Received: 03 Jun 2020 | Revised: 19 Mar 2021 | Accepted: 28 Mar 2021

Electronic Journal of Plant Breeding

Research Article

Heterosis and combining ability studies in sesame (*Sesamum indicum L.*)

A. Disowja[1], C. Parameswari[1,3*], R. P. Gnanamalar[1,4] and S. Vellaikumar[2]

[1]Department of Plant Breeding and Genetics, AC&RI, TNAU, Madurai-625 104, Tamil Nadu, India
[2]Department of Biotechnology, AC&RI, TNAU, Madurai-625 104, Tamil Nadu, India
[3]Agricultural Research Station, TNAU, Vaigai Dam-625 562, Tamil Nadu, India
[4]Department of Pulses, CPBG, TNAU, Coimbatore-641 003, Tamil Nadu, India
***E-Mail:** parameswari.c@tnau.ac.in

Abstract

A line × tester analysis was carried out in Sesame (*Sesamum indicum L.*) with four lines *viz.,* VRI 3, SVPR 1, TMV 6, and TMV 7 and six testers *viz.,* Thilathara, Thilak, TKG 55, RT 125, RT 127 and Thilottama. A total of 24 cross combinations were made and ten biometrical characters *viz.,* days to 50 % flowering, height to first capsule, plant height, the number of primary branches, the number of capsules per plant, the number of capsules on main stem, capsule length, days to maturity, 1000 seed weight and seed yield per plant were recorded and analysed for combining ability and heterosis. In this present investigation, the variance due to SCA was higher than the variance due to GCA, which indicates that the inheritance of seed yield/plant is governed by non-additive gene action. Combining ability was analysed based on *gca* and *sca* effects. VRI 3 was the best general combiner among lines and among testers Thilathara was the best general combiner. The *sca* effects showed that seven hybrids *viz.,* VRI 3 × Thilak, VRI 3 × RT 127, VRI 3 × Thilottama, SVPR 1 × Thilathara, TMV 6 × Thilathara, TMV 7 × TKG 55 and TMV 7 × RT 125 exhibited significant and positive values and these crosses can be evaluated further in advanced generations. Heterosis over standard parent was estimated and the highest positive significant heterosis for seed yield per plant was registered by the cross TMV 6 × Thilathara (39.32 %) followed by VRI 3 × Thilottama (21.41 %).

Key words

Sesame, nature of gene action, *gca* effects and *sca* effects, heterosis

INTRODUCTION

Sesame is an ancient oilseed crop (Weiss, 1971) and archaeological evidence shows that the sesame was found in Mesopotamian Civilization (Bedigian, 1986). Sesame is used as a spice and an important source of edible vegetable oil. Sesame is a self-pollinated crop with a small percentage of cross-pollination, which is an advantage for exploitation of heterosis. Outcrossing between diverse parents helps in breaking the yield barriers and this in turn helps in identifying and developing new cultivars. Therefore, identifying parents with desirable characters is crucial along with the knowledge of their combining ability and gene action for any breeding programme to achieve success.

Among the several techniques available for evaluating the cultivars in terms of their genetic makeup and combining ability, line × tester, diallel and partial diallel mating techniques are mostly in use. Combining ability gives an idea about the nature and magnitude of gene action in inheritance of biometrical or quantitative traits, which helps in identifying parents with good general combining ability effects and hybrids or crosses with good specific combining ability effects. Selection of parents based on *per se* performance alone is not a better option because parents with superior phenotype can result in inferior or poor hybrids in later generations (Banerjee and Kole, 2010). Hence it is important to select parents based on *per se* performance and high *gca* value for the traits to be improved. Estimation of heterosis helps in identifying hybrids which are more economical with desirable characters.

The main objective of the present study is to evaluate the nature and magnitude of gene action controlling the inheritance of yield and yield-related traits by estimating *gca* and *sca* and to estimate heterosis over standard parent.

