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Studies on Line×Tester Analysis in Sesame (*Sesamum indicum* L.)

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Abstract

The present investigation was carried out in sesame involving 7 lines and 3 testers to identify the nature of gene action, combining ability and heterosis in association with yield and its component traits in sesame during December 2017 –March 2019. The parents were mated in the Line×Tester method. The variance due to SCA was higher than the corresponding variance due to GCA for all the characters indicating the preponderance of non-additive gene action. Among the lines ACM 14- 007 SI-2 and GT 10 and among the tester TMV 7 and TMV 5 exhibited high and significant *per se* performance for seed yield and its component traits. The *gca* effects of the lines indicated that the line GT 10 was positive and maximum significant for the yield attributing characters. The hybrids ACM 14-007 SI-2×TMV 5 and GT 10×TMV 7 recorded high *per se* performance with significant *sca* effects for seed yield per plant its component traits. Based on standard heterosis, the cross combinations GT 10×TMV 7, ACM 14-007 SI-2×TMV 5 and GT 10×TMV 5 possessed significant high standard heterosis for seed yield per plant and its associated traits. The hybrids GT 10× TMV 7, ACM 14-007 SI-2×TMV 5 and GT 10×TMV 5 were rated as the best since it possessed desirable performance based on *per se*, *sca* effects and standard heterosis for most of the yield attributing characters and so these hybrids could be exploited for further crop improvement.

Keywords: Sesame, line×tester, SCA, GCA, hybrids, yield

1. Introduction

Sesame (*Sesamum indicum* L.) is normally called sim sim, til and benniseed belongs to the family pedaliaceae one of the most important oil seed crop in India. In India, it is grown in an area of 1.8mha with production of 0.75 mt. It is cultivated in Asia from a period of over 5000 years (Troncoso et al., 2011). This is evidenced by the presence of archaeological remnants of the crop dating back to 5500BC in the Harappa valley in the Indian subcontinent (Ashri and Singh, 2007). Sesame seeds are rich in oil and protein and two unique substances namely sesamin and sesamolin known to have a cholesterol lowering effect in human and to prevent high blood pressure (Anilakumar et al., 2010). Also, it is rich in micronutrients such as minerals, liganans, tocopherol and phytosterol (Hassan et al., 2018). Sesame is an important source of high quality oil and protein (Elleuch et al., 2007). Brown seeded genotypes records higher polyphenol content (Gadade et al., 2017). Sesame seed cake is a by-product of traditional oil processing (Plaitho et al., 2017). Sesame seed oil was found to be rich in tocopherols (Gharby et al., 2017). The substitution of sesame oil as

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the sole edible oil has an additive effect in further lowering BP and plasma glucose in hypertensive diabetics (Sankar et al., 2001). The lack of high yielding varieties, poor stand establishment and poor fertilizer response are the major constraints in the cultivation of sesame (Alex et al., 2017). It offers several advantages by virtue of its faster growth, short duration, drought tolerant capacity cultivated throughout the year in sub-tropical and tropical conditions. Sesame had more preference from farmers because of low input required and high price of produce (De et al., 2013). In spite of all these, it has not contributed enormously to the total oil seed production in India, Mainly because of low productivity (417.2 kg ha^{-1}) (FAO, 2017). For breaking the present yield barrier and evolving varieties with high yield potential, it is desirable to combine the genes from genetically diverse parents (Wadikar et al., 2019). The use of the seeds for decoration on the surface of breads and cookies is most familiar to the Americans (Shilpi et al., 2012). 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). The success in identifying such parents mainly depends on the gene action that controls the character under improvement, combining ability and genetic makeup. The knowledge on combining ability and type of gene action helps in selecting the most suitable breeding procedure and in turn for the proper planning of successful breeding programme. During recent years developing hybrid varieties through heterosis breeding are being attempted (Duhoon,2004).In the present investigation an attempt was made to study the nature of gene action, combining ability and magnitude of heterosis for seed yield and its component characters in sesame for 21 crosses.

