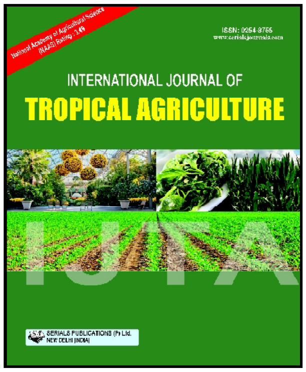


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# Studies on line x tester analysis in sesame (*Sesamum indicum* L.)

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***Abstract:*** In sesame 15 lines and 4 testers were used to studies combining ability and heterosis by line x tester methods. This revealed the additive type of gene action in the inheritance of days to flowering, capsule bearing length, seed per capsule and oil content. Non-additive gene action were noted for days to maturity, plant height, branches per plant, capsule per plant, capsule length, 1000 seed weight and seed yield per plant. Estimate of SCA effect revealed that no cross combination was good for all the characters over all the three environments under study. But some of the crosses, showing consistently superior and desirable SCA effect in desired direction across the environment for seed yield per plant and for several other traits in one of the sowing dates. The parents RT-54, HT-1, CST-783, TNAU-65 and RT-49 were better general combiners for seed yield and its components traits and for high oil content CST-783, RT-127, and RT-49 were good general combiners. The highest desirable heterosis expression over standard check were observed for grain yield (425%) followed by seed per capsule (159%), capsules per plant (150%), capsule bearing length (64%), branches per plant (59%) and days to earliness (6%).

***Key words:*** line x tester, gene action, combining ability, heterosis, sesame,

## INTRODUCTION

Development of varieties with high yielding potential should be the first step in the direction of up-grading the sesame yield. In order to develop a sound breeding programme to identify such varieties, the knowledge of combining ability together with *per se* performance of parents and hybrids over environments is essential to selection of suitable parents and crosses. Furthermore, because of the genotype x environment interaction, the information obtained under one environment and or one set of genetic material may not apply to another, because of the estimates from one environment may be biased and would not present a true picture of genetic nature and breeding value of the population. Therefore, the present study has assessed combining ability and heterosis for seed yield and its component traits over three environments.

## MATERIALS AND METHODS

Fifteen diverse varieties/ advance lines of sesame viz., RT-46, RT-103, RT-106, RT-125, RT-127, RT-238, RT-282, TC-25, HT-1, IS-231, TKG-21, Pb. Til No.1, Uma, TNAU-65 and CST-783, used as females were crossed with four male parents viz., RT-54, IS-208, RT-49 and BS-6-1 to develop 60 $F_1$s using line x tester mating design during *kharif* 1997. The resultant $F_1$s along with their parents were evaluated in randomized block design with three replications at three dates of sowing representing three environments, 20$^{th}$ June (E1), 5$^{th}$ July (E2) and 20$^{th}$ July (E3) at ARS Mandor- Jodhpur. Individual plots consisted of two rows of 2 m length following a geometry of 30 x 15 cm. Data were recorded on ten randomly selected competitive plants for seed yield/ plant, capsule bearing length, capsules/plant, capsule length, seeds/capsule, branches/plant, plan height, 1000- seed weight and oil content. Days to flowering and days to maturity were recorded on plot basis. The data were subjected to L x T analysis according Kempthorne [4] and standard heterosis over commercial national check variety TC-25 was calculated as per standard procedure.

## RESULTS AND DISCUSSION

Pooled analysis of variance showed differences due to genotype (G), environment (E) and the interaction were highly significant for all the characters (Table 1). Significant G x E interactions indicated differential response of genotypes to changing environments. The linear component of environment accounted more than the G x E (linear) component. Pooled deviation was significant for all the characters, indicating the greater role of unpredictable components in the G x E interaction. Such results are commonly reported in sesame by Kumar [7], Madhy and Bakheit [8] and Verma and Mahto [14].

