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Combining ability studies through line X tester analysis in sesame (*Sesamum indicum* L.)

P Karthikeyan, R Eswaran, KR Saravanan and P Thangavel

Abstract
An attempt was made to study the general and specific combining ability in sesame (*Sesamum indicum* L.) through L X T analysis with seven lines and three testers. Seven characters *viz.,* plant height, number of branches per plant, number of capsules per plant, capsule length, number of seeds per capsule, 1000 seed weight and seed yield per plant were studied. Based on the general combining ability effects of parents and *per se* performance, the genotypes FFAT0841, SVPR1 and FFAT0820 have considerable potential and can be utilized for developing cultivars, with high yield by using appropriate breeding strategy. Based on *sca* effects, the hybrids FFAT0818 X TMV6, FFAT0845 X SVPR1 and FFAT0831 X CO1 were adjudged as better hybrids for yield and yield component traits and hence recommended for yield improvement.

Keywords: Sesame, General combining ability, Specific combining ability

Introduction
Sesame *(Sesamum indicum* L.) is one of the most important oil seed crop, not only in India but also in the world. This crop is probably the most ancient oil seed known and used by man. Locally it is known as Til, Tilli, Gingelly, Ellu, Sim-sim, Benni Seed, Nurvulu, Vellvor Rasi and sesame in different parts of India. is cultivated in around 60-65 countries of the world, while Asian and African countries are the major producers (Al-Bachir, 2016) [1]. It is often referred as the epithet "the queen of oilseeds by virtue of quality of oil it produces. Sesame seed contains oil (57-63%), protein (22-24%), carbo- hydrates (10-12%), and crude fiber (4-7%) (Makinde and Akinoso, 2013) [7]. It is rich in unsaturated fatty acids, methionine, and tryptophan. Also, it is rich in micronutrients such as minerals, lignans, tocopherol, and phytosterol (Hassan *et al*., 2018) [2]. Sesame oil is considered to have excellent quality. As much as 20 per cent of sesame produced is used for direct domestic consumption. The oil of sesame is widely used for different purposes such as cooking, varnishes, lubricants and medicine.

According to Vavilov (1951) [11], India is basic centre of origin of sesame. It is a self pollinated annual herb belonging to genus *Sesamum* of the family Pedaliaceae. More than 36 species have been described in genus *Sesamum*. The somatic chromosome number of *Sesamum indicum* (L.) was first reported by Moringa *et al.* (1929) to be 2n = 26. It is mainly *kharif* crop but it is also grown in *pre-rabi, rabi* and *summer* season.

India occupies a premier position in the worldwide oilseeds scenario for about 29 per cent of the total area and 26 per cent of production. Worldwide, China and India are the major sesame producers. The average productivity is very low when compared to other sesame growing countries and almost flattened during last few years. In India, sesame is grown in 19.50 lakh hectare with a production of 8.50 lakh tonnes and productivity of 436 kg /ha (http://www.sopa.org/india-oilseeds-area-production-and-productivity/2015-16) [3].

An acute shortage of edible oil is being felt in India since last three decades. This had led to very high prices, unavailability of the oil and its adulteration. To increase the consumption of oil and supply it at reasonable rates, it is necessary to increase the production of oil which can be achieved by increasing the area under oil seeds as sesame crop and also evolving the varieties which will have high yield as well as high percentage of oil under variable environmental conditions. Inadequate, untimely and abnormal distribution of rains adversely affects the oil seed production in India Sesame can withstand the adverse conditions better than groundnut.

To facilitate the development of new varieties with high yield and high oil percentage, it is necessary to understand the genetic basis and the nature of inheritance of these traits with diverse parents (Ketthaisong *et al*., 2014) [5]. The combining ability is an important tool for the selection of desirable parents together with the information regarding nature and magnitude of gene effects controlling quantitative traits (Kumari *et al*., 2015) [6]. There are number of techniques available for evaluating the varieties or cultivars or lines in terms of their combining ability and genetic construction like diallel, partial diallel and line X tester techniques. Of these, Line x Tester investigation method is more suitable for large number of genotypes for understanding the genetical basis at population level (Kempthorne, 1957) [4].

