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Genetic Association between Oil and its Biochemical Parameters in Linseed (*Linum Usitatissimum* L.)

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Abstract

Flax (Linseed) is valued for its fiber, seed oil and nutraceuticals. Recently, the fiber industry has invested in the development of products made from linseed. Linseed are the major source of raw materials such as fats, proteins, carbohydrates, etc. with potential application as nutraceutical and function foods. They might also endow with low-cost renewable resource of high value-added compounds such as tocopherol and phytochemicals. Seed oils are the main source of dietary ingredients related to their fatty acid composition and tocopherol content.

Keywords: Genetic Association, Oil, Biochemical Parameters, Linseed (*Linum Usitatissimum* L.)

1. Introduction

Linseed is a diploid, self-pollinating crop. It is cool temperate erect annual herb, 1.2 m (3 fit 11 inch) tall, with cylindrical stem. The stems are branched near from base of the plants reaching 75-1000mm in height. Leaves are alternate, lanceolate and grayish-green with 3 veins, 20-40mm long 3mm broad. Flowers have 5 petals arranged in a cluster, 15-25mm diameter.

Linseed is a world crop. The major linseed growing countries in the world are Argentina, U.S.S.R., India, China, and Australia. In India, major linseed growind states are Madhya Pradesh, Uttar Pradesh, Maharashtra, Bihar, Rajasthan, Orissa, Andhra Pradesh and West Bengal. Madhya Pradesh and Uttar Pradesh alone produce 70% of total linseed production of the country. The principal linseed growing tracts of Uttar Pradesh are the gangetic alluvial plains and Bundelkhand, the two well defined agro climatic regions.

Linseed crops are grown for seed oil, which has a high (over 50% total oil content) α -linolenic acid content and the presence of this polyunsaturated fatty acid makes the oil highly susceptible to oxidation. Linseed oil is a clear to yellowish obtained from dried ripe seeds of plant.

2. Materials and Methods

The present investigation was conducted at the experimental plot of National Botanical Research Institute, Lucknow (U.P.). The experimental material consisted of 30 distinct cultivars of linseed (*Linum Usitatissimum*) which are being maintained at NBRI, Lucknow. The crop was shown in Nov. first week of 2009-10 in a randomize block design (RBD) with three replication. The row to row distance was 30cm and plant to plant was 10cm. During crop season normal cultural practices were followed. Randomly selected five plants from each replication were tagged before obtaining agronomical data. Data was recorded of these tagged randomly selected plant in each replication for four morphological traits i.e. bulk density, True Density, Porosity, Moisture Content, Oil Percentage, Colour Value, Refractive Index, Acid Value, Specific Gravity, Carbohydrate, Free Amino Acid, Protein and Fatty Acid of oil and seed were recorded as follows:-

(A) Quantitative Traits

1. Capsule / Plant- Total number of capsules is one plant was conducted.
2. Test weight- weight of 1000 seeds per plant.
3. Seed Yield/Plant- Total seeds obtained from per plant in gram.

(B) Quality Traits

1. Bulk Density- It is defined as the mass of particles of the material divided by the total volume they occupy. The total volume includes particle volume, inter-particle void volume and internal pore volume.

2. True Density- It is defined as the ratio of mass of the sample to its seed volume and was determined using the water displacement method. 50ml of water was poured in a 100ml graduated measuring cylinder and 5gm seeds were immersed in that water. The amount of displaced water was recorded from the graduate scale of the cylinder. The ratio of weight of seeds to volume of displaced water gave the true density.

3. Porosity- The porosity is the fraction of the space in the bulk grain which is not occupied by the grain. The porosity of bulk seed was calculated from the values of true density and bulk density.

4. Moisture Content- Moisture content of the flaxseeds was determined according to AOAC approved method. Weigh 5gm seeds of sample in a weighed porcelain dish and place it in an air oven and dry it at 105°C- 110°C for 2 hours. Cool it in a desiccators and weigh it. Repeat drying till the weight is constant. Report loss in weight as moisture%.

5. Oil percentage -Total oil extracted from each cultivar through Soxhlet extraction method. The percentage of oil was calculated by the formula

$$\text{Oil}\% = \frac{(\text{weight of oil with vial} - \text{wt of vial}) \times 100}{\text{Weight of the sample}}$$

6. Colour value- It was determined using the Lovibond Tintometer. Desired Sample was filtered to a filter paper for removing any impurities and last traces of moisture. Cleaned the glass cell and filled it with the cleared filtered sample and placed the cell in position in the tintometer. Place along side of it such red, yellow, blue or natural lovibond glass slides or any combination of them that was necessary to match the colour shade of the oil. Observed the colour of the oil and of the combination of the glass slide through an eye piece and then recorded the different values.

