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COMBINING ABILITY ANALYSIS IN LINSEED

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ABSTRACT

Eighteen crosses developed by crossing nine lines and two testers in line x tester fashion were evaluated in randomized block design with three replications during *rabi* 2017, to study the general and specific combining ability of parents and crosses respectively and to select good combiner parents and superior crosses for studying them in next generation. Observations were taken on days to 50% flowering, days to maturity, plant height (cm), number of primary branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}, 1000 seed weight (g) and seed yield plant^{-1} (g).Analysis of variance for combining ability recorded that, the mean squares due to lines and testers were significant for all the characters. The mean squares due to line x tester were significant for all characters studied except days to 50% flowering. The parents CI-1924 and GS-64 and PKVNL-260 were identified as good general combiners for seed yield plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}which can be exploited for intensive breeding programme. Out of eighteen crosses, cross i.e. CI-1924 x PKVNL-260 exhibited high mean performance and having both the parents with significant gca effect for four characters *viz*., plant height, number of capsules plant^{-1}, number of seeds capsule^{-1} and seed yield plant^{-1}. The cross CI-1924 x PKVNL-260 also exhibited significant sca effect for seed yield plant^{-1}, indicating potential for exploiting hybrid vigour in breeding programme.
(Key words: Linseed, combining ability, gca, sca, Line x Tester)

INTRODUCTION

Linseed (*Linum usitatissimum* L.) is a pristine crop cultivated since ages getting its mention in Vedas and manusmriti. The Genus *Linum* has over 200 species of which *Linum usitatissimum* (L.) is the only economically important species. It has somatic chromosome number 2n=30 and varies from 16 to 86 in other species. It is an annual autogamous plant grown during *rabi* season in India. It contains 35 to 45 % oil. Each and every part of plant is endowed with some quality. It's medicinal and nutraceutical properties have paved the way for its diversified uses value addition in various forms. Its seed comprises of complete protein (rich in eight essential amino acids), higher order linolenic acid (an essential poly unsaturated omega-3 fatty acid) highest in plant kingdom, complex carbohydrates, vitamins and minerals. Recent advances neuro-biology has established that it is the best herbal source of Omega-3 (57%) and Omega-6 fatty acid (8%) which helps in regulating the nervous system and act as brain tonic known to cure the diseases like cardiovascular disease, diabetes, rheumatoid arthritis and behavioral problem.

The success of any hybridization programme chiefly depends on combining ability of parents used in crossing programme. Selection of superior segregants followed by the selection of the best one are the basic tasks of any breeding process. To initiate an effective breeding programme, combining ability analysis is a powerful tool to identify parents with better potential to transmit desirable characteristics to the progenies and to identify the best specific crosses for yield parameters. It provides the base to select good combiners and also to understand the nature of gene action. Moreover, the exploitation of heterosis is primarily dependent on the development of high *per se* performing lines with good general combining ability (Singh *et al*., 2016).

Keeping in view the importance of this crop and the above fact, the present study was under taken to estimate general and specific combining ability of parents and crosses respectively and to identify superior hybrids with good yield potential.

MATERIALS AND METHODS

The experimental material comprised of nine lines and two testers crossed in line x tester fashion to obtain eighteen crosses during *rabi* 2015-2016.These eighteen crosses (F_1's) along with parents were grown in Randomised Block Design in three replications with the spacing of 30 cm x 5 cm during *rabi* 2016-2017 at the experimental farm of All India Coordinated Research Project on Linseed, College of Agriculture, Nagpur. Observations were recorded on five

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randomly selected plants for each cross in each replication for the characters including days to 50% flowering, days to maturity, plant height (cm), number of primary branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1},1000 seed weight (g) and seed yield plant^{-1} (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 data regarding analysis of variance for various characters are presented in table 1. The mean squares of genotypes was highly significant for all the eight characters studied. This indicated the presence of sufficient variability in the material used for this study which allows the exploitation of the material for further analysis. Similar to this result Pali and Mehta (2014) and Singh *et al.* (2016) also reported significant mean squares for genotypes in linseed.

