The Evaluation of General and Specific Combining Ability Analysis in Sesame (*Sesamum indicum* L.)

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ABSTRACT

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| The selection of appropriate parental lines for hybridization plays a crucial role in crop improvement programs, as the performance of the resulting hybrids can provide insights into their relative superiority. Hence, in any breeding program, the appropriate selection of parents based on their combining ability is essential. An attempt was made to study the general and specific combining ability in sesame (*Sesamum indicum* L.) through line x tester mating design. The four lines and seven testers were mated in line x tester fashion in *Kharif* 2024 and an evaluation study was conducted during *Rabi* 2024–25 at the Experimental Farm, Department of Genetics and Plant Breeding, College of Agriculture, Latur. Observations were recorded on randomly selected five plants in each row entry for all ten characters viz., days to 50 % flowering, days to maturity, plant height (cm), number of branches per plant, number of capsule per plant, number of seeds per capsule, length of capsule (cm), 1000 seed weight (g), seed yield per plant (g) and oil content (%). Among lines, no one exhibited a significant effect of GCA for all traits, but line TBS-10 showed a significant effect for five characters *viz.,* days to 50% flowering, number of branches per plant, number of capsules per plant, seed yield per plant and oil contentin the desired direction. In case of testers, R-22 revealed significant GCA effect for six characters *viz.,* plant height, number of capsule per plant, number of seeds per capsule, 1000 seed weight, seed yield per plant and oil content. For seed yield per plant, cross, TBA-10 x V-22 exhibited the highest (2.57) significant SCA effect, with TBS-07 x TS-24 (2.13), TBS-09 x TS-24 (0.97) and TBS 02 x TKG-22 (0.90) ranking next. Overall, the findings provide valuable insight for formulating efficient breeding strategies in sesame, combining both selection and hybridization approaches to achieve genetic improvement. |

*Keywords: Sesame, line x tester, cross, general combining ability, specific combining ability*

1. INTRODUCTION

Combining ability analysis provides precise estimates of nature and magnitude of gene action involved in the inheritance of quantitative characters. it is helpful for identification of good general combiner parents and good specific combiner hybrids. General Combining Ability (GCA) and Specific Combining Ability (SCA) studies provide basic information regarding the genetic properties of the lines based on which breeding methods are formulated for further improvement of the crop (Sikarwar et al., 2021). Presence of variability and selection of appropriate types from variable types are considered as backbone of plant breeding program (Prakash & Dasgupta, 2021). Sesame (*Sesamum indicum* L.) is considered one of the oldest cultivated oilseed crops (Weiss, 1971), with archaeological findings indicating its presence in the Mesopotamian civilization (Bedigian, 1986). Sesame, a member of the family *Pedaliaceae* and order *Tubiflorae*, includes approximately 16 genera and 36 species. It is an annual, diploid crop (2n = 2x = 26) that predominantly exhibits self-pollination. Sesame exhibits substantial genetic diversity within its extensive germplasm collections. In sesame, few wild characters like, non-synchronous maturity get mixed up in the cultivated accessions make the varieties to produce poor or moderate yield. Breaking the linkage and generate desirable recombinants obviously lead to development of promising types (Prakash & Dasgupta, 2021). Sesame seed contain approximately 50% oil, 25% protein and 15% 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 (Parameshwarappa et al., 2021). The selection of appropriate parental lines for hybridization plays a crucial role in crop improvement programs, as the performance of the resulting hybrids can provide insights into their relative superiority. Hence, in any breeding program, the appropriate selection of parents based on their combining ability is essential. Investigations aimed at assessing combining ability not only offer critical insights for parent selection but also reveal the nature and extent of gene action governing the traits. Accordingly, the present study was conducted to identify superior general combiners and specific cross combinations that could be utilized to develop populations enriched with favorable alleles for seed yield and its contributing traits.