MATERIALS AND METHODS

The present investigation was carried out in the research farm of Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai, geographically located in 9.96˚ N latitude and 78.20˚E longitude during the *summer of,* 2019 and *rainy* season, 2019. Four lines *viz.,* VRI 3, SVPR 1, TMV 6, TMV 7 and six testers *viz.,* Thilathara, Thilak, TKG 55, RT 125, RT 127 and Thilottama were raised in crossing block during *summer,* 2019. Crosses were effected following line × tester mating design (Kempthorne, 1957) following hand emasculation and pollination technique. Using these parents, 24 cross combinations were obtained and seeds were harvested from all the crosses. All 24 cross combinations were raised along with the parents in Randomized Block Design with two replications during the *rainy season of,* 2019.

Observations were documented from five randomly selected plants in the parents and hybrids for ten quantitative traits *viz.,* days to 50 per cent flowering, height to the first capsule (cm), plant height (cm), the number of primary branches, the number of capsules per plant, the number of capsules on the main stem, capsule length (cm), days to maturity, 1000 seed weight (g) and seed yield per plant (g).

ANOVA for Randomized Block Design was formed by subjecting the traits under study based on the mean values. The combining ability was analyzed using the values of *gca* and *sca* effects and their ratios. Heterosis was estimated over the standard parent (VRI 3). Data analysis was done using TNAUSTAT software.

RESULTS AND DISCUSSION

Combining ability analysis is done to identify appropriate parents with greater potential to produce desired lines or cultivars. In this study, the ANOVA for combining ability analysis revealed that the mean squares due to lines, testers and line × testers were significant for all the characters except the number of primary branches and capsule length (**Table 1**). In case of 1000 seed weight, the mean squares due to lines and line × testers were significant, but the testers were non-significant. The estimates of σ^2SCA were higher than the corresponding σ^2GCA for all the characters, which indicates the presence of non-additive gene action. The ratio of σ^2GCA/σ^2SCA was found to be less than one for all the characters indicating the predominance of non-additive gene action. In sesame, non-additive gene action for the inheritance of seed yield per plant was earlier reported by Manivannan (1997), Yamanura *et al.* (2009), Prajapati (2010), Devi *et al.* (2002) and Praveenkumar *et al.* (2012). However, the prevalence of additive gene action for seed yield was observed by Backiyarani *et al. (*1997*)*, Parameshwarappa and Salimath (2010), Das and Gupta (1999), Pawar and Monpara (2016).

The estimates of *gca* effects for seed yield and yield contributing traits indicated that the VRI 3 was the good general combiner among lines, concurrently for eight characters *viz.,* days to 50 per cent flowering, height to first capsule, plant height, the number of capsules per cent plant, the number of capsules on the main stem,

Table 1. ANOVA for seed yield and its contributing characters

Character	Df	DFF	HFC	PH	NPB	NCP	NCM	CL	DM	1000 SW	YLD
Replication	1	17.520	1.32	7.254	7.760	9.8102	4.56	0.0012	2.08	0.67	6.77
Cross	23	6.760	394.63	383.101	9.24	3988.31	304.26	0.0249	9.89	0.22	71.55
Line	3	25.909 **	1158.17 **	1372.51 **	9.44	11987.33 **	303.39 **	0.0299	14.88 *	0.39 **	70.11 **
Tester	5	7.570 **	178.02 **	226.30 **	12.20	2169.69 **	243.09 **	0.0202	13.48 **	0.17	51.46 **
L × T	15	2.659 *	314.12 **	237.48 **	8.21	2994.71 **	324.82 **	0.0255	7.70 *	0.19 *	78.53 **
Error	23	1.651	0.86	2.26	9.64	0.58	0.93	0.0237	3.21	0.08	3.04
σ^2gca	9	0.155	3.04	5.50	0.0389	37.58	-0.77	-0.0001	0.08	0.0008	-0.26
σ^2sca	23	0.504	156.63	117.61	-0.7124	1497.06	161.94	0.0009	2.24	0.0598	37.74
σ^2gca/ σ^2sca		0.30	0.019	0.046	-0.054	0.025	-0.004	0.11	0.035	0.0133	0.0068

**and* = 1 % and 5 % significance, respectively.
DFF - days to 50% flowering, HFC - height to first capsule, PH - plant height, NPB - number of primary branches, NCP - number of capsules per plant, NCM - number of capsules on main stem, CL - capsule length, DM - days to maturity, 1000 SW - 1000 seed weight and YLD – seed yield per plant.

