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# Study of Combining Ability for Seed Yield and its Attributing Traits in Linseed (*Linum usitatissimum* L.) under Late Sown in Rainfed Condition

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## Abstract

The present investigation was carried out with 36 genotypes (eight parents and their 28 hybrids generated as per Griffing's diallel approach model I and method II), were evaluated in randomized block design with three replications for twelve distinct morphological characters, during Rabi season of 2019-20, at Agriculture Research Station, Kota, to estimate the general combining ability (GCA) of the parents and specific combining ability (SCA) of hybrids considered for the development of high yielding varieties for early planting in rainfed condition. Analysis of variance revealed wide spectrum of variation among 36 genotypes (parents and their hybrids) for all the traits under study except parents for biological yield per plant. Significant meant sum of square of parent vs crosses component indicated existence of heterosis for almost all the characters. Significant mean squares of both general and specific combining abilities observed for all the traits revealed the importance of both additive and non-additive gene effects for these all the traits except number of secondary branches per plant controlled by non additive gene action and days to maturity by controlled by additive gene action; however, low GCA/SCA variance ratios (<1) for all the traits indicated the predominance of non additive gene effects in their inheritance except days to maturity. Parent Meera has been found good general combiner with highest magnitude of GCA effects for seed yield per plant along with number of primary branches per plant, number of capsules per plant and harvest index. In addition to above, KBA 3, KBA 4 and Padmani also showed good GCA effects for oil content, earliness and other component characters. Among the 28 crosses Meera x KBA3 showed highest positive significant SCA effects for seed yield per plant and its component characters, indicating potential for exploiting hybrid vigour in breeding programme.

***Key words*** *: combining ability, gene action, yield and linseed.*

## Introduction

Linseed (*Linum usitatissimum* L.) is self pollinated, diploid, annual, oldest, oilseed crop generally grown during Rabi season in India. It is cultivated for seed (linseed) and its fibre (Flax) since centuries. The whole plant has commercial use directly or indirectly as a food ingredient, industrial purposes and medicinal purposes worldwide. Oils are an essential part of our diet by supplying concentrate source of energy, improving flavor to food and helps in absorption of vitamins in body. Linseeds oil is also used in food industries because of its nutritional quality, essential poly unsaturated fatty acids such as alpha-linolenic acid with botanical source of omaga 3 and rich supply of soluble dietary fiber. Linseed seed oil is used as an industrial ingredient of drying oil due to its high linolenic acid content. However, some linseed genotypes have been developed which contain very low levels of linolenic acid in their oil, making them suitable for use as edible-oil. It is most important and oldest crop cultivated for its seed and fibre mostly on rainfed condition by poor farmers, over 172.71 thousand hectares area with production of 99.07 thousand tones. The average seed yield of linseed in India is 574 Kg/ha which is comparably very low in comparison with world average seed yield that is 975 Kg/ ha. (1). The low seed yield is chiefly due to limited resources available to poor farmers along with non availability of high-yielding cultivars. So, the development of high-yielding varieties is needed to compete with other linseed growing countries. Such varieties can easily be developed through suitable hybridization and selection programmes to isolate superior segregants. However, the success of any hybridization programme chiefly depends on combining ability of parents used in crossing programme. Combining ability provides an important tool for selection of desirable parents and to get required information regarding the nature of gene action controlling desirable trait. Generally, plant breeders use Griffing's diallel mating design to identify desirable parents along with their specific cross combinations and to get the knowledge of genetic effects, estimates of general combining ability (GCA), specific combining ability.

## Materials and Methods

The experimental materials consisted of 8 parents which were crossed as per diallel analysis (Griffing, 1956), (Model 1 and Method 2) in Rabi 2018-19 to generate 28 crosses. The seeds of these 36 entries were sown in the field using a randomized complete block design with three replications, on 25$^{th}$ September, 2019. This experiment

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was carried out at experimentation Station, Kota, (Raj.). The seed of each genotype was sown in a single row of 4 m length with a spacing of 30 cm ×10 cm between and within the row respectively. Recommended package of practices was followed to raise a healthy crop. Five randomly selected competitive plants from each row were used to record the biometric observations for plant height (PH), number of primary branches per plant (PBPP), number of secondary branches per plant (SBPP), number of capsules per plant (CPP), number of seeds per capsule (SPC), biological yield per plant (BYPP) and seed yield per plant (SYPP). But days to 50% flowering (DF), days to maturity (DM), test weight (TW), oil content (OC), was recorded on whole row basis. The biochemical analysis was done for oil content by Soxhlet procedure as described in AOCS.

