostratum* and *S. laciniatum* and the last group pusses 2n=64 and species under this group *S. radiatum* and *S. occidentale* (Joshi 1961) [7]. It is cultivated in warm regions of the tropics and sub tropics. It requires average temperature of 25-27 °C for rapid germination, initial growth and flowering. Gujarat, Rajasthan, Uttar Pradesh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Orissa, Tamil Nadu, West Bengal and Karnataka are major sesame growing states of the country. Sesame seed contain approximately 50 percent oil, 25 percent protein and 15 percent carbohydrate. Its seed is rich in vitamin A, E, B complex and contain mineral like phosphorus, iron, calcium, zinc, magnesium, and potassium. Its oil contains an antioxidant called sesamol which impart high degree of resistance against oxidative rancidity. Selection of parents based on *per se* performance alone is not better option because parents with superior phenotype can result in poor or inferior hybrids in later generations (Banerjee and Kole, 2010) [1]. Hence, it is important to select parent based on *per se* performance and high GCA value for traits to be improved.

Materials and Methods
The experimental material was consisting of 7 lines (TBS-02, TBS-05, TBS-06, TBS-07, TS-11, TS-13 & TS-14) and 3 testers (V-18, V-21 & V-22) obtained from Oilseed Research Station, Latur including 1 check variety (AKT-101). The experiment was laid out in a randomized block design with two replications at ATS, Latur during late *Rabi*-2022-23. The data recorded for ten characters on five plants from each treatment in each replication at different growth stages of crop and average value for plant were worked out. Combining ability analysis for seed yield per plant and yield contributing traits was done by using method given by Kempthorne (1957) [9].

Results and Discussion

The data investigated on different characters for various entries were averaged and subjected to statistical analysis of variance (Table 1) revealed that, treatments, parents and crosses were found highely significant for most of characters indicating presence of considerable amount of variability in the experimental material present in study. Similar result reported by Hassan and Sedeck (2015) [6], Priya *et al*. (2016) [10], Virani *et al.* (2018) [16] and Dela *et al*. (2019) [3].

The estimate of GCA of lines and testers and SCA of crosses presented in Table 2 and Table 3, respectively. An early day to 50 percent flowering and day to maturity is desirable trait. The lines having negative GCA effects are important in breeding programme. In the present evaluation, the line TBS-05 (-1.429) recorded significantly negative GCA effect for days to 50% flowering. The line, TS-14 (-2.881), TBS-02 (-2.214), TBS-05(-2.214), and tester, V-18 (-1.095) recorded significantly negative GCA effect for days to maturity. Among the 21 crosses, the cross TBS-06 x V-18 (-2.905) expressed significantly desirable negative SCA effects for days to maturity.

The tester, V-22 (5.326) and line, TS-11 (4.383) showed positive significant GCA for plant height. Among the 21 crosses, the cross TS-13 x V-18 (8.269) expressed significantly desirable positive SCA effects for plant height. For number of branches, line TBS-05 (0.235) expressed significant positive GCA effect and out of 21 crosses, five crosses TS-13 x V-22 (0.586), TBS-07 x V-22 (0.494), TS-14 x V-22 (0.461) TS-11 x V-21 (0.407) and TBS-06 x V-21 (0.407) showed significantly positive SCA effects for this trait. For number of capsules per plant, the tester, V-22 (9.548) and lines, TBS-07 (4.310) and TBS-06 (3.143) exhibited highest significant positive GCA effect and the crosses, TBS-07 x V-22 (9.786), TS-14 x V-18 (8.786) and TBS-06 x V-21 (6.762) expressed significantly desirable positive SCA effects.

Study of combining ability effect revealed that, out of seven lines and three testers, the line TS-13 (0.161) and TBS-05 (0.121) showed significant positive GCA effect and out of 21 crosses, three crosses depicted significant and positive SCA effect for length of capsule (cm). For number of seeds per capsule, the lines, TS-14 (4.448) and TBS-05 (2.481) showed significant positive GCA effect. For 1000 seed weight, study of combining ability effect revealed that the tester, V-18 (0.345) and lines, TS-13 (0.334), TBS-06 (0.127) TS-11 (0.114) and TS-14 (0.127) showed significant positive GCA effect and the cross, TBS-06 x V-21 (0.235) expressed highest significantly desirable positive SCA effects. For oil content, the line, TS-14 (2.749) showed significant positive GCA effect and cross, TS-14 x V-18 (5.255) expressed highest significantly desirable positive SCA effects.

