International Journal of Genetics and Genomics
2023; 11(3): 97-103
http://www.sciencepublishinggroup.com/j/ijgg
doi: 10.11648/j.ijgg.20231103.16
ISSN: 2376-7340 (Print); ISSN: 2376-7359 (Online)

Development of Linseed and Ethiopian Mustard Lines for Seed Coat Color and Oil Quality Traits

Mohammed Abu*, Berhanu Mengistu

Ethiopian Institute of Agricultural Research, Holetta Agricultural Research Center, Holetta, Ethiopia

Email address:
mabu4196@gmail.com (Mohammed Abu)
*Corresponding author

To cite this article:
Mohammed Abu, Berhanu Mengistu. Development of Linseed and Ethiopian Mustard Lines for Seed Coat Color and Oil Quality Traits. *International Journal of Genetics and Genomics*. Vol. 11, No. 3, 2023, pp. 97-103. doi: 10.11648/j.ijgg.20231103.16

Received: July 2, 2023; **Accepted**: July 21, 2023; **Published**: July 31, 2023

Abstract: Ethiopian mustard and Linseed are among oil bearing crops species containing edible oil and oil quality traits with several medicinal, food and industrial applications. Oil content and other oil quality traits in these crops need further improvement to meet the requirement of the crop for different purposes. This study was conducted to develop linseed and Ethiopian mustard lines with improved oil quality traits. Back crossing technique was used to transfer traits of interest from parents to promising linseed and Ethiopian mustard varieties which lack some of the quality traits. For brassica carinata improvement intra specific crossings were made between Ethiopian mustard and Rape seed varieties which are low in erucic acid and glucosinolate content. Linseed improvement for high omega-3 fatty acid was used back cross techniques to transfer recessive allele. Whereas; for development of linseed lines for yellow seed coat color back cross techniques for dominant alleles were used. For all traits back cross followed by selection were used. Eighty one lines for development of low erucic acid and glucosinolate brassica carinata crosses and one hundred twenty two lines for low or high linolenic acid (omega-3 fatty acid) where analyzed for their fatty acid profile. In addition one hundred twenty promising lines for development of linseed yellow seed coat color lines were promoted to next crossing program.

Keywords: Erucic Acid, Glucosinolate, Linolenic Acid, Omega-3, Yellow Seed

1. Introduction

Ethiopia has suitable climatic condition, soil types and range of altitudes for cultivation of different types of oil crops that are used as edible oils and as income sources for the farmers. Among them linseed and Ethiopian Mustard are widely grown in the highland parts of the country. Linseed (*Linum usitatissimum* L.), is an oil seed crop in the family Linaceae. The leading linseed producing countries in the world are Russia, Kazakhstan, Canada, China, India and United States of America [1]. It is an annual self-pollinated diploid crop (2n = 2× = 30) that can be used for dual purpose (stem fiber or seed oil) production [2]. Fiber types and oil types are genetically the same but morphologically different [3]. The plant has an erect main shoot; the stem bears lateral branches from its basal part. Evidence for the use of linseed as an oil crop dates back to about 8,000 B. C. Linseed (*Linum usitatissimum* L.) is an important crop with different fatty acid profile and bioactive compounds in its seed and seed hull.

It has high content of the polyunsaturated fatty acids a-linolenic acid (C18: 3) and linoleic acid (C18: 2) in seed oil, soluble dietary fiber or mucilage, insoluble dietary fiber, and lignin in seed hull, which makes linseed as an important source of functional compounds [4]. Bioactive compounds in linseed is used in the prevention of some chronic diseases such as, cardiovascular diseases, cancer and diabetes [5]. Yellow seed coat is directly associated with oil quality traits and typically a desirable quality trait in breeding of *linseed and brassica* such as the higher quality of oil and meal, lower fiber content and higher protein content [6].

Brassica is the most prominent genus which belongs to the tribe Brassiceae (family Brassiceae) and comprises 338 genera (assigned to 25 tribes) and 3709 species. Brassica craniate is a domestic plant commonly grown in the Ethiopian highlands, Spain, California and Italy. It is believed to have been arisen about 10,000 years ago as a result of interspecific cross between brassica nigra and brassica oleraceae. It is thought to have originated in Ethiopia, and is well adapted to altitudes between 2000 and 2800 m above sea level [7].

