

View of Nature of Gene Action and Estimation of Combining Ability Effects and Heterosis for Seed Yield and its Yield Component Traits in Sesame (*Sesamum indicum* L.)

S. Ranjith Raja Ram*¹ and Harini²

¹ Assistant Professor, Plant Breeding and Genetics, Tapioca and Castor Research Station (TCRS), Tamil Nadu Agriculture University (TNAU), Yethapur, PG.Palayam, Salem - 636 119, Tamil Nadu, India

² Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Chidambaram, Cuddalore - 608 002, Tamil Nadu, India

Received: 11 August 2026; Revised accepted: 24 Sept 2026

Abstract

The Present investigation entitled “Combining ability analysis in sesame (*Sesamum indicum* L.)” through Line × Tester mating design were undertaken with seven lines viz., VS-07-023, TKG- 87, Black diamond, LT-8, TKG 22, Subhiksha gold, CST-2008 crossed with three testers viz., TMV 4, VRI 2 and Paiyur-1 were evaluated for yield and important yield contributing characters for eight traits viz., days to 50 per cent flowering, 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 analysis resulted in the pre-pondance of non-additive gene action for seed yield and its components traits. The variance due to SCA was higher than the corresponding variance due to GCA for all the characters. Based on the general combining ability effects and *per se* performance of parents, the genotypes L₁ VS-07-023 and L₃ Black diamond and T₁ TMV4 have considerable potential and can be utilized for developing promising cultivars, with high yield potential by using appropriate breeding strategy. The top high yielding cross combinations viz., VS-07-023 × TMV 4, Black diamond × TMV 4, TKG 22 × Paiyur 1 and CST-2008 × Paiyur 1 showed highly significant and positive *sca* effects for yield and involved either good × good, good × poor or poor × poor combining parents. Based on *sca* effects, the hybrids VS-07-023 × TMV 4, Black diamond × TMV 4, CST-2008 × Paiyur 1 were adjudged as better hybrids for seed yield and other yield component traits and hence recommended for yield improvement. Better segregation can be obtained from such hybrid combination for seed yield and yield contributing traits.

Key words: GCA, SCA, Gene action, Sesame, *Sesamum indicum*

Sesame is a vital oilseed crop belonging to the family Pedaliaceae, one of the most important ancient oilseed crops cultivated globally. Sesame is diploid (2n+26) in nature and is commonly known as Til, Tilli, Gigelly, Ellu, sim-sim, Benni seed, Nurvulu, Velvor Rasi and sesame in different part of India and often referred as the “Queen of oilseed crop”. Generally, the oil content in sesame ranges from 34 to 63 percent [1]. The quality of sesame oil is largely determined by its fatty acid composition, particularly the proportions of oleic, linoleic, palmitic and stearic acids, which influence its nutritional value, stability and suitability for various food and industrial applications. Its seeds are highly valued not only for culinary use but also for their extensive health benefits, containing essential fatty acids, antioxidants like sesamin, sesamol and sesamol and a wealth of vitamins and minerals, including vitamin E, calcium, magnesium and iron [2]. This nutrient-dense composition provides health benefits such as anti-aging properties, antioxidant support and potential heart health improvement, making sesame an increasingly important crop in the health food industry. Globally, sesame is a significant crop with leading producers such as India, Myanmar and Tanzania,

with India being one of the largest exporters. In India, sesame production primarily occurs in Gujarat, West Bengal and Tamil Nadu. Due to its adaptability to semi-arid conditions, sesame contributes importantly to sustainable agriculture, particularly in marginal areas unsuitable for other crops. The world production of sesame hovers around 6.5 million metric tons annually, reflecting growing demand in both culinary and health product sectors. The crop is also valued for its high-quality edible oil, rich nutritional profile and diverse industrial uses, making it an important component of food security and income generation for small and marginal farmers [3].

