SSRG International Journal of Agriculture & Environmental Science
ISSN: 2394-2568/ https://doi.org/10.14445/23942568/IJAES-V9I3P101

Volume 9 Issue 3, 1-9, May-June 2022

Original Article

Combining Ability Analysis in Linseed (*Linum usitatissimum* L.) for Improvement of Seed Yield, Oil & Quality Component Traits

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Received: 27 February 2022 Revised: 18 April 2022 Accepted: 27 April 2022 Published: 21 May 2022

***Abstract* -** *The present study deals with the development scope of linseed lines for industrial and edible purposes by estimating oil and its quality traits; for this, a combining ability study was carried out for seed yield, oil, and quality traits in a diallel set of eleven parents and their 55 F_1 s. The analysis of variance revealed that the parents and hybrids included in the investigation exhibited significant differences between treatments for all the characters, indicating a considerable amount of variability among the genotypes. The ratio of gca variance to that of sca variance was less than unity for almost all the traits except omega-6, suggesting that these traits were governed by non-additive gene action. T 397 proved to be the best general combiner for seed yield per plant, Shubhra for oil content and iodine value omega-6 and omega-3 in the positive direction, Gaurav for omega-6 content, oil content and omega-3 in the negative direction, LC 185 for iodine value, palmitic acid, oleic acid, the protein content of seed and omega-3 in the positive direction, N.P. 22 for palmitic acid, oleic acid and omega -3 in the negative direction. In sca effects, the crosses Sweta × T 397 for seed yield per plant, oil content, and omega-3 in the negative direction, R-17× 1/76 for oil content, T 397 × Gaurav and N3 × T 397 for omega-3 in the negative direction. Gaurav × LC 185 for oil content, iodine value, and omega 3 in the positive direction, EC 41498 × 1/76 for plamitic acid, stearic acid, omega 6, and omega 3 in the negative direction, R 17 × EC 41498 and Shubhra NP22 for omega 3 in the positive direction and Sweta × LC 185 for omega 3 in negative direction were found promising.*

***Keywords* -** *Combining ability, Gene action, Hybrid, Linseed, Oil content.*

1. Introduction

Oilseeds stand next only to food grains in the agriculture production and economy of the country. Among the oilseeds crop growing during *rabi*, linseed (*Linum usitatissimum* L.) lies second in the area and production. Linseed occupies an area of 1.8 lakh ha yielding 1.2 lakh tonnes with average productivity of 671kg per hectare in India (Annonymous 2021). In contrast, U.P. occupies an area of 27 thousand hectares with production and productivity of about 19 thousand tones and 688 kg/ha, respectively. Linseed is unique among the oilseeds as it has a high content of omega-3 fatty acid and alpha-linolenic acid (A.L.A.), which can be a future edible oilseed crop. The commercial demand for linseed is currently dominated by the industrial uses of its oil in varnishes, paints, and additives (Kaur *et al*., 2018), manufacture of linoleum and oilcloth, printing ink, and soaps (Walsh, 1965).

Every part of the linseed plant is utilized commercially, directly or indirectly, as a food ingredient for industrial and medicinal purposes worldwide (Bayrak*et. al*., 2010; Ganorkar and Jain, 2013; Singh *et al*., 2016; and Kaur *et al*., 2018). Dried flax seeds are used in cookery and prepare various medicines for breast and prostate cancers, intestinal and urinary problems, hypercholesterolemia, thrombosis, platelet adhesiveness, and chest problems (Chen *et al*. 2006, Coskuner and Karababa, 2007). They are also beneficial for developing the brain and retinal tissues of infants (Payne 2000).

The development of linseed varieties with high yield potential combined with good quality attributes and oil content can certainly contribute to the Indian vegetable oil industry and can be healthy oil to society. Keeping in view, the present investigation was undertaken to study the combining ability of genotypes for the development of varieties having high yield potential and for genetic modification of fatty acid profile to develop designer linseed, i.e., high linolenic acid (H.L.A.) for industrial and medicinal use and low linolenic acid (L.L.A.) for use as cooking oil.

2. Materials and Methods

The present investigation was conducted at Oilseeds Research Farm, Kalyanpur, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India. The experimental material comprised eleven parents and their 55 F_1s. The experiment was laid out in

Randomized Block Design with three replications during *rabi* season. Each plot consisted of two rows of three-meter length with row to row and plant to plant spacing of 30 cm and 10 cm, respectively, and all the recommended cultural practices and fertilizers were applied during the whole crop season.