Analysis of variance in the three environments also revealed that significant differences among parents and their hybrids for all the traits. The parents v/s hybrid's sum of squares was also significant for all the traits revealing the presence of heterosis. The present result is in line with the reports of Dora and Kamala [2] and Jadon and Mehrotra [3]

The analysis of combining ability (Table 2) revealed that the estimation of GCA and SCA were significant for almost all the traits in each environment including the importance of both additive and non additive gene effects were involved in the inheritance of the characters. These results are in close agreement with Murty [9], Narkhede and Sudhir Kumar [10]. However, the additive (fixable) type of gene action was predominant in the inheritance days to flowering, capsule bearing length, seeds per capsule and oil content. On the other hand, preponderance of non additive gene action was noted for days to maturity, plant height, branch per plant, capsule per plant, capsule length, 1000- seed weight and seed yield per plant. In general the magnitude of GCA/SCA decreased as the sowing were delayed in case of days to flowering, days to maturity, and plant height and the value increased as sowing was delayed in case of capsule bearing length and oil content. In rest of the cases either there was little change. The results are in agreement with the findings of Murty [9] for days to flowering, Dora and Kamala [2] for days to maturity, plant height, branches per plant, capsule per plant, capsule length, 1000- seeds weight and seed yield per plant, Chandraprakash [1] for seeds per capsule and oil content.

### Combining ability effects

The estimates of GCA effects revealed the parents RT-54, HT-1, CST-783, TNAU-65,RT-127, and RT-

**Table 1**

**ANOVA for experimental design for seed yield per plant, its components and oil content data pooled over environments**

| *Source of variation* | *df* | *Mean squares* Days to flower | Days to maturity | Plant height | Capsule bearing length | Branches per plant | Capsule per plant | Capsule length | Seeds per Capsule | 1000 seed weight | Seed yield per plant | Oil content |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Environments | 2 | 5174.410** | 8066.890** | 149088.200** | 15063.500** | 65.957** | 17445.83** | 1.959** | 5960.488** | 9.908** | 201.476** | 801.958** |
| Replications/ environments | 6 | 5.322** | 12.620** | 783.980** | 379.710** | 0.137** | 55.195** | 0.031** | 120.011** | 0.038** | 1.532** | 4.591* |
| Genotypes | 78 | 27.717** | 24.223** | 744.502** | 618.296** | 3.073** | 583.708** | 0.104** | 944.833** | 0.200** | 12.253** | 227.115** |
| Parents | 18 | 23.314** | 34.788** | 597.500** | 235.536** | 2.234** | 337.282** | 0.072** | 512.801** | 0.113** | 5.757** | 162.631** |
| Hybrids | 59 | 28.727** | 18.807** | 757.196** | 739.689** | 2.897** | 665.294** | 0.105** | 1073.540** | 0.225** | 14.299** | 236.061** |
| Patents vs hybrids | 1 | 47.380** | 153.57** | 2641.581** | 345.781** | 28.576** | 205.849** | 0.643** | 1127.702** | 0.246** | 8.444** | 860.032** |
| Genotypes x environments | 156 | 3.923** | 6.775** | 173.537** | 137.295** | 0.771** | 148.149** | 0.027** | 138.502** | 0.065** | 2.271** | 9.564** |
| Patents x environments | 36 | 3.387** | 5.907** | 124.462** | 111.294** | 0.477** | 119.069** | 0.031** | 87.282** | 0.052** | 1.879** | 9.053** |
| Hybrids x environments | 118 | 4.088** | 6.595** | 186.718** | 146.267** | 0.766** | 152.524** | 0.025** | 147.928** | 0.069** | 2.327** | 9.433** |
| Patents vs hybrids x environments | 2 | 3.808* | 33.032* | 279.240** | 75.990** | 6.359** | 413.481** | 0.037** | 504.266** | 0.009 | 6.113** | 26.498** |
| Error | 468 | 1.140 | 1.439 | 27.107 | 13.829 | 0.100 | 6.530 | 0.003 | 14.309 | 0.005 | 0.063 | 1.290 |