Sesame (*Sesamum indicum* L.) is an important oilseed crop valued for its edible oil, protein-rich seed and desirable nutritional qualities. However, comparatively low seed productivity remains a major constraint to its wider production. Since seed yield is a complex quantitative trait governed by several component traits and influenced by environmental conditions, understanding its genetic control is essential for effective breeding. Combining ability analysis provides useful information on the genetic potential of parents and crosses by estimating general combining ability (GCA) and specific

*Correspondence to: S. Ranjith Raja Ram, E-mail: ranjithplantbreeder@gmail.com

Citation: Ram SRR, Harini. 2026. View of nature of gene action and estimation of combining ability effects and heterosis for seed yield and its yield component traits in sesame (*Sesamum indicum* L.). *Res. Jr. Agril. Sci.* 17(5): 606-610.

combining ability (SCA) effects. GCA is mainly associated with additive genetic effects, whereas SCA reflects non-additive effects such as dominance and epistasis. Line $\times$ tester analysis is therefore an effective approach for identifying superior parents, promising cross combinations and the relative contribution of additive and non-additive gene action. Previous studies in sesame have demonstrated significant GCA and SCA effects for seed yield and its component traits, along with substantial heterosis in selected crosses [4-6]. The estimation of heterosis further helps identify cross combinations with superior performance over their parents or standard checks, thereby providing opportunities for exploiting hybrid vigour. Moreover, information on the nature of gene action facilitates the choice of appropriate breeding strategies for improving seed yield and its associated traits [7]. Good general and specific combiners provide the basic information regarding the genetic properties of the parents and hybrids based on which breeding methods are formulated for further improvement of the crop. Keeping in view of above facts, the present investigation was carried out to identify the good general combiner and good specific combiners for increasing the seed yield and its components traits in sesame. Such studies in sesame not only contribute to increased productivity but also support genetic improvements that can help meet the rising global demand for high-quality sesame seeds.

MATERIALS AND METHODS

The experiment was conducted at the department of Genetics and Plant Breeding Research Farm, Faculty of agriculture, Annamalai University, Chidambaram, Tamil Nadu, India. The research utilized a diverse set of seven lines, comprising varieties VS-07-023, TKG- 87, Black diamond, LT-8, TKG 22, Subhiksha gold and CST-2008 crossed with three testers MV 4, VRI 2 and Paiyur 1. In kharif season 2023 ten parents were grown for making Line $\times$ Tester crosses among them. Flower buds anticipated to open the following morning were selected between 3:00 P.M. and 6:00 P.M. for emasculation. Pollination was performed the next morning,

between 7:00 A.M. and 9:00 A.M, by gently dusting pollen from chosen male parents onto the stigmas of the emasculated buds. Once the crossed seeds reached physiological maturity, they were harvested individually and shade-dried until the capsules released the seeds. Next year in Kharif 2024 ten parents and 21 F1 hybrids were grown in RBD design with three replications for evaluation of yield and yield attributing traits. Observations were meticulously recorded for eight distinct traits, including days to 50% flowering, plant height, number branches per plant, number of capsules per plant, capsule length, number of seeds per capsule, thousand seed weight and seed yield per plant. The mean values of these traits, derived from the plot-wise averages of five plants, were used for subsequent statistical analyses. The performance of both parents and hybrids underwent thorough statistical scrutiny for each trait. This approach aims to unravel the genetic intricacies and interactions contributing to the observed traits, providing valuable insights into the potential for successful hybrid development and breeding strategies. The analysis of variance for combining ability was made based on method developed by Kempthorne [8]. Combining ability was evaluated for the hybrids and parents.

RESULTS AND DISCUSSION

Analysis of variance

For all traits examined, the analysis of variance for combining ability revealed that the mean sum of squares associated with general and specific combining ability effects were significant for all the traits. Since GCA and SCA mean square were found to be significant for most of the characters revealed that additive as well as non-additive genes were operating in the expression of these traits which is in agreement with Banerjee and Kole [9]. This indicated the existence of huge amount of genetic variability in the experimental material and indicating potential for favorable transgressive segregants in subsequent generations. The general combining ability of the parents and the specific combining ability of the crosses are tabulated in (Table 2-3) respectively for all the eight traits.

Table 1 Estimation of general combining ability (GCA) effect associated with parents for various characters

Parents	Days to 50% flowering	Plant height	No. of branches per plant	No. of capsules per plant	Capsule length	No. of seeds per capsule	Thousand seed weight	Seed yield per plant
VS-07-023	40.67	95.37**	5.18	84.43**	2.45	70.4**	2.56**	9.65**
TKG 87	39.20**	83.08	3.36	62.36	2.40	54.41	2.44**	6.82
Black diamond	43.67	83.57	6.69**	77.44**	2.52	64.32**	2.74**	10.57**
LT-8	42.00	80.72	4.18	65.66	2.52	60.26	2.11	7.47
TKG 22	46.00	75.30	6.09**	82.37**	2.56**	63.54**	2.25	8.16
Subhiksha gold	37.03**	73.10	6.18**	81.31**	2.53*	63.05	2.21	8.53**
CST-2008	45.33	80.22	3.00	75.55	2.54**	62.23	2.05	5.88
TMV 4	38.00**	107.50**	6.07**	111.05**	2.62	80.51**	2.94**	18.93**
VRI 2	40.50	95.33	5.63	95.81	2.74**	74.18	2.71	12.16
Paiyur 1	44.50	90.43	5.17	92.66	2.52	72.47	2.69	7.65