The mean values of above twelve traits were subjected to analysis of variance proposed by (2) and the estimates of combining ability as per (3) method-II and Model-1.

## Results and Discussion

**Analysis of variance** : Analysis of variance revealed wide spectrum of variation among 36 genotypes for all 12 characters which includes eight parents and their twenty-eight $F_1$'s that were developed by 8×8 diallel fashion excluding reciprocals (Table-1). Significant meant sum of square of parent vs crosses component indicated existence of heterosis for all the characters except days to maturity and harvest index. This variability can be exploited through selection by studying general combining ability (GCA) and specific combining ability (SCA). The analysis of variance for combining ability revealed the importance of both additive and non-additive gene action for cause of observed variation in all the traits which are an important indicator of its potentiality for generating superior breeding populations. A high GCA estimate represents a strong evidence of favorable gene flow from parents to offspring at high frequency and gives information about the concentration of the predominantly additive genes. In addition, crosses involving genotypes with greater estimates of GCA should be potentially superior for the selection of lines in the advanced generations (4).

Significant mean squares of both general and specific combining abilities observed for all the traits except GCA for number of secondary branches per plant and SCA for days to maturity revealed the importance of both additive and non-additive gene effects for these all the traits. The non-significant for GCA and significant for SCA for number of secondary branches per plant indicated the is governed by non-additive gene effect and significant GCA but Non-significant SCA for days to maturity indicated that the days to maturity is govern by additive gene effect. The low GCA/SCA ratios of for all the traits (Table-2) indicated the predominance of non-additive gene effects in their inheritance except days to maturity which was governed by additive gene effect.

**General combining ability (GCA) effects :** The General combining ability (GCA) effects of parent are presented in Table-3. Where, none of the parent was found as a good general combiner for all the twelve characters. However, Padmani and RL 15582 were found good general combiner for earliness viz., days to 50% flowering and days to maturity; KBA4, Padmani and RL15582 were found good general combiner for dwarfness viz., plant height. PA2 and Meera were found good general combiner for number of primary branches per plant. KBA4, RL 15583 and Meera were found good general combiner for number of capsules per plant. KBA3 and RL 15583 were found good general combiner for number of seeds per capsule. PA2, KBA4 and RL15583 were found good general combiner for 1000-seed weight. KBA3, KBA4 and Padmani were found good general combiner for oil content. KBA4 were found good general combiner for biological yield per plant. Meera was found good general combiner for seed yield/plant. Meera were found good general combiner for harvest index. On the basis of overall performance, KBA4, Padmani, RL15583and Meera was identified as desirable general combiners for most of the characters. These parents showed both additive and non-additive type of gene action involving different combinations of high and low general combiners. Similar result was also reported by (5,6,7).

**Specific combining ability (SCA) :** Analysis of specific combining ability is important parameter for judging the specific cross combination for exploiting it through heterosis breeding program. It is assisted with interaction effects, which may be due to dominance and epistasis components of genetic variation that are non-fixable in nature. The significant and positive SCA effects in desirable direction are presented in Table-3. The Meera x KBA3 (1.58) was best performing cross combination which exhibited positive and significant SCA effects for seed yield per plant followed by RL15583 x KBA3 (1.57), RL 15582 x KBA4 (1.47), RL15583 x KBA4 (1.19), RL15583 x RL13161 (1.14), Padmani x KBA3 (1.13), RL15582 x Padmani (1.11) KBA3 x PA2(1.09), RL15582 x PA2 (1.04) and Meera x Padmani (0.62). Out of twenty-eight cross eight promising cross having significant SCA effect for days to 50% flowering, six crosses for plant height, six cross for primary branches per plant, five cross for number of secondary branches/plant, thirteen cross for number of capsule per plant, eight cross for number of seeds per capsule, eleven cross for test weight, ten cross for seed yield per plant, nine cross for biological yield per