Out of seven lines and three testers, the tester, V-22 (1.460) and lines, TS-11 (1.529) and TBS-06 (0.787) showed significant positive GCA effect for seed yield per plant (g)**.** Among 21 crosses, the cross, TS-14 x V-18 (1.419) expressed highest significantly desirable positive SCA effects for seed yield per plant (g).

The concept of combining ability is a land mark in the development of efficient and effective breeding methodology in various crop plants. Analysis of combining ability provides guidelines for an early assessment of the relative breeding worth of the parental material. The GCA attributed to additive genetic effects which is fixable. On the other hand, SCA attributed to non- additive gene action may be due to dominance, additive x dominance and dominance or higher order gene interaction and is unfixable. The presence of non-additive genotypic variance is primary justification for initiating hybrid development programme. The parental material may be used to develop hybrids or build up favourable fixable genes depending on nature of gene action. The result of anlysis of variances of combining ability for ten different characters in line x tester analysis (Table 1) indicate variance due to parents was highley significant for all characters thus justifying the selection of parent for combing ability. The high GCA effects in desirable direction for seed yield and its components indicated that such lines would combine well with other lines to produce superior progeny.

In the present investigation, among the lines, TS-11 (1.529) was the best general combiner for seed yield per plant and recorded positive significant GCA effect for the traits *viz.*, no of capsule per plant (13.476), Plant height (cm) (4.383), Number of branches per plant (0.525) and 1000 seed weight (0.114). The other line, TBS-07 (0.787) also exhibited desirable and significant GCA for seed yield per plant and expressed positive significant GCA effects for the traits *viz.*, number of capsules per plant (4.310) and 1000 seed weight (0.127). Among the testers, V-22 showed positive GCA effects for Plant height, number of capsules per plant and seed yield per plant. These observations clearly indicate that there appeared to be close relationship between GCA and *per se* performance of most of the characters expressed by the parents. In turns it will help as criteria to select the parents for breeding programmes. Since, high GCA effect attributed to additive gene action, the parent having highly significant and positive GCA effect could be used in breeding programme for yield improvement through pedigree breeding. Similar result registered by Vidhyavati *et al*. (2005) [13], Virani *et al.* (2018) [16], Karthikeyan *et al*. (2019) [8], Sirohi *et al*. (2020) [11] and Ghule *et al*. (2022) [5].

The results on specific combining ability effects of crosses for different characters under study are presented in Table 3. Among the all combination, none of the cross combination showed significantly desirable negative SCA effects for days to flowering. Earliness is desirable in crop plants, hence the cross combinations with negative SCA effects are great value as they would result into early segregates. In the present investigation for days to maturity the hybrid combination TBS-06 x V-18 (-2.905) showed maximum negatively SCA effects for days to maturity. Similar result registered by Vidhyavati *et al*. (2005) [13], Deshmukh *et al*. (2019) [4], Sonwane *et al.* (2019) [12], Dela *et al.* (2019) [3], Sirohi *et al.* (2020) [11] and Ghule *et al*. (2022) [5].

In case of plant height (cm), number of branches per plant, length of capsule, number of seeds per capsule, 1000 seed weight (g), seed yield per plant (g) and oil content (%) positive SCA were desirable. In this investigation, out of 21 crosses evaluated, significant and positive SCA effect for 10 characters were found in different crosses discus above. When SCA significantly positive for this characters were using heterosis breeding method is desirable. This traits can be improved by biparental mating and reciprocal recurrent selection and exploitation of heterosis in hybrid vigour. Similar result reported by Visat *et al.* (2016) [17], Vimala *et al*. (2017), Virani *et al.* (2018) [16], Karthikeyan *et al.* (2019) [8], Sirohi *et al*. (2020) [11], Bhattacharjee *et al.* (2021) [14] and Ghule *et al*. (2022) [5].

Table 1: Analysis of variance for combining ability for different ten characters including parents in sesame (*Sesamum indicum* L.).