2. materialS and methods

This study was undertaken during the *Rabi* season of 2024-25 at the Experimental Farm, Department of Genetics and Plant Breeding, College of Agriculture, Latur (VNMKV, Parbhani). The experimental material comprised eleven parental lines, consisting of four female genotypes *viz.,* TBS-02, TBS-07, TBS-09 and TBS-10 and seven male genotypes *viz.,* TS-24, TS-20, V-22, TKG-22, R-33, R-22 and TBS 12-1. A total of 28 F₁ hybrids were developed during *Kharif* 2024 by crossing the selected parents using the Line x Tester mating design. A total of 40 treatments comprising 4 female parents, 7 male parents, 28 F₁ hybrids and one standard check (JLT-408) were evaluated in a randomized block design with two replications. Each plot consisted of a row length of 3 m with a spacing of 45 cm between rows and 15 cm between plants. The recommended package of practices for sesame was followed throughout the crop growing period. Observations were recorded on randomly selected five plants in each row entry for all ten characters *viz.,* days to 50 % flowering, days to maturity, plant height (cm), number of branches per plant, number of capsule per plant, number of seeds per capsule, length of capsule (cm), 1000 seed weight (g), seed yield per plant (g) and oil content (%). The analysis of the Line x Tester mating design was carried out using the method proposed by Arunachalam (1974).

3. results and discussion

The data recorded for various traits across different genotypes were averaged and subjected to analysis of variance (Table 1). The results indicated that treatments, parents and crosses showed highly significant differences for most of the traits, highlighting the existence of substantial genetic variability in the experimental material used in this study. Similar results reported by Hassan and Sedeck (2015), Priya *et al.* (2016), Virani *et al.* (2018) and Dela *et al.* (2019)

 The estimates of general combining ability of lines and testers and the specific combining ability of crosses are presented in Table 2 and Table 3. For days to 50% flowering, the line TBS-10 showed a significant and desirable negative GCA effect, indicating its potential for earliness. Among the 28 crosses, only TBS-09 x V-22 and TBS-02 x TKG-22 exhibited significant negative SCA effects. Similar results were found by Disowja *et al.* (2021). For days to maturity, the line TBS-07 and tester TS-24 showed significant and desirable negative GCA effects. Among the crosses, only TBS-07 x V-22 (-3.11) exhibited a significant SCA effect in the desired direction. Similar results were revealed by Deshmukh *et al.* (2019). In case of plant height, TBS-09 and R-22 showed the highest GCA effects. The cross TBS-10 x R-22 recorded the highest SCA effect, followed by TBS-02 x TBS 12-1, TBS-09 x TKG-22 and TBS-09 x TS-20. For number of branches per plant lines TBS-07 and tester R-33 reflected the highest significant and positive GCA values. While, highest SCA effect was registered by TBS-09 x TBS 12-1. These results were similar with Jeeva *et al.* (2020) In case of, number of capsules per plant two lines *viz.,* TBS-09 and TBS-10 and three testers *viz.,* R-33, TS-20 and R-22 reflected significant and positive GCA effect. Whereas, the cross, TBS-09 x TBS 12-1 recorded the highest significant SCA effect, followed by TBS-10 x V-22, TBS-02 x R-33 and TBS-09 x TS-24.

 For trait number of seeds per capsule all parents showed significant GCA effect except TBS-07, TBS-10, TS-24, V-22, TKG-22. In case of SCA effect among 28, five crosses manifested positive and significant SCA effect *viz.,* TBS 02 x TBS 12-1, TBS-09 x TKG-22, TBS-07 x TS-24 and TBS-07 x TKG-22. Similar results were found by Saxena and Bisen (2017). For character length of capsule among parents only tester, R-33 revealed a significant and positive GCA effect. Likewise, none of the crosses showed a significant and positive SCA effect. Which means, a positive and significant GCA effect indicates that R-33 contributes desirable additive genes for this trait and implies lack of strong non-additive gene action in specific crosses. Similar results were revealed by Anyanga *et al.* (2016). Only one tester R-22 among the parents expressed a significant and positive GCA effect for the trait 1000 seed weight. While, TBS-02 x TS-24, TBS-10 x V-22 and TBS 07 x TKG-22 reflect significant and positive SCA effects. For character seed yield per plant, lines *viz.,* TBS-10 (0.77), TBS-09 (0.69) and testers *viz.,* R-22 (1.22), R-33 (0.99) reported significant GCA effect. The cross, TBA-10 x V-22 exhibited highest (2.57) significant SCA effect, with TBS-07 x TS-24 (2.13), TBS-09 x TS-24 (0.97) and TBS 02 x TKG-22 (0.90) ranking next. Similar results were revealed by Amarnath *et al.* (2019), Salunke *et al*. (2023), Prakash *et al.* (2021), Gore *et al. (2024).* For character oil content line TBS-10 and tester V-22 manifested the highest significant GCA effect. While, highest significant SCA effect was recorded by cross TBS-09 x TS-20.