Brassica carinata has good resistance ability to blackleg, alternaria leaf spot and shattering [8]. A significant amount of erucic acid in its oil makes it non-suitable for food and well suited for use in non-food applications [9]. Therefore developing of low erucic acid Ethiopian mustard lines for food and developing of high erucic acid lines for industrial application such as bio-diesel, lubricants, soaps, bio-polymers and surfactants is found to be important. Hence this study was being undertaken to develop linseed and Ethiopian Mustard lines with improved oil content, oil quality and yellow seed coat color.

2. Materials and Methods

Crossing of parents and selection of lines were followed as follows for both linseed and brassica carinata improvement. Four different experiments were conducted separately based on the following procedures.

Development of linseed lines for low Linolenic acid (LNA) (< 5%) and for high Omega-3 fatty acid (> 55%)

Crossing of linseed was conducted during 2014/15-2019/20 followed by selection at Holetta. The crossing materials were Jeldu, Berene, and Kulumsa-1 with kassa-2, CD71, CD73, E-88 and LD71; and back crossing method to transfer recessive trait was used. During 2019/2020 34BC1F1 were planted in family row with 2 lines of 2m length, 20 cm between lines and 40cm between plots spacing were used for the study. All agronomic practices were carried out as per recommendation.

2.1. Development of Yellow Seeded Linseed Lines with High Seed Yield and Oil Content

To develop linseed lines with high seed yield and oil content crossing of parents followed by selection was carried out during 2015/2016-2019/2020 using E14, E88, E79, E87, E13 and E64 with Kulumsa-1, Belay-96, Jeldu, Tolle, and Kassa-2 and back crossing method to transfer dominant allele. At 2019/2020 main cropping season 30 BC1F1 lines grown using family row. Two rows of 2m length were used with 20 cm and 40 cm spacing between rows and between plots were used respectively. All agronomic practices were made as per national recommendation.

2.2. Development of Ethiopian Mustard Lines for Low Erucic Acid (< 5%) and /or Low Glucosinolate (15µmoles/g)

Crossing of rape seed with Ethiopian mustard was done during 2014/15-2019/2020 to develop Ethiopian mustard lines with low erucic acid and low glucosinolate content. Ethiopian mustard yellow dodolla was used as maternal parent whereas Axana, Blinda, Campino, Marko, Agmax, Trapper and Dodger from rape seed where used as paternal parents. Backcrossing method to transfer recessive gene procedure was followed and 28BC1F1were grown in two rows of 2m length during 2019/2020 cropping season and all recommended agronomic practices were followed; single plants were selfed, harvested and threshed separately.

Crossing and Evaluation of Linseed segregating material for desirable traits.

To develop Linseed lines with high oil content and desirable agronomic traits four linseed varieties namely Kulumsa, Berene, Kassa-2 and Bekoji were crossed with PI523353 and reciprocal crossing was made followed by selection. During 2019/2020 a total of seven F6 lines were planted in family rows. Four rows of 2m length were used and all agronomic practices were performed as per recommendation.

3. Results and Discussion

From the experiment undertaken during 2019/2020 cropping season number of plants selected promising lines obtained and promoted to next breeding stages. Those for which fatty acid profile was analyzed were shown in Table 1&2.

Development of linseed lines for low Linolenic acid LNA (< 5%) and for high Omega-3 fatty acid (> 55%):

Yellow-seeded families had higher values of phenological traits, plant height and number of capsules and lower values of seed number, linolenic acid, palmitic acid, stearic acid, aspartic acid, leucine and lysine content than the brown-seeded types [10]. Selection of best performing single plants was carried out and a total of 340 plants (10 plants from each plot) were selected from 34 BC1F1 and each single plant was threshed for each entry separately in 2018/19.

A total of 122 promising materials were promoted to the next backcross program and planted in crossing block during 2019/20 season. Those promising lines were similar in characteristics to the maternal parent will be backcrossed with maternal parent. Their fatty acid profile was analyzed using NIRS and the results are shown in Table 1. The mean value of Palmitic acid ranged from 4.047 to 7.289. The highest mean value was recorded by BC1F1B20/2019 whereas, the lowest mean was observed for RTJ20/2019. The mean value of stearic acid was ranged from 5.390 for BC1F1J1/2019 to 2.421 for RTJ18/2019. The highest mean value of oleic acid (22.87) is observed for BC1F1B12/2019 while the lowest mean value (15.96) was recorded by BC1F1B8/2019. The mean value of linoleic acid ranged from 13.30 to 18.3. The highest mean value of linoleic acid was recorded by RT K6/2019, whereas the lowest mean value is observed for BC1F1K19/ 2019. The mean value of linolenic acid ranged from 50.88 for RTJ14/2019to 58.10 for RTB2/2019. The fatty acid result for lines BC1F1B18/219, BC1F1K11/2019, BC1F1J11/219, BC1F1J17, RTK10/219, RTK13/2019, RTK17/2019 and RTJ21/2109 were not quantified because the amount of sample seeds is not sufficient for fatty acid analysis.