Observations were recorded on five randomly selected plants of each line per replication for nine traits: *viz.*, seed yield per plant, oil content (%), iodine value, protein content (%), palmitic acid content (%), stearic acid content (%), oleic acid content (%), omega-6 fatty acid and omega-3 fatty acid. Oil content was determined by 'Soxhlet method (A.O.A.C., 1970, pp 174), protein content by 'Kjeldahl's method' and iodine value by 'Wijs method' (A.O.A.C., 3rd Ed. 1976). Methyl esters of fatty acids for determining fatty acid composition of the oil were prepared by 'Transestrification procedure, described by "Jamieson and Reid (1965)". Methyl esters were subjected to Gas-liquid-chromatographic analysis to determine fatty acid composition. Combining ability analysis in the diallel scheme was carried out by following the method given by Griffings (1956) Model I method 2.

3. Results and Discussion

The selection of best-performing lines is the main objective of the crop breeding program. The study of combining abilities helps select the best combiners and provides an opportunity to use these combiners in a hybridization program to transfer the desirable genes or characters to their progenies. General combining ability (*gca*) is primarily a function of additive gene action and additive × additive gene interaction, whereas specific combining ability (sca) is due to non-additive gene interaction. Analysis of variance for combining ability and estimation of variance components of the present study has been presented in Table 1. Analysis of variance displayed that variances both owing to general combining ability (*gca*) and specific combining ability (sca) were highly significant for all the traits indicating that both additives and non-additive genetic components were involved in the determination of these traits. Banerjee and Cole also reported a similar result (2009) and Sood *et al.* (2011). The ratio between estimated variance ♂^{2}g/♂^{2}s was less than unity for all the traits except omega-6, reflecting that these traits were primarily governed by non-additive gene action. The mean degree of dominance (♂^{2}s/♂^{2}g)$^{0.5}$exceeded unity for these traits showing over dominance. However, for omega-6, the preponderance of additive type of gene action and partial dominance was reported. Due to a negative estimate of ♂^{2}g for seed yield per plant, the degree of dominance was not worked out for this trait.

In the present study (Table-2), none of the parents was a good general combiner for all the traits. However, based on overall performance (Table 3), parent T-397 proved to be the best general combiner for seed yield. Variety Shubhra was the best combiner for oil content and a good combiner for iodine value, omega-6, and omega-3 in the positive direction; Gaurav was the best general combiner for omega-6 and a second-best combiner for oil content and omega-3 in the negative direction and palmitic acid. Parent LC 185 was noted to be the best combiner for iodine value and omega-3 in the positive direction and the second-best combiner for protein content of the seed, palmitic acid content, and oleic acid content. Genotype N.P. 22 was the best combiner for palmitic acid, oleic acid, and omega 3 in a negative direction or lower values. Therefore, these parents may be utilized in a hybridization program for high yield coupled with a high oil content of good quality oil for industrial and edible preferences.

Analyzing specific combining ability is an important parameter for judging the specific combination for exploiting it through a 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. The results (Table 4&5) indicated that none of the crosses expressed good combining ability for all the traits under study. Out of 55 crosses, 26 hybrids for seed yield per plant, 17 for oil content, 10 for protein content, 23 for iodine value, 8 for palmitic acid, 21 for stearic acid, 22 for oleic acid, 7 for omega -6, 17 for omega -3(in the positive direction) for technical grade oil and twenty-five for omega -3 content (in the negative direction) for edible grade oil, were observed exhibiting significant and desirable *sca* effects.

These cross combinations involved all the three possible combinations between the parents with high and low *gca* effects *viz* high × high, high × low, and low × low. The cross combinations Sweta× T397 for seed yield and omega-3 in the negative direction; N3 × Sweta for oil content; T397 × Gaurav, and N3 × T397for omega-3 in the negative direction could be placed in the first category where both the parents had significant and desirable *gca* effects for respective traits. These crosses are valuable because of the additive × additive type of gene interaction. Such crosses may be effectively utilized in the selective breeding program's pedigree method to improve respective traits. IIker *et al.* (2009). The crosses R-17 × 1/76 for seed yield and oil content; Gaurav × LC 185 for seed yield, oil content, iodine value, and omega 3 in the positive direction; EC 41498 ×1/76 for palmitic acid, stearic acid, and omega 3 in the negative direction; R 17 × EC 41498 and Shubhra× NP 22 for omega 3 in the positive direction, Sweta× LC 185 for omega 3 in negative direction were high × low *gca* combinations in which additive gene action was present in the high gca parent and complementary epistatic gene action in low gca parent. It might produce better transgressive segregates in later generations (Langham,

