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Jaishri
Department of Genetics and
Plant Breeding, IGKV,
Raipur, Chhattisgarh, India

Dr. Nandan Mehta
Department of Genetics and
Plant Breeding, IGKV,
Raipur, Chhattisgarh, India

Dr. SS Rao
Department of Genetics and
Plant Breeding, IGKV,
Raipur, Chhattisgarh, India

Combining ability analysis in linseed (*Linum usitatissimum* L.)

Jaishri, Nandan Mehta and SS Rao

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Abstract

The experiment involves 34 genotypes (10 parents, 24 crosses including check). An aggregate of 24 single cross resulted from crossing 6 lines and 4 testers in a line x tester mating design during year-I i.e. *Rabi* 2021-22 and these F_1 's along with their parents including check i.e., RLC-148 were sown in a randomized block design during year-II i.e. *Rabi* 2022-23 at the Research-cum-Instructional Farm of the Department of Genetics and Plant Breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh was undertaken to get information on the nature of combining ability. The negative and significant general combining ability of days to 50% flowering, were recorded for lines IC-0076542 & IC-0498589 and tester RLC-153 & RLC-133 which indicated good general combining ability of these genotypes for earliness. However, for days to maturity lines viz. IC-0525968, IC-0564661 and tester RLC-133, RLC-148 were identified as good general combiner. GCA effect for plant height, technical height & stem diameter was recorded as good general combiner for IC-0498589 and among testers RLC-92 for technical height (cm), seed yield/plant (g), yield/plot (g). Tester RLC-133 and RLC-153 shows good GCA effect for harvest index (%), no of seeds/capsule, 1000 seed weight (g). In RLC-148 shows good general combiners for no of primary branches/plant, no of secondary branches/plant and oil content (%). Therefore, these parents are considered as good general combiners for these traits. The superior cross combinations identified on the basis of specific combining ability for seed yield and contributing traits were IC-0076542xRLC-92, IC-0564654xRLC-133, IC 0564661xRLC-148. The value of SCA variance was found higher than GCA variance, which shows that there is preponderance of non-additive gene action.

Keywords: Good general combiner, good specific combiner, tester, lines

Introduction

Linseed is an important *rabi* oilseed crop chiefly grown under rainfed (63%), utera (25%) and irrigated (12%) conditions. In India, it is predominantly cultivated as an oil seed crop under the sole cropping or utera cropping system. 25-30 °C temperature is good for the germination of seed and approximately 15-20 °C during seed formation. But the crop grown for fiber requires still lower temperature (10-19 °C) and high humidity (76%) the crop is susceptible to frost. It is grown best in well drained, fertile silt loam, clay loam and silt clay soil. It grows well in soil having pH ranging from 5 to 7. A row spacing of 20-30 cm with a plant spacing of 7-10 cm is ideal for getting good production. General seed rate of linseed depends on the method of sowing i.e., 40 kg/ha for line sowing and 60 kg/ha for broadcasting method. Seed rate for growing fiber crop is 60 to 80 kg/ha. Linseed is cultivated in monocropping, intercropping and sequence cropping and *Paira/utera* cropping. Linseed can be grown in fields where other crop may fail to grow. In rainfed areas linseed is generally grown as intercrop with lentil, wheat, chickpea, barley, safflower etc. Nutrient and moisture stress conditions are the main reason for the low productivity of linseed in India.

Line x tester analysis is one of the most powerful tools for predicting the general combining ability (GCA) of parents and selection of suitable parents and crosses with high specific combining ability (SCA). Line x tester analysis provides information about combining ability effects of genotypes and also, knowledge regarding genetic mechanism controlling yield components. Information of general and specific combining abilities influencing yield and its components has become increasingly important to plant breeders to select appropriate parents.

Corresponding Author:
Jaishri
Department of Genetics and
Plant Breeding, IGKV,
Raipur, Chhattisgarh, India

Combining ability analysis is one of the most powerful tools for estimating combining ability variation and effects in order to pick desirable parents and crosses for heterosis exploitation. For estimating genetic control of a certain trait. Estimates of additive and non-additive gene action obtained using this technique may be valuable in establishing the commercial viability of heterosis and pure line isolation. Gene action is a theory that evaluates allelic interactions for characteristics that show phenotypic behavior and lead to perfect trait selection (Nirala *et al.*, 2018) [9].