Table 2. ***GCA*** **effects of parents for seed yield and its contributing traits in sesame**

Parents	DFF	HFC	PH	NPB	NCP	NCM	CL	DM	1000 SW	YLD
VRI 3	1.48 **	14.54 **	8.83 **	-0.37	47.34 **	5.41 **	-0.04	-1.50 **	-0.23 **	3.47 **
SVPR 1	-1.85**	-2.78 **	-12.76 **	1.33	-16.56 **	-1.55 **	0.07	0.00	0.21 *	-0.16
TMV 6	0.44	-5.06 **	8.84 **	-0.42	-17.44 **	-6.21 **	-0.03	0.33	0.00	-1.66 **
TMV 7	0.81 *	-6.70 **	-4.91 **	-0.53	-13.34 **	2.35 **	0.00	1.17 *	0.02	-1.65 **
Thilathara	-1.48 **	-0.06	5.60 **	2.40 *	27.36 **	0.83 *	-0.00	0.54	0.01	4.01 **
Thilak	0.77	-0.15	0.18	-0.39	-4.65 **	8.45 **	-0.05	1.42 *	-0.18	-2.21 **
TKG 55	0.65	8.15 **	-7.28 **	0.20	2.71 **	-2.33 **	0.09	0.92	0.14	2.17 **
RT 125	0.90	-0.80 *	2.36 **	-0.87	4.34 **	3.87 **	-0.01	0.17	-0.11	-0.62
RT 127	0.02	-0.53	-5.48 **	-0.70	-22.51 **	-4.75 **	-0.04	-0.96	0.21 *	-2.19 **
Thilottama	-0.85	-6.62 **	4.63 **	-0.65	-7.26 **	-6.07 **	0.01	-2.08 **	-0.07	-1.16
CD (95%) GCA (line)	1.08	0.78	1.27	2.62	0.64	0.81	0.13	1.51	0.23	1.47
CD (95%) GCA (Tester)	1.33	0.96	1.55	3.21	0.79	0.99	0.15	1.85	0.29	1.80

**and* = 1 % and 5 % significance, respectively
DFF - days to 50% flowering, HFC - height to first capsule, PH - plant height, NPB - number of primary branches, NCP - number of capsules per plant, NCM - number of capsules on main stem, CL - capsule length, DM - days to maturity, 1000 SW - 1000 seed weight and YLD – seed yield per plant

days to maturity, 1000 seed weight and seed yield/plant (**Table 2**). Other good general combiners identified for various characters were TMV 7 for days to 50 per cent flowering, height to the first capsule, plant height, the number of capsules per plant, the number of capsules on the main stem, days to maturity and seed yield/plant; SVPR 1 for days to 50 per cent flowering, height to first capsule, plant height, the number of capsule per plant, the number of capsules on the main stem and days to maturity. Among testers, Thilathara was found to be good general combiner concurrently for six traits *viz.,* days to 50 per cent flowering, plant height, the number of primary branches, the number of capsules per plant, the number of capsules on the main stem and seed yield per plan. RT 127 was good general combiner for plant height, the number of capsules per plant, the number of capsules on the main stem, 1000 seed weight and seed yield per plant; TKG 55 for height to first capsule, plant height, the number of capsules/plant, the number of capsules on the main stem and seed yield per plant; Thilottama for height to first capsule, plant height, the number of capsules per plant, the number of capsules on the main stem and days to maturity.