1961) and help break undesirable linkages, if any (Janson, 1970). The crosses EC 41498 × 1/76 and Shubhra × N.P. 22 for seed yield per plant, T 397 × Gaurav and Jawahar-23 × Shubhra for protein content, and R17 × 1/76 for stearie acid content were associated with low × low gene effects, exhibiting the role of non-additive gene action which could not be easily exploited in a further breeding program (Sneep, 1977).

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 must be undertaken simultaneously.

Based on the above findings, it was concluded that T 397 for seed yield per plant, Shubhra and Gaurav for oil content and omega-6, LC185 and Shubhra for omega-3 in the positive direction, and N.P. 22 and Gaurav for omega-3 in negative direction were found best combiners. The crosses Sweta × T 397 for seed yield per plant, oil content, and omega-3 in the negative direction, R 17× 1/76 for oil content, T 397 × Gaurav and N3 × T 397 for omega-3 in the negative direction. Gaurav × LC 185 for oil content, iodine value, and omega 3 in the positive direction, EC 41498 × 1/76 for palmitic acid, stearic acid, omega 6, and omega 3 in the negative direction, R 17 × EC 41498, and Shubra NP 22 for omega 3 in the positive direction and Sweta × LC 185 for omega 3 in negative direction adjudged as best specific combiners. The crosses selected based on *per se* performance were almost the same as those selected based on the specific combining ability effects in most characters. However, the ranking was not the same in most of the cases.

4. Conclusion

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Table 1. Analysis of variance for combining ability of seed yield and quality traits of oil in linseed (*Linum usitatissimum* L.)

Source of Variance	**df**	**Seed yield per plant**	**Oil content**	**The protein content of seed**	**Iodine value**	**Palmitic acid**	**Stearic acid**	**Oleic acid**	**Omega -6**	**Omega -3**
gca	10	3.453**	8.42**	1.97**	119.32**	0.21**	1.34**	25.55**	10.12**	34.39**
sca	55	16.35**	3.07**	1.30**	19.95**	0.04**	0.49**	2.50**	0.14**	4.67**
Error	130	0.36	0.19	0.25	0.03	0.01	0.02	0.13	0.05	0.18
♂^{2}*gca*		-0.99	0.41	0.05	7.64	0.01	0.07	1.77	0.77	2.29
♂^{2}*sca*		15.99	2.88	1.05	19.65	0.03	0.47	2.37	0.09	4.49
Potance Ratio (♂^{2} *g* / ♂^{2}*s*)		-0.06	0.14	0.05	0.39	0.45	0.14	0.75	8.63	0.51
Predictability Ratio (♂^{2}*s*/♂^{2}*g*)$^{0.5}$		$	2.65	4.53	1.60	1.49	2.70	1.16	0. 34	1.40

*** = 0.01*

$ = due to a negative estimate of ♂^{2}g, the degree of dominance not worked out

Table 2. Estimates of general combining ability (*gca*) effects and *per se* performance of parents for seed yield and quality traits in linseed (*Linum usitatissimum* L.)