**Table-1 : Analysis of variance for diallel crosses for seed yield and its component characters in linseed.**

| Source of variation | D.F. | Mean sum square | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DF | DM | PH | PBPP | SBPP | CPP | SPC | TW | OC | BYPP | SY | HI |
| Replication | 2 | 1.75 | 1.19 | 2.95 | 0.12 | 7.13 | 6.49 | 0.44* | 0.03 | 5.00* | 21.57 | 0.56 | 47.17 |
| Genotypes | 35 | 18.46** | 23.49** | 57.53** | 1.04** | 25.33** | 1058.61** | 1.11** | 2.45** | 7.13** | 52.99** | 3.41** | 44.24** |
| Parents | 7 | 24.47** | 48.86** | 98.96** | 0.70** | 7.44 | 472.86* | 1.62** | 1.43** | 5.75** | 4.07 | 2.64** | 45.03* |
| Crosses | 27 | 17.44** | 16.30** | 43.43** | 1.10** | 17.78 | 734.40** | 1.03** | 2.67** | 7.39** | 26.06* | 1.96** | 45.10** |
| Parents v/s Crosses | 1 | 3.72 | 40.02** | 148.21** | 1.79** | 354.48** | 13912.51** | 0 | 3.39** | 9.90** | 1122.42** | 47.69** | 15.45 |
| Error | 70 | 1.53 | 1.46 | 4.52 | 0.08 | 12.22 | 185.51 | 0.14 | 0.05 | 1.32 | 13.87 | 0.31 | 17.1 |

*, ** significant at 5% and 1% level, respectively.

**Table-2 : Analysis of variance and estimates of components of variance for combining ability for seed yield and its component characters in linseed.**

| Source of variation | D.F. | Mean sum square | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DF | DM | PH | PBPP | SBPP | CPP | SPC | TW | OC | BYPP | SY | HI |
| GCA | 7 | 19.84** | 31.06** | 73.75** | 0.31** | 1.82 | 272.43** | 0.29** | 1.68** | 3.96** | 3.3 | 0.85** | 15.71* |
| SCA | 28 | 2.73** | 2.02** | 5.53** | 0.36** | 10.10** | 372.98** | 0.39** | 0.60** | 1.98** | 21.25** | 1.21** | 14.50** |
| Error | 70 | 0.51 | 0.49 | 1.51 | 0.03 | 4.07 | 61.84 | 0.05 | 0.02 | 0.44 | 4.62 | 0.1 | 5.7 |
| | | Components of variance | | | | | | | | | | | |
| $ó^2g$ | | 2.25 | 3.57 | 8.43 | 0.03 | -0.26 | 24.57 | 0.03 | 0.19 | 0.41 | 0.15 | 0.09 | 1.17 |
| $ó^2s$ | | 10.36 | 7.18 | 18.79 | 1.54 | 28.13 | 1452.01 | 1.61 | 2.71 | 7.2 | 77.6 | 5.14 | 41.08 |
| $ó^2g$ / $ó^2s$ | | 0.22 | 0.5 | 0.45 | 0.02 | -0.01 | 0.02 | 0.02 | 0.07 | 0.06 | 0 | 0.02 | 0.03 |

*, ** significant at 5% and 1% level, respectively.
DF= Days to 50% flowering, DM= Days to maturity, PH= Plant height (cm), PBPP= Number of primary branches per plant, SBPP= Number of secondary branches per plant, CPP= Number of capsules per plant, SPC= Number of seeds per capsule, TW = Test weight (g), OC= oil content (%), BYPP= Biological yield per plant (g), SY= Seed yield per plant (g), HI= harvest index (%).

**Table-3 : Estimates of general combining ability (GCA) effect for seed yield and its component characters in linseed.**