2. Materials and Methods

The present investigation on combining ability and heterosis in sesame (*sesamum indicum* L.) through line×tester analysis was carried out at the Plant Breeding Farm, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India during December 2017–March 2019. In 2017 December, ten genotypes were collected from Viruthachallam and Thindivanam oil seed research stations in Tamil Nadu. Out of ten genotypes, seven genotypes were selected as line and three genotypes were selected as testers. The experimental material consists of seven lines *viz,* L_1-GT 10, L_2- SVPR 1, L_3-ACM 14-007 SI-2, L4-ACM 14-010 SI-9, L_5-ORM 14, L6-ORM 17 and L_7-Paiyur 1 and three testers *viz,* T_1-TMV 5, T2-TMV6 and T_3-TMV7 were crossed in Line×Tester mating design and produced 21 hybrids during March 2018 - June 2018. This Twenty one hybrids and ten parents were evaluated during December 2018–March 2019. Hand emasculation was followed in the crossing block. The flower bud which is expected to open in the next day morning is selected in the previous day evening between 3 P.M. to 6 P.M. During the next day morning, between 7 A.M. and 9 .A.M., pollen from the desired male parents were dusted gently on the surface of the stigmas of the emasculated flower buds. The crossed seeds are harvested separately after reaching physiological maturation and shade dried until the capsules shed seeds. The resulted 21 hybrids and 10 parents were sown in randomized block design with three replications during October-December, 2018. The observations were recorded on ten randomly selected plants for both in parents and hybrids in each replication for the following traits namely, days to 50% flowering, plant height, number of branches plant^{-1}, number of capsules plant^{-1}, capsule length, number of seeds capsule^{-1}, 1000 seed weight and seed yield per plant. Combining ability and heterosis was evaluated.

3. Results and Discusion

The analysis of variance for the eight traits were studied and presented in Table 1. All the twenty one hybrids and ten parents showed significance for all the characters, the interaction effect (Line×tester) indicating the existence of substantial amount of vigour in hybrids. As a result highly significant at 1% level variation was observed among the hybrids which offering the scope for selection and further improvement by adopting suitable breeding procedure. The combining ability variance was studied for all the eight characters and furnished in Table 2. The estimates of GCA and SCA variances revealed that the SCA variances were higher for

Table 1: ANOVA for Analysis of variance for eight characters in sesame

Source	Df	Days to 50% Flowering	Plant height (cm)	No. of branches plant^{-1}	No. of capsules plant^{-1}	Capsule length	No. of seeds capsule^{-1}	1000 seed weight	Seed Yield plant^{-1}
Replication	2	3.4810	1.2745	0.0174	1.4704	0.0021	3.0220	0.0180	0.2627
Hybrids	20	47.0165**	460.8541**	3.1858**	635.1918**	0.0536**	76.7020**	1.16103**	12.6800**
Lines	60	38.9549**	582.6426**	2.9678**	795.2892**	0.0594**	85.9221**	1.5616**	15.2405**
Testers	2	125.7636**	940.9732**	10.4112**	2170.2710**	0.0879**	114.3639**	2.1099**	48.3752**
Lines×tester	12	37.9228**	319.940**	2.0906**	299.2965**	0.0449**	65.81**	0.8014**	5.4506**
Error	60	1.1202	24.0814	0.0192	19.2075	0.0038	7.1424	0.044	0.1154

*: Significant at 5% level, **: Significant at 1% level

Table 2: Analysis of variance for combining ability in sesame

Source	Days to 50% Flowering	Plant height (cm)	No. of branches plant^{-1}	No. of capsules plant^{-1}	Capsule length	No. of seeds capsule^{-1}	1000 seed weight	Seed Yield plant^{-1}
GCA	0.2368	3.6696	0.0285	8.7473	0.0002	0.2835	0.0093	0.1883
SCA	12.4348	100.3656	0.6887	91.7079	0.0140	18.9015	0.2539	1.7676
GCA / SCA	0.019	0.0365	0.041	0.095	0.0141	0.0149	0.03	0.1065

most of the characters, which indicating the preponderance of non-additive gene action for all the characters. Heterosis was estimated for eight characters in twenty one cross combinations and expressed as percentage over mid parent (di-relative heterosis), better parent (dii-heterobeltiosis) and standard parent (diii-standard heterosis).