Analysis of variance for combining ability has been presented in table 2. The variation between crosses was partitioned into different components representing mean squares due to lines, testers and line x tester. The mean squares due to lines and testers were significant for all the characters. The mean squares due to testers for all characterswere higher in magnitude than those due to lines, indicating large diversity among the testers than in lines for these characters. The mean squares due to line x tester were significant for all characters under studied except days to 50% flowering indicating considerable genetic variability for specific combining ability among crosses. The significant mean squares for line, tester and lines x testers were also observed by Pali and Mehta (2014), Kumar *et al.* (2016) and Naik (2017). Significance of mean squares indicates significant variation among crosses for combining ability hence, allows the estimates of gca and sca effects.

The predictability ratio (gca vs sca) was for days to 50% flowering (0.99), days to maturity (0.98), number of primary branches plant^{-1} (0.91), number of capsules plant^{-1} (0.85), number of seeds capsule^{-1} (0.93), 1000 seed weight (0.96) and seed yield plant^{-1} (0.85) was almost close to unity which indicated the preponderance of additive genetic component for the development of these characters. The closer this ratio to unity, the greater is predictability based on general combining ability alone. It is concluded that general combining ability of parents is the important criteria for selecting genetically superior parents that would give promising cross combinations for isolating desirable segregates. The present finding was in accordance with the results reported earlier by Mohammadi *et al.* (2010), Singh *et al.* (2016) and Kumar *et al.* (2017) which also found predictability ratio close to unity.

The gca effects of lines and testers were estimated for the eight characters presented in table 3. Sca effects of 18 crosses for all characters except days to 50% flowering were calculated and are presented in table 4. The sca effect of crosses for days to 50% flowering was not estimated as its respective mean squares was non significant.The estimates of gca and sca effects among the parents and crosses showed wide variation in the level of significance for various characters. Some of the parents and crosses had a high and significant gca and sca effects in the desirable direction for some of the characters studied. The significant gca and sca effects were also reported by Prasad *et al.* (2014) and Kumar *et al.* (2016) in linseed.

The estimates of gca effects showed that among the testers, PKVNL-260 was found to be the best general combiner as it recorded significant gca effects for almost all the characters in desirable direction. The lines CI-1924 and GS-64 were found to be good general combiner. Line CI-1924 exhibited significant positive gca effects for four economically important characters i.e. seed yield plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1} and 1000 seed weight and GS-64 also exhibited significant positive gca effects for two economically importance characters i.e. seed yield plant^{-1} and number of seeds capsule^{-1}. These three genotypes PKVNL-260, CI-1924 and GS-64 were identified as good general combiners and an intermating population involving all possible crosses among these selected parents subjected to biparental mating may be expected to offer maximum promise in breeding for high yield.

Out of eighteen crosses studied,two crosses i.e.CI-1924 x PKVNL-260 and GS-61 x NL-97 had significant positive sca effect for the economically important characters i.e. seed yield plant^{-1}, number of capsules plant^{-1} and number of seeds capsule^{-1}.

The cross CI-1924 x PKVNL-260 which exhibited high mean performance, involved both the parents with significant positive gca effect for seed yield plant^{-1}, number of capsules plant^{-1} and number of seeds capsule^{-1} and also with positive significant sca effect for seed yield plant^{-1} was identified as potential cross for exploitation through heterosis breeding, providing that the technical problems hampering economical production hybrid seeds in linseed could be overcome.

Table 1. Analysis of variance for various characters

Sources of variation	d.f.	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of primary branches plant^{-1}	No. of capsules plant^{-1}	No. of seeds capsule^{-1}	1000 seed weight (g)	Seed Yield plant^{-1} (g)
		Mean squares							
Replications	2	2.22	8.93	11.86	0.021	44.53	0.57	0.019	0.21
Genotypes	28	38.99**	133.24**	98.50**	5.38**	517.3**	2.35**	1.45**	0.63**
Error	56	2.37	2.87	19.34	0.21	46.92	0.34	0.012	0.082

Note: * , ** = Significant at 5% and 1% level respectively.