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

Days to 50% flowering

Negatively significant *gca* effects were recorded in line L3 (-4.63) and tester T1 (-1.85), positioning them as strong general combiners for early flowering, a favorable trait in sesame breeding. Among the hybrids, *sca* effects ranged from -0.85 to -4.10. The hybrid L5 $\times$ T3 exhibiting the highest significant negative *sca* (-4.10), followed closely by L7 $\times$ T2 (-2.47) and L3 $\times$ T1 (-2.42). These results highlight the potential

of these crosses for promoting earliness in flowering. Similar results reported by Virani *et al.* [10] and Saleem *et al.* [11].

Plant height

Significant positive *gca* effects were observed in two lines, L3 (18.43) and L1 (11.22), marking them as effective general combiners for plant height, with L6 (3.31) also contributing positively. Among the testers, T1 showed the

highest significant positive *gca* (10.38), supporting its selection as a valuable parent for height traits. In terms of *sca* effects, hybrids ranged from 2.52 to 7.69. The hybrid L1 × T1 achieving the highest significant positive *sca* (7.69), followed by L2 × T3 (6.17) and L4 × T2 (5.99). Joshi *et al.* [12], Meenakumari *et al.* [13], Beniwal *et al.* [14] and Chaudhary *et al.* [15] also noticed such effects for plant height.

Number of branches per plant

Among the lines, L6 displayed the highest significant positive *gca* (1.54), followed by L3 (0.83). Among the testers, T1 exhibited the highest significant positive *gca* (0.81). The *sca* values for hybrids ranged from 0.31 to 1.16. The hybrid L6 × T3 recorded the highest significant positive *sca* (1.16), followed by L1 × T1 (0.80) and L7 × T1 (0.61). Conversely, the hybrids L7 × T3 (-1.08) and L1 × T2 (-0.64) showed the highest significant negative *sca* for this trait. Chaudari *et al.* [16], Priya *et al.* [17] and Sirohi *et al.* [18] also recorded such results.

Number of capsules per Plant

Within the lines, L3 (21.83) and L6 (11.62) exhibited highly significant and positive *gca* effects, establishing them as strong general combiners for this trait. In the tester group, T1 recorded the highest significant positive *gca* effect (7.71). The Specific Combining Ability (*sca*) effects across hybrids ranged from 2.20 to 12.02. The hybrid L1 × T1 showing the most substantial positive *sca* effect (12.02), followed by L4 × T3 (4.51). These results underscore the potential of these combinations for enhancing the number of capsules per plant. Similar results founded by Saxena and Bisen *et al.* [19], Ismail *et al.* [20], Sirohi *et al.* [18] and Disowja *et al.* [21].

Capsule length

Among the lines, the highest significant and positive *gca* was observed in L₁ (0.11) followed by L₃ (0.10). The highest significant and positive *gca* was noticed in T₁ (0.12) among testers. The range of *sca* for hybrid was between 0.04 to 0.26. Among the hybrids evaluated, L₁ × T₁ showed the maximum significant and positive *sca* (0.26) followed by L₃ × T₁ (0.10) for this character. It was also mentioned in the works of Joshi *et al.* [12], Meenakumari *et al.* [13] and Bhalodiya *et al.* [22].

Number of seeds per capsule

The general combining ability was notably significant for lines, L₃ (8.10) and L₁ (4.39). The highest significant and positive *gca* among testers was noticed in T₁ (3.56) among testers. The range of *sca* for hybrid was between 0.88 to 5.45. Among the hybrids evaluated, L₇ × T₃ showed the maximum significant and positive *sca* (5.45) followed by L₁ × T₂ (3.37) for this character. Priya *et al.* [17], Saxena and Bisen *et al.* [19] and Parmar *et al.* [23] also recorded such effects for this trait.