3.1. *per se* performance of parents

Among the lines studied, L_3 (ACM 14-007 SI-2) was outstanding with high *per se* values for yield component traits like plant height, number of branches per plant, number of capsule per plant, capsule length, 1000 seed weight and seed yield per plant. The line L_1 (GT 10) was also noteworthy with high *per se* performance for plant height, number of branches per plant, number of capsules per plant, capsule length, number of seeds per capsule and seed yield per plant. The line L_2 (SVPR 1) registered earliness for days to 50% flowering and it also registered maximum number of seeds per capsule, capsule length and 1000 seed weight. Among the testers, T_1 (TMV 5) recorded earliness for days to 50% flowering with high *per se* performance for the characters like plant height, number of branches per plant and capsule length. The tester T_3 (TMV 7) recorded high *per se* performance for number of capsules per plant, 1000 seed weight and seed yield per plant. The tester T_2 (TMV 6) recorded maximum for number of seeds per capsule. This showed that the above mentioned parents might be useful for the incorporation of the respective characters in hybridization programme.

3.2. *Combining ability analysis*

In the present investigation, the *gca* effects of the lines indicated that the line L_1 (GT 10) was positive and maximum significant for the yield attributing characters *viz*., number of branches per plant, number of capsules per plant, capsule length, 1000 seed weight and seed yield per plant. L_2 (SVPR 1) showed negative significant *gca* effect for days to 50% flowering and also had significant and positive *gca* effect for capsule length and number of seeds per capsule. The similar result was reported by Vimala and Parameshwarappa (2017). The line L_3 (ACM 14-007 SI-2) also had significant and positive *gca* effects for the traits *viz*., plant height, number of branches per plant, number of capsules per plant, number of seeds per capsule, 1000 seed weight and seed yield per plant. The line L_5 (ORM 14) recorded positive and significant *gca* effect for the characters like number of capsules per plant and seed yield per plant. Among the testers, T_1 (TMV 5) possessed desirable *gca* effects for the characters such as plant height, number of branches per plant, number of capsules per plant, capsule length and with negative significant *gca* effect for days to 50% flowering. The next best tester was T_3 (TMV 7) recorded desirable positive significant *gca* effects for the traits *viz*., number of capsules per plant, number of seeds per capsule, 1000 seed weight and seed yield per plant, Table 3.

Among the hybrids, the hybrid $L_3 \times T_1$ (ACM 14- 007 SI-2×TMV 5) identified as positive significant *sca* effects for the characters *viz*., plant height, number of capsules per plant, capsule length, number of seeds per capsule, 1000 seed weight and seed yield per plant. The hybrid, $L_1 \times T_3$ (GT 10×TMV7) registered positive significant *sca* effects for the traits *viz*., plant height, number of branches per plant, number of seeds per capsule, capsule length, seed yield per plant and with negative significant effect for days to 50 per cent flowering. Also the cross, $L_4 \times T_2$ (ACM 14-010 SI-9×TMV 6) registered positive *sca* significant effects for the characters like number of branches per plant, capsule length, number of seeds capsule^{-1} and seed yield plant^{-1}. From the above discussion, it was concluded as the top ranked hybrids had either a good general combining line or a good general combining tester as one of the parents.

3.3. *Heterosis analysis*

Devaraja and Nadarajan (1995) indicated the need for computing standard heterosis for commercial exploitation of hybrid vigour. Hence, for the evaluation of hybrids, standard heterosis is to be given importance rather than the other two types of heterosis. So, the hybrids were evaluated based on standard heterosis. Among the hybrids, $L_1 \times T_3$ (GT 10×TMV 7) was identified as the best performing hybrid since it had possessed significant and positive standard heterosis for all the traits with earliness for day to 50% flowering. The next best hybrid identified was $L_3 \times T_1$ (ACM 14-007 SI-2×TMV 5), since it possessed desirable standard heterosis for almost all the traits except day to 50% flowering. The hybrid $L_1 \times T_1$ (GT 10×TMV 5) recorded desirable standard heterosis for all the characters except plant height and number of seeds per capsule. The hybrid $L_7 \times T_3$ (Paiyur 1×TMV 7) recorded significant standard heterosis for plant height, capsule length and 1000 seed weight. The heterotic effect over the standard check were also reported by Kannan et al. (2001) and Raghunaiah et al. (2008). Hence, from the above discussion, it may be concluded that the crosses $L_1 \times T_3$ and $L_3 \times T_1$ can be rated as best hybrid and the hybrids $L_1 \times T_1$ and $L_7 \times T_3$ can be rated as better hybrids based on the magnitude of heterosis (Table 4).