7. Refractive Index- It was measured by using ABBE Refractometer. First recorded the ambient temperature of the local environment then open the prism of ABBE type refractometer and cleaned it with soft cotton. Again placed a drop of the oil to be tested on lower part of the prism and closed the refractometer. Now observe through the eye piece and turned the dispersion correction compensator knob until the colored indistinct boundary seen between light and dark fields become a sharp line. Now adjust the knurled knob until the sharp line exactly intersect the mid-point of the cross wire in the image. Read the refractive index and record the reading. Then clean the prism with wet cotton with hexane.

8. Acid Value- Weight 2.5gm of appropriate sample of the material and dissolved it in 20ml ethyl alcohol, previously neutralized to phenolphthalein with KOH solution. Titrated with KOH 0.1N solution until the solution remained faintly pink after 10 sec of shaking. Then note the volume of KOH consumed and put the value in the formula as given below

$$\text{Acid Value} = \frac{56.1 \times V \times N}{M}$$

Where:

V = vol. of KOH consumed

N = Normality of KOH solution

M = Mass in gm of material taken

9. Specific Gravity- It was measured by weighing Pycnometer (specific gravity bottle) filled by oil. Filled the specific gravity bottle with oil avoiding air bubbles, insert the stopper immersed in water bath as required and holed it for 30 minutes. Removed the bottle from water bath, then clean, dry and weight it. Again calculate the specific gravity by the formula

$$\text{Specific gravity} = \frac{A-B}{C-B}$$

Where,

A= Weight in gm of the specific gravity bottle with oil

B= Weight in gm of the specific gravity bottle

C= Weight in gm of the specific gravity bottle with water

10. Carbohydrate- The total carbohydrate of defatted powder were determined spectrophotometrically by Phenol-Sulphuric acid method. For the estimation of carbohydrate, air-dried defatted powder (100 gm) was suspended in 5ml of water with heating for 5 min. and filtered through Whatman filter paper. The residue was re-suspended in 1% HCL to remove all the traces of soluble sugar and filtered. Sample (100 µl) was placed in a beaker. The sample was diluted to 900 µl. of de-ionized water and then added 1ml. of 5% sulphuric acid. The absorbance of each sample was monitored at 625 nm using spectrophotometer. Total soluble sugars or starch were then calculated as under.

$$\text{Soluble sugar or starch} = \frac{0.2857 \times \text{Abs. of sample} \times \text{Dilution factor}}{(\text{Wt. of seed})}$$

11. Amino Acid- The total free amino acids of defatted powder were determined spectrophotometrically following the procedure of Hamilton and Van Slyke (1943). Sample (100mg defatted powder + 1.0ml of buffer extract) was placed in a test tube, mixed in a mixture of 1.0ml ninhydrin and 1.0ml of pyridine solution. The test tube was heated for 30 min. on a boiling water bath. The content of tubes were diluted with 50ml water and the absorbance of the solution was measured at 570nm using spectrophotometer. Total free amino acids were then calculated as under.

$$\text{Total free amino acids (g/kg)} = \frac{\text{Abs. of sample} \times \text{Vol. of sample} \times \text{Dilution factor}}{\text{Weight of the sample}}$$

12. Protein- The soluble protein of defatted powder was determined by using Bradford method. Sample (air-dried defatted powder + 800 µl. buffer extract) was placed in a test tube and then centrifuge for 10 min. The sample was placed (10 µl.) in a ELISA plate and treated it with 200 µl. of Bradford reagent and absorbance of the sample was measured at 590 nm using spectrophotometer. Total protein were then calculated as under.