1000 seed weight

The evaluation of general combining ability (*gca*) effects indicated that L₅ (0.21) and L₃ (0.15) exhibited the highest significant and positive *gca* among the lines, marking them as commendable general combiners for this trait. In the tester group, T₁ also demonstrated a significant positive *gca* effect of 0.21. The range of Specific Combining Ability (*sca*) effects for hybrids varied from 0.03 to 0.19. Notably, hybrids L₁ × T₃ and L₅ × T₃ achieved the highest significant and positive *sca* effects (0.19), followed closely by L₇ × T₃ (0.18). These findings suggest strong potential for improving seed weight through selective breeding of these combinations. Similar results recorded by Bhalodiya *et al.* [22] and Chaudhary *et al.* [15].

Table 2 Estimation of specific combining ability (SCA) effect associated with each cross for various characters

Parents	Days to 50% flowering	Plant height	No. of branches per plant	No. of capsules per plant	Capsule length	No. of seeds per capsule	Thousand seed weight	Seed yield per plant
VS-07-023 × TMV 4	-1.31**	7.69**	0.80**	12.02**	0.26**	0.11	0.19**	3.47**
VS-07-023 × VRI 2	-0.08	-4.66**	-0.64**	-5.32**	-0.16**	3.37**	0.06**	-1.01**
VS-07-023 × Paiyur 1	1.40**	-3.03*	-0.16	-6.70**	-0.10**	-3.48**	-0.25**	-2.45**
TKG 87 × TMV 4	-0.38	-5.94**	-0.18	-3.11**	-0.11**	0.41	-0.04**	-0.41**
TKG 87 × VRI 2	-0.64	-0.23	0.59**	1.60**	0.04**	0.30	0.01	-0.05**
TKG 87 × Paiyur 1	1.01**	6.17**	-0.42**	1.51**	0.06**	-0.72**	0.03*	0.46**
Black diamond × TMV 4	-2.42**	2.56*	-0.40*	2.55**	0.10**	1.45**	0.13**	1.46**
Black diamond × VRI 2	-0.85*	-0.07	-0.04	2.14**	-0.01	0.43	0.05**	0.03
Black diamond × Paiyur 1	3.27**	-2.49	0.44**	-4.69**	-0.10**	-1.88**	-0.18**	-1.50**
LT-8 × TMV 4	0.18	-3.61	-0.02	-4.22**	-0.10**	1.90**	-0.19**	-1.05**
LT-8 × VRI 2	-1.08**	5.99**	0.28	-0.30	0.07**	-1.90**	0.10**	1.57**
LT-8 × Paiyur 1	0.90*	-2.38	-0.25	4.51**	0.04**	0.01	0.10**	-0.52**
TKG 22 × TMV 4	2.35**	1.24	-0.16	-5.33**	-0.08**	-1.56**	-0.16**	-1.21**
TKG 22 × VRI 2	1.75**	-2.44	-0.15	2.20**	0.05**	0.37	-0.03*	0.04*
TKG 22 × Paiyur 1	-4.10**	1.02	0.31*	3.13**	0.02	1.19**	0.19**	1.17**
Subhiksha gold × TMV 4	-1.71**	2.52*	-0.65**	2.79**	-0.05**	-0.31	0.04**	-1.56**
Subhiksha gold × VRI 2	3.36**	0.61	-0.51**	-2.43**	0.02	0.88**	0.02	0.46**
Subhiksha gold × Paiyur 1	-1.66**	-3.13*	1.16**	-0.35	0.04**	-0.57*	-0.07**	1.10**
CST-2008 × TMV 4	3.29**	-4.45**	0.61**	-4.70**	-0.03*	-2.00**	0.03*	-0.70**
CST-2008 × VRI 2	-2.47**	0.79	0.47**	2.10**	-0.02	-3.45**	-0.21**	-1.04**
CST-2008 × Paiyur 1	-0.82*	3.66**	-1.08**	2.60**	0.04**	5.45**	0.18**	1.75**

*- Significant at 5% level,

** - Significant at 1% level

Seed yield per plant

The analysis of general combining ability (*gca*) effects revealed that L3 (5.94) and L1 (3.35) exhibited the highest significant and positive *gca* among the lines, establishing them as commendable general combiners for seed yield per plant. Among the testers, T1 recorded a significant positive *gca* effect of 2.27. The Specific Combining Ability (*sca*) effects for hybrids ranged from 0.04 to 3.47. Notably, hybrids L1 × T1 and L5 × T3 achieved the maximum significant and positive *sca* effects (3.47), followed by L7 × T3 (1.75). These results underscore the potential for enhancing seed yield through strategic breeding of these combinations. It was also reported by Karthikeyan *et al.* [24], Ismail *et al.* [20], Disowja *et al.* [21], Saleem *et al.* [11] and Chaudhary *et al.* [15].

