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Combining Ability Analysis for Yield and Yield Contributing Traits in Linseed (*Linum usitasissimum* L.)

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A B S T R A C T

The present investigation was carried out with a set of ten genotypes of linseed and their forty five F_1S synthesized through diallel design excluding reciprocals. These were grown in Randomized Block Design during *rabi* season of 2019-2020 at farm of AICRP on linseed and mustard, College of Agriculture, Nagpur and studied for eight quantitative characters. The observations were recorded on *i.e.* plant height (cm), number of branches plant^{-1}, number of capsule plant^{-1}, budfly infestation (%), days to 50% flowering (on plot basis), days to maturity (on plot basis), seed yield plant^{-1} (g) and 1000 seed weight (g). Analysis of variance showed highly significant differences among the genotypes for all the characters studied. Four parents *viz.*, NL 115, Neelum, Tiara and PKV NL 260 possesed positive significant gca effects and NL 115 and PKV NL 260 gaves high mean performance and were found good general combiners for seed yield plant^{-1}, number of capsule plant^{-1} and 1000 seed weight and the six parents namely Neela, EC 99001, NL 367, NL 142, Padmini and NL 165 possesed negative GCA effects and were found good general combiners for bufly resistance. Hence, PKV NL 260 on crossing with EC 99001 and Neela and NL 115 on crossing with EC 99001 and Neela can be used in hybridization programme to get better transgressive segregates' for yield and budfly resistance. Among the 45 crosses studied, the crosses NL 165 × Neelum, NL 142 × Padmini, EC 99001 × PKV NL 260 and NL 367 × Tiara were found most promising as they possessed high mean performance for most the yield and yield contributing character along with negative non significant SCA effect for seed yield plant^{-1}, number of capsule plant^{-1} and 1000 seed weight. The parents involved in these crosses also possessed high mean performance for yield and yield contributing characters and desirable GCA effects for yield and yield contributing characters in both the parents and thus can be used in varietal development.

Introduction

Linseed (*Linum usitatissimum* L.) ia an annual self pollinated diploid (2x=2n=30) oilseed crop belonging to linaceae family rich in oil (41%), protein (20%) and rich source of omega 3 fatty acids which reduces the heart diseases.

The study of combining ability helps in selection of best combiners and provides opportunity for the use of these combiners in hybridization 5 programme.

General combining ability (GCA) is primarily a function of additive gene action and additive x additive gene interaction, whereas specific combining ability (SCA) is due to non-additive gene interaction. General combining ability (GCA) and SCA effects determine the potential of parents / crosses for mobilizing them in an efficient breeding programme.

Materials and Methods

The experimental material comprised of ten parents crossed in fashion to obtain 102 crosses during *rabi* 2019-20. These 45 crosses along with 37 parents were grown in Randomized Block Design in two replications with the spacing of 30 cm x 5 cm during *rabi* 2020-21 at farm of AICRP on linseed and mustard, College of Agriculture, Nagpur. Five plants were taken randomly from each plot for recording the observations.

Observations were recorded for eight quantitative characters viz., plant height (cm), number of branches plant^{-1}, number of capsule plant^{-1}, budfly infestation (%), days to 50% flowering (on plot basis), days to maturity (on plot basis), seed yield plant^{-1} (g) and 1000 seed weight (g). The combining ability analysis was carried out as per standard method given by Kempthrone (1957) and ANOVA as per Panse and Sukhatme (1954).

Results and Discussion

The study of combining ability helps in selection of best combiners and provides opportunity for the use of these combiners in hybridization programme. General combining ability (GCA) is primarily a function of additive gene action and additive x additive gene interaction, whereas specific combining ability (SCA) is due to non-additive gene interaction. General combining ability (GCA) and SCA effects determine the potential of parents/crosses for mobilizing them in an efficient breeding programme.