 Among the line, no one showed a significant effect of GCA for all character but line TBS-10 showed a significant effect for five characters *viz.,* days to 50% flowering, number of branches per plant, number of capsules per plant, seed yield per plant and oil contentin the desired direction. In case of testers, R-22 revealed significant GCA effect for six characters *viz.,* plant height, number of capsule per plant, number of seed per capsule, 1000 seed weight, seed yield per plant and oil content.

Combining ability plays a key role in shaping effective and practical breeding strategies, making it a valuable concept in the improvement of different crops. Combining ability analysis offers an effective way to evaluate the genetic potential of parental lines early in the breeding process. GCA is mainly associated with additive genetic effects and can be fixed through selection. In contrast, SCA is governed by non-additive genetic effects which may arise from dominance, additive x dominance interactions or higher order gene interactions and are typically non-fixable.

Table 4 represents the best GCA parents and SCA crosses for all ten characters studied in the present investigation. A cross showing high SCA doesn't always perform well in all situations, since the effect is often due to non-additive genes that may not consistently express the same way every time. When SCA effects are significantly positive for a given trait, the use of heterosis breeding becomes desirable. Such traits can be effectively improved through biparental mating, reciprocal recurrent selection and by exploiting heterosis to enhance hybrid vigour. Similar result reported by Visat *et al.* (2016), Vimala & Parameshwarappa (2017) and Sirohi *et al.* (2020).

4. Conclusion

The present study on the assessment of combining ability in sesame revealed significant variation among parental lines and their hybrids, highlighting the importance of both general and specific combining ability effects. The predominance of GCA for certain traits suggests the role of additive gene action, which can be effectively utilized through selection to develop improved genotypes. Meanwhile, the presence of significant SCA effects for other traits indicates the influence of non-additive gene action, which can be exploited through hybrid development. Overall, the findings provide valuable insight for formulating efficient breeding strategies in sesame, combining both selection and hybridization approaches to achieve genetic improvement.

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| **Source of****Table 1. Analysis of variance for combining ability for different ten characters in sesame (*Sesamum indicum* L.).****Variation** | **d.f.** | **Days to 50 per cent flowering** | **Days****to maturity** | **Plant height****(cm)** | **No. of branches per plant** | **No. of capsule per plant** | **No. of****Seed per****capsule** | **Length****of****capsule****(cm)** | **1000 Seed****weight****(g)** | **Seed yield per plant****(g)** | **Oil****Content****(%)** |
| Replications | 1 | 1.28 | 5.12 | 28.32 | 0.23 | 17.64 | 12.72 | 0.06 | 0.01 | 0.07 | 0.07 |
| Treatments | 38 | 26.66\*\* | 55.13\*\* | 155.56\*\* | 0.97\*\* | 233.94\*\* | 196.52\*\* | 0.05\* | 0.14\* | 4.74\*\* | 6.83\*\* |
| Parents | 10 | 16.28\*\* | 15.33 | 74.17\*\* | 1.41 | 274.02\*\* | 26.67 | 0.0165 | 0.03\* | 4.65\*\* | 6.40\*\* |
| Lines | 3 | 11.00 | 28.50 | 18.33 | 1.35 | 300.67\*\* | 7.89 | 0.0154 | 0.04 | 0.31\*\* | 9.23\*\* |
| Testers | 6 | 21.28\*\* | 2.73 | 102.82\*\* | 1.24 | 277.45 | 38.91\*\* | 0.0198 | 0.02 | 7.00\*\* | 4.49\*\* |
| Lines v/s Testers | 1 | 2.10 | 51.43 | 69.82 | 2.67 | 173.47\*\* | 9.57\*\* | 0.0001 | 0.01 | 3.52\*\* | 9.33\*\* |
| Parents v/s Crosses | 1 | 23.22\*\* | 739.87\*\* | 98.69 | 0.31 | 380.54\*\* | 58.71\*\* | 0.26\*\* | 0.0015 | 0.45\*\* | 14.13\*\* |
| Crosses | 27 | 30.64 | 44.50 | 187.81\*\* | 0.83 | 213.67\*\* | 264.53\*\* | 0.05\*\* | 0.18\*\* | 4.94\*\* | 6.72\*\* |
| Error | 38 | 3.38 | 2.57 | 11.16 | 0.06 | 6.18 | 4.01 | 0.02 | 0.02 | 0.14 | 0.34 |