The results indicated that parents *viz.,* TMV 7, SVPR1, Thilathara, RT 127, TKG 55 and Thilottama showed a favourable *gca* for more components with a high concentration of propitious genes for more traits and should be employed in various crossing programmes to merge important characters for evolving high yielding sesame varieties. Vavdiya *et al.* (2014) suggested that the parents with good general combing ability for more traits should be considered as sound parents, and preferred in breeding programmes to combine more number of desirable characters.

The estimates of *sca* effects of the crosses (**Table 3**) indicated that seven hybrids *viz.,* VRI 3 × Thilak, VRI 3 × RT 127, VRI 3 × Thilottama, SVPR 1 × Thilathara, TMV 6 × Thilathara, TMV 7 × TKG 55 and TMV 7 × RT 125 evinced significant and positive *sca* effects for seed yield per plant. Contrarily six crosses *viz.,* VRI 3 × Thilathara, VRI 3 × RT 125, SVPR 1 × Thilottama, TMV 6 × TKG 55, TMV 7 × Thilathara, TMV 7 × RT 127 exhibited significant negative *sca* values for seed yield per plant.

TMV 6 × Thilathara seemed to be promising for developing high yielding genotypes due to its high and significantly positive *sca* values for the trait seed yield per plant and involving average × high type of general combiners. This cross may be further be subjected to improvement in later generations. The *gca* values of parents are classified into high, average and low, based on total range of *gca* values and the possible combinations are high × high, high × average, high × low, average × average, average × low, low × low types. Due to the segregation of genes possessing strong potentials and their specific buffers, a high x low cross can result in strong transgressive segregants for desired characters (Langham, 1961). Such type of combinations were found in the hybrids *viz.,* VRI 3 × RT 125, VRI 3 × Thilottama, SVPR 1 ×Thilottama, TMV 6 × RT 127, TMV 7 × RT 127 for 1000 seed weight, SVPR 1 × RT 125, SVPR 1 × Thilathara, SVPR 1 × Thilottama, TMV 6 × Thilak, TMV 6 × TKG 55, TMV 7 × Thilak, TMV 7 × TKG 55 for capsule length; VRI 3 × RT 125, SVPR 1 × Thilak, SVPR 1 × Thilottama, TMV 6 × Thilak, TMV 6 ×Thilottama for days to maturity; VRI 3 ×Thilathara for the number of capsules on main stem;

Table 3. ***SCA*** **effects of hybrids for seed yield and its component traits in sesame**