| Parents | DF | DM | PH | PBPP | SBPP | CPP | SPC | TW | OC | BYPP | SY | HI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PA 2 | 2.20** | 1.98** | 4.76** | 0.03 | -0.52 | -4.85* | 0.17** | 0.34** | 0.02 | 0.58 | 0.38** | 0.49 |
| KBA 3 | -0.3 | -0.86** | 0.15 | -0.18** | 0.34 | -6.54** | 0.01 | 0.13** | 0.31 | -0.27 | -0.15 | -0.64 |
| KBA 4 | -0.53* | -0.89** | -2.05** | 0.13** | 0.61 | 5.87* | -0.24** | -0.60** | 1.13** | 0.08 | -0.08 | -0.13 |
| RL13161 | -0.37 | -0.42* | -0.14 | -0.08 | -0.53 | -2.02 | -0.04 | -0.15** | -0.29 | 0.43 | -0.06 | -0.35 |
| Padmani | -2.23** | -1.79** | -3.65** | -0.16** | 0.13 | -2.81 | 0.03 | 0.19** | 0.29 | 0.78 | -0.38** | -2.04** |
| RL15582 | -0.83** | -0.16 | -1.61** | -0.18** | 0.13 | 0.28 | -0.26** | -0.39** | -0.25 | -0.82 | -0.23* | -0.24 |
| RL15583 | 1.63** | -1.23** | -0.39 | 0.19** | 0.23 | 1.34 | 0.16* | 0.67** | -0.14 | -0.64 | 0.46** | 2.40** |
| Meera | 0.43* | 3.38** | 2.93** | 0.26** | -0.39 | 8.72** | 0.16* | -0.18** | -1.07** | -0.15 | 0.08 | 0.5 |
| SE (gi) | 0.21 | 0.21 | 0.36 | 0.05 | 0.6 | 2.33 | 0.06 | 0.04 | 0.2 | 0.64 | 0.1 | 0.71 |
| SE (gi-gj) | 0.32 | 0.31 | 0.55 | 0.07 | 0.9 | 3.52 | 0.1 | 0.06 | 0.3 | 0.96 | 0.14 | 1.07 |

**Table-3 : Estimates of specific combining ability (SCA) effect for seed yield and its component characters in linseed.**