This method gives the general genetic picture of the particular materials under investigation in single generation, and clear understanding of the combining ability and gene action is a needed one for any successful hybridization programme. Therefore, the present study was carried out with a view to comprehend the type of gene action controlling yield and other traits, to spot the best general combiners and the best combinations on the basis of their estimates of general and specific combining ability for yield, its attributes through line x tester analysis in sesame.

Materials and Methods

The current research work was done at Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Tamil Nadu, India, during 2016-17. Ten genetically diverse sesame genotypes comprised of seven lines viz., FFAT082 (L1), FFAT0816 (L2), FFAT0818 (L3), FFAT0820(L4), FFAT0831(L5), FFAT0841(L6), FFAT0845(L7) and three testers viz., CO1(T1), SVPR1(T2) and TMV6(T3) were used for this study. In 2016, a line x tester cross set was done among the ten parents, using hand emasculation and pollination as described by Yermanos (1980) [12]. The resulting twenty one F1 hybrids along with their parental genotypes were evaluated in a layout of randomized block with three replications,with a single row of four meter length. All the cultural operations were done as per the recommendation for the better growth of the plants.

Observations were recorded on three randomly selected plants for all the characters viz., plant height, number of branches per plant, number of capsules per plant, capsule length, number of seeds per capsule, thousand seed weight and seed yield per plant. The data obtained for each character were analysed by following the usual standard statistical procedure given by Panse and Sukhatme, (1978) [8]. The variation among the hybrids were partitioned further into sources attributed to general combining ability and specific combining ability components in accordance with the procedure suggested by Kempthorne (1957) [4].

Results and Discussion

The analysis of variance showed highly significant differences among the genotypes for all the characters studied, indicating the presence of sufficient variability in the experimental material (Table 1). The lines and testers differed significantly among themselves for all the seven characters. The line x tester interaction was significant for all the characters except days to capsule length and 1000 seed weight.

Choice of parents: In any breeding programme, the choice of parent is of prime importance. The *per se* performance of parents can be measured as one of the important criterion. Among the 10 parents, the line FFAT0820 (Table 2) showed superior *per se* performance for seed yield/plant followed by the line FFAT0818 and FFAT0831 (Table 2). Evaluation of parents based on *per se* performance and *gca* effects separately might lead to contradiction in selection of promising parents, since *per se* performance of the parents was not always associated with high *gca* effects (Singh and Hari Singh, 1985) [9] due to non-additive gene action. Knowledge on general combining ability coupled with *per se* performance would result in the identification of parents with good reservoir of superior genes. The results of the present study revealed that, the line FFAT0841 had desirable *per se* performance and *gca* effects for plant height, number of branches per plant, number of capsules per plant, capsule length, number of seeds per capsule, 1000 seed weight and seed yield per plant. The tester SVPR 1 for number of capsules per plant, capsule length, number of seeds per capsule, 1000 seed weight and seed yield per plant and FFAT0820 for plant height, number of capsules per plant, number of seeds per capsule seed yield per plant. Vavdiya *et al*. (2014) [10] reported that, the parents which are good general combiners for more number of characters are considered as the potential parents, and should be preferred in breeding programme in order to combine more number of characters, by involving fewer numbers of parents in a crossing programme. However, the parents that showed superior *per se* performance for seed yield and its component characters could not express high *gca* effects for the other respective characters. It indicates the poor relationship between *per se* performance and *gca* effects of parents for yield component characters.