* Significant at p=0.05 and ** Significant at p=0.01

**Table 2**
**Estimation of components of variance for seed yield and various traits evaluated in different environments**

| *Source of variation* | *Environment* | *Mean squares* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Days to flower* | *Days to maturity* | *Plant height* | *Capsule bearing length* | *Branches per plant* | *Capsule per plant* | *Capsule length* | *Seeds per Capsule* | *1000 seed weight* | *Seed yield per plant* | *Oil content* |
| $\sigma^2$ gca | E 1 | 3.473** | 3.830** | 34.124** | 41.83** | 0.080** | 38.63** | 51.50** | 56.08** | 89.14** | 0.85** | 12.58** |
| | E 2 | 1.56** | 0.36 | 28.12** | 63.44** | 0.12** | 56.89** | 31.65** | 78.77** | 4.21 | 1.43** | 18.70** |
| | E 3 | 0.94** | 0.80** | 13.73** | 1110.39** | 0.06** | 7.71** | 47.73** | 82.09** | 58.57** | 0.14** | 22.94** |
| $\sigma^2$ sca | E 1 | 1.16** | 0.87** | 54.61** | 39.80** | 0.25** | 61.94** | 94.56** | 41.46** | 278.70** | 1.04** | 8.73** |
| | E 2 | 0.94** | 1.31** | 73.35** | 87.48** | 0.41** | 82.59** | 93.15** | 94.07** | 490.25** | 1.91** | 13.19** |
| | E 3 | 1.031** | 0.92** | 34.14** | 27.17** | 0.23** | 13.74** | 51.02** | 63.39** | 97.96** | 0.16** | 8.03** |
| $\sigma^2$ gca/ $\sigma^2$ sca | E 1 | 2.99 | 4.39 | 0.63 | 1.05 | 0.32 | 0.62 | 0.55 | 1.35 | 0.32 | 0.82 | 1.44 |
| | E 2 | 1.66 | 0.28 | 0.38 | 0.73 | 0.28 | 0.69 | 0.34 | 0.84 | 0.01 | 0.75 | 1.42 |
| | E 3 | 0.91 | 0.87 | 0.40 | 40.86 | 0.28 | 0.56 | 0.93 | 1.30 | 0.60 | 0.88 | 2.86 |

* Significant at p=0.05 and ** Significant at p=0.01

49 were better general combiners for seed yield per plant, days to flowering, capsule bearing length, capsule per plant and 1000- seed weight. The parent CST-783, RT-127 and RT-49 were also good general combiners for high oil content these parent may be utilized for hybridization programme for improving the seed yield coupled with oil content in sesame (Table 3). The parent of distant origin having high additive x additive interaction effects are likely to result better genotypes with high yield in advance generations as revealed by Sharma and Chouhan [11]. The *per se* performance and GCA effects of the parents revealed that these two parameters were in general directly related to each other. In no case a parent with poor *per se* performance was the best combiner. Thus when the character is unidirectionaly controlled by a set of alleles and additive effects are more important, than the choice of parents on the basis of *per se* performance may be effective. However, in case where non-allelic interaction is more important, the combining ability estimates must be considered for parental choice.

Estimate of SCA effect revealed that no cross combination was good for all the characters over all the three environments under study. nevertheless, some of the crosses showing consistently superior and desirable SCA effect in desired direction across the environment for seed yield per plant were RT-46 X RT-54, RT-106 X RT-49, RT-125 X IS-208, RT-127 X BS-6-1, RT-282 X RT-54, HT-1 X BS-6-1, IS-231 X RT-49, TKG-21 X RT-49, TNAU-65 X RT-54 and CST-783 X RT-54. The cross TNAU-65 X RT-54 and CST-783 X RT-54 exhibited significant and desirable SCA effects for seed yield per plant across thee environments as well as also showed significantly superior SCA effects for several other traits in one of the sowing dates.