| Crosses | DF | DM | PH | PBPP | SBPP | CPP | SPC | TW | OC | BYPP | SY | HI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KBA 3 x PA2 | -0.34 | 2.86** | -0.83 | -0.23 | 3.99* | -9.61 | 0.42* | 0.44** | 0.13 | -0.2 | 1.00** | 3.7 |
| KBA 4 x PA2 | -3.11** | -3.11** | -0.2 | -0.58** | -0.62 | 5.41 | 0.3 | -0.71** | -1.69** | 1.38 | -0.21 | -1.86 |
| RL13161x PA2 | 0.39 | -1.24 | -0.57 | -0.70** | -1.48 | 8.85 | 0.73** | -0.83** | 1.2 | 1.17 | 0.26 | -0.61 |
| Padmani x PA2 | -0.74 | -1.88** | -2.70* | 0.06 | -0.13 | 9.43 | -0.66** | 0.40** | 1.71** | 1.7 | 0.17 | -0.73 |
| RL15582 x PA2 | 1.86** | 0.16 | -1.83 | -1.05** | 1.87 | 11.26 | -0.72** | 0.44** | -1.07 | 2.59 | 1.19** | 1.63 |
| RL15583 x PA2 | -1.28 | 0.56 | 0.6 | 0.52** | -1.9 | -3.6 | -0.38 | 0.59** | 1.32* | 5.24** | 0.51 | -3.26 |
| Meera x PA2 | 2.92** | -1.38* | 0.86 | 0.78** | -0.28 | -1.18 | -0.04 | -0.02 | 0.98 | 1.52 | 0.14 | -0.89 |
| KBA 4 x KBA 3 | 0.39 | 0.39 | -0.83 | 0.2 | 1.86 | -6.61 | 0.54** | 1.00** | 2.45** | 2.79 | 0.18 | -1.98 |
| RL13161 x KBA 3 | -0.44 | -0.74 | 2.38* | 0.99** | 2.67 | 23.57** | 0.48* | -0.35** | 0.23 | 9.72** | 0.84** | -3.94 |
| Padmani x KBA 3 | 0.76 | -0.71 | -0.26 | -0.11 | 3.35 | 22.06** | -0.15 | -0.59** | -1.32* | -0.41 | 1.25** | 4.45* |
| RL15582 x KBA 3 | 0.02 | 0.66 | -1.74 | -0.17 | -1.98 | -18.73* | 0.16 | -0.92** | 1.1 | -0.89 | -0.73* | -1.92 |
| RL15583 x KBA 3 | 2.89** | -1.28* | -2.13 | -0.34* | 0.58 | 19.63** | -1.25** | 1.28** | -0.08 | 0.73 | 1.65** | 4.61* |
| Meera x KBA 3 | -0.91 | -1.21 | -1.79 | -0.25 | -1.27 | 10.17 | -0.25 | 0.41** | 0.45 | -2.49 | -1.13** | -1.94 |
| RL13161 x KBA 4 | 2.46** | -1.38* | -0.71 | 0.58** | 1.72 | -6.79 | 0.68** | 1.81** | 0.54 | -0.83 | 1.46** | 7.20** |
| Padmani x KBA 4 | -0.68 | -0.01 | 5.31** | 0.96** | 3.07 | -10.91 | 0.19 | 0.71** | 1.13 | 4.82* | -0.08 | -3.94 |
| RL15582 x KBA 4 | -1.08 | -0.64 | -3.40** | -0.35* | 4.41* | 25.16** | 0.13 | -0.95** | 0.72 | 4.63* | 0.59* | -1.52 |
| RL15583 x KBA 4 | -0.21 | 0.42 | -1.16 | 0.52** | 2.3 | 33.81** | -0.87** | -1.50** | 0.47 | -2.16 | 0.86** | 4.64* |
| Meera x KBA 4 | -3.01** | 0.82 | -0.07 | -0.23 | 0.89 | -2.24 | 0 | 0.19 | -1.97** | -1.39 | 0.55 | 3.81 |
| Padmani x RL13161 | 0.16 | 0.86 | -0.25 | -0.1 | 3.08 | 13.52 | -0.36 | 0.43** | -1.61** | 1.05 | 0.25 | -0.01 |
| RL15582 x RL13161 | -1.24 | -0.11 | -1.91 | -0.64** | -4.89** | 21.43** | -0.89** | -0.56** | 0 | -0.15 | -0.2 | -0.11 |
| RL15583 x RL13161 | -1.04 | 0.96 | -1.86 | 0.61** | 2.77 | 7.05 | -0.33 | 0.25* | -2.78** | 3.67 | -0.1 | -4.28 |
| Meera x RL13161 | -0.18 | -1.98** | -1.62 | -0.15 | 2.01 | -1.35 | -0.17 | -0.01 | 1.98** | 1.99 | 0.79** | 0.48 |
| RL15582 x Padmani | -1.04 | -0.08 | -2.52* | 0.84** | -0.91 | -12.62 | 0.98** | 0.50** | 0.27 | 1.64 | 0.89** | 1.35 |
| RL15583 x Padmani | -0.18 | -0.34 | -2.02 | -0.33* | 2.89 | -17.29* | 0.64** | 0.54** | 0.08 | 4.47* | -0.48 | -5.26* |
| Meera x Padmani | -0.31 | 0.39 | -0.15 | 0.04 | -1.92 | 23.11** | -0.13 | -0.16 | -0.3 | 4.16* | 0.26 | -2.46 |
| RL15583 x RL15582 | 2.42** | -0.64 | 3.17** | 0.54** | 1.54 | 19.35** | 1.34** | 0.49** | 1.16 | -1.8 | 1.19** | 6.39** |
| Meera x RL15582 | 0.62 | 0.76 | 1.32 | 0.66** | 2.32 | 3.36 | 0 | 0.22 | 1.27* | 3.96* | 0.25 | -2.77 |
| Meera x RL15583 | -1.84** | -1.18 | -2.60* | -0.14 | 1.21 | 3.62 | -0.37 | -0.43** | -1.83** | 1.35 | -1.41** | -6.44** |
| SE (sij) | 0.65 | 0.63 | 1.11 | 0.15 | 1.83 | 7.13 | 0.2 | 0.12 | 0.6 | 1.95 | 0.29 | 2.16 |
| SE(Sij-ik) | 0.96 | 0.94 | 1.65 | 0.22 | 2.71 | 10.55 | 0.29 | 0.18 | 0.89 | 2.89 | 0.43 | 3.2 |

*, ** significant at 5% and 1% level, respectively.

plant, seven cross for harvest index and nine cross for oil content. Since sca effect of the cross is an estimated for making selection of best cross combinations, high specific combining ability denotes undoubtedly a high heterotic response, this however, does not mean high performance of the hybrid as well as. The above finding were more or less closely in agreement with the result of earlier reports (5,6,7).

## Conclusions

Based on the above discussion combining ability analysis revealed that Meera was emerged as good general combiner for yield and its important contributors. The cross Meera x KBA3 was identified as most promising cross for yield and components based on SCA effects.

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