The analysis of variance (Table-1) for combining ability revealed that mean square due to parents and crosses were significant for all the characters studied indicating substantial genetic variability for general combining ability among the parents and specific combining ability among the crosses. The significant mean squares for parents and crosses were also observed by Singh *et al.*, (2016), Nirala *et al.*, (2018) and Shekhar *et al.*, (2019). Significance of mean squares indicates significant variation among crosses for combining ability hence allows the estimates of gca and sca effects.

General Combining Ability (GCA)

The General combining ability (GCA) effects of parent are presented in Table-2. While considering gca effect of the parent was found that none of the parent was found as a good general combiners for all the nine characters.

However NL 115, Neelum, Tiara and PKV NL 260 were found good general combiners for days to 50% flowering and days to maturity. NL 115, NL 142, Neelum and Tiaraa were found good general combiners for plant height. NL 115, Padmini, Neelum, Tiara and PKV NL 260 were found good general combiners for number of branches plant^{-1}.

Table.1 Analysis of variance for combining ability in linseed

Source of variation	d.f.	Plant height	No. of branches plant^{-1}	No.of capsule plant^{-1}	Budfly infestation	Days to 50% flowering	Days to maturity	Seed yield plant^{-1}	1000 seed weight
Due to gca	9	2,477.76**	2,345.92**	1,780.92**	1,930.32**	1,540.25**	1,457.60**	2,353.57**	2,526.77**
Due to sca	**44**	3,309.59**	2,656.86**	2,560.91**	2,310.29**	2,332.07**	2,480.12**	2,479.61**	2,926.99**
Error	**54**	18.394	14.348	13.298	10.362	12.851	13.999	10.601	25.952

Table.2 General combining ability effects of the parents for different characters

Sr. No.	Genotypes	Plant height (cm)	Number of branches plant^{-1}	Number of capsules plant^{-1}	Bud fly infestation (%)	Days to 50% flowering	Days to maturity	Seed yield plant^{-1} (g)	1000 seed weight (g)
	Lines								
1	NL 115	5.664**	2.666**	10.049**	4.371**	3.951**	7.256**	5.694**	**5.179****
2	NL 165	-2.272	0.26	-0.147	-3.65	-0.809	-1.079	-0.257	**2.323***
3	NL 142	4.332**	-5.637	-2.187	-3.377	-6.829	-3.457	-10.252	**-5.088**
4	NL 367	-10.598	-8.007	-6.98	-4.855	-7.371	-6.716	-6.304	**-7.888**
5	Padmini	-1.347	8.385**	-0.899	-2.055	-2.078	-2.125	-0.832	**5.948****
6	Neelum	13.689**	18.267**	11.93**	15.829**	15.196**	12.566**	18.939**	**19.141****
7	Neela	-10.745	-10.617	-12.736	-9.975	-7.18	-8.612	-10.017	**-13.192**
8	Tiara	15.183**	5.799**	8.081**	7.974**	7.515**	9.003**	3.822**	**3.335****
9	EC 99001	-14.983	-14.628	-11.217	-12.844	-8.754	-10.3	-11.135	**-14.695**
10	**PKV NL 260**	**1.077**	**3.513****	**4.106****	**8.581****	**6.36****	**3.465****	**10.341****	**4.936****

T**able.3** Specific combining ability effects of crosses for different characters

