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COMBINING ABILITY ANALYSIS FOR SEED YIELD AND QUALITY COMPONENTS OF SEED AND OIL IN LINSEED (*LINUM USITATISSIMUM* L.)

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ABSTRACT

Combining ability study was carried out for seed yield and quality traits based on pooled data of a diallel set of 10 diverse varieties of linseed grown in four environments (E). It revealed highly significant variances for gca and sca x E for all the characters and sca and gca x E for all the traits except oil content. Among the parents, T 397 proved to be a good general combiner for seed yield per plant, Neelum for palmitic acid and stearic acid, LCK 152 for oil, linoelic acid and reduced linoleic acid contents, while LC 185 was the best general combiner for high linolenic acid. In sca effects, the crosses SPC 23-10 x LC 185 for seed yield per plant, oleic acid and low content of linolenic acid, Sweta x LCK 152 for palmitic acid and oleic acid and Neelum x R 17 for iodine value and higher linolenic acid content were promising.

Key words: Combining ability, seed yield, quality characters, linseed.

Combining ability analysis in linseed for yield and yield components is well investigated and documented. However, for quality traits, information is scanty. Quality traits of linseed include protein, oil content, and fatty acid profile. Among the fatty acids, linolenic acid is an important quality determiner for edible and industrial purposes. High percentage of the highly unsaturated linolenic acid is desired for the manufacture of paint and varnishes. For nutritional purposes, high oleic acid and linoleic acid content and less linolenic acid content is desired. Since the quality traits are influenced by the environment to a considerable extent [1], the present study has been carried out over environments to have a broad based estimates and formulate breeding strategies for improvement of quality traits in linseed.

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MATERIALS AND METHODS

Ten diverse varieties of linseed were crossed in all possible combinations excluding reciprocals. Seeds of parents and their 45 F_1s were sown under irrigated as well as rainfed conditions at two locations, i.e. Ajitmal and Kanpur, in randomized block design with three replications, keeping single rows of the genotypes with the inter- and intrarow distances 25 cm and 5 cm, respectively.

Biochemical analysis was done using the Soxhlet procedure for oil content, micro-Kjeldahl method for protein content and transesterification, and gas–liquid chromatography to determine fatty acid profile as described in [2, 3]. Combining ability analysis was done by Method 2, Model 1 of Griffing [4]. Pooled analysis over four environments was done by the procedure of Singh [5, 6].

RESULTS AND DISCUSSION

Considerable variability has been reported for protein, oil and fatty acid composition in linseed [7–9]. Pooled analysis of variance for combining ability (Table 1) showed highly significant gca for all the characters and significant sca for all the traits except oil content, indicating importance of both additive and nonadditive gene effects in their inheritance. The gca x E was highly significant for all the characters except oil content and thus revealed

Table 1. Analysis of variance (MS) for combining ability pooled over four environments in linseed

Source	d.f.	Seed yield per plant	Protein content	Oil content	Iodine value	Palmitic acid content	Stearic acid content	Oleic acid content	Linoleic acid content	Linolenic acid content
Gca	9	9.53**	29.02**	14.31**	43.26**	1.36**	0.91**	10.82**	13.00**	18.05**
Sca	45	6.32**	7.89**	1.65	52.19**	1.14**	0.59**	11.67**	4.26**	13.91**
Environments (E)	3	419.53**	241.46**	124.85**	984.50**	25.98**	50.28**	170.15**	94.32**	86.88**
Gca x E	27	3.59**	4.86**	2.34	39.73**	1.10**	0.42**	7.44**	3.41**	12.82**
Sca x E	135	3.55**	3.90**	2.04**	32.45**	1.08**	0.59**	7.84**	4.17**	10.51**
Error	432	1.07	2.85	1.88	4.28	0.13	0.16	1.02	1.02	1.51
$\sigma^2 g$	—	0.23	0.60	0.03	0.08	0.0025	0.003	0.019	0.019	0.029
$\sigma^2 s$	—	0.23*	0.60**	0.50	0.91*	0.0280	0.034	0.216	0.216	0.327

$^{*, **}$Significant at 5% and 1% levels, respectively.

the influence of environment on genetic parameters. These results are in agreement with those of Patil and Chopde [10]. Nonsignificant gca x E and significant sca x E for oil content indicated that the nonadditive effects were more influenced by environment than the additive effects controlling this trait. The magnitude of σ^2_s was greater than σ^2_g for these traits, showing that the expression of these characters is governed by nonadditive gene action.