The evaluation of Specific Combining Ability (*sca*) effects revealed that no cross consistently performed well across all traits assessed. Out of the 21 crosses examined, only nine demonstrated significant and positive *sca* effects for seed yield per plant. The *gca* effect revealed VS-07-023, Black diamond and the testers TMV 4 to be superior for seed yield per plant and its component traits. The hybrids VS-07-023 × TMV, Black diamond × TMV 4, CST-2008×Paiyur1 emerged as superior hybrids, warranting further large-scale testing and potential deployment in breeding programs. Hence, seed yield per plant improvement can be improved by delaying the selection to later generation, when the dominance and epistatic gene action disappear and resorting to inter matting of segregants followed by recurrent selection. Saxena and Bisen [19], Bhattacharjee *et al.* [25] and Saleem *et al.* [11] recorded the predominance of non-additive gene action and have suggested recurrent

selection. Ismail *et al.* [20] recommended that the cross could be advanced in order to produce desirable plant type in the segregating generation. Also, the identified high heterotic hybrids could be advanced either by single seed decent method or by line to progeny method to produce the desirable plant type in the sesame. Diallel selection matting design suggested by Chaudhary *et al.* [15] can also be adopted, which will promote more recombination.

CONCLUSION

The present study underscores significant variability in seed yield and its associated components among the evaluated materials. A marked influence of non-additive genetic variance was particularly evident in the traits such as days to 50% flowering, days to maturity, plant height, effective branches per plant, capsules per plant, capsule length, number of seeds per capsule, thousand seed weight and seed yield per plant. Effective specific combiners identified in this study include VS-07-023 × TMV 4), Black Diamond × TMV 4 and CST-2008 × Paiyur 1. The findings provide critical insights for optimizing sesame breeding strategies, spotlighting several promising parental lines, namely L3 (Black Diamond), L1 (VS-07-023), L6 (Subiksha Gold) and T1 (TMV 4). These parents demonstrate favorable General Combining Ability (*gca*) across all the eight traits studied. Collectively, these identified parents hold substantial potential for application in sesame breeding programs, offering a diverse array of advantageous traits that could markedly enhance overall crop performance.