Perusal of crosses with high and desirable SCA effect in general had parents which had either low GCA effects or at least one parent with undesirable GCA effects. In other words two combiners with high GCA effect did not necessarily result in a combination with high SCA effects. For example crosses TNAU-65 X RT- 49 AND HT-1 X RT-54, where both the parent had the significant GCA effects across the environments gave negative SCA effects for seed yield across the environments. This indicate that the parent TNAU-65, RT-49, HT-1, though, had high GCA effects were probably not genetically different from each other. It is further observed that significant desirable SCA effects were not always associated with high per se performance. This indicates that the choice of best combination on the basis of high SCA effects may not always necessarily be the one which would give highest per se performance.

## HETEROSIS

The highest desirable heterosis expression over standard check TC-25 in seed yield and its components was observed in order of seed yield per plant in cross TNAU-65 X RT-54 (425.46%) followed by seeds per capsule in CST-783 X RT-54 (158.61%), capsule per plant in CST-783 X RT-49 (149.69%), capsule bearing length in IS-231 X RT-49 (63.98%), branches per plant in TKG-21 X RT-54 (59.32%), plant height in TC-25 X BS-6-1 (45.39%), 1000-seed weight inRT-127 X RT-49 (22.12%), capsule length in RT-282 X RT-54 (17.64%), oil content in HT-1 x RT-49 (7.46%), days to flower in HT-1 X RT-54 (-5.77%) and days to maturity in RT-127 X BS-6-1 (-5.56%). In sesame earliness is desirable, the crosses possessing negative heterosis effects are considered to be superior. Heterotic effects were either low or negative for oil content. High heterosis for seed yield and its several components has also been reported by Krishnaswami and Appadurai [5], Singh et al. [12], Tu et al. [13] and Kumar [6].

A total of sixteen crosses (Table 4) showed stable superiority over check TC-25 across the environment for seed yield per plant and superior in

**Table 3**

**Element of general combining ability(gca) effects for seed yield per plant, its components and oil content in individual environments**