Choice of hybrids: The *per se* performance was considered as the first and foremost important criterion for the selection of superior crosses. The cross combination (Table 3) FFAT0841 X TMV6(L6xT3) recorded superior mean seed yield followed by the crosses FFAT0818 X TMV6(L3 x T3), FFAT0845 X SVPR1(L7 x T2) and FFAT0820 X SVPR1(L4 x T2). The Specific Combining Ability (SCA) was used to designate those effects in certain combinations which significantly depart from what would be expected on the basis of average performance of the lines involved. The *sca* effect is an key criteria for the evaluation of hybrids. Accordingly in this present study the cross combination FFAT0818 X TMV6(L3 x T3) recorded high sca effects for seed yield per plant,1000 seed weight, number of seeds per capsule, number of capsules per plant and number of branches per plant with desirable per se performance followed by the crosses FFAT0845 X SVPR1(L7 x T2) and FFAT0831 X CO1(L5 x T1). Based on *sca* effects, these hybrids were adjudged as better hybrids for yield improvement in sesame.

Table 1: Analysis of Variance for Line X Tester in Sesame

Source of variation	d.f	Mean Squares						
		Plant height	Number of ranches per plant	Number. Of capsules per plant	Capsule length	Number of seeds per capsule	Thousand seed weight	Seed yield per plant
Replication	2	45.52	0.55	8.77	0.01	43.57	0.03	0.02
Genotypes	30	501.96*	1.51*	2837.23*	0.11*	263.69*	0.21*	164.22*
Hybrids	20	556.39	1.22	2918.43	0.05	236.05	0.19	148.98
Lines	6	1178.20	0.97	2981.63	0.07	276.14	0.19	181.28
Testers	2	819.84	2.10	3476.21	0.03	99.23	0.10	169.72
Lines/Testers Interaction	12	201.57	1.18	2926.32	0.04	238.81	0.20	115.02
Error	60	17.94	0.33	25.70	0.06	9.84	0.02	0.52

** Significant at per cent level *Significant at 5 per cent level

Table 2: General Combining Ability of Parents

Parents	Plant height		Number of branches per plant		Number of capsules per plant		capsule length		Number of seeds per capsule		Thousand seed weight		Seed yield per plant	
	Mean	gca	Mean	gca	Mean	gca	Mean	gca	Mean	gca	Mean	gca	Mean	gca
Lines														
FFAT08 2	71.67	-23.79**	4.11	-0.44**	90.33	-20.73	2.13	-0.09**	72.67	-2.94**	3.10	-0.08**	18.34	-4.27
FFAT08 16	104.16	-4.31**	4.33	-18.00	96.33	-19.1**	2.83	-0.05	71.33	-1.94**	3.07	-0.11**	18.39	-4.29
FFAT08 18	81.70	2.31	4.67	-0.16	131.89	-9.73**	2.63	-0.11**	71.33	-6.27**	2.71	-0.05	22.88	-0.2
FFAT0820	87.62	7.19**	3.67	0.08	152.00	23.83**	2.73	0.004	61.33	6.73**	3.13	-0.25	28.27	3.48
FFAT08 31	92.40	8.66**	4.44	-0.16	93.00	-4.53**	2.87	-0.01	73.67	-1.27**	3.05	0.11**	21.97	-2.58
FFAT08 41	86.73	8.10**	4.44	0.41*	93.56	12.17**	2.67	0.11**	73.67	8.73**	2.57	0.22**	20.76	7.68
FFAT08 45	75.03	1.84	4.33	0.45	77.44	17.99**	2.57	0.10**	53.00	-3.05**	2.47	0.13**	10.97	0.81
Tester														
CO 1	77.33	-6.61**	4.67	-0.37**	63.00	-14.62**	2.73	-0.04**	59.00	-0.98	2.71	-0.01**	7.63	-3.27
SVPR1	83.98	0.79	5.67	0.14	92.67	5.03**	2.43	0.04*	55.33	2.49**	2.73	0.07**	12.13	1.84
TMV6	68.57	5.82**	3.89	0.23	83.56	9.59**	3.12	-0.01	71.01	-1.51*	2.97	-0.06	18.93	1.42