Table 3: Relationship between *gca* and *sca* effects

Sl. No.	Characters	*gca* effect	*sca* effect	Based on two criteria		
				High×high	High×low (or) Low ×high	Low×low
1.	Days to 50% Flowering	L_2, T_1	$L_4\times T_3$, $L_2\times T_1$, $L_3\times T_2$, $L_1\times T_3$	$L_2\times T_1$	-	$L_4\times T_3$, $L_1\times T_3$, $L_3\times T_2$
2.	Plant height (cm)	L_1, L_3, L_7, T_1	$L_5\times T_2$, $L_2\times T_1$, $L_4\times T_1$, $L_1\times T_3$, $L_3\times T_1$, $L_7\times T_3$	$L_3\times T_1$	$L_1\times T_3$, $L_2\times T_1$, $L_3\times T_3$, $L_7\times T_3$	$L_5\times T_2$
3.	No. of branches plant^{-1}	L_3, L_1, T_1	$L_4\times T_2$, $L_1\times T_3$, $L_2\times T_3$, $L_3\times T_3$	-	$L_1\times T_3$	$L_2\times T_3$, $L_4\times T_2$, $L_7\times T_3$
4.	No. of capsules plant^{-1}	L_1, L_3, L_5, T_3, T_1	$L_7\times T_1$, $L_2\times T_3$, $L_3\times T_1$, $L_3\times T_2$	$L_3\times T_1$	$L_2\times T_3$, $L_7\times T_1$	$L_2\times T_2$
5.	Capsule length	L_1, L_7, L_2, T_1	$L_4\times T_2$, $L_5\times T_2$, $L_1\times T_3$, $L_7\times T_3$, $L_3\times T_1$	$L_7\times T_4$, $L_1\times T_4$	$L_1\times T_3$, $L_7\times T_3$	$L_4\times T_2$, $L_5\times T_2$
6.	No. of seeds capsule^{-1}	L_2, L_3, T_3	$L_3\times T_1$, $L_2\times T_2$, $L_1\times T_3$, $L_4\times T_2$	-	$L_3\times T_1$, $L_1\times T_3$, $L_2\times T_2$	$L_4\times T_2$
7.	1000 seed weight	L_1, L_3, T_3	$L_3\times T_1$, $L_4\times T_2$, $L_5\times T_3$, $L_1\times T_1$	-	$L_3\times T_1$, $L_1\times T_1$, $L_5\times T_3$	$L_4\times T_2$
8.	Seed yield plant^{-1}	L_1, L_3, L_5, T_3	$L_5\times T_2$, $L_1\times T_3$, $L_3\times T_1$, $L_1\times T_1$	$L_1\times T_3$	$L_1\times T_1$, $L_3\times T_1$, $L_5\times T_2$	-