Objectives

Recognizing the benefit and desire for “Combining ability analysis in linseed (*Linum usitatissimum* L.)” the following objectives were managed at Research-Cum-Instructional-Farm, Department of Genetics and Plant Breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during the Rabi 2021-22 & 2022-23 season.

1. To estimate the relative magnitude of general combining ability.
2. To estimate the relative magnitude of specific combining ability.

Materials and Methods

The research work “Combining ability analysis in linseed (*Linum usitatissimum* L.)” was carried out at the Research-cum-Instructional Farm of the Department of Genetics and Plant Breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during the Rabi 2021-22 & 2022-23 season. The experimental material comprises six lines (IC-0076542, IC-0498589, IC-0525968, IC-0526026, IC-0564661, IC-0564654) and four testers (RLC-92, RLC-133, RLC-148 ©, RLC-153) including one

check variety i.e RLC-148 were crossed in line × tester fashion during rabi 2022-23 and during rabi 2023-24, 24 F₁s produced which were planted

IC-0564661×RLC-92	IC-0564654×RLC-148
IC-0525968×RLC-92	IC-0564661×RLC-148
IC-0564654×RLC-92	IC-0525968×RLC-148
IC-0498589×RLC-92	IC-0498589×RLC-148
IC-0564661×RLC-133	IC-0564654×RLC-153
IC-0564654×RLC-133	IC-0525968×RLC-153
IC-0525968×RLC-133	IC-0498589×RLC-153
IC-0525969×RLC-133	IC-0564661×RLC-153

Results and Discussion

Lines from the parents as a good general combiner, IC-0498589 exhibits good GCA effect for plant height, technical height, and stem diameter. Among testers, RLC-92 exhibits good GCA effect for technical height (cm), seed yield/plant (g), and seed yield/plot (g), while RLC-133 and RLC-153 exhibit good GCA effect for harvest index (%), number of seeds/capsule, and 1000 seed weight (g). RLC-148 displays good general combiners for the number of primary and secondary branches per plant as well as the percentage of oil content. As a result, their parents are regarded as effective general combiners for these characteristics.

The cross combinations IC-0076542×RLC-92 for days to 50% flowering, plant height (cm), no of Primary branches/plant, stem diameter (mm) shows good SCA effect followed by IC-0564654×RLC-133 for days to maturity, plant height (cm), no of primary branches/plant, no of seeds/capsule, stem diameter (mm) and IC-0564661×RLC-148 for days to maturity, no of secondary branches/plant, harvest index (%), seed yield/plant (g), seed yield/plot (g).

Table 1: General combining ability (GCA) effects of lines and testers for seed yield and its components in linseed at Raipur (C.G.) Year-II (2022-23).