Table 6: Phenotypic correlation values for different traits in linseed among 30 germplasm lines

Traits	Test wt.	Yield	Bulk D	True I Mois.	Oil (%)	Porosity	Acid value	FFA	Specific Gravity	Carbohy ydrate	Amino acid	Protein	Linoleni acid	Linoleic Acid
Cap.dia	-0.011	0.249	-0.043	0.154	-0.099	-0.189	0.395*	-0.010	-0.135	-0.063	-0.151	-0.086	0.304	0.240
Test wt	0.004	0.067	-0.062	0.067	-0.203	-0.036	-0.120	0.253	-0.008	-0.004	0.213	-0.195	-0.210	-0.156
Seed Yield		-0.278	0.104	-0.021	0.016	0.324	0.100	0.100	-0.123	-0.062	0.246	-0.126	-0.121	-0.229
Bulk D			-0.162	-0.141	-0.027	-0.364	0.038	-0.038	0.220	-0.439*	-0.018	0.171	0.126	0.191
True D				0.017	-0.000	0.366	0.091	0.091	-0.021	0.016	0.077	-0.073	-0.128	-0.116
Mois.					-0.109	0.108	0.059	-0.059	-0.118	0.397*	-0.301	0.102	0.020	0.019
Oil(%)						0.061	-0.337	-0.337	0.702**	-0.120	0.144	0.123	-0.398	-0.395*
Porosity							0.152	0.152	0.011	0.144	0.073	-0.199	-0.135	-0.162
Acid Value							1.000**	-0.427*	-0.083	-0.028	-0.028	-0.216	0.060	0.110
FFA								-0.427*	-0.083	-0.028	-0.028	-0.216	0.060	0.110
Specific Grv.									-0.242	0.073	0.167	-0.382	-0.35	
Carbohydrate										-0.209	0.023	0.042	0.024	
Amino Acid											0.096	-0.298	-0.133	
Protein												0.080	0.024	
Linolenic A.														0.870**

*** significant at 5% and 1%.

Table 7: Environmental correlation values among different traits in linseed for 30 germplasm lines.

Traits	Test wt	Yield	Bulk D	True D	Mois.	Oil (%)	Porosity	Acid value	FFA	Specific Gravity	Carbohydrate	Amino acid	Protein	Linolenic acid	Linolenic Acid
Cap.dia	-0.114	0.167	0.376	0.072	0.042	-0.085	-0.473	0.100	0.100	-0.271	-0.106	-0.588**	0.094	0.192	0.256
Test wt		0.245	-0.063	0.299	0.339	-0.158	0.235	0.077	0.077	0.197	0.217	0.087	-0.093	0.139	0.133
Seed Yield			0.013	-0.073	0.373	0.004	0.197	0.077	0.084	0.093	-0.349	-0.000	0.163	0.269	0.084
Bulk D				0.230	0.002	0.185	-0.095	-0.231	-0.233	0.116	0.090	0.018	-0.084	0.030	0.087
True D					0.218	-0.064	0.274	0.191	0.191	0.183	0.214	-0.067	0.045	-0.004	0.426*
Mois.						-0.328	0.113	0.032	0.032	0.097	0.079	-0.030	0.211	0.232	0.279
Oil (%)							-0.033	0.052	0.052	0.407*	-0.035	0.213	-0.100	0.138	0.066
Porosity								-0.168	-0.168	0.353	-0.076	0.197	0.014	0.049	0.199
Acid Value									1.000**	0.250	0.263	-0.131	-0.114	-0.078	-0.004
FFA										0.250	0.263	-0.114	-0.078	-0.004	0.001
Specific Grv.											0.034	0.319	0.000	0.155	0.068
Carbohydrate												0.294	0.001	-0.321	-0.046
Amino Acid													0.009	-0.326	-0.238
Protein														0.328	0.264
Linolenic A.															0.432*

*** significant at 5% and 1%.

(B) Study of parameters for analysis of quality of oil (Table 5)

The data on various quality traits of oil are presented in Table 5 and the results of each parameters are described separately as follows:

1. Colour value- The colour value of the oil lies in the yellow and red group and ranged from 15 to 70 using white colour at 2.0 level. The highest colour value was reported for germplasm no. ES-15888 (70+2w) followed by germplasm ES-1476, ES-13230, ES-13239, EX-53-913, PB-3-No-3 and FR-3 which was according to the colour value in the BIS standard noted.

2. Specific gravity-The specific gravity ranged from 0.732 to 1.02 with Average mean value 0.66 ± 0.04 . The highest specific gravity was noticed for germplasm EX-53-913(0.92) followed by ES-1534, ES-13239 and PB-3-No-3 that was also accordance to BIS standard in which the specific gravity was up to 1.2%.

3. Refractive index- The refractive index was 1.47 approx with average mean value 1.47 ± 0.01 .

4. Seed colour-The colour of seed ranged from light brown to dark brown and lie in group 165A, 199A, 199D and 200D according to Royal Botanical Garden Horticultural society, U.K.