| *Genotypes* | *Days to flower* | | | *Days to maturity* | | | *Plant height* | | | *Capsule bearing length* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *E 1* | *E 2* | *E 3* | *E 1* | *E 2* | *E 3* | *E 1* | *E 2* | *E 3* | *E 1* | *E 2* | *E 3* |
| **Females** | | | | | | | | | | | | |
| RT-46 | 1.00** | -0.06 | 0.09 | -0.09 | 0.68 | 1.40** | -1.32 | 6.72** | 6.02** | -2.88* | -1.49 | 3.87** |
| RT-103 | 0.50 | -0.06 | 0.42 | -0.84** | -0.57 | 0.32 | 2.30 | 8.87** | -0.68 | -1.67 | 3.40** | -1.54 |
| RT-106 | 1.25** | 1.28** | 1.43** | 0.66 | 1.09** | 1.32** | -5.98** | -3.29* | -7.49** | -9.42** | -0.98 | -4.34** |
| RT-125 | 2.17** | 1.11** | 2.68** | 1.82** | -0.41 | -0.85** | -3.75* | -12.68** | -9.93** | -9.69** | -15.36** | -8.66** |
| RT-127 | -0.58 | -0.89** | 0.26 | -0.26 | -2.74** | -0.27 | 11.72** | 9.33** | -2.54* | 11.73** | 9.43** | -0.22 |
| RT-238 | 1.75** | 0.78** | 1.51** | 3.07** | 0.59 | -0.10 | 7.17** | -1.37 | -5.89** | -2.14 | -3.90** | -8.74** |
| RT-282 | 0.08 | -0.6 | -0.16 | 1.41** | -0.41 | 0.07 | 10.02** | 2.88 | 3.51** | 6.69** | 2.81* | 3.39** |
| TC-25 | 0.33 | 0.03 | -0.32 | 1.16** | 0.09 | 1.15** | 5.83** | 1.32 | 8.62** | 2.62* | -1.09 | 4.81** |
| HT-1 | -0.92* | -1.14** | -1.32** | 0.43 | 0.51 | 1.90** | -6.33** | 8.47** | 3.15** | -0.32 | 14.36** | 6.26** |
| IS-231 | 0.08 | 1.03** | 0.09 | -0.34 | 1.01* | 0.40 | -3.40 | 2.87 | 8.12** | -2.99* | -0.23 | 3.42** |
| TKG-21 | -1.92** | -1.64** | -1.66** | -3.26** | 0.34 | -1.02** | 1.27 | 2.22 | 1.91 | 3.10** | 2.32 | 0.19 |
| Pb Til No. 1 | -1.08** | 0.39 | -1.32** | -1.51** | -1.16** | -2.35** | -0.52 | 2.98 | 1.57 | 1.50 | 1.30 | 4.11** |
| Uma | -2.92** | -0.31 | -0.91** | -2.67** | -0.39 | -1.68** | 21.27** | -23.78** | -18.83** | 0.72 | -11.05** | -12.05** |
| TNAU-65 | 0.33 | 0.94** | 0.26 | -0.76* | 0.01 | -0.60 | 0.54 | -0.62 | 6.39** | -1.45 | -1.54 | 4.16** |
| CST-783 | -0.08 | -0.64* | -1.07** | 2.16** | 1.43** | 0.32 | 3.73 | -3.93* | 6.07** | 4.21** | 1.80 | 5.34** |
| SE(gi)± | 0.37 | 0.30 | 0.27 | 0.36 | 0.41 | 0.30 | 1.76 | 1.59 | 1.11 | 1.20 | 1.30 | 0.81 |
| **Male** | | | | | | | | | | | | |
| RT-54 | -2.14** | -1.55** | -0.82** | -1.69** | -0.81** | -1.17** | -6.37** | -4.53** | -2.51** | 1.99** | 0.25 | -0.16 |
| IS-208 | 2.66** | 1.56** | 1.32** | 1.16** | 0.51* | 0.88** | -3.58** | -3.36** | -1.93** | -0.80 | -11.28** | -5.58** |
| RT-49 | -0.83** | -0.71** | -0.71** | 0.20 | 0.57** | 0.50** | 3.93** | 6.80** | 1.80** | 7.24** | 10.55** | 5.19** |
| BS-6-1 | 0.31 | -0.69** | 0.21 | 0.33 | -0.27 | -0.21 | 6.02** | 1.09 | 2.64** | 0.56 | 0.48 | 0.56 |
| SE(gi)± | 0.19 | 0.16 | 0.14 | 1.19 | 0.21 | 0.16 | 0.91 | 0.82 | 0.57 | 0.62 | 0.67 | 0.42 |