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

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| **Lines and Testers****Table 2. Estimates of general combining ability (GCA) of lines and testers for yield and yield contributing traits in sesame  (*Sesamum indicum* L.)** | **Days to 50 per cent flowering** | **Days to maturity** | **Plant height** | **No. of branches per plant** | **No. of capsules per plant** | **No. of seeds per capsule** | **Length of capsule** | **1000 seed weight** | **Seed yield per plant** | **Oil content** |
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| **Lines** |
| TBS-02 | 1.16 \* | -0.14 | 3.14 \*\* | -0.46 \*\* | -8.61 \*\* | 2.49 \*\* | -0.04 | 0 | -1.33 \*\* | 0.19 |
| TBS-07 | 1.59 \*\* | -3.21 \*\* | -6.28 \*\* | 0.39 \*\* | 1.01 | -3.49 \*\* | -0.10 \* | 0.03 | -0.13 | -0.32 |
| TBS-09 | -0.91 | 0.14 | 3.45 \*\* | -0.1 | 6.07 \*\* | 1.01 \* | 0.05 | -0.13 \* | 0.69 \*\* | -0.44 \* |
| TBS-10 | -1.84 \*\* | 3.21 \*\* | -0.31 | 0.17 \* | 1.53 \* | -0.02 | 0.08 | 0.1 | 0.77 \*\* | 0.57 \*\* |
| **S.E(±)** | 0.5 | 0.42 | 0.93 | 0.06 | 0.58 | 0.47 | 0.04 | 0.04 | 0.1 | 0.18 |
| **CD @5%** | 1.47 | 1.24 | 2.69 | 0.2 | 1.58 | 1.38 | 0.13 | 0.14 | 0.29 | 0.52 |
| **CD @1%** | 1.98 | 1.68 | 3.64 | 0.27 | 2.28 | 1.86 | 0.17 | 0.19 | 0.39 | 0.7 |
| **Testers** |
| TS-24 | -1.70 \* | -1.55 \* | -5.04 \*\* | 0.07 | -5.80 \*\* | -7.33 \*\* | -0.19 \*\* | 0.08 | -0.53 \*\* | -1.78 \*\* |
| TS-20 | -0.2 | -0.43 | 1.88 | 0.1 | 4.14 \*\* | 8.77 \*\* | 0.04 | 0.04 | -0.04 | -0.14 |
| V-22 | -2.20 \*\* | -0.43 | -6.22 \*\* | -0.15 | -6.38 \*\* | -5.28 \*\* | 0.01 | -0.02 | -0.69 \*\* | 1.30 \*\* |
| TKG-22 | -0.2 | 0.2 | -1.69 | -0.46 \*\* | -1.93 \* | -3.97 \*\* | 0.05 | -0.20 \*\* | -0.95 \*\* | -0.96 \*\* |
| R-22 | 2.18 \*\* | 2.20 \*\* | 7.93 \*\* | 0.18 | 4.01 \*\* | 3.68 \*\* | -0.06 | 0.40 \*\* | 1.22 \*\* | 0.91 \*\* |
| R-33 | 3.93 \*\* | -0.3 | 3.23 \* | 0.42 \*\* | 5.79 \*\* | 2.73 \*\* | 0.13 \* | -0.1 | 0.99 \*\* | -0.3 |
| TBS 12-1 | -1.82 \* | 0.32 | -0.09 | -0.16 | 0.17 | 1.41 \* | 0.02 | -0.21 \*\* | 0.01 | 0.98 \*\* |
| **S.E(±)** | 0.67 | 0.56 | 1.23 | 0.09 | 0.77 | 0.63 | 0.06 | 0.06 | 0.13 | 0.23 |
| **CD @5%** | 1.94 | 1.64 | 3.56 | 0.26 | 2.23 | 1.82 | 0.17 | 0.18 | 0.38 | 0.69 |
| **CD @1%** | 2.62 | 2.22 | 4.82 | 0.35 | 3.02 | 2.46 | 0.23 | 0.25 | 0.52 | 0.93 |