Parents	Seed yield per plant (g)		Oil Content		Protein Content of seed		Iodine Value		Palmitic Acid		Stearic Acid		Oleic Acid		Omega-6		Omega-3	
	gca	***Mean***	***gca***	***Mean***	***gca***	***Mean***	***gca***	***Mean***	***gca***	***Mean***	***gca***	***Mean***	**gca**	**Mean**	***gca***	***Mean***	***gca***	***Mean***
N3	-0.27	7.07	0.25*	45.02	-0.87**	16.74	-1.53**	175.08	-0.13**	5.97	0.39**	5.33	0.35**	27.60	0.32**	11.83	-0.77**	50.37
Jawahar 23	0.23	8.79	-0.04	43.56	0.14	19.11	1.61**	176.00	-0.11**	6.00	-0.68*	4.63	-0.88*	26.47	0.73**	13.10	0.43**	50.13
R 17	0.41*	11.90	0.42**	43.55	0.11	20.43	-0.39**	173.10	-0.04	6.20	0.01	5.80	0.07	28.43	-0.43**	10.57	0.45**	50.70
Sweta	0.38*	8.87	0.44**	44.52	-0.62**	16.85	-0.06**	170.86	0.01	6.13	0.17**	5.63	1.02**	29.47	-0.93**	09.73	-0.57**	48.77
T 397	0.84**	6.41	0.20	43.10	0.02	17.59	-1.43**	171.05	-0.13**	5.77	0.07	4.67	1.00**	28.67	0.12*	12.20	-1.17**	47.57
Gaurav	-0.04	4.42	0.67**	45.80	-0.01	17.93	-0.55**	173.10	0.09**	6.10	-0.20**	4.93	-0.69**	25.57	2.12**	15.17	-1.44**	46.43
Shubhra	0.20	6.81	1.24**	45.69	0.16	19.63	4.05**	180.57	-0.16**	5.87	-0.50**	4.37	1.29**	25.20	0.42**	12.73	1.66**	52.67
LC 185	0.41*	5.90	-1.39**	40.34	0.32*	19.82	5.85**	188.34	0.18**	6.60	-0.55**	4.77	2.08**	21.57	-0.74**	10.07	3.55**	58.27
EC 41498	-0.66	6.26	-1.10**	40.71	0.22	17.87	-2.54**	164.73	-0.01**	6.30	0.42**	5.27	1.19**	31.40	-0.48**	10.53	-0.98**	48.57

1/76	0.22	3.25	0.22	42.74	0.34*	19.83	0.89**	168.91	0.10**	6.33	-0.02	6.27	-1.25	24.30	-0.45**	10.60	-0.96**	50.67
NP 22	-0.91	4.98	-0.90	39.41	0.20	18.53	-5.10**	166.04	0.20**	6.33	0.28**	6.20	2.70**	32.33	-0.68**	10.57	-2.11**	45.03
Grand Mean		6.79		43.13		18.58		173.43		6.15		5.26		27.35		11.61		50.02
Range		3.25 to 1.90		39.41 to 45.80		16.74 to 20.43		164.30 to 188.34		5.77 to 6.60		4.37 to 6.27		21.57 to 32.33		09.73 to 15.77		45.03 to 58.27
SE(gi)	±0.16		±0.11		±0.13		±0.15		±0.03		±0.04		±0.09		±0.06		±0.11	
SE(gi-gj)	±0.24		±0.17		±0.20		±0.22		±0.04		±0.06		±0.14		±0.08		±0.17	

**Þ=0.05*
***Þ=0.01*

Table 3. Ranking of desirable parents based on *per se* performance and *gca* effects for seed yield and quality traits in linseed (*Linum usitatissimum* L.)

S.No.	Character	Best parent *per se* performance	Best general combiner based on significant *gca* effects
1.	Seed yield per plant	R 17 (11.90) Sweta (8.87) Jawahar 23 (8.70) N 3 (7.07) Shubhra (6.81)	T 397 (0.84**) R 17 (0.41*) LC 185 (0.41*) Sweta (0.38*)
2.	Oil Content (%)	Gaurav (45.80) Shubhra (45.69) N 3 (45.02) Sweta (44.52) Jawahar 23 (43.56)	Shubhra (1.24**) Gaurav (0.67*) Sweta (0.44**) R 17 (0.42**) N 3 (0.25*)
3.	Protein Content of seed (%)	R 17 (20.43) 1/76 (19.83) LC 185 (19.82) Shubhra (19.63) Jawahar 23 (19.11)	1/76 (0.34**) LC 185 (0.32**)
4.	Iodine Value	LC 185 (188.34) Shubhra (180.57) Jawahar 23 (176.00) N 3 (175.08) R 17 (173.10)	LC 185 (5.85**) Shubhra (4.05*) Jawahar 23 (1.61**) 1/76 (0.80**)
5.	Palmitic acid content (%)	LC 185 (6.60) 1/76 (6.33) NP 22 (6.33) EC 41498 (6.30) R 17 (6.20)	NP 22 (0.20) LC 185 (0.18**) 1/76 (0.10**) Gaurav (0.09**)
6.	Stearic acid content (%)	1/76 (6.27) NP 22 (6.20) R 17 (5.80) Sweta (5.63) N 3 (5.33)	EC 41498 (0.42**) N3 (0.39**) NP 22 (0.28**) Sweta (0.17**)
7.	Oleic acid content (%)	NP 22 (32.33) EC 41498 (31.40) Sweta (29.47) T 397 (28.53) R 17 (28.43)	NP 22(2.70**) LC 185 (2.08**) EC 41498 (1.19**) Sweta (1.02**) T 397 (1.00**)
8.	Omega-6 content (%)	Gaurav (15.17) Jawahar-23 (13.10) Shubhra (12.73) T 397 (12.20) N 3 (11.83)	Gaurav (2.12**) Jawahar 23 (0.73**) Shubhra (0.42*) N 3 (0.32**) T 397 (0.12**)
9.	Omega-3 content (%) (Positive)	LC 185 (58.27) Shubhra (52.67) R 17 (50.70) 1/76(50.67) N3 (50.37)	LC 185 (3.55**) Shubhra (1.66**) 1/76(0.96**) R 17 (0.45**) J -23 (0.43**)
10.	Omega 3 content (%) (Negative)	N3 (50.37) EC 41498 (48.57) T 397 (47.57) Gaurav (46.43) NP 22 (45.03)	NP 22 (-2.11**) Gaurav (-1.44**) T 397 (-1.17**) EC 41498 (-0.98**) N 3 (-0.77**)