*contd. table 3*

| *Genotypes* | *Days to flower* | | | *Days to maturity* | | | *Plant height* | | | *Capsule bearing length* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *E 1* | *E 2* | *E 3* | *E 1* | *E 2* | *E 3* | *E 1* | *E 2* | *E 3* | *E 1* | *E 2* | *E 3* |
| **Females** | | | | | | | | | | | | |
| RT-46 | 0.18* | 0.11 | 0.43** | -4.38** | 0.94 | 5.03** | 3.26* | 5.93** | 4.16** | 3.21* | 5.68** | -1.21 |
| RT-103 | -0.28** | 0.38** | -0.07 | -1.46 | 3.94** | -1.05* | 2.74* | 13..60** | -1.34 | 3.74** | 11.53** | 0.88 |
| RT-106 | -0.33** | -0.09 | -0.17* | -7.58** | -1.89* | -3.05** | -13.59** | -5.15** | -7.68** | -9.61** | -3.55** | -0.68 |
| RT-125 | -0.22** | -0.72** | -0.44** | -10.29** | -16.29** | -5.20** | -7.25** | -13.23** | -7.51** | -8.24** | -5.42** | -4.45** |
| RT-127 | -0.05 | -0.32** | -0.34** | 9.46** | 3.74** | -0.54 | 5.24** | 4.68** | -5.93** | 0.16 | 2.11* | -1.68 |
| RT-238 | -0.12 | -1.27** | -0.85** | 1.49 | -12.00** | -3.79** | 3.33* | -0.23 | -6.51** | -3.06* | -6.52** | -8.54** |
| RT-282 | -0.12 | -0.27* | 0.37** | 6.71** | 2.76** | 0.45 | 5.66** | 1.43 | 0.74 | -4.12** | -4.13** | -3.23** |
| TC-25 | -0.27** | 0.16 | 0.17* | 0.12 | 0.27 | 1.58** | 3.08* | 0.02 | 8.41** | 2.57* | -0.63 | 0.52 |
| HT-1 | 0.22** | 0.76** | 0.38** | 0.79 | 18.34** | 5.70** | 9.24** | 13.18** | 12.16** | 13.33** | 4.56** | 8.00** |
| IS-231 | 0.10 | 0.09 | -0.20* | -6.79** | -3.92** | 1.16* | -14.92** | 0.10 | -0.01 | 0.31 | -2.87** | -11.40** |
| TKG-21 | 0.72 | 0.46** | 0.15 | 3.82** | 1.07 | 0.30 | -3.34* | -8.48** | 2.66 | -3.62** | -0.70 | 0.84 |
| Pb Til No. 1 | 0.07 | -0.30** | 0.07 | -1.81* | -4.34** | -0.42 | -7.59** | 4.27** | 1.74 | -2.69* | 0.87 | 4.89** |
| Uma | 0.65** | 0.24* | -0.44** | 5.23** | -8.12** | -5.61** | -0.42 | -23.40** | -18.68** | -6.73** | -0.03 | 3.51** |
| TNAU-65 | -0.15 | 0.78** | 0.57** | -3.10** | 4.97** | 1.42** | 11.66** | -3.07 | 5.24** | 11.43** | 1.35 | 10.24** |
| CST-783 | -0.42** | 0.01 | 0.38** | 7.78** | 10.69** | 4.03** | 9.41** | 10.35** | 12.66** | 3.32** | -2.25* | 2.33* |
| SE(g1)± | 0.08 | 0.11 | 0.08 | 0.84 | 0.84 | 0.52 | 1.38 | 1.57 | 1.59 | 1.28 | 1.06 | 1.04 |
| **Male** | | | | | | | | | | | | |
| RT-54 | 0.49** | 0.51** | 0.38** | 3.75** | 4.47** | 0.66* | 3.59** | -6.36* | 1.92* | 12.09** | 14.23** | 15.01** |
| IS-208 | -0.19** | 0.01 | -0.07 | -8.66** | -10.53** | -3.66** | -7.23** | -5.38** | -7.59** | -5.05** | -9.69** | -6.14** |
| RT-49 | -0.18** | -0.32** | -0.09* | 7.14** | 7.63** | 3.44** | 9.28** | 7.19** | 8.86** | -2.71** | 0.42 | -2.09** |
| BS-6-1 | -0.11** | -0.20** | -0.22** | -2.23** | -1.57** | -0.44 | -5.63** | -1.45 | -3.19** | -4.33** | -4.96** | -6.78** |
| SE(g1)± | 0.04 | 0.06 | 0.04 | 0.43 | 0.43 | 0.27 | 0.71 | 0.81 | 0.82 | 0.66 | 0.55 | 0.54 |