Table 4: Superior hybrids selected based on per se, sca and standard heterosis

Sl. No.	Characters	*per se* of hybrids	*sca* effect	Standard heterosis	Combination of three criteria
1.	Days to 50% Flowering	$L_1\times T_1$, $L_1\times T_3$, $L_2\times T_1$, $L_7\times T_1$, $L_3\times T_1$, $L_4\times T_3$, $L_3\times T_2$	$L_1\times T_3$, $L_2\times T_1$, $L_4\times T_3$, $L_3\times T_2$	$L_1\times T_1$, $L_1\times T_3$, $L_2\times T_1$, $L_7\times T_1$	$L_1\times T_3$, $L_2\times T_1$
2.	Plant height (cm)	$L_3\times T_1$, $L_2\times T_1$, $L_1\times T_3$, $L_2\times T_3$, $L_5\times T_2$, $L_1\times T_1$	$L_1\times T_3$, $L_2\times T_1$, $L_5\times T_2$, $L_3\times T_1$, $L_4\times T_1$, $L_7\times T_3$	$L_1\times T_3$, $L_3\times T_1$, $L_2\times T_1$	$L_1\times T_3$, $L_2\times T_1$, $L_3\times T_1$
3.	No. of branches plant^{-1}	$L_3\times T_1$, $L_3\times T_3$, $L_1\times T_3$, $L_1\times T_1$, $L_7\times T_1$, $L_4\times T_2$	$L_1\times T_3$, $L_2\times T_3$, $L_4\times T_2$, $L_3\times T_3$	$L_1\times T_1$, $L_1\times T_3$, $L_3\times T_1$, $L_4\times T_2$	$L_1\times T_3$, $L_4\times T_2$
4.	No. of capsules plant^{-1}	$L_3\times T_1$, $L_1\times T_3$, $L_1\times T_1$, $L_5\times T_3$, $L_7\times T_1$, $L_2\times T_3$	$L_3\times T_1$, $L_2\times T_3$, $L_3\times T_2$, $L_7\times T_1$	$L_1\times T_1$, $L_1\times T_3$, $L_3\times T_1$	$L_3\times T_1$
5.	Capsule length	$L_1\times T_3$, $L_3\times T_1$, $L_1\times T_1$, $L_4\times T_2$, $L_7\times T_3$, $L_7\times T_1$	$L_1\times T_3$, $L_3\times T_1$, L4 ×T2, L5×T_2, $L_7\times T_3$	$L_1\times T_3$, $L_1\times T_1$, $L_3\times T_1$, $L_7\times T_3$	$L_1\times T_3$, $L_3\times T_1$, $L_7\times T_3$
6.	No. of seeds capsule^{-1}	$L_2\times T_2$, $L_3\times T_1$, $L_1\times T_3$, $L_7\times T_3$, $L_4\times T_2$	$L_3\times T_1$, $L_1\times T_3$, $L_4\times T_2$, $L_2\times T_2$	$L_1\times T_3$, $L_3\times T_1$, $L_2\times T_2$	$L_3\times T_1$, $L_1\times T_3$, $L_2\times T_2$
7.	1000 seed weight	$L_1\times T_3$, $L_1\times T_1$, $L_3\times T_1$, $L_4\times T_2$, $L_7\times T_3$	$L_3\times T_1$, $L_1\times T_1$, $L_4\times T_2$, $L_5\times T_3$	$L_1\times T_1$, $L_1\times T_3$, $L_3\times T_1$, $L_7\times T_3$	$L_3\times T_1$, $L_1\times T_1$
8.	Seed yield plant^{-1}	$L_1\times T_3$, $L_1\times T_1$, $L_3\times T_1$, $L_3\times T_3$, $L_7\times T_3$	$L_1\times T_1$, $L_1\times T_3$, $L_3\times T_1$, $L_5\times T_2$	$L_1\times T_1$, $L_1\times T_3$, $L_3\times T_1$, $L_3\times T_3$	$L_1\times T_1$, $L_1\times T_3$, $L_3\times T_1$

4. Conclusion

The hybrids $L_1\times T_3$ (GT 10×TMV 7), $L_3\times T_1$ (ACM 14-007 SI-2×TMV 5) and $L_1\times T_1$ (GT 10×TMV 5) were rated as the best since it possessed desirable performance based on *per se*, *sca* effects and standard heterosis for the seed yield plant^{-1} and its component traits.

5. Reference

Alex, T., Srinivasan, K., Arthanari, P.M., 2017. Effect of Seed Pelleting and Foliar Nutrition on Growth and Yield of Summer Irrigated Sesame (*Sesamum indicum* L.). Madras Agricultural journal, 104(10/12), 350–353.

Anilakumar, K.R., Pal, A., Khanum, F., Bawa, A.S., 2010. Nutritional, medicinal and industrial uses of sesame

(*Sesamum indicum* L.) seeds-an overview. Agriculturae Conspectus Scientificus, 75(4), 159–168.

Ashri, A., Singh, R.J., 2007. Sesame (*Sesamum indicum* L.). Genetics resources chromosome Engineering and crop improvement, Oilseed crop 4, 231–289.