Source of Variation	d.f.	Days to 50 percent flowering	Days to maturity	Plant height (cm)	No. of branches per plant	No. of capsule per plant	Length of capsule (cm)	No. of Seeds per capsule	1000 Seed weight (g)	Seed yield per plant (g)	Oil Content (%)
Replications	1	5.225	0.790	7.455	0.003	34.129	0.047	0.612	0.016	2.088	0.299
Treatments	30	9.964 **	22.164 **	92.183 **	0.610 **	267.465 **	0.093 **	44.716 **	0.382 **	6.180 **	9.042 **
Parents	9	23.088 **	20.088 **	170.973 **	0.743 **	177.161 **	0.152 **	44.114 **	0.503 **	3.678 **	10.718 **
Lines	6	23.809 **	28.500 **	188.899 **	0.991 **	243.642 **	0.132 **	40.258 **	0.545 **	5.017 **	14.045 **
Testers	2	3.500	1.166	25.216	0.346 *	24.666	0.007	48.500 **	0.526 **	0.640	3.770 **
Lines v/s Testers	1	57.942 **	7.466	354.936 **	0.047	83.259 **	0.566 **	58.478 **	0.206 **	1.715	4.653 **
Parents v/s Crosses	1	5.516	55.230 **	5.607	0.842 **	1091.041 **	0.238 **	172.129 **	0.091 **	36.830 **	0.493
Crosses	20	4.280	21.445 **	61.057 **	0.538 **	266.923 **	0.059 **	38.617 **	0.342 **	5.773 **	8.715 **
Error	30	2.592	2.790	11.430	0.068	10.295	0.010	4.838	0.007	0.579	0.181

*and ** indicated significance at 5and 1 percent level, respectively.

Table 2: Estimates of general Combining Ability (GCA) of lines and testers for yield and yield contributing traits in sesame (*Sesamum indicum* L.)

Lines and Testers	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of capsules per plant	Length of capsule (cm)	Number of seeds per capsule	1000 seed weight (g)	Seed yield per plant (g)	Oil content %
Line										
TBS-02	-0.095	-2.214 **	-0.067	-0.700 **	-7.857 **	-0.212 **	1.681	-0.538 **	-1.621 **	-0.511 **
TBS-05	-1.429 *	-2.214 **	-2.200	0.235 *	3.143 *	0.121 **	2.481 *	-0.146 **	-0.046	-0.481 *
TBS-06	0.571	0.500	0.500	0.025	4.310 **	-0.139 **	-4.386 **	0.127 **	0.787 *	-0.788 **
TBS-07	-0.762	-1.881 *	-2.067	-0.009	-6.857 **	0.033	-1.719	0.017	-1.238 **	-0.998 **
TS-11	0.405	3.619 **	4.383 **	0.525 **	13.476 **	-0.024	-1.719	0.114 **	1.529 **	0.319
TS-13	2.071 **	4.452 **	1.917	0.000	-1.357	0.161 **	-0.786	0.334 **	0.395	-0.291
TS-14	-0.762	-2.881 **	-2.467	-0.075	-4.857 **	0.061	4.448 **	0.091 *	0.195	2.749 **
S.E.(Gi)	0.657	0.681	1.380	0.106	1.309	0.040	1.681	0.036	0.310	0.174
S.E.(Gi-Gj)	0.929	0.964	1.992	0.151	1.852	0.058	1.270	0.050	0.439	0.246
CD @ 5%	1.371	1.422	2.879	0.222	2.732	0.085	1.873	0.074	0.648	0.363
CD @ 1%	1.870	1.940	3.927	0.303	3.727	0.116	2.555	0.101	0.883	0.495
Tester										
V-18	-0.262	-1.095 *	-1.802	0.101	-3.952 **	0.036	-0.695	0.345 **	-0.819 **	0.198
V-21	0.595	0.333	-3.524 **	-0.073	-5.595 **	-0.059	-0.081	-0.208 **	-0.640 **	-0.286 *
V-22	-0.333	0.762	5.326 **	-0.028	9.548 **	0.023	0.776	-0.137 **	1.460 **	0.088
S.E.(Gi)	0.430	0.446	0.903	0.070	0.857	0.027	0.587	0.023	0.204	0.114
S.E.(Gi-Gj)	0.608	0.631	1.277	0.099	1.212	0.038	0.831	0.033	0.288	0.161
CD @ 5%	0.897	0.931	1.884	0.146	1.788	0.055	1.226	0.049	0.424	0.237
CD @ 1%	1.224	1.270	2.571	0.199	2.440	0.076	1.673	0.066	0.579	0.324

*and ** indicated significance at 5 and 1 percent level, respectively.