Crosses	HFC	DFF	PH	NPB	NCP	NCM	CL	DM	1000 SW	YLD
VRI 3 ×Thilathara	-4.65 **	1.15	2.25 *	-2.13	-38.17 **	2.71 **	-0.06	-1.13	-0.29	-7.81 **
VRI 3 × Thilak	-9.91 **	0.40	2.27 *	0.31	39.14 **	-13.46 **	-0.08	-2.50	0.03	3.72 **
VRI 3 × TKG 55	-16.41 **	-2.48 *	-0.42	- 1.18	-21.52 **	1.22	0.06	-0.50	0.11	-1.40
VRI 3 × RT 125	11.64 **	-0.23	-15.16 **	1.20	-38.95 **	-6.72 **	0.01	2.75 *	-0.21	-5.59 **
VRI 3 × RT 127	9.82 **	-0.35	5.98 **	1.17	12.60 **	8.09 **	0.02	0.37	0.12	3.30 *
VRI 3 × Thilottama	9.51 **	1.52	5.07 **	0.62	46.90 **	8.16 **	0.04	1.00	0.23	7.79 **
SVPR1×Thilathara	6.22 **	-1.52	12.79 **	4.07	28.12 **	10.38 **	-0.00	1.88	0.24	4.78 **
SVPR1× Thilak	4.75 **	1.23	-6.89 **	-0.99	-2.87 **	9.40 **	0.05	2.00	-0.24	-1.20
SVPR1× TKG 55	22.30 **	0.85	-5.93 **	1.02	10.97 **	3.64 **	0.09	-2.50	-0.08	1.35
SVPR1 × RT 125	-0.55	0.60	12.79 **	-1.25	-0.81	2.34 **	-0.07	0.25	0.11	0.03
SVPR1X × RT 127	-10.61 **	-0.02	-2.13	0.22	10.94 **	-16.90 **	-0.20	-1.13	-0.03	0.26
SVPR1 × Thilottama	-22.12 **	-1.15	-10.64 **	-3.08	-46.36 **	-8.87 **	0.15	-0.50	-0.00	-5.23 **
TMV 6 ×Thilathara	2.69 **	0.06	0.51	1.07	52.75 **	5.29 **	0.12	-1.96	0.58 **	11.62 **
TMV 6 × Thilak	-2.06 **	-0.69	5.36 **	1.01	-18.19 **	-17.09 **	-0.05	0.17	0.11	-1.73
TMV 6 × TKG 55	-5.16 **	0.94	-8.83 **	-0.18	-20.90 **	-6.25 **	-0.17	0.67	-0.37	-6.16 **
TMV 6 × RT 125	-10.11 **	0.19	3.78 **	-0.55	-20.87 **	8.60 **	0.08	-1.58	0.12	-1.66
TMV 6 × RT 127	10.03 **	0.06	6.32 **	-0.78	8.98 **	13.66 **	0.08	2.54	-0.37	-0.71
TMV 6 × Thilottama	4.61 **	-0.56	-7.14 **	-0.58	-1.77 **	-4.21 **	-0.07	0.17	-0.06	-1.36
TMV 7 ×Thilathara	-4.26 **	0.31	-15.56 **	-3.02	-42.70 **	-18.38 **	-0.06	1.21	-0.53 *	-8.50 **
TMV 7 × Thilak	7.22 **	-0.94	-0.74	-0.33	-18.09 **	21.15 **	0.08	0.33	0.09	-0.79
TMV 7 × TKG 55	-0.73	0.69	15.17 **	0.33	31.45 **	1.38	0.02	2.33	0.34	6.21 **
TMV 7 × RT 125	-0.98	-0.56	-1.41	0.61	60.63 **	-4.22 **	-0.02	-1.42	-0.02	7.22 **
TMV 7 × RT 127	-9.24 **	0.31	-10.18 **	-0.62	-32.52 **	-4.85 **	0.10	-1.79	0.28	-2.85 *
TMV 7 × Thilottama	8.00 **	0.19	12.71 **	3.03	1.23 *	4.92 **	-0.12	-0.67	-0.17	-1.20

**and* = 1 % and 5 % significance, respectively.

DFF - days to 50% flowering, HFC - height to first capsule, PH - plant height, NPB - number of primary branches, NCP - number of capsules per plant, NCM - number of capsules on main stem, CL - capsule length, DM - days to maturity, 1000 SW - 1000 seed weight and YLD - yield per single plant.

VRI 3 × Thilak, VRI 3 × TKG 55, VRI 3 × RT 125, SVPR 1 ×Thilak, SVPR 1 × TKG 55, SVPR 1 × RT 125 for the number of capsules/plant; VRI 3 ×Thilathara, TMV 6 × Thilathara, SVPR 1 × Thilak, SVPR 1 × TKG 55 for the number of primary branches; VRI 3 × Thilak, VRI 3 × RT 125, SVPR 1 × Thilak, SVPR 1 × RT 125, TMV 6 × Thilak, TMV 6 × RT 125 for plant height, VRI 3 ×Thilathara, VRI 3 × Thilak, VRI 3 × RT 125, VRI 3 × RT 127, TMV 6 × Thilak, TMV 6 × RT 125, TMV 6 × RT 127, TMV 7 × Thilak, TMV 7 × RT 125, TMV 7 × RT 127 for height to first capsule; VRI 3 × RT 127, SVPR 1 × RT 127, TMV 6 × Thilathara for days to 50 per cent flowering.