Table 2. Estimates of general combining ability effects and per say performance for 10 linseed varieties pooled over environments

Parent	Seed yield per plant (g)	Protein content (%)	Oil content (%)	Iodine value	Palmitic acid content (%)	Stearic acid content (%)	Oleic acid content (%)	Linoleic acid content (%)	Linolenic acid content (%)
Neelum	0.367	0.614	- 0.634	- 0.736	0.389**	0.230*	- 0.595*	0.372	- 0.327
	(5.89)	(19.62)	(41.02)	(178.67)	(7.17)	(4.50)	(23.67)	(12.10)	(52.51)
T 397	0.575*	- 0.879	0.443	0.258	- 0.269**	0.036	0.464	- 0.399	0.125
	(4.62)	(26.43)	(42.96)	(178.91)	(6.13)	(3.82)	(25.95)	(12.58)	(51.49)
R 552	0.478	0.826	- 0.714	1.123	0.012	0.046	- 0.769**	- 0.103	0.642
	(5.29)	(18.70)	(40.68)	(178.83)	(6.25)	(3.77)	(25.44)	(13.12)	(51.38)
Sweta	0.009	- 1.697**	0.420	0.599	0.049	- 0.040	- 0.185	0.026	0.267
	(4.26)	(18.15)	(43.76)	(181.05)	(6.35)	(3.90)	(25.37)	(13.52)	(51.99)
K 2	- 0.257	0.483	0.047	- 0.839	- 0.116	- 0.210	0.588*	- 0.193	- 0.074
	(4.04)	(20.45)	(42.03)	(181.98)	(5.75)	(3.96)	(25.73)	(12.89)	(52.66)
SPS 23-10	- 0.086	0.428	0.291	0.707	0.029	- 0.239*	0.054	- 0.074	0.317
	(4.02)	(20.45)	(42.46)	(181.97)	(5.84)	(3.30)	(24.68)	(13.81)	(52.26)
LCK 152	- 0.434	0.058	0.770*	- 1.302*	- 0.059	0.028	0.109	1.139**	- 1.181
	(3.26)	(19.02)	(43.40)	(179.27)	(5.55)	(3.40)	(25.11)	(16.94)	(49.35)
R 17	- 0.411	0.817	- 0.422	0.267	- 0.170	0.014	- 0.189	0.144	- 0.059
	(4.90)	(21.41)	(42.13)	(184.78)	(5.65)	(2.80)	(23.64)	(14.64)	(52.34)
LS 2	- 0.440	0.416	0.403	- 1.569**	0.021	0.100	0.641*	0.294	- 0.629
	(5.17)	(23.45)	(42.92)	(177.05)	(5.53)	(3.32)	(26.88)	(14.27)	(49.13)
LC 185	- 0.684*	- 0.316	- 0.604	0.693	0.193	0.036	- 0.119	- 0.823**	0.918**
	(2.23)	(19.95)	(40.41)	(179.19)	(0.57)	(3.30)	(25.85)	(12.34)	(51.87)
SE (gi)	0.280	0.460	0.370	0.57	0.100	0.110	0.280	0.280	0.340

*,**Significant at 5% and 1% levels, respectively.

Figure in parentheses indicate per se performance.

Analysis of mean performance of the parents and their gca effects revealed that Neelum was good general combiner for palmitic and stearic acids, T 397 for seed yield per plant, K 2 and LS 2 for oleic acid, LCK 152 for oil content, linoleic acid and low linolenic acid contents and LC 185 for increased linolenic acid content. None of the varieties tested was a good general combiner for all the characters in desired direction.

Most of the crosses selected on the basis of significant sca effects also had high per se values. A perusal of results (Table 3) indicated that the cross SPS 23-10 x LC 185 showed significant sca effect for seed yield per plant, high oleic acid and low linolenic acid content in the pooled estimates. The cross Sweta x LCK 152 was the best cross for palmitic acid, oleic acid content, and low linolenic acid content. The crosses Neelum x R 17 and Sweta x LC 185 had positive sca effects for iodine value and high linolenic acid content.