Table 2.Analysis of variance for combining ability

Sources of variation	d.f.	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of primary branches plant^{-1}	No. of capsules plant^{-1}	No. of seeds capsule^{-1}	1000 seed weight (g)	Seed Yield plant^{-1} (g)
		Mean squares							
Lines	8	14.27**	41.75**	71.55*	1.68**	222.12*	3.16**	2.43**	0.43**
Testers	1	462.3**	1968.07**	177.05*	6.82**	2083**	16.58**	1.11**	3.23**
Line x Tester	8	1.88	38.24**	82.86*	0.802*	418.75**	1.51*	0.14**	0.66**
Error	34	3.92	4.73	31.85	0.32	77.27	0.56	0.019	0.13
Predictability ratio (GCA vs SCA)		0.996	0.98	0.75	0.91	0.85	0.93	0.96	0.85

*, ** = Significant at 5% and 1% level respectively.

Table 3.Mean performance and general combining ability effects of parents for different characters

Sr. No.	Parents	Days to 50% flowering		Days to maturity		Plant height (cm)		No. of primary branches plant^{-1}		No. of capsules plant^{-1}		No. of seeds capsules^{-1}		1000 seed weight (g)		Seed yield plant^{-1} (g)	
	Lines	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA
1	CI-1924	61.67	1.52	108.00	2.17*	49.47	5.96*	2.80	0.34	31.13	7.60**	6.93	0.75*	5.35	0.49**	1.37	0.34*
2	EC-511	66.33	-2.48**	111.33	-0.83	48.00	-1.31	2.00	0.49*	23.40	-1.18	7.33	-0.57	6.88	0.76**	1.27	-0.33*
3	EC-704	57.67	-0.65	104.33	-0.83	57.27	0.66	2.20	0.18	25.40	2.09	6.93	-0.32	5.98	-0.28**	1.53	-0.41*
4	EX-313-23	60.00	1.35	112.33	4.83**	51.67	-2.76	3.40	0.54*	28.53	-11.17**	7.23	-1.37**	4.77	-0.83**	1.40	-0.05
5	FR-11	61.33	-1.98*	104.33	-1.83*	50.80	5.47*	2.87	-0.37	30.60	-0.90	7.93	-0.04	6.25	0.16**	1.60	-0.08
6	FRW-9	69.33	0.02	115.33	-3.17**	55.00	-1.03	4.30	0.52*	44.40	7.45**	6.40	0.08	6.57	0.87**	1.97	0.04
7	GS-61	61.33	-0.48	110.67	0.33	60.60	-3.02	2.53	-0.70**	38.80	-0.01	7.33	0.11	5.47	-0.65**	1.85	-0.02
8	GS-64	69.67	0.85	117.00	-2.83**	56.13	-3.03	2.03	-0.79**	31.93	2.76*	6.13	1.13**	5.75	-0.65**	1.33	0.40*
9	GS-85	61.00	1.85*	106.67	2.17*	57.07	-0.92	2.53	-0.20	43.20	-6.63**	7.47	0.23	6.13	0.13*	2.13	0.11
	SE(g_i)		0.81		0.89		2.30		0.24		1.35		0.43		0.06		0.15
	Testers																
1	NL-97	63.33	2.93**	114.00	6.04**	68.00	-1.81	1.80	-0.36**	25.00	-6.21**	7.27	-0.55**	6.47	-0.14**	1.27	-0.24**
2	PKVNL-260	58.33	-2.93**	99.00	-6.04**	50.40	1.81	1.60	0.36**	56.80	6.21**	8.03	0.55**	7.07	0.14**	2.33	0.24**
	SE(g_j)		0.38		0.42		1.09		0.11		1.69		0.14		0.03		0.07

*, ** = Significant at 5% and 1% level respectively.