Table 1. *Mean of fatty acid profile for crossing of linseed for oil quality traits.*

Treatment code	Treatment based on 2020 field planting	Palmitic acid (C16: 0)	Stearic acid (C18: 0)	Oleic acid (C18: 1)	Linoleic acid (C18: 2)	Linolenic acid (C18: 3)
1	Bc1f1B1/2019	6.093	4.508	17.304	15.27	57.032
2	BC1F1B2/2019	6.308	5.222	18.775	14.139	55.503
3	BC1F1B3/2019	6.176	4.672	18.143	15.126	55.131
4	BC1F1B4/2019	5.994	4.931	20.377	14.264	54.438
5	BC1F1B5/2019	4.869	4.301	21.513	14.681	53.053
6	BC1F1B6/2019	5.758	4.903	19.814	13.529	56.028
7	BC1F1B7/2019	5.629	4.791	20.762	13.646	52.403
8	BC1F1B8/2019	5.979	3.071	15.964	16.835	57.526
9	BC1F1B9/2019	5.825	5.077	19.991	13.897	54.971
10	BC1F1B10/2019	6.416	4.912	19.046	14.347	54.795
11	BC1F1B11/2019	6.179	4.604	18.453	14.96	55.326
12	BC1F1B12/2019	6.143	5.313	22.874	14.818	51.202
13	BC1F1B13/2019	5.739	4.865	19.789	13.555	56.474
14	BC1F1B14/2019	5.88	3.821	17.741	15.246	56.686
15	BC1F1B15/2019	5.588	5.161	20.707	13.415	55.174
16	BC1F1B16/2019	6.207	4.922	20.237	14.005	54.993
17	BC1F1B17/2019	6.061	4.697	19.476	14.247	55.894
18	BC1F1B18/2019					
19	BC1F1B19/2019	6.034	4.63	18.44	14.273	56.615
20	BC1F1B20/2019	7.289	4.628	16.376	16.069	55.293
21	BC1F1B21/2019	5.738	3.18	18.447	15.735	56.341
22	BC1F1K1/ 2019	6.205	4.815	18.829	13.893	56.706
23	BC1F1K2/ 2019	5.931	4.608	19.456	14.294	55.84
24	BC1F1K3/ 2019	5.722	5.248	20.571	13.977	53.656
25	BC1F1K4/ 2019	5.826	4.7	18.852	14.434	55.819
26	BC1F1K5/ 2019	5.83	4.565	18.697	14.651	55.848
27	BC1F1K6/ 2019	6.068	4.194	19.646	14.635	54.655
28	BC1F1K7/ 2019	5.865	4.992	19.254	13.914	55.902
29	BC1F1K8/ 2019	6.126	4.817	19.459	13.991	56.467
30	BC1F1K9/ 2019	6.228	4.075	18.352	14.71	56.103
31	BC1F1K10/ 2019	5.893	4.543	18.442	14.732	56.132
32	BC1F1K11/ 2019					
33	BC1F1K12/ 2019	6.002	4.4	18.647	15.496	54.908
34	BC1F1K13/ 2019	6.146	4.129	18.644	15.225	55.302
35	BC1F1K14/ 2019	6.121	4.235	18.112	15.477	55.301
36	BC1F1K15/ 2019	6.058	3.974	19.846	14.186	55.995
37	BC1F1K16/ 2019	6.018	4.676	19.805	14.362	54.756
38	BC1F1K17/ 2019	5.832	4.948	20.264	13.653	55.68
39	BC1F1K18/ 2019	6.107	5.067	19.336	13.817	55.704
40	BC1F1K19/ 2019	5.811	5.318	21.284	13.296	54.346
41	BC1F1K20/ 2019	6.257	4.995	18.484	13.979	56.29
42	BC1F1K21/ 2019	6.343	4.137	21.251	14.059	54.855
43	BC1F1K22/ 2019	6.051	5.22	19.563	13.856	54.62
44	BC1F1K23/ 2019	6.47	5.057	17.984	13.695	56.469
45	BC1F1K24/ 2019	6.851	4.215	19.505	14.811	54.664
46	BC1F1J1/2019	6.219	5.39	20.568	13.749	53.054
47	BC1F1J2/2019	5.902	4.585	17.734	14.485	56.373
48	BC1F1J3/2019	5.718	4.56	18.64	14.591	55.082
49	BC1F1J4/2019	6.235	5.078	18.577	13.794	55.718
50	BC1F1J5/2019	6.407	3.931	17.737	15.617	55.416
51	BC1F1J6/2019					
52	BC1F1J7/2019					
53	BC1F1J8/2019	5.968	4.494	19.226	14.559	54.716
54	BC1F1J9/2019	6.062	4.58	18.338	14.408	55.243
55	BC1F1J10/2019	6.142	4.098	16.738	15.677	55.569
56	BC1F1J11/2019					
57	BC1F1J12/2019	5.53	3.407	18.147	15.453	55.885
58	BC1F1J13/2019	5.966	4.193	19.744	14.91	54.357
59	BC1F1J14/2019	5.799	4.662	19.518	14.808	54.373
60	BC1F1J15/2019	5.541	4.182	18.076	15.617	54.773
61	BC1F1J16/2019	5.84	4.617	19.445	15.098	53.667
62	BC1F1J17/2019					
63	BC1F1J18/2019	5.734	4.974	18.641	14.028	55.857
64	BC1F1J19/2019	5.613	4.462	21.379	14.49	53.111
65	BC1F1J20/2019	5.773	4.71	19.707	14.603	54.222