** Significant at per cent level *Significant at 5 per cent level

Table 3: Specific Combining Ability of Hybrids for Different Traits in Sesame

Cross	Plant height		Number of branches per plant		Number of capsules per plant		Capsule length		Number of seeds per capsule		Thousand seed weight		Seed yield per plant	
	Mean	*sca*	Mean	*sca*	Mean	*sca*	Mean	*sca*	Mean	*sca*	Mean	*sca*	Mean	*sca*
L1xT1	46.23	0.41	3.17	0.31	35.33	-7.67*	2.33	-0.04	52.34	-2.02	2.33	-0.22**	4.52	0.65
L1xT2	53.15	-0.07	3.17	-0.21	70.56	7.86**	2.55	0.05	60.38	2.84	2.84	0.18**	9.95	0.98**
L1xT3	57.91	-0.34	3.33	-0.21	67.26	6.20	2.45	-0.01	52.67	-0.83	2.52	0.02	6.93	-1.63**
L2xT1	70.33	5.03	3.00	-0.11	52.12	7.29*	2.43	0.02	55.67	0.65	2.47	-0.03	6.27	3.19**
L2xT2	76.07	3.37	3.67	0.04	52.33	-12.37**	2.37	-0.013**	57.67	-0.83	2.69	0.01	6.17	-2.03**
L2xT3	69.33	-8.39**	3.78	0.07	74.17	5.08	2.57	0.11	54.67	0.17	2.47	0.02**	6.63	-1.16**
L3xT1	71.22	-0.72	2.83	-0.29	37.83	-16.16**	2.37	0.02	38.58	-12.68**	2.33	-0.22	3.71	-4.14
L3xT2	75.86	-3.45	2.88	-0.76*	41.33	-32.31**	2.32	-0.13**	47.67	-6.49**	2.47	-17.24**	5.33	-7.66**
L3xT3	88.55	4.16	4.78	1.05**	126.67	48.47**	2.50	0.11	69.33	19.17**	2.97	0.41**	24.37	11.84**
L4xT1	73.415	-3.65	2.78	-0.59	82.33	-5.21	2.47	-0.14	63.33	-0.35	2.43	0.02	8.13	-3.48**
L4xT2	88.67	4.47	4.33	0.46	109.00	1.81	2.63	0.05	71.32	3.84	2.45	-0.18	20.55	3.91**
L4xT3	88.40	-0.82	4.12	0.13	115.17	3.41	2.53	-0.01	59.67	-3.49	2.43	0.07	15.73	-0.55
L5xT1	70.37	-7.91	3.83	0.72*	83.78	24.58**	2.5	0.04	62.67	6.32**	3.07	0.36**	10.07	4.62**
L5xT2	78.87	-6.80	3.67	0.03	94.67	15.82**	2.63	0.09*	64.67	5.51**	2.74	-0.17	10.93	0.35
L5xT3	105.41	14.71**	3.11	-0.73*	43.00	-40.42**	2.37	-0.13**	43.33	-11.83**	2.43	-0.26**	5.23	-4.95**
L6xT1	75.17	-2.54	3.75	0.05	63.08	-12.83**	2.47	-0.13*	68.33	2.65	2.87	0.06	15.13	-0.67
L6xT2	85.53	-1.57	3.88	-0.32	74.47	-18.11**	2.63	-0.02	63.55	-6.16**	2.73	-0.16*	16.2	-4.65**
L6xT3	94.25	4.12	4.57	0.27	131.00	30.93**	2.73	0.12**	68.67	3.51	2.87	0.11	25.70	5.25**
L7xT1	80.82	9.37**	3.67	-0.07	91.67	9.96**	2.67	0.11*	59.33	5.43**	2.77	0.02	8.57	-0.29
L7xT2	82.94	4.06	5.00	0.75*	138.67	37.33**	2.73	0.09*	58.67	1.29	3.17	0.34**	23.07	9.09**
L7xT3	70.45	-13.42*	3.67	-0.67*	58.67	-47.26**	2.41	-20.15**	46.67	-6.7.13*	2.33	-0.36**	4.77	-8.83**

** Significant at per cent level *Significant at 5 per cent level

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