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

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| **Sr. No.****Table 3. Estimates of specific combining ability (SCA) for ten characters in sesame (*Sesamum indicum* L.)** | **Crosses** | **Days to 50 per cent flowering** | **Days to maturity** | **Plant height (cm)** | **No. of branches per plant** | **No. of capsule per plant** | **No. of seeds per capsule** | **Length of capsule (cm)** | **1000 Seed weight (g)** | **Seed yield per plant (g)** | **Oil content (%)** |
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| 1 | TBS-02 x TS-24 | 0.07 | 2.13 \* | 6.06 \*\* | -0.56 \*\* | -13.22 \*\* | -1.62 | -0.30 \* | 0.39 \*\* | -2.29 \*\* | 0.31 |
| 2 | TBS-02 x TS-20 | 4.95 \*\* | -1.63 | -10.64 \*\* | 0.68 \*\* | 8.46 \*\* | 0.33 | 0.14 | -0.14 | 0.80 \* | -0.1 |
| 3 | TBS-02 x V-22 | -0.43 | 1.25 | 1.93 | -0.01 | 0.16 | -3.24 | 0 | 0.11 | 0.2 | -0.49 |
| 4 | TBS-02 x TKG-22 | -3.18 \* | -0.88 | 0.9 | 0.16 | -0.8 | -6.04 \*\* | 0 | -0.17 | 0.90 \*\* | -0.4 |
| 5 | TBS-02 x R-33 | -0.55 | 2.13 \* | -2.54 | 0.32 | 11.61 \*\* | 1.63 | 0.04 | 0.02 | 0.85 \* | 1.51 \*\* |
| 6 | TBS-02 x R-22 | -2.55 | -1.75 | -5.64 \*\* | -0.02 | -6.00 \*\* | 3.23 | 0.03 | -0.08 | 0 | 2.07 \*\* |
| 7 | TBS-02 x TBS 12-1 | 1.7 | -1.25 | 9.93 \*\* | -0.57 \*\* | -0.21 | 5.71 \*\* | 0.1 | -0.13 | -0.45 | -2.89 \*\* |
| 8 | TBS-07 x TS-24 | 0.79 | 2.77 \* | 4.49 \* | 0.39 \* | 6.23 \*\* | 4.63 \*\* | 0.05 | 0.09 | 2.13 \*\* | 1.55 \*\* |
| 9 | TBS-07 x TS-20 | -0.84 | -2.48 \* | 4.09 | -0.43 \* | -5.63 \*\* | -0.03 | -0.05 | -0.25 \* | -1.88 \*\* | -2.09 \*\* |
| 10 | TBS-07 x V-22 | 0.29 | -3.11 \*\* | 1.97 | -0.41 \* | 0.67\*and \*\* indicated significance at 5and 1 percent level, respectively | 1.7 | 0 | -0.13 | -0.88 \*\* | 0.2 |
| 11 | TBS-07 x TKG-22 | 1.54 | 1.27 | -5.62 \*\* | -0.05 | 2.56 | 3.50 \* | -0.02 | 0.26 \* | 0.05 | 0 |
| 12 | TBS-07 X R-33 | -0.34 | -1.73 | 1.59 | 0.46 \* | 3.07 | -2.72 | 0.12 | 0.03 | -0.16 | 0.06 |
| 13 | TBS-07 x R-22 | -2.34 | 1.89 | -0.71 | 0.27 | 2.56 | -3.73 \* | -0.06 | 0.01 | 0.28 | 0.26 |
| 14 | TBS-07 x TBS 12-1 | 0.91 | 1.39 | -5.83 \*\* | -0.23 | -9.46 \*\* | -3.35 \* | -0.05 | 0 | 0.47 | 0.02 |
| 15 | TBS-09 x TS-24 | 0 | -2.80 \* | -3 | 0.18 | 9.39 \*\* | -1.46 | 0.1 | -0.09 | 0.97 \*\* | -0.56 |
| 16 | TBS-09 x TS-20 | -1.62 | 0.95 | 6.50 \*\* | -0.73 \*\* | -7.22 \*\* | 1.69 | 0.01 | 0.2 | 0.48 | 2.98 \*\* |
| 17 | TBS-09 x V-22 | -3.50 \* | 0.32 | -3.42 | -0.42 \* | -16.42 \*\* | -0.09 | -0.02 | -0.28 \* | -1.88 \*\* | -1.02 \* |
| 18 | TBS-09 x TKG-22 | 2.75 \* | -0.3 | 6.84 \*\* | 0.04 | 1.61 | 5.11 \*\* | 0.04 | 0.02 | -0.06 | -0.18 |
| 19 | TBS-09 x R-33 | 0.88 | -2.30 \* | -0.5 | -0.50 \*\* | -10.97 \*\* | -0.61 | -0.1 | -0.09 | -0.51 | -1.31 \*\* |
| 20 | TBS-09 x R-22 | 2.38 | 2.32 \* | -6.30 \*\* | 0.12 | 7.06 \*\* | -2.91 | -0.09 | 0.08 | 0.58 | -1.62 \*\* |
| 21 | TBS-09 x TBS 12-1 | -0.88 | 1.82 | -0.12 | 1.32 \*\* | 16.55 \*\* | -1.74 | 0.07 | 0.16 | 0.43 | 1.71 \*\* |
| 22 | TBS-10 x TS-24 | -0.86 | -2.09 | -7.56 \*\* | -0.01 | -2.4 | -1.55 | 0.15 | -0.39 \*\* | -0.81 \* | -1.29 \* |
| 23 | TBS-10 x TS-20 | -2.48 | 3.16 \*\* | 0.04 | 0.48 \*\* | 4.39 \* | -2 | -0.11 | 0.2 | 0.6 | -0.79 |
| 24 | TBS-10 x V-22 | 3.64 \*\* | 1.54 | -0.48 | 0.84 \*\* | 15.59 \*\* | 1.63 | 0.02 | 0.30 \* | 2.57 \*\* | 1.31 \*\* |
| 25 | TBS-10 x TKG-22 | -1.11 | -0.09 | -2.12 | -0.14 | -3.37 | -2.57 | -0.02 | -0.1 | -0.89 \*\* | 0.59 |
| 26 | TBS-10 x R-33 | 0.02 | 1.91 | 1.44 | -0.28 | -3.71 | 1.7 | -0.06 | 0.04 | -0.18 | -0.27 |
| 27 | TBS-10 x R-22 | 2.52 | -2.46 \* | 12.64 \*\* | -0.37 \* | -3.62 | 3.40 \* | 0.12 | -0.01 | -0.85 \* | -0.71 |
| 28 | TBS-10 x TBS 12-1 | -1.73 | -1.96 | -3.98 | -0.52 \*\* | -6.88 \*\* | -0.62 | -0.11 | -0.03 | -0.44 | 1.15 \* |
|   | **S.E(±)** | 0.39 | 0.37 | 1.02 | 0.09 | 1.54 | 0.56 | 0.01 | 0.03 | 0.2 | 0.24 |