Table 4. Ranking of desirable crosses for gca and sca effects and their *per se* performance in 11x11 diallel cross in linseed (*Linum usitatissimum* L.)

Character ↓	Significant crosses	sca effect	gca effect			*Per se* performance	
			Female parent	Male parent	F_1	Female parent	Male parent
1.Seed yield per plant	Sweta x T 397	8.53**	0.38*	0.84**	22.60	8.87	6.41
	EC 41498 x 1/76	8.21**	-0.66	-0.22	20.62	6.26	3.25
	R 17 x 1/76	6.95**	0.41*	0.22	20.43	11.90	3.25
	Shubhra x NP 22	2.45**	0.20	-0.91	14.60	6.81	4.98
	N 3 x Sweta	2.29**	-0.27	0.38*	15.26	7.07	8.87
	Gaurav x LC 185	1.18*	-0.04	0.41*	13.60	4.42	5.90
	T 397 x Gaurav	1.78**	0.84**	-0.04	15.44	6.41	4.42
	R 17 x EC 41498	1.14*	0.41*	-0.66	13.75	11.90	6.26
	N 3 x T 397	6.08**	-0.27	0.84**	19.51	7.07	6.41
	Sweta x LC 185	2.04**	0.38*	0.41*	14.87	8.87	5.90
2. Oil content	R 17 x 1/76	2.69**	0.42**	0.22	45.66	43.55	42.74
	Gaurav x LC 185	2.32**	0.67**	-1.39**	43.93	45.80	40.34
	Sweta x T 397	2.19**	0.44**	0.20	45.17	44.52	43.10
	Shubhra x NP 22	2.17**	1.24**	-0.90	44.85	45.69	39.41
	N 3 x Sweta	1.57**	0.25*	0.44**	44.59	45.02	44.52
3. Protein content	T 397 x Gaurav	2.19**	0.02	-0.01	22.46	17.59	17.93
	Sweta x Gaurav	2.01**	-0.62*	-0.01	21.63	16.85	17.93
	Jawahar 23 x Shubhra	1.26**	0.14	0.16	21.83	19.11	19.63
	N 3 x T 397	1.19**	-0.87**	0.02	20.59	16.74	17.59
	N 3 x 1/76	0.98**	-87**	0.34*	20.71	16.74	19.83
4. Iodine value	Gaurav x LC 185	10.41**	-0.55**	5.85**	187.53	173.10	188.34
	R 17 x EC 41498	5.60**	-0.39**	-2.45**	174.59	173.10	164.73
	1/76 x NP 22	7.53**	0.89**	-5.10**	175.14	169.91	166.04
	Sweta x T 397	3.50**	-0.96**	-1.43**	172.95	170.86	171.05
	EC 41498 x 1/76	3.37**	-2.45**	0.89**	173.63	164.73	168.91
5. Palmitic acid content	Sweta x Gaurav	0.56**	0.01	0.09**	6.97	6.17	6.10
	Jawahar 23 x R 17	0.34**	-0.11**	-0.04	6.50	6.00	6.20
	EC 41498 x 1/76	0.27**	-0.01	0.10**	6.67	6.30	6.33
	Sweta x T 397	0.22*	0.01	-0.13**	6.40	6.13	5.77
	Jawahar 23 x Shubhra	0.19*	-0.11**	-0.16**	6.23	6.00	5.87
6. Stearic acid content	T 397 x Gaurav	1.12**	0.07	-0.20**	6.03	4.67	4.93
	EC 41498 x 1/76	0.46**	0.42**	-0.02	5.90	5.27	6.27
	Sweta x LC 185	0.80**	0.17**	-0.55**	5.47	5.63	4.77
	N 3 x Sweta	0.77**	0.39**	0.17**	6.37	5.33	5.63
	R 17 x 1/76	0.30**	0.01	-0.02	5.33	5.80	6.27
7. Oleic acid content	LC 185 x EC 41498	2.94**	2.08**	1.19**	30.77	21.57	31.40
	N 3 x T 397	2.70**	0.35**	1.00**	32.77	27.60	28.53
	Shubhra x NP 22	2.43**	-1.29**	2.70**	32.57	25.20	32.33
	Sweta x T 397	1.19**	1.02**	1.00**	31.93	29.47	28.53
	Gaurav x NP 22	2.30**	-0.69**	2.70**	33.03	25.57	32.33
8. Omega -6	R 17 x LC 185	0.88**	-0.43**	-0.74**	11.23	10.57	10.07
	Sweta x LC 185	0.84**	-0.93**	-0.74**	10.70	09.73	10.07
	EC 41498 x 1/76	0.58**	-0.48**	-0.45**	11.17	10.53	10.60
	Jawahar 23 x EC 41498	0.60**	0.73**	-0.48**	12.37	13.10	10.53
	N 3 x EC 41498	0.54**	0.32**	-0.48**	11.90	11.83	10.53
9. Omega -3 (Negative)	T 397 x Gaurav	-3.40**	-1.17**	-1.44**	42.67	62.57	46.43
	Sweta x T 397	-1.38**	-0.57**	-1.17**	45.57	48.77	47.57
	EC 41498 x 1/76	-1.43**	-0.98**	0.96**	47.23	48.57	50.67
	N 3 x T 397	-1.31**	-0.77**	-1.17**	45.43	50.37	47.57
	Sweta x LC 185	-2.56**	-0.57**	3.55	49.10	48.77	58.27
10. Omega-3 (Positive)	Gaurav x LC 185	5.52**	-1.44**	3.55**	56.30	46.43	58.27
	R 17 x EC 41498	3.22**	0.45**	-0.98**	51.37	50.70	48.57
	Jawahar23 x R 17	2.14**	0.43**	0.45**	51.70	50.13	50.70
	Shubhra x N.P. 22	2.11**	1.66**	-2.11**	50.33	52.67	45.03
	Sweta x Gaurav	1.57**	-0.57**	-1.44**	48.23	48.77	46.43