LITERATURE CITED

1. Spandana B, Prasad RBN, Sarika CH, Anuradha G, Sivaraj N, Sivaramakrishnan S. 2013. Variation in seed oil content and fatty acid composition in sesame (*Sesamum indicum*). *Indian Journal of Agricultural Sciences* 83(12): 1402-1405. doi:10.56093/ijas.v83i12.35972.
2. Wei P, Zhao F, Wang Z, Wang Q, Chai X, Hou G, Meng Q. 2022. Sesame (*Sesamum indicum* L.): A comprehensive review of nutritional value, phytochemical composition, health benefits, development of food, and industrial applications. *Nutrients* 14(19): 4079. doi:10.3390/nu14194079.
3. Malunjar B, Magar NM. 2025. Sesame – A vital crop for farmers and the global economy. *AgroScience Today* 6(6): 1122-1127.
4. Sumathi P, Muralidharan V, Manivannan N. 2008. Study of gene action and heterosis in monostem/shybranching genotypes in sesame (*Sesamum indicum* L.). *Indian Journal of Genetics* 68: 313-316.
5. Virani MB, Kachhadia VH, Vachhani JH, Dobariya KL. 2017. Heterosis studies in sesame (*Sesamum indicum* L.). *Electronic Journal of Plant Breeding* 8: 1128-1134.
6. Anuragi H, Srivastava RK, Mahajan RK, Pal AK, Thakur MC. 2019. Line × tester analysis for seed yield, protein and oil content and SSR based diversity in sesame (*Sesamum indicum* L.). *Ecological Genetics and Genomics* 13: 100048. doi:10.1016/j.egg.2019.100048.
7. El-Ghonemy M, Drwech H, Amer E. 2014. Combining ability for yield and some agronomic traits by using line × tester analysis. *Journal of Plant Production* 5(9): 1601-1609. doi:10.21608/jpp.2014.64688.
8. Kempthorne O. 1957. *An Introduction to Genetic Statistics*. John Wiley and Sons Inc., New York.
9. Banerjee PP, Kole PC. 2009. Analysis of genetic architecture for some physiological characters in sesame (*Sesamum indicum* L.). *Euphytica* 168(1): 11-22.
10. Virani MB, Vachhani JH, Kachhadia VH, Chavadhari RM, Sharma S. 2018. Combining ability for seed yield and its components in sesame (*Sesamum indicum* L.). *Electronic Journal of Plant Breeding* 9(1): 107-115.
11. Saleem H, Sadaqat HA, Razzaq H, Chattha AA, Khan SH. 2023. Heterotic grouping with combining ability and gene action in *Sesamum indicum* L. using line × tester analysis. *SABRAO Journal of Breeding and Genetics* 55(2): 367-378. doi:10.54910/sabrao2023.55.2.9.
12. Joshi HK, Patel SR, Pathak AR, Patel RK. 2015. Combining ability analysis for yield and yield components in sesame (*Sesamum indicum* L.). *Electronic Journal of Plant Breeding* 6(2): 454-458.
13. Meena Kumari B, Manivannan N, Ganesamurthy K. 2015. Combining ability analysis in sesame (*Sesamum indicum* L.). *Electronic Journal of Plant Breeding* 6(3): 700-708.
14. Beniwal BR, Sastry EVD, Solanki ZS. 2018. Combining ability and heterosis studies in sesame (*Sesamum indicum* L.). *International Journal of Genetics* 10(5): 415-419.
15. Chaudhary N, Jagtap PK, Rana VB, Patel VB, Joshi RJ, Patel DP, Prajapati MR, Pandya H. 2024. Heterosis studies for various yield-attributing traits in *Sesamum indicum* L. *Plant Archives* 24(1): 1585-1595. doi:10.51470/plantarchives.2024.v24.no.1.222.

16. Chaudhari GB, Anarase SA, Ban YG. 2016. Combining ability and gene action over environments in sesame (*Sesamum indicum* L.). *Electronic Journal of Plant Breeding* 7(1): 71-77.
17. Priya R, Thiagarajan K, Pechiappan Bharathi S, Krishnasamy V. 2016. Combining ability studies through line $\times$ tester analysis in sesame (*Sesamum indicum* L.). *Electronic Journal of Plant Breeding* 7(4): 883-887.
18. Sirohi S, Kumhar SR, Kumari B. 2020. Heterosis and combining ability studies in sesame (*Sesamum indicum* L.). *Journal of Oilseeds Research* 37(1): 16-20.
19. Saxena K, Bisen R. 2017. Line $\times$ tester analysis in sesame (*Sesamum indicum* L.). *International Journal of Current Microbiology and Applied Sciences* 6(7): 1735-1744.
20. Ismail S, Khan FA, Mubarak S, Kanwal B. 2020. Heterosis in relation to combining ability studies in sesame (*Sesamum indicum* L.). *Journal of Genetics, Genomics and Plant Breeding* 4(2): 68-75.
21. Disowja A, Parameswari C, Gnanamalar RP, Vellaikumar S. 2021. Heterosis and combining ability studies in sesame (*Sesamum indicum* L.). *Electronic Journal of Plant Breeding* 12(2): 347-352.
22. Bhalodiya D, Dhaduk HKL, Kumar S, Gediya LN, Patel HP. 2019. Line $\times$ tester analysis for seed yield, protein and oil content and SSR based diversity in sesame (*Sesamum indicum* L.). *Ecological Genetics and Genomics* 13: 100048.
23. Parmar RS, Chovatia VP, Patel RV, Dudhat AS, Sangani JL, Hariyani SA. 2019. Genetic analysis for seed yield and its traits in summer sesame (*Sesamum indicum* L.) over environments. *Journal of Pharmacognosy and Phytochemistry* 8(3): 3124-3131.
24. Karthikeyan P, Eswaran R, Saravanan KR, Thangavel P. 2019. Combining ability studies through line $\times$ tester analysis in sesame (*Sesamum indicum* L.). *Journal of Pharmacognosy and Phytochemistry* 8(2S): 311-314.
25. Bhattacharjee M, Kundagrami S, Dasgupta T. 2021. Combining ability for quantitative traits in sesame through line $\times$ tester analysis. *The Bioscan* 16(4): 239-246.