S.N.	Characters	Days to 50% flowering	Days to Maturity	Plant Height (cm)	Technical Height (cm)	No of Primary Branches/ Plant	No of secondary Branches/ Plant	Stem diameter (mm)	Oil Content (%)	Harvest Index (%)	No of Seeds/ capsule	1000 Seed Weight (g)	Seed yield/ plant (g)	Yield/ plot (g)	Seed yield (kg/ha)
Lines															
1	IC-0076542	-1.15**	-1.58	2.39**	0.00	-0.71**	0.92*	-0.03	0.17	-4.12**	-0.62**	-0.01	0.05	2.84	18.98
2	IC-0498589	-1.04**	0.48	3.22**	2.40*	0.35**	0.77**	0.22**	-1.03	-0.45*	0.48**	0.06*	0.33**	-16.73*	-111.57**
3	IC-0525968	0.54	-3.81	-3.94**	-2.81**	0.27*	2.73**	-0.12**	0.72	0.91**	-0.04	-0.02	0.32**	-16.31**	-108.79**
4	IC-0526026	2.26**	0.40	0.80*	0.58	-0.29*	-0.56**	-0.03	0.92	0.66**	0.00	-0.09**	0.64**	32.01**	213.42**
5	IC-0564661	-0.25	4.92	-2.11**	-0.057	0.50**	-0.20	0.06*	1.50	2.95**	-0.11	-0.02	0.36**	18.26**	121.75**
6	IC-0564654	-0.35	-0.41	-0.36	-0.12	-0.11	-3.65**	-0.09**	-2.27*	0.05	0.30*	0.08**	-0.40**	20.06**	-133.79**
Testers															
		Days to 50% flowering	Days to Maturity	Plant Height (cm)	Technical Height (cm)	No of Primary Branches/ Plant	No of secondary Branches/ Plant	Stem diameter (mm)	Oil Content (%)	Harvest Index (%)	No of Seeds/ capsule	1000 Seed Weight (g)	Seed yield/ plant (g)	Yield/ plot (g)	Seed yield (kg/ha)
5	RLC-92	1.69**	1.60	-1.38**	-2.26*	-0.55**	-0.08	-0.03	-0.19	-0.52**	-0.40**	0.04	0.19**	9.65**	64.35**
6	RLC-133	-0.63*	-3.80	0.50	0.65	-0.55**	-1.31**	-0.06**	0.21	2.67**	0.47**	-0.08**	-0.03	-1.73	-11.57
7	RLC-148 ©	-0.06	-0.01	-0.78**	0.43	0.96**	2.19**	-0.06**	-0.37	-0.76**	-0.04	0.05*	0.02	1.31	0.22**
8	RLC-153	-0.99**	2.22	1.66**	1.17	0.15	-0.79**	0.16**	0.36	-1.38**	-0.02	-0.01	-0.18**	-9.23**	-0.12**

Table 2: Specific combining ability (SCA) effects of F₁ for seed yield and its components in linseed at Raipur (C.G.) Year-II (2022-23).