5. Acid value- Acid value of oil ranged from 0.2 to 3.00 with average mean value 3.84 ± 0.31 . The lowest acid value was noticed for EX-131-10(0.20).

6. FFA- The value ranged from 0.6 to 1.5 with average mean value 0.24 ± 0.02 .

Table 8: Per se performance of Different characters for 30 germplasm lines in linseed.

Germplasm	Cap. diameter	Test weight	Yield	Bulk density	True density	Moisture content	Oil (%)	Poro sity	Acid value	Specific gravity	Carbohy drate	Amino acid	Protein	Linolenic acid	Linoleic Acid	Refractive index	FFA
ES 567	0.48	5.01	2.70	52.88	4.50	0.07	20.24	21.64	0.22	0.74	0.34	3.99	0.39	60.53	24.09	1.45	0.11
ES 1440	0.43	7.52	1.88	50.90	4.50	0.03	23.75	6.50	0.24	0.83	0.25	3.66	0.21	54.64	22.02	1.47	0.12
ES 1444	0.55	7.90	4.41	51.51	5.50	0.03	18.23	37.05	0.71	0.66	0.19	5.30	0.33	67.60	26.94	1.48	0.36
ES 1445	0.44	4.41	5.39	48.77	4.50	0.08	32.12	28.46	0.71	0.85	0.27	3.01	0.30	72.24	28.65	1.47	0.35
Es 1449	0.46	6.97	3.55	53.60	4.50	0.06	24.98	1.72	0.50	0.86	0.15	2.55	0.39	71.49	36.63	1.45	0.25
ES 1456	0.44	7.52	5.35	51.70	4.50	0.02	10.39	5.22	0.86	0.32	0.16	6.06	0.10	89.88	35.95	1.47	0.43
ES 1462	0.46	6.58	3.58	49.81	4.50	0.04	15.13	8.68	0.99	0.38	0.16	1.86	0.28	71.80	28.69	1.46	0.50
ES 1476	0.56	7.53	3.81	47.60	4.50	0.03	10.56	12.69	0.67	0.34	0.35	3.23	0.20	91.05	46.27	1.47	0.34
ES 1496	0.54	6.25	4.40	53.11	4.50	0.02	16.24	22.11	0.72	0.57	0.15	5.63	0.31	73.76	37.46	1.47	0.36
ES 1534	0.48	4.86	3.83	55.34	4.50	0.02	27.53	18.54	0.40	0.88	0.05	3.73	0.24	73.17	36.81	1.47	0.20
ES 13219	0.40	4.33	5.63	52.01	4.50	0.04	12.07	4.66	0.47	0.42	0.26	2.20	0.14	48.45	19.70	1.47	0.23
ES 13230	0.42	6.15	4.72	47.38	4.50	0.02	22.64	13.13	0.22	0.77	0.23	4.06	0.34	60.25	24.19	1.46	0.11
ES 13239	0.40	5.24	2.40	52.34	4.50	0.03	27.17	4.03	0.45	0.92	0.34	3.46	0.59	72.04	36.55	1.47	0.22
ES 15888	0.42	5.99	5.15	51.57	4.50	0.04	20.94	5.33	0.79	0.68	0.16	5.90	0.52	53.51	21.38	1.47	0.39
ES 15889	0.46	5.30	4.74	49.73	4.50	0.02	37.49	8.81	0.23	0.84	0.15	5.40	0.29	61.66	24.76	1.45	0.12
ES 15890	0.53	5.50	4.16	48.91	4.50	0.03	19.27	10.33	0.44	0.64	0.21	2.24	0.44	77.82	31.08	1.47	0.22
ES 16381	0.49	5.67	5.07	49.76	4.50	0.03	20.12	27.01	0.22	0.70	0.18	5.52	0.41	62.16	25.12	1.47	0.11
EX 3-3	0.54	4.75	4.40	51.99	4.50	0.05	9.62	4.01	0.36	0.29	0.12	5.91	0.38	91.53	46.74	1.48	0.18
EX 6-3	0.53	7.46	6.43	51.50	4.50	0.02	17.65	5.56	0.40	0.64	0.24	3.39	0.21	88.18	35.70	1.46	0.20
EX 53-913	0.53	3.95	7.36	48.47	5.50	0.02	27.22	40.40	0.51	0.92	0.13	5.94	0.14	47.94	18.97	1.47	0.25
EX 7959	0.66	2.96	6.25	50.97	4.50	0.05	18.93	25.24	0.18	0.62	0.29	2.40	0.39	90.37	35.91	1.45	0.09
EX131-10	0.54	5.89	4.52	50.30	4.50	0.06	17.76	26.23	0.40	0.61	0.23	1.11	0.26	91.16	36.12	1.47	0.20
EX 304-1	0.57	7.48	3.75	52.85	4.50	0.02	26.84	3.06	0.39	0.88	0.07	2.65	0.19	54.44	22.01	1.46	0.20
FATEHPUR	0.47	9.90	5.99	49.64	4.50	0.03	32.10	8.95	0.19	0.85	0.25	6.90	0.26	47.47	18.84	1.46	0.09
PB 3 No. 3	0.55	8.77	6.28	51.51	4.50	0.02	25.22	24.41	0.62	0.89	0.16	5.69	0.46	48.95	19.46	1.47	0.31
Flax 1	0.55	6.64	5.67	47.03	5.50	0.05	21.75	42.35	0.59	0.29	0.33	2.55	0.16	58.23	23.62	1.47	0.30
Flax C-16	0.43	5.97	5.92	50.84	4.50	0.04	23.15	6.75	0.49	0.39	0.26	6.06	0.65	61.33	24.45	1.47	0.25
Flax 16	0.48	6.51	4.76	50.81	4.50	0.06	19.08	6.83	0.49	0.68	0.21	1.62	0.23	57.52	22.88	1.48	0.25
FR 3	0.51	4.86	4.24	53.21	4.50	0.02	24.07	2.42	0.22	0.77	0.14	1.37	0.68	89.33	27.41	1.47	0.11
FR 11	0.55	7.53	5.55	51.44	4.50	0.04	15.37	24.52	0.96	0.49	0.24	1.91	0.08	68.10	26.97	1.47	0.48
Mean	0.49	6.18	4.73	50.91	4.60	0.04	21.25	15.22	0.49	0.66	0.21	3.84	0.32	68.55	28.85	1.47	0.24
SE	0.01	0.28	0.23	0.36	0.06	0.00	1.22	2.19	0.04	0.04	0.01	0.31	0.03	2.68	1.43	0.00	0.02