Table 3: Estimates of specific combining Ability (SCA) for ten characters in sesame (*Sesamum indicum* L.)

S. No.	Crosses	Days to 50 percent flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of capsules per plant	Length of capsule (cm)	Number of seeds per capsule	1000 seed weight (g)	Seed yield per plant (g)	Oil content %
1	TBS-02 x V-18	-1.405	0.429	1.502	0.157	0.286	0.091	3.062	0.066	0.036	-0.555
2	TBS-02 x V-21	0.738	-1.000	1.524	0.257	0.429	-0.015	-1.052	-0.195 **	0.057	-0.130
3	TBS-02 x V-22	0.667	0.571	-3.026	-0.414 *	-0.714	-0.076	-2.010	0.129 *	-0.093	0.685 *
4	TBS-05 x V-18	-0.071	0.429	-2.564	0.022	-0.714	0.012	-2.238	0.225 **	-1.214 *	-0.555
5	TBS-05 x V-21	0.071	1.000	0.557	0.127	-2.571	0.002	0.848	0.218 **	0.432	0.100
6	TBS-05 x V-22	0.000	-1.429	2.007	-0.149	3.286	0.010	1.390	-0.443 **	0.782	0.455
7	TBS-06 x V-18	1.429	-2.905 *	-1.064	0.332	3.619	0.088	-2.071	-0.359 **	0.502	-0.188
8	TBS-06 x V-21	0.571	-0.333	1.657	0.407 *	6.762 **	0.002	-2.886	0.235 **	0.799	-0.454
9	TBS-06 x V-22	-2.000	3.238 *	-0.593	-0.739 **	-10.381**	-0.090	4.957 **	0.124	-1.301	0.642 *
10	TBS-07 x V-18	-0.238	0.095	-3.898	-0.034	-9.214 **	-0.099	-1.238	-0.189 **	-0.848	-0.708 *
11	TBS-07 x V-21	-1.095	0.667	0.124	-0.460 *	-0.571	-0.080	3.448 *	0.065	0.274	0.546
12	TBS07 x V-22	1.333	-0.762	3.774	0.494 *	9.786 **	0.179 *	-2.210	0.124	0.574	0.162
13	TS-11 x V-18	0.095	0.595	-1.748	-0.168	-6.548 **	-0.232 **	-3.038	0.005	-0.714	-2.525 **
14	TS-11 x V-21	0.738	-1.333	-1.626	0.407 *	7.595 **	0.047	2.548	-0.072	0.807	2.250 **
15	TS-11 x V-22	-0.833	0.738	3.374	-0.239	-1.048	0.185 *	0.490	0.067	-0.93	0.275
16	TS-13 x V-18	0.429	0.262	8.269	-0.043	3.786	0.008	7.529 **	0.115	0.819	-0.725 *
17	TS-13 x V-21	-0.429	1.333	-2.060	-0.543 **	-7.571 **	0.072	-1.086	0.038	-1.410 *	0.130
18	TS-13 x V-22	0.000	-1.595	-6.210*	0.586 **	3.786	-0.080	-6.443 **	-0.153 *	0.590	0.595
19	TS-14 x V-18	-0.238	1.095	-0.498	-0.268	8.786 **	0.158 *	-2.005	0.138 *	1.419 *	5.255 **
20	TS-14 xV-21	-0.595	-0.333	-0.176	-0.193	-4.071	-0.028	-1.819	-0.289 **	-0.960	-2.440 **
21	TS-14 x V-22	0.833	-0.762	0.674	0.461*	-4.714	-0.130	3.824 *	0.151 *	-0.460	-2.815 **
	S.E (+)	1.138	1.181	2.390	0.185	2.669	0.071	1.555	0.062	0.538	0.301

*and ** indicated significance at 5 and 1 percent level, respectively

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