**Table 4. Best GCA parents and best SCA crosses for different characters in sesame (*Sesamum indicum* L.)**

|  |  |  |
| --- | --- | --- |
| **Characters** | **Best general combining parent** | **Best specific combining crosses** |
| Days to 50 per cent flowering | V-22 | -2.20\*\* | TBS-09 x V-22 | -3.50\* |
| Days to maturity | TBS-07 | -3.21\*\* | TBS-07 x V-22 | -3.11\*\* |
| Plant height (cm) | R-22 | 7.93\*\* | TBS-10 x R-22 | 12.64\*\* |
| No. of branches per plant | R-33 | 0.42\*\* | TBS-09 x TBS 12-1 | 1.32\*\* |
| No. of capsules per plant | TBS-09 | 6.07\*\* | TBS-09 x TBS 12-1 | 16.55\*\* |
| No. of seeds per capsule | TS-20 | 8.77\*\* | TBS-02 x TBS 12-1 | 5.71\*\* |
| Length Of capsule (cm) | R-33 | 0.13\* | TBS-10 x TS-24 | 0.15 |
| 1000 Seed weight (g) | R-22 | 0.40\*\* | TBS-02 x TS-24 | 0.39\*\* |
| Seed yield per plant (g) | R-22 | 1.22\*\* | TBS-10 x V-22 | 2.57\*\* |
| Oil content (%) | V-22 | 1.30\*\* | TBS-09 x TS-20 | 2.98\*\* |

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