Table 9: Direct and indirect effect of different characters on oil (%) at genotypic levels in linseed.

Traits	Cap.dia	Test wt.	Yield	Bulk D	True D	Mois.	Porosity	Acid value	FFA	Specific Gravity	Carbohydrate	Amino acid	Protein	Linolenic acid	Linoleic Acid	Genotypic correlation of oil (%)
Cap.dia	1.696	0.051	0.556	-0.153	-0.331	-0.308	0.953	-0.029	-0.029	-0.289	-0.144	-0.359	-0.714	0.720	0.555	-0.285
Test wt	-0.037	-1.244	0.113	0.082	-0.142	0.408	0.164	-0.341	-0.340	0.019	0.010	-0.287	0.458	0.285	0.213	0.007
Seed Yield	-0.394	0.110	-1.203	0.466	0.407	0.276	-0.538	-0.163	-0.163	0.214	0.086	-0.410	0.434	0.206	0.396	0.027
Bulk D	0.035	0.026	0.154	-0.398	-0.108	0.064	0.145	0.015	0.015	-0.088	0.175	0.007	-0.145	-0.050	-0.076	-0.050
True D	0.027	-0.016	0.049	-0.039	-0.143	-0.026	0.077	0.017	0.017	-0.008	0.001	0.016	-0.053	-0.027	-0.029	-0.108
Mois.	-0.071	-0.128	-0.090	-0.063	0.072	0.391	0.047	-0.026	-0.026	-0.054	0.176	-0.134	0.012	0.008	0.006	-0.003
Porosity	-0.910	0.214	-0.725	0.593	0.872	-0.199	-1.620	-0.247	-0.247	-0.017	-0.235	-0.118	0.668	0.219	0.263	0.084
Acid Value	-0.015	0.242	0.120	-0.033	-0.110	-0.061	0.135	0.884	0.883	-0.379	-0.073	-0.025	-0.390	0.053	0.097	-0.464*
FFA	0.000	0.002	0.001	-0.003	-0.005	0.001	0.125	0.004	0.051	0.040	0.025	0.006	0.060	0.001	0.005	-0.464*
Specific grv.	-0.243	-0.022	-0.256	0.317	0.082	-0.199	0.016	-0.615	-0.615	1.432	-0.348	0.105	0.498	-0.549	-0.514	0.936**
Carbohydrate	-0.050	-0.005	-0.042	-0.257	-0.004	0.263	0.085	-0.049	-0.049	-0.142	0.583	-0.121	0.027	0.025	0.014	-0.164
Amino Acid	-0.356	0.388	0.575	-0.030	-0.194	-0.579	0.123	-0.048	-0.048	0.124	-0.352	1.683	0.336	-0.502	-0.224	0.197
Protein	0.296	0.259	0.254	-0.258	-0.262	-0.023	0.290	0.311	0.311	-0.245	-0.033	-0.141	0.337	-0.107	-0.020	-0.548**
Linolenic A.	0.422	-0.228	-0.170	0.126	0.188	0.021	-0.134	0.060	0.060	-0.381	0.043	-0.296	0.151	0.992	0.863	-0.545**
Linoleic A.	-0.684	0.359	0.690	-0.401	-0.436	-0.032	0.341	-0.231	-0.231	0.751	-0.052	0.279	-0.062	-1.822	-2.091	-0.555**