Treatment code	Treatment based on 2020 field planting	Palmitic acid (C16: 0)	Stearic acid (C18: 0)	Oleic acid (C18: 1)	Linoleic acid (C18: 2)	Linolenic acid (C18: 3)
66	BC1F1J21/2019	5.328	3.877	17.468	15.599	55.78
67	BC1F1J22/2019	5.241	3.971	19.467	14.993	55.471
68	RTB1/ 2019	5.832	4.99	17.771	14.144	56.851
69	RTB2/ 2019	5.862	3.601	17.358	15.195	58.1
70	RTB3/ 2019	5.788	4.154	17.833	14.128	57.357
71	RTB4/ 2019	5.775	4.198	17.195	15.226	57.005
72	RTB5/ 2019	4.914	2.904	16.785	16.845	56.262
73	RTB6/ 2019	6.035	4.989	19.681	14.083	55.596
74	RTB7/ 2019	6.247	3.584	16.633	16.033	56.611
75	RTB8/ 2019	6.176	3.923	17.896	15.565	55.432
76	RTB9/ 2019	6.075	4.398	17.649	15.322	55.923
77	RTB10/ 2019	6.276	3.775	16.197	16.551	56.018
78	RTB11/ 2019	5.691	4.623	17.879	13.89	57.648
79	RTB12/ 2019	5.659	4.465	17.171	14.864	56.951
80	RTB13/ 2019	5.817	4.833	18.018	14.201	57.066
81	RTB14/ 2019	6.194	4.62	17.312	14.36	57.957
82	RTB15/ 2019	5.768	4.23	17.835	15.181	56.432
83	RTB16/ 2019	4.496	4.039	21.834	15.273	52.526
84	RTK1/ 2019	5.658	4.541	19.126	14.44	56.203
85	RT K2/2019	5.433	3.956	18.675	15.535	56.4
86	RT K3/2019	4.408	4.955	22.316	13.859	51.664
87	RT K4/2019	6.125	4.311	19.265	14.507	57.09
88	RT K5/2019	6.109	3.762	17.143	15.939	56.586
89	RT K6/2019	6.045	2.602	17.735	18.3	53.253
90	RT K7/2019	4.969	3.611	19.379	16.277	53.459
91	RT K8/2019	5.075	4.721	17.853	13.835	57.179
92	RT K9/2019	5.626	4.581	18.048	13.877	56.222
93	RT K10/2019					
94	RT K11/2019	6.036	4.454	17.729	14.486	56.408
95	RT K12/2019	5.682	4.352	20.154	14.51	55.062
96	RT K13/2019					
97	RT K14/2019	4.489	3.693	17.876	15.51	55.057
98	RT K15/2019	4.868	4.566	17.986	14.228	55.555
99	RT K16/2019	5.418	3.386	18.771	15.405	55.072
100	RT K17/2019					
101	RTJ1/2019	6.009	4.616	18.347	14.622	55.818
102	RTJ2/2019	5.76	4.306	19.041	14.884	55.292
103	RTJ3/2019	5.038	3.35	17.857	16.298	54.328
104	RTJ4/2019	4.447	3.085	18.627	16.498	53.497
105	RTJ5/2019	4.548	3.566	19.658	16.019	53.834
106	RTJ6/2019	6.745	4.546	21.87	13.59	54.541
107	RTJ7/2019	4.654	3.331	19.445	15.591	53.496
108	RTJ8/2019	6.229	4.771	17.841	14.688	55.158
109	RTJ9/2019	4.254	3.397	20.143	15.777	55.508
110	RTJ10/2019	5.186	4.286	19.037	15.065	55.07
111	RTJ11/2019	4.137	3.202	16.995	16.698	54.598
112	RTJ12/2019	4.365	3.74	20.229	15.514	52.928
113	RTJ13/2019	4.119	4.047	20.646	15.114	53.022
114	RTJ14/2019	4.165	3.928	21.618	15.754	50.884
115	RTJ15/2019	5.384	4.849	19.913	14.091	54.563
116	RTJ16/2019	5.633	5.009	19.648	13.763	55.286
117	RTJ17/2019	4.525	3.937	21.507	15.165	52.875
118	RTJ18/2019	4.207	2.421	16.303	16.944	56.224
119	RTJ19/2019	4.886	3.299	20.459	15.467	54.032
120	RTJ20/2019	4.047	3.327	19.982	15.613	54.072
121	RTJ21/2019					