Table 5. Best specific crosses exhibiting maximum sca effects for seed yield per plant and their performance in other quality traits of linseed (*Linum usitatissimum* L)

S.No.	Promising hybrids	Other characters with significant *sca* effects in the desirable direction
1.	Sweta × T 397 (8.53**)	Seed yield per plant, oil content iodine value, palmitic acid,oleic acid, omega - 3 (in the negative direction)
2.	EC 41498 × 1/76 (8.21**)	Seed yield per plant, iodine value, palmitic acid, stearic acid, omega-6, omega-3 (in the negative direction)
3.	R 17 × 1/76 (6.95**)	Seed yield per plant, oil content, stearic acid
4.	Shubhra × N.P. 22 (2.45**)	Seed yield per plant, oil content, oleic acid, omega-3 (in the positive direction)
5.	N 3 × Sweta (2.29**)	Seed yield per plant, oil content, stearic acid
6.	T 397 × Gaurav (1.78**)	Seed yield per plant, protein content, stearic acid, omega-3 (in the negative direction)
7.	Gaurav × LC 185 (1.64**)	Seed yield per plant, oil content, iodine value, omega-3 (in the positive direction)
8.	R 17 × EC 41498 (1.14**)	Seed yield per plant, oil content, iodine value, omega-3 (in the positive direction)
9.	N 3× T 397 (6.08**)	Seed yield per plant, oleic acid,omega-3 (in the negative direction), protein content
10.	Sweta × LC 185 (2.04**)	Seed yield per plant, stearic acid, omega-6, omega-3 (in the negative direction)