For the exploitation of heterosis, *sca* value can be utilized as a useful index. In the present study, the cross combinations *viz.,* VRI 3 × Thilak, VRI 3 × RT 127, VRI 3 × Thilottama, SVPR 1 × Thilathara, TMV 6 × Thilathara, TMV 7 × TKG 55 and TMV 7 × RT 125 registered positive and high *sca* values for seed yield per plant and other yield contributing traits.

In the present investigation, standard heterosis over VRI 3 ranged from -56.13 to 39.32 per cent **(Table 4)**. Two cross combinations *viz*., TMV 6 × Thilathara and VRI 3 × Thilottama registered significant positive standard heterosis for seed yield per plant. Heterosis for seed yield per plant was earlier reported by Singh *et al.* (2005), Banerjee and Kole, (2010) and Jadhav and Mohir (2013). The cross TMV 6 × Thilathara recorded the highest positive significant heterosis over the standard parent (39.32 %). The other cross with positive significant heterosis over the standard parent for seed yield/plant was VRI 3 × Thilottama with 21.41 per cent of standard heterosis. The range of standard heterosis for days to 50 per cent flowering was -13.41 to 2.44 per cent . Negative significance is favourable for this character as early flowering results in short duration, which helps the crop to escape from drought and other abiotic and biotic stresses. The cross with the highest negative standard heterosis for days to 50 per cent flowering was SVPR 1 × Thilottama (-13.41 %). Height to first capsule is an important yield attributing trait as plants with capsules formed at less height, accommodate more number of capsules on the main stem and thus increase yield. In the present study, for height to first capsule, the cross SVPR 1 × Thilottama showed a significant negative heterosis of -54.63 per cent . The cross showing the highest negative significant heterosis for plant height was SVPR 1 × TKG 55 (-35.02 %). More number of primary branches is required to accommodate more number of capsules. The highest positive significant heterosis for the number of primary branches was recorded by SVPR 1 × Thilathara with 133.33 per cent heterosis. The cross TMV 7 × Thilak registered 63.75 per cent of positive significant heterosis for the number of capsules on main stem. The range of heterosis for days to maturity was found to be -5.73 to 1.56 per cent and two crosses registered significant negative heterosis. The crosses VRI 3 × Thilak and SVPR 1 × RT 127 registered the highest negative significant heterosis of -5.73 per cent for days to maturity. The range of heterosis for 1000 seed weight was -19.94 to 23.11 per cent. TMV 6 × Thilathara cross showed the highest positive significant heterosis of 23.11 per cent among all the crosses for 1000 seed weight.

Among all the crosses, TMV 6 × Thilathara showed the highest positive significant standard heterosis for seed yield per plant and for some of the yield contributing characters *viz.,* days to 50 per cent flowering, plant height, days to maturity, 1000 seed weight and seed yield per plant, with standard heterosis in the desirable direction. VRI 3 × Thilottama showed the positive