*contd. table 3*

| Genotypes | 1000 seed weight | | | Seed yield per plant | | | Oil content | | |
|---|---|---|---|---|---|---|---|---|---|
| | E 1 | E 2 | E 3 | E 1 | E 2 | E 3 | E 1 | E 2 | E 3 |
| **Females** | | | | | | | | | |
| RT-46 | -18.13** | -4.21* | 5.71** | -0.41** | 0.40** | 0.36** | 0.05 | -0.72* | 1.45** |
| RT-103 | 1.96 | -1.04 | -0.38 | 0.00 | 1.16** | -0.14** | 0.05 | -0.76* | -2.36** |
| RT-106 | -12.21** | -3.54 | -5.38** | -1.22** | -0.63** | -0.21** | -0.91** | 0.47 | 1.94** |
| RT-125 | -27.79** | -10.87** | -12.21** | -1.42** | -1.93** | -0.48** | -3.13** | -3.39** | -2.24** |
| RT-127 | 26.21** | 10.46** | 18.29** | 0.97** | 0.30** | -0.03 | 0.96** | 3.32** | 2.81** |
| RT-238 | 10.12** | -8.79** | -16.63** | -0.21** | -1.60** | -0.52** | 1.20** | 3.42** | 2.97** |
| RT-282 | 7.62** | -8.62** | 1.62 | 0.56** | -0.07 | -0.04 | -0.62 | 0.45 | 0.24 |
| TC-25 | -14.13** | -5.71** | 2.71 | 0.01 | -0.04 | 0.17** | -0.25 | -1.42** | 0.55 |
| HT-1 | -1.25 | 17.46** | 10.79** | 0.94** | 2.17** | 0.57** | -0.09 | 0.46 | -0.71* |
| IS-231 | -12.63** | -6.46** | 9.12** | -0.76** | -0.64** | -0.25** | -1.30** | -0.71* | -2.80** |
| TKG-21 | 7.54** | 15.54** | -1.04 | -0.02 | 0.24* | -0.02 | 0.09 | -0.46 | -0.96** |
| Pb Til No. 1 | 21.54** | 19.54** | 2.54 | -0.13 | -0.39** | 0.11** | 2.13** | 1.38** | 1.11** |
| Uma | -2.71 | -7.46** | -15.36** | -0.16* | -0.84** | -0.43** | -1.46** | -2.80** | -3.21** |
| TNAU-65 | 2.46 | -9.29** | -4.71* | 0.72** | 0.64** | 0.41** | 1.15** | -0.86** | -0.09 |
| CST-783 | 11.46** | 2.96 | 5.21* | 1.15** | 1.23** | 0.49** | 2.13** | 1.61** | 1.32** |
| $SE(g_1)\pm$ | 2.23 | 1.93 | 2.04 | 0.07 | 0.10 | 0.04 | 0.32 | 0.32 | 0.32 |
| **Male** | | | | | | | | | |
| RT-54 | 0.35 | 5.18** | 3.92** | 1.25** | 1.56** | 0.46** | -5.81** | -7.18** | -7.96** |
| IS-208 | -9.58** | -5.29** | -8.39** | -1.12** | -1.48** | -0.43** | 0.38 | 0.66** | 1.26** |
| RT-49 | 13.13** | 6.13** | 9.18** | 0.36** | 0.55** | 0.19** | 3.52** | 3.62** | 3.34** |
| BS-6-1 | -3.89** | -6.02** | -4.71** | -0.49** | -0.63** | -0.22** | 1.90** | 2.90** | 3.36** |
| $SE(g_1)\pm$ | 1.15 | 0.99 | 1.05 | 0.04 | 0.05 | 0.02 | 0.17 | 0.16 | 0.17 |