Table 4.Mean performance and specific combining ability effects of crosses for different characters

Sr. No.	Parents	Days to maturity		Plant height (cm)		No. of primary branches plant^{-1}		No. of capsules plant^{-1}		No. of seeds capsule^{-1}		1000 seed weight (g)		Seed yield plant^{-1} (g) (g)	
	Lines	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA
1	CI-1924 x PKVNL-260	100.67	-1.46	64.18	5.45	5.57	0.06	68.72	6.28	8.87	0.30	7.25	0.09	2.98	0.49*
2	CI-1924 x NL-97	115.67	1.46	49.67	-5.45	4.75	-0.06	43.75	-6.28	7.17	-0.30	6.78	-0.09	1.51	-0.49*
3	EC-511 x PKVNL-260	98.00	-1.13	48.12	-3.35	5.40	-0.27	43.00	-10.67*	6.97	-0.28	7.40	-0.03	1.71	-0.10
4	EC-511 x NL-97	112.33	1.13	51.20	3.35	5.22	0.27	51.92	10.67*	6.42	0.28	7.18	0.03	1.43	0.10
5	EC-704 x PKVNL-260	100.00	0.87	55.47	2.03	5.57	0.21	47.73	-9.21	7.33	-0.17	6.38	-0.01	1.75	0.01
6	EC-704 x NL-97	110.33	-0.87	47.78	-2.03	4.44	-0.21	53.72	9.21	6.56	0.17	6.12	0.01	1.24	-0.01
7	EX-313-23 x PKVNL-260	102.00	-2.80*	49.91	-0.10	5.33	-0.39	46.07	2.39	6.80	0.35	5.82	-0.03	1.62	-0.49*
8	EX-313-23 x NL-97	119.67	2.80*	46.50	0.10	5.40	0.39	28.87	-2.39	5.00	-0.35	5.58	0.03	2.10	0.49*
9	FR-11 x PKVNL-260	97.67	-0.46	63.09	4.85	5.40	0.59	59.27	5.32	7.75	-0.03	6.77	-0.07	2.15	0.08
10	FR-11 x NL-97	110.67	0.46	49.78	-4.85	3.50	-0.59	36.21	-5.32	6.70	0.03	6.62	0.07	1.50	-0.08
11	FRW-9 x PKVNL-260	98.00	1.20	50.53	-1.21	5.63	-0.06	64.40	2.10	7.93	0.03	7.88	0.34**	2.37	0.18
12	FRW-9 x NL-97	107.67	-1.20	49.33	1.21	5.04	0.06	47.77	-2.10	6.77	-0.03	6.93	-0.34**	1.53	-0.18
13	GS-61 x PKVNL-260	98.67	-1.63	43.83	-5.92	3.97	-0.51	42.52	-12.33*	7.02	-0.91*	6.07	0.05	1.60	-0.52*
14	GS-61 x NL-97	114.00	1.63	52.06	5.92	4.28	0.51	54.75	12.33*	7.73	0.91*	5.69	-0.05	2.16	0.52*
15	GS-64 x PKVNL-260	96.67	-0.46	50.27	0.52	4.33	-0.06	65.67	8.06	9.87	0.91*	5.87	-0.16	2.80	0.26
16	GS-64 x NL-97	109.67	0.46	45.60	-0.52	3.73	0.06	37.13	-8.06	6.93	-0.91*	5.90	0.16	1.80	-0.26
17	GS-85 x PKVNL-260	108.00	5.87**	49.60	-2.26	5.40	0.42	56.28	8.06	7.85	-0.20	6.63	-0.17*	2.37	0.10
18	GS-85 x NL-97	108.33	-5.87**	50.50	2.26	3.84	-0.42	27.73	-8.06	7.14	0.20	6.69	0.17*	1.67	-0.10
	SE(s_{ij})		1.26		3.26		0.34		5.08		0.43		0.08		0.21

*, ** = Significant at 5% and 1% level respectively.

Note:-sca effect of crosses for days to 50% flowering was not estimated as mean square due to Line x Tester was non significant.

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