Table 4. Standard heterosis for yield and its contributing traits in sesame

Crosses	DFF	HFC	PH	NPB	NCP	NCM	CL	DM	1000 SW	YLD
VRI 3 X Thilathara	-1.22	46.22 **	-6.19 **	-5.26	-80.14 **	8.52 **	-10.17	-5.21 **	-18.16	-26.77 **
VRI 3 X Thilak	2.44	33.17 **	-9.84 **	-11.40	-74.76 **	-12.00 **	-12.57 *	-5.73 **	-13.07	-2.24
VRI 3 X TKG 55	-4.88	37.56 **	-16.70 **	-27.19	-81.08 **	-2.64	-2.22	-4.17 *	1.71	-5.68
VRI 3 X RT 125	1.22	84.15 **	-20.15 **	-4.39	-82.96 **	-6.84 *	-7.95	-1.56	-19.94	-37.92 **
VRI 3 X RT 127	-1.22	80.37 **	-11.16 **	-1.75	-80.03 **	8.04 **	-8.69	-5.21 **	4.73	-4.08
VRI 3 X Thilottama	1.22	64.76 **	-4.94 **	-10.53	-74.15 **	5.04	-5.73	-5.73 **	-1.58	21.41 **
SVPR1X Thilathara	-15.85 **	30.49 **	-13.66 **	133.33 **	-79.85 **	10.20 **	-4.07	-0.52	18.21	14.65
SVPR1X Thilak	-3.66	26.71 **	-30.63 **	-4.39	-87.33 **	26.17 **	-3.88	0.52	-6.55	-41.74 **
SVPR1X TKG 55	-4.88	89.76 **	-35.02 **	41.23	-84.81 **	-13.57 **	2.77	-4.69 *	11.08	-9.73
SVPR1X RT 125	-4.88	12.20 **	-15.86 **	-17.54	-86.02 **	-1.80	-6.65	-2.60	8.81	-28.69 **
SVPR1X RT 127	-8.54 *	-11.71 **	-31.24 **	11.40	-87.81 **	-68.67 **	-12.75 *	-5.21 **	15.81	-34.88 **
SVPR1X Thilottama	-13.41 **	-54.63 **	-30.16 **	-45.61	-92.80 **	-52.58 **	2.22	-5.73 **	6.50	-55.51 **
TMV 6 X Thilathara	-8.54 *	16.32 **	-7.36 **	50.00	-77.03 **	-13.21 **	-2.96	-4.17 *	23.11 *	39.32 **
TMV 6 X Thilak	-4.88	4.51 *	-7.74 **	0.00	-89.25 **	-48.62 **	-10.91 *	-1.04	-1.37	-51.10 **
TMV 6 X TKG 55	-1.22	17.20 **	-22.38 **	-10.53	-88.70 **	-48.50 **	-10.17	-1.04	-7.98	-51.35 **
TMV 6 X RT 125	-2.44	-16.71 **	-7.34 **	-35.96	-88.50 **	2.04	-4.81	-4.17 *	1.09	-43.40 **
TMV 6 X RT 127	-4.88	33.05 **	-10.92 **	-36.84	-88.15 **	-6.48 *	-5.73	-1.04	-5.18	-46.29 **
TMV 6 X Thilottama	-8.54 *	5.00 *	-13.18 **	-32.46	-87.61 **	-52.58 **	-9.43	-4.69 *	-3.91	-44.51 **
TMV 7 X Thilathara	-4.88	-4.63 *	-27.52 **	-23.68	-87.87 **	-49.46 **	-8.69	0.00	-17.89	-54.05 **
TMV 7 X Thilak	-2.44	23.17 **	-21.16 **	-25.44	-88.75 **	63.75 **	-5.36	0.00	-1.54	-46.73 **
TMV 7 X TKG 55	1.22	24.02 **	-15.45 **	-3.51	-82.00 **	-9.60 **	-2.22	1.56	19.51	5.82
TMV 7 X RT 125	-1.22	1.59	-20.15 **	-17.54	-78.34 **	-8.16 **	-7.21	-3.13	-3.36	-2.38
TMV 7 X RT 127	-1.22	-17.93 **	-31.37 **	-35.96	-92.58 **	-30.37 **	-3.88	-4.69 *	20.09	-56.13 **
TMV 7 X Thilottama	-3.66	9.27 **	-9.06 **	28.95	-86.77 **	-10.08 **	-10.17	-4.69 *	-7.08	-43.76 **

**and* = 1 % and 5 % significance, respectively.

DFF - days to 50% flowering, HFC - height to first capsule, PH - plant height, NPB - number of primary branches, NCP - number of capsules per plant, NCM - number of capsules on main stem, CL - capsule length, DM - days to maturity, 1000 SW - 1000 seed weight and YLD - yield per single plant.

significant heterosis for yield along with plant height, days to maturity and seed yield per plant in desirable direction **(Table 4)**. Results revealed that the heterosis for seed yield per plant is cognate with component traits. This type of combinational heterosis was earlier reported by Singh *et al.* (2005), Thiyagu *et al.* (2007), Banerjee and Kole (2010) and Jadhav and Mohir (2013).