S.N.	F ₁ 's	Days to 50% flowering	Days to Maturity	Plant Height (cm)	Technical Height (cm)	No of Primary Branches/Plant	No of secondary Branches/Plant	Stem diameter (mm)	Oil Content (%)	Harvest Index (%)	No of Seeds/capsule	1000 Seed Weight (g)	Seed yield/plant (g)	Yield/plot (g)	Seed yield (kg/ha)
1	IC-0076542×RLC-92	-2.47**	1.14	-5.77**	-4.68*	0.74*	-5.45**	-0.26**	-1.40	3.92*	-1.26*	-0.06	0.335*	-16.73*	111.57*
2	IC-0498589×RLC-92	-1.61*	4.26	1.33	2.10	2.22*	5.27**	0.16**	-2.810	4.54**	1.35**	0.15**	-0.207	-10.34	-68.9
3	IC-0525968×RLC-92	-2.17**	0.64	3.28*	1.19	-0.09	2.63*	0.26**	1.87	2.84**	1.26**	0.14**	0.49**	24.931*	166.**
4	IC-0526026×RLC-92	6.25**	-3.76	1.16	1.39	-1.38*	-2.45*	-0.16**	2.33	-3.46**	-1.35**	-0.23**	0.04	2.15	14.35
5	IC-0564661×RLC-92	-3.38**	-0.71	7.38*	4.69*	-0.84**	0.22	0.47**	0.90	-3.98**	0.12	-0.11*	0.25*	12.84*	85.64*
6	IC-0564654×RLC-92	3.27**	1.03	-6.50**	-2.30	0.35	-2.74*	-0.29*	1.43	3.80**	0.44	0.11*	-0.51*	25.76**	-171.75**
7	IC-0076542×RLC-133	1.14	-0.65	-2.21*	-0.23	0.23	-1.58**	-0.46**	-0.61	-2.75**	-0.43	-0.07	0.12	6.18	41.20
8	IC-0498589×RLC-133	-1.02	0.33	1.33	-2.15	0.25	4.10**	0.27*	-1.72	2.93**	-0.12	0.07	0.13	6.73	44.90
9	IC-0525968×RLC-133	-0.63	2.58	-0.44	-2.16	0.43	7.03*	0.12*	-1.85	6.67**	0.04	0.17**	1.04*	52.43*	349.5*
10	IC-0526026×RLC-133	6.12**	1.56	9.9**	5.62**	-0.66**	-7.03**	0.04	0.04	-8.16**	-1.13**	-0.19**	0.11	5.48	36.57
11	IC-0564661×RLC-133	1.12	2.21	-4.05*	-4.52*	-1.08*	4.95**	0.18**	2.22	2.04**	-0.44	-0.04	-0.88**	-44.23**	-294.9**
12	IC-0564654×RLC-133	-6.61*	-6.36	-5.50*	1.06	1.32*	-4.95*	-0.27**	-0.41	-0.56	1.53**	0.06	-0.27*	13.68*	-91.20*
13	IC-0076542×RLC-148	-0.92	-6.09	-4.19**	-1.74	0.39	-4.96**	-0.56**	-1.05	6.97**	-1.59*	-0.12*	-0.81*	-40.90*	-272.68**
14	IC-0498589×RLC-148	-3.70*	10.44	-2.75**	-2.61	0.06	3.26**	0.26**	-0.56	-0.25	0.06	0.13*	0.21	10.48	69.90
15	IC-0525968×RLC-148	4.73**	-3.67	2.19*	1.54	1.28**	4.25***	0.06	3.22	12.08***	1.51***	0.02	0.949**	47.43***	316.20***
16	IC-0526026×RLC-148	-0.10	-0.67	4.74*	2.81	-1.60**	-2.55**	0.23***	-1.61	-4.85***	0.022	-0.048	-0.34**	-17.01**	-113.42**
17	IC-0564661×RLC-148	3.82**	-6.48	3.39**	1.88	0.13	5.03**	0.23**	-1.63	7.63**	1.122**	0.073	0.55***	27.84**	185.64**
18	IC-0564654×RLC-148	-4.17**	10.9	-1.16	1.22	-1.06**	0.19	0.06	1.85	2.46***	1.04***	0.00	0.215	-10.764	-71.75
19	IC-0076542×RLC-153	-2.51**	-6.99	2.42**	1.45	-0.24	4.60**	-0.23*	-0.05	-16.76***	-2.83***	-0.10	-0.176	-8.819	-58.79
20	IC-0498589×RLC-153	2.85**	2.56	-4.66**	-4.55*	1.16**	-0.62	-0.06	-0.16	6.66**	0.67*	0.031	-0.165	-8.264	-55.09
21	IC-0525968×RLC-153	3.59**	11.85	-0.36	2.01	0.62*	-1.88**	-0.007	5.04**	0.57	1.57**	0.060	0.710**	-35.486**	-236.57***
22	IC-0526026×RLC-153	0.09	-28.2**	-0.91	-4.03	-0.77**	1.04*	-0.17**	0.04	-2.40**	-1.77*	-0.22**	0.618**	30.903**	206.02**
23	IC-0564661×RLC-153	-2.31*	8.47	-1.63*	0.58	-0.09	-5.65**	0.18**	-6.67**	2.53**	0.94***	0.04	-0.510*	-25.486**	-169.91**
24	IC-0564654×RLC-153	-1.37	7.90	2.91**	1.43	0.25	6.49**	-0.007	1.58	-0.70	-0.74**	0.117*	0.601**	30.069**	200.46**
	CD (5%)	1.38	12.21	1.35	4.17	0.47	0.66	0.83	1.76	0.68	0.53	0.10	0.24	12.31	2.102

** and * Significant at P = 1% & 5% level, respectively

Conclusion

Line x Tester mating design is an extension (modified version) of top cross method in which several testers are used. The line x tester analysis is a common approach for assessing the expression of genetic aspects of traits (Kempthorne, 1957) [6], which provides information about GCA and SCA of parents and at the same time it is helpful in identifying best heterotic crosses. Also, line x tester analysis provides information regarding genetic mechanism controlling yield and yield components. It is one of the most powerful tools for predicting the general combining ability (GCA) of parents and selection of suitable parents and crosses with high specific combining ability (SCA).

The general (GCA) and specific (SCA) combining ability had a significant impact on evaluation of genotypes and population improvement. The GCA is the average performance of a genotype in hybrid combinations with number of genotypes. The SCA is the average performance of a specific cross combination expressed as deviation from the population mean. Combining abilities estimation can be

used to determine the usefulness of the parents in hybrid combinations and to develop best hybrid adaptable to the different environments (Sprague and Tatum, 1942) [12].

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