**Table 4**

**Promising crosses with high per se performance for seed yield per plant and their related parameters in different environments**

| *Best crosses* | *Mean seed yield per plant (g)* | | | *Heterobeltiosis* | | | *Standard heterosis* | | | *SCA effects* | | | *GCA Effects* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | *P 1* | | | *P 2* | | |
| | *E 1* | *E 2* | *E 3* | *E 1* | *E 2* | *E 3* | *E 1* | *E 2* | *E 3* | *E 1* | *E 2* | *E 3* | *E 1* | *E 2* | *E 3* | *E 1* | *E 2* | *E 3* |
| CST-783 x RT-54 | 6.71 | 7.90 | 2.45 | +** | +** | +** | +** | +** | +** | +** | +** | +** | +** | +** | +** | +** | +** | +** |
| TNAU-65 x RT-54 | 6.19 | 7.24 | 2.88 | +** | +** | +** | +** | +** | +** | +** | +** | +** | +** | +** | +** | +** | +** | +** |
| RT-282 x RT-54 | 6.40 | 6.89 | 1.71 | +* | + | +** | +** | +** | +** | +** | +** | +** | +** | - | - | +** | +** | +** |
| HT-1 x RT-49 | 4.75 | 7.00 | 1.56 | +** | +** | -* | +** | +** | +** | +** | +** | -** | +** | +** | +** | +** | +** | +** |
| HT-1 x RT-54 | 4.51 | 6.51 | 2.23 | -* | + | +** | +** | +** | +** | - | - | + | +** | +** | +** | +** | +** | +** |
| RT-46 x RT-54 | 3.63 | 6.06 | 2.38 | -** | - | +** | +** | +** | +** | +* | +** | +** | + | - | +** | +** | +** | +** |
| TC-25 x RT-54 | 3.93 | 5.83 | 2.11 | -* | - | +** | +** | +** | +** | + | +** | +** | + | - | +** | +** | +** | +** |
| CST-783 x RT-49 | 3.31 | 4.99 | 2.18 | +** | +** | + | +** | +** | +** | -** | + | +** | +** | +** | +** | +** | +** | +** |
| HT-1 x BS-6-1 | 3.57 | 4.97 | 1.81 | +** | +** | - | +** | +** | +** | +** | +** | +** | +** | +** | +** | -** | -** | -** |
| RT-103 x RT-54 | 2.82 | 6.61 | 1.04 | -** | + | -** | +** | +** | +** | -** | +** | -** | - | +** | -** | +** | +** | +** |
| RT-103 x RT-49 | 2.11 | 3.64 | 1.20 | +* | +** | - | +** | +** | +** | + | +** | + | - | +** | -** | +** | +** | +** |
| Pb Til No. 1 x RT-54 | 4.75 | 2.75 | 1.81 | - | -** | +* | +** | - | +** | +** | -** | +* | - | -** | +** | +** | +** | +** |
| TKG-21 x RT-49 | 3.24 | 4.42 | 1.38 | +** | +** | + | +** | +** | +** | +** | +** | +* | - | +* | - | +** | +** | +** |
| TKG-21 x BS-6-1 | 2.11 | 4.99 | 1.33 | - | +** | + | +* | +** | +** | + | +** | +** | - | +* | - | -** | -** | -** |
| Pb Til No. 1 x RT-49 | 2.14 | 3.85 | 1.54 | +** | + | + | +** | +** | +** | -** | +** | +* | - | -** | +** | +** | +** | +** |
| RT-46 x RT-49 | 2.11 | 3.64 | 1.20 | +* | + | - | +** | +* | +* | - | - | -** | -** | +** | +** | +** | +** | +** |

* Significant at p=0.05 and ** Significant at p=0.01

their per se performance for seed yield per plant and its components traits and also had significant desirable SCA effects. Several superior crosses on the basis of SCA, high heterotic effect and high *per se* performance may be used frequently in future breeding programme. Hence, transgrassive segregants obtained for seed yield with more percentage of oil.

All the type of general combiner i.e. high x high, high x low and low x low were involved in the crosses. This showed that additive x additive, additive x dominance and dominance x dominance type of gene action were involved in the crosses. These results are in close conformity with the findings of Sharma and Chouhan [11].

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