It was evident that the cross exhibiting desirable sca effects involved high x high, high x low and low x low gca parents. The cross K 2 x LS 2 between high x high gca parents for oleic acid content is valuable because of the presence of additive gene action and may be effectively utilized in pedigree method of selection. The crosses T 397 x R 552 for iodine value, Neelum x K 2 for palmitic acid and LS 2 x LC 185 for higher linolenic acid were high x low gca combinations in which additive gene action was present in the high gca parent and complementary epistatic gene action in a low gca parent. It might produce better transgressive segregates in later generations [11] and help in breaking undesirable linkage, if any [12]. The crosses SPS 23-10 x LC 185 for seed yield per plant, Neelum x R 552 for oleic acid and K 2 x LS 2 for linolenic acid (lower value) were between low x low gca parents for the respective traits, exhibiting the role of nonadditive gene action which could not be easily exploited in further breeding programme [13].

Availability of CMS system in linseed [14] and certain cross combinations showing high sca effects indicated a definite possibility of developing hybrids for commercial cultivation, as heterosis in a number of traits in various studies is well established. However, lot of ground would have to be covered on developing and exploiting effective restorer and maintainer lines if exploitation of heterosis in linseed is contemplated. Nevertheless, significant progress can be made by fixing desirable genes by intermating promising cross combinations and selecting desirable types. As the two breeding approaches are not mutually exclusive, both need to be undertaken simultaneously. Similarly, bidirectional selection pressure need to be put to breed varieties for edible and technical purposes separately by adequately sampling and utilizing variability in linolenic acid content of oil in linseed. Such a breeding strategy is considered important as particularly in tribal areas linseed oil is used as edible oil as well.

Table 3. Ranking of desirable crosses for gca effects and there per se performance in a 10 x 10 diallel cross in linseed

Character	Significant crosses	Sca effect	Gca effects		Per se performance		
			female parent	male parent	F_1	female parent	male parent
Seed yield per plant	SPS 23-10 x LC 185	2.035*	-0.086	-0.684*	7.2	4.0	2.2
Protein content	SPS 23-10 x LCK 152	3.149**	0.428	0.058	24.3	20.5	19.0
Oil content	Nil						
Iodine value	Neelum x R 17	6.987**	-0.736	0.267	184.5	178.7	184.8
	T 397 x R 552	3.570*	0.258	1.123	182.9	178.9	178.8
	Sweta x LC 185	3.460*	0.599	0.693	182.7	181.1	179.2
Palmitic acid content	T 397 x LS 2	0.903**	-0.269**	0.021	6.7	6.1	5.5
	Sweta x LCK 152	0.900**	0.049	-0.059	6.9	6.4	5.6
	R 552 x R 17	0.861**	0.012	-0.170	6.8	6.3	5.7
	R 17 x LS 2	0.754*	-0.170	0.021	6.7	5.7	5.5
	Neelum x K 2	0.750*	0.389**	-0.116	7.0	7.2	5.8
Stearic acid content	R 552 x R 17	0.776*	0.046	0.014	4.5	3.8	2.9
Oleic acid content	SPS 23-10 x LC 185	5.556**	0.054	-0.119	30.1	24.7	25.9
	Sweta x LCK 152	3.938**	-0.185	0.109	30.5	25.4	25.1
	K 2 x LS 2	3.154**	0.588*	0.641*	31.1	25.7	26.9
	T 397 x K 2	2.751**	0.464	0.588*	30.5	26.0	25.7
	Neelum x R 552	1.783	-0.595	-0.769	27.1	23.7	25.4
Linoleic acid content	Sweta x K 2	1.786*	0.026	-0.193	14.6	13.5	12.9
Linolenic acid content (lower value)	Sweta x LCK 152	-5.300**	0.267	-1.181**	44.5	52.0	49.4
	K 2 x LS 2	-3.789**	-0.074	-0.629	46.2	52.7	49.1
	Neelum x SPS 23-10	-3.327**	-0.327	0.317	47.4	52.5	52.3
	SPS 23-10 x LC 185	-2.778**	0.317	0.918*	49.2	52.3	51.9
	R 17 x LS 2	-2.691**	-0.058	-0.629	47.3	52.3	49.1
Linolenic acid content (higher value)	LS 2 x LC 185	2.948**	-0.629	0.918**	54.0	49.1	51.9
	Neelum x R 17	2.902**	-0.327	-0.058	53.2	52.5	52.3
	Sweta x LC 185	2.208*	0.026	0.918**	54.1	52.0	51.9
	R 552 x LCK 152	2.076*	0.642	-1.181	52.2	51.5	49.4

*,**Significant at 5% and 1% levels, respectively.

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