Devaraja, M., Nadarajan, N., 1995. Gene action for seven biometrical traits in rice. Annals of Agricultural Research 16(3), 360–361.

De, P.S., Bhale, V.M., Khadse, V.A., 2013. Quality and Economics of summer sesame (*Sesamum indicum* L.) as influenced by irrigation and nutrient levels. International Journal of Bio-resource and stress Management 4(2), 369–371.

Duhoon, S.S., 2004, September. Exploitation of heterosis for raising productivity in sesame. In New directions for a diverse planet: Proceedings of the 4th international crop science congress, Brisbane, Australia (Vol. 26).

Elleuch, M., Besbes, S., Roiseux, O., Blecker, C., Attia, H., 2007. Quality characteristics of sesame seeds and by-products. Food chemistry, 103(2), 641–650.

Food and Agriculture Organization, 2017, WWW.FAO.Otg., Area, production and productivity of sesame.

Gadade, B.V., Kachare, D.P., Satbhai, R.D., Naik, R.M., 2017. Nutritional Composition and Oil Quality Parameters of Sesame (*Sesamum indicum* L.) Genotypes. International Research Journal of Multidisciplinary Studies, *3*(7).

Gharby, S., Harhar, H., Bouzoubaa, Z., Asdadi, A., El Yadini, A., Charrouf, Z., 2017. Chemical characterization and oxidative stability of seeds and oil of sesame grown in Morocco. Journal of the Saudi society of Agricultural sciences 16(2), 105–111.

Hassan, A.B., Mahmoud, N.S., Elmamoun, K., Adiamo, O,Q., Ahmed I.A.M., 2018. Effects of gamma radiation on the protein characteristics and functional properties of sesame (*Sesamum indicum* L.) seeds. Radiation Physics and Chemistry, 144, 85–91.

Kannan, K., Senthilkumar, P., Ganesan, J., 2001. Heterosis in Sesame (*Sesamum indicum* L.) In: Nat. Seminar on Sesame crop improvement and its future prospects. 28th Feb. And 1st March, Annamalai Univ., Annamalai nagar, 11.

Kumari, J., Dikshit, H.K., Singh, B., Singh, D., 2015. Combining ability and character association of agronomic and biochemical traits in pea (*Pisum sativum* L.). Scientia Horticulturae, 181, 26–33.

Plaitho, Y., Rattanasena, P., Chaikham, P., Prangthip, P., 2017. Biochemical and antioxidative properties of unprocessed and sterilized white and black sesame by-product from northern Thailand. Current research in nutritive and food science 5(3),196–205.

Raghunaiah, E., Kishan, A.G., Ansari, N.A., 2008. Combining ability and heterosis for yield and yield components in sesame (*Sesamum indicum* L.). Journal of Research ANGRAU, 36(2&3), 9–16.

Sankar, D., Rao, M.R., Sambandam, G., Pugalendi, K.V., 2001. A pilot study of open label sesame oil in hypertensive diabetics, Journal of medicinal food 9(3), 408–412.

Shilpi, S., Islam, M.N., Sutradhar, G.N.C., Husna, A., Akter, F., 2012. Effect of nitrogen and sulfur on the growth and yield of sesame, International Journal of Bio-resource and stress Management 3(2), 177–182.

Troncoso-ponce, M.A., Kilaru, A., Cao, X., Durrett, T.P., Fan, J., Jensen, J.K., Thrower, N.A., Pauly, M., Wilkerson, C., Ohlrogge, J.B., 2011. Comparative deep transcriptional profiling of four developing oilseeds. The Plant Journal, 68(6), 1014–1027.

Vimala, G., Parameshwarappa, S. G., 2017. Combining ability analysis for yield and yield attributing traits in sesame (*Sesamum indicum* L.). Journal of Farm Science 30(3), 418–420.

Wadikar, P.B., Dhare, S.L., Thorat, G.S., 2019. Line×Tester Analysis for yield and yield contributing traits in sesame (*Sesamum indicum* L.), Bulletin of environment, Pharmacology and Life Sciences 8(6), 88–91.