(C) Path analysis

Capsule diameter showed direct effect on the oil (%), via all the indirectly. Test weight showed direct effect on the oil (%) and indirectly via seed yield, bulk density, true density, moisture, porosity, acid value, FFA, specific gravity, carbohydrates, amino acid, protein, linolenic acid and linoleic acid. Bulk density showed direct effect on the oil (%) and indirectly via true density, moisture, porosity, acid value, FFA, specific gravity, carbohydrates, amino acids, protein, linoleic acid. True density also showed direct effect on the oil (%) and indirectly via moisture, porosity, acid value, FFA,

specific gravity, carbohydrate, amino acid, protein, linolenic acid and linoleic acid. moisture showed direct effect on oil (%) and indirectly via porosity, acid value, FFA, specific gravity, carbohydrate, amino acid, protein, linolenic acid and linoleic acid. Porosity showed direct effect on the oil (%) and indirect through acid value, FFA, specific gravity, carbohydrate, amino acid, protein, linolenic acid and linoleic acid. Acid value also showed direct effect on the oil (%) and indirectly via FFA, specific gravity, carbohydrate, amino acid, protein, linolenic acid and linoleic acid. FFA showed direct effect on the oil (%) and indirectly through specific gravity,

4. Discussion & Conclusion

Linseed is an old world's crop and majorly utilized for industrial purposes due to presence of high amount of linolenic acid. The oil of the linseed has a high drying property that is why it is used for marking varnishes and paints. In India much research work has been done on various aspects of linseed except to explore its use of oil for edible purposes. Seeing the ability of linseed oil as cooking oil, Genetics and Plant Breeding section of NBRI is trying to develop and transform linseed for edible purposes. To achieve this target it is prerequisite to test the physical and chemical properties of seed and oil of various germplasm lines of linseed in research programmes related to transformation or development of edible linseed. The present study is an effort to test the physical characters of seeds and quality characters of oil of 30 genotypes of linseed (*L.usitatissimum L.*). Sixteen quantitative and qualitative characters were studied in present study. The analysis of variance revealed significant differences among the genotype for all the characters except capsule diameter, true density, acid value, FFA, specific gravity, carbohydrates and protein content which suggest sufficient variability existing among the genotypes.

The germplasm having lowest acid value can be used for edible purposes as it was reported by literature that oil having less acid value, had decreased oxidation ability of the oil for polymerization. The pale brown colour (165A) of the seeds can also be utilized for research work as yellow and pale colour seeds considered as morphological marker of the edible oil in linseed (Abbasi *et al.* 2003, Mittapalli and Rowland 2003). The refractive index of the oil showed the same value as reported for the sunflower and soyabean oil (Biswas *et al.* 2001). The light colour value of oil leads to oil used for edible purposes as formation of polymers promotes the darkening of oil. The darkening of oil may be caused by oxidative deterioration (Jaswir *et al.* 2005; Abramovic and Abram 2005). It is concluded from the present study that the seed yield of the germplasm can be increased by direct selection of test weight, seed yield, specific gravity and amino acid. The quality characters also may be great impetus towards increase of seed yield and oil percentage.

5. Reference

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