Sr. No.	Genotypes	Plant height (cm)	Number of branches plant^{-1}	Number of capsules plant^{-1}	Bud fly infestation (%)	Days to 50% Flowering	Days to maturity	Seed yield plant^{-1} (g)	1000 seed weight (g)
	Lines								
1	NL 115 ×NL 165	-32.94	-29.51	-34.69	-27.82	-28.61	-31.92	-32.88	**-37.36**
2	NL 115× NL 142	55.66**	42.64**	41.36**	51.76**	34.96**	76.12**	25.91**	**52.88****
3	NL 115× NL 367	2.67	-2.66	-7.55	-9.98	2.47	-12.45	-10.98	**-8.77**
4	NL 115× Padmini	-29.46	-8.43	-22.58	-11.22	-19.75	-21.41	-27.73	**-33.33**
5	NL 115×Neelum	-49.74	-49.22	-49.95	-45.79	-45.31	-45.75	-51.59	**-53.27**
6	NL 115× Neela	19.14**	44.45**	29.81**	32.91**	31.01**	31.24**	45.48**	**33.65****
7	NL 115× tiara	49.21**	60.54**	60.49**	65.96**	64.82**	49.12**	61.64**	**54.63****
8	NL 115× EC 99001	-19.90	-15.81	-25.88	-17.19	-22.22	-22.25	-21.19	**-17.48**
9	NL 115× PKV NL 260	-38.50	-37.59	-45.84	-40.95	-37.88	-35.68	-45.80	**-40.01**
10	NL 165 × NL142	5.12	9.67**	13.25	11.73**	11.30**	-0.58	22.67**	**22.49****
11	NL 165 ×NL 367	-16.70	-20.04	-21.13	-17.89	-19.33	-18.58	-20.91	**-24.21**
12	NL 165×Padmini	67.13**	49.07**	48.13**	14.48**	30.59**	14.58**	29.12**	**81.74****
13	NL 165× Neelum	-20.65	-32.82	-23.31	-24.01	-25.93	-1.67	-26.37	**-34.59**
14	NL 165× Neela	-11.39	-1.52	-8.76	-1.29	-7.16	-1.19	13.31**	**-6.29**
15	NL 165× Tiara	-43.53	-34.16	-36.57	-29.82	-32.85	-33.37	-29.10	**-34.81**
16	NL 165×EC99001	40.81**	41.87**	47.98**	42.80**	40.35**	42.76**	40.05**	**37.01****
17	NL 165× NL260	59.75**	68.73**	69.16**	67.87**	74.23**	72.49**	55.07**	**58.38****
18	NL 142 ×NL 367	-26.12	-17.68	-20.27	-20.91	-14.18	-16.76	-11.46	**-18.27**
19	NL 142×Padmini	-31.75	-28.12	-23.27	-20.04	-15.01	-18.04	-14.61	**-29.31**
20	NL 142×Neelum	5.41	17.17**	15.87**	11.15**	-2.28	-14.10	7.47**	**8.79***
21	NL 142×Neela	-24.28	-11.90	-13.79	-12.18	-15.01	-14.93	-5.95	**-9.08**
22	NL 142×tiara	124.10**	35.44**	39.71**	29.57**	27.57**	25.38**	-2.91	**18.49****
23	NL 142×EC99001	-2.72	1.76	8.12**	4.70*	14.39**	11.84**	18.86**	**8.17***
24	NL	4.58	10.87**	15.74**	17.38**	-2.45	-13.77	24.74**	**19.79****