The results indicated that among parents, the parents *viz.,* TMV 7, SVPR1, Thilathara, RT 127, TKG 55 and Thilottama showed a favourable *gca* for more components and should be employed in crossing programmes. Among the crosses evaluated, two crosses *viz.,* TMV 6 × Thilathara (39.32 %) and VRI 3 × Thilottama (21.41 %) exhibited a significant standard heterosis along with positive significant *sca* for yield. Hence these two crosses are suggested for testing in large scale trials to confirm their superiority.

REFERENCES

Backiyarani, S., Devarathinam, A. and Shanthi, S. 1997. Combining ability studies on economic traits in sesame (*Sesamum indicum* L.). *Crop Research,* **13**: 121-125.

Banerjee, P. P. and Kole, P. C. 2010. Heterosis, inbreeding depression and their relationship with genetic divergence in sesame (*Sesamum indicum L.). Acta Agronomica Hungarica,* **58**: 313-321. [Cross Ref]

Bedigian, D. and Harlan, R. 1986. Evidence for Cultivation of Sesame in the Ancient World. *Economic Botany,* **40**: 137-154. [Cross Ref]

Das, S. and Gupta, T. D. 1999. Combining ability in sesame (*Sesamum indicum L*.). *Indian Journal of Genetics and Plant Breeding,* **59**: 69-75.

Devi, M. K., Kumar, S. T. and Ganesan, J. 2002. Combining ability and heterosis for reproductive efficiency in sesame *(Sesamum indicum L.). Sesame Safflower Newsletter,* **17**: 22-25.

Jadhav, R. S. and Mohrir, M. N. 2013. Heterosis studies for quantitative traits in sesame (*Sesamum indicum L.). Electronic Journal of Plant Breeding*, **4**: 1056-1060.

Kempthorne, O. 1957. An Introduction to Genetic Statistics. *John Wiley and Sons Inc, New York.*

Langham, D.G. 1961. The high low method in crop improvement. *Crop Science,* **1**: 376-378. [Cross Ref]

Manivannan, N. 1997. Combining ability in sesame (*Sesamum indicum L.). Journal of Oilseed Research,* **14**: 165-167.

Parameshwarappa, S. G. and Salimath, P. M. 2010. Studies on combining ability and heterosis for yield and yield components in sesame (*Sesamum indicum L.*). *Green Farming,* **3**: 91-94.

Pawar, A. K. and Monpara, B. A. 2016. Breeding for components of earliness and seed yield in Sesame. *Plant Gene and Trait,* **7**: 1-7.

Prajapati, N. N. 2010. Combining ability for seed yield and its components in sesame (*Sesamum indicum L.). International Journal of Plant Science,* **5**: 180-183.

Praveenkumar, K., Madhusudan Nadaf, H. L., Patil, R. K. and Deshpande, S. K. 2012. Combining ability and gene action studies in inter-mutant hybrids of sesame (*Sesamum indicum L.). Karnataka Journal of Agricultural Sciences,* **25**: 1-4.

Singh, A. K., Lal, J. P. and Kumar, H. 2005. Identification of certain heterotic crosses for their exploitation in the improvement of sesame (*Sesamum indicum* L.). *Sesame and Safflower Newsletter,* **20**: 34-37.

Thiyagu, K., Kandasamy, G., Manivannan, N. and Muralidharan, V. 2007. Studies on heterosis in genetically diverse lines of cultivated sesame (*Sesamum indicum* L.). *Madras Agricultural Journal,* **94**: 162-167.

Vavdiya, P. A., Dobariya, K. L. and Babariya, C. A. 2014. Combining ability and gene action studies for seed yield and its components in sesame (*Sesamum indicum L.). Electronic Journal of Plant Breeding,* **5**: 688-694.

Weiss, E. A. 1971. Castor, Sesame, Safflower. Barnes and Noble, *New York.*

Yamanura, K. M. and Nadaf, H. L. 2009. Combining ability and gene action for yield and yield components in Sesame (*Sesamum indicum L.). Karnataka Journal of Agricultural Sciences,* **22**: 255-260.