	142×PKVNL260								
25	NL 367×Padmini	38.50**	32.62**	46.00**	52.21**	36.24**	45.72**	43.29**	**36.08****
26	NL 367×Neelum	63.47**	63.24**	61.67**	66.33**	66.96**	74.03**	50.52**	**63.89****
27	NL367×Neela	-8.24	-9.23	-8.00	-11.94	-10.47	-10.44	-11.59	**-6.37**
28	NL 367× Tiara	-37.19	-27.92	-30.44	-32.06	-28.77	-31.33	-26.59	**-26.18**
29	NL 367× EC99001	-2.61	-3.41	-6.46	-7.55	-7.84	-6.38	-8.23	**-7.58**
30	NL 367× PKVNL260	4.58	10.87**	15.74**	17.38**	-2.45	-0.04	24.74**	**19.79****
31	Padmini×Neelum	11.71**	66.72**	13.18**	7.75**	30.39**	10.02**	40.76**	**69.08****
32	Padmini×Neela	9.42**	10.99**	-2.16	10.05**	2.88	7.21**	1.84	**-4.34**
33	Padmini× Tiara	-23.99	-32.99	-28.87	-20.71	-27.92	-18.41	-21.72	**-32.13**
34	Padmini× EC99001	-13.89	-23.01	-15.68	-11.29	-16.06	-13.32	-15.49	**-20.28**
35	Padmini× PKVNL260	31.33**	23.10**	35.91**	23.28**	24.00**	37.54**	16.15**	**16.75****
36	Neelum×Neela	-33.18	-34.54	-25.30	-29.70	-33.01	-29.70	-35.90	**-34.66**
37	Neelum× Tiara	-62.67	-53.59	-49.74	-53.15	-50.52	-51.14	-53.92	**-53.27**
38	Neelum× EC99001	-26.25	-31.39	-25.52	-30.46	-31.73	-28.41	-34.24	**-32.83**
39	Neelum× PKVNL260	16.54**	-17.53	-12.42	15.59**	19.64**	-10.78	54.72**	**5.16**
40	Neela× Tiara	49.05**	23.10**	35.36**	30.60**	35.25**	53.49**	25.55**	**34.50****
41	Neela× EC99001	23.69**	5.24*	9.02**	6.00**	27.99**	2.22	5.93**	**13.13****
42	Neela× PKVNL260	-10.13	-11.32	-13.36	-15.15	-21.99	-16.35	-24.85	**-16.57**
43	Tiara× EC99001	21.36**	44.33**	37.25**	36.17**	34.02**	43.18**	51.47**	**39.00****
44	Tiara× PKVNL260	44.80**	65.19**	60.43**	57.75**	62.91**	52.41**	65.99**	**71.87****
45	EC99001× PKVNL260	-18.44	-20.27	-22.19	-25.12	-24.97	-19.54	-27.86	**-21.98**
46	**SE(s_{ij})**	**2.794**	**2.467**	**2.375**	**2.097**	**2.335**	**2.437**	**2.121**	**3.318**

NL 115, Neelum, Tiara and PKV NL 260 were found good general combiners for number of capsule plant^{-1}, seed yield plant^{-1}, 1000 seed weight. NL 115, Neelum, Tiara and PKV NL 260 were found good general combiners for budfly resistance in linseed. 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 (Moneum *et al.,* 2014 and Singh *et al.,* 2016).

Specific Combining Ability (SCA)

The choice of parents for hybridization influences the success in any crop improvement program. The selection of parents based on *per se* performance is not always good indicator of superior combining parents. Hence, the combining ability analysis serve as an important tool for selection of parents with highest breeding value. The parents with high general combining ability effects may be used for improvement of individual trait *per se*. The SCA effects do not contribute tangibly in the improvement of self fertilizing crops, except where commercial exploitation of heterosis is feasible. The SCA value represents the dominance and epistatic interactions which are non-fixable in nature and related to heterosis (Griffing, 1956). Therefore, if both or one of the parents involved in the crosses with high SCA values they could be successfully exploited in varietal improvement program and expected to give superior transgressive segregants. Among the 45 crosses studied, the crosses NL 165 × Neelum, NL 142 × Padmini, EC 99001 × PKV NL 260 and NL 367 × Tiara were found most promising as they possessed high mean performance for most the yield and yield contributing character along with negative non significant SCA effect for seed yield plant^{-1}, number of capsule plant^{-1} and 1000 seed weight. The parents involved in these crosses also possessed high mean performance for yield and yield contributing characters and desirable GCA effects for yield and yield contributing characters in both the parents. The above findings less more closely in agreement with the result of earlier reports (Nirala *et al.,* 2018 and Shekhar *et al.,* 2019).

Based on the above discussion combining ability analysis revealed that NL 115, Neelum, Tiara and PKV NL 260 were found good general combiners for yield and yield contributing characters. The crosses NL 165 × Neelum, EC 99001 ×PKV NL 260, NL 367 × Tiara and NL 142 × Padmini were identified most promising crosses for yield and its components based on sca effects.

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