3.1. Development of Yellow Seeded Linseed Lines with High Seed Yield and Oil

A total of 300 best performing single plants (ten best performing single plants from each entry) were selected from 30 BC1F1 and threshed separately and 120 promising lines with yellow seed coat color were identified and promoted to next back crossing.

3.2. Crossing and Evaluation of Linseed Segregating Material for Desirable Traits

Selections for best performing single plants were performed and a total of 105 plants (15 best performing single plants from each plot) were selected and threshed separately. 84 promising lines were promoted to preliminary observation nursery.

Development of Ethiopian Mustard lines for low erucic acid (< 5%) and /or low glucosinolate (15µmoles/g)

A total of 280 best performing single plants from 28BC1F1 grown (ten best performing single plants from each entry) were selected, 81 promising lines were identified and those similar in characteristics to the recurrent parent were planted and backcrossed with recurrent parent. Their fatty acid profile was analyzed by NIRS and the results are shown in Table 2.

The breeding of yellow-seeded Brassica napus to improve seed quality with higher oil content, improved oil and meal quality with fewer antinutrients merits attention [11]. Carinata shows low genetic diversity due to a stronger genetic bottleneck during domesti-cation [12]. Narrow genetic base shapes population structure and linkage disequilibrium in an industrial oilseed crop, Brassica carinata A. Braun. Therefore characterization and evaluation of lines is important to improve brassica carinata crop for different quality traits. The result from the present study shows Palmitic acid ranged from 3.5 to 2.36. The highest value was observed for BC1F1Y31/ 2019; whereas the lowest value was recorded by BC1F1Y28/ 2019. Streak acid values ranged from 1.43 to 0.91. The highest value of streak acid was recorded by BC1F1Y10/ 2019 andRTY47/2019; while its lowest value was observed for BC1F1Y19/2019. The maximum mean value of oleic acid (30.44) was observed for genotype BC1F1Y30/ 2019; while it's minimum value (3.84) was recorded by RTY71/2019. The mean value of linoleic acid was ranged from 15.92 for BC1F1Y19/2019 to9.84 for RTY50/2019. The highest mean value of linolenic acid (23.14) was observed forRTY75/2019; while the lowest (12.04) was recorded by RTY69/2019. Erucic acid ranged from 30.49 to 45.61. Its maximum mean value was recorded by RTY71/2019; whereas its minimum value was recorded by BC1F1Y30/ 2019. For lines BC1F1Y35/209 and RTY61/2019; the results were not stated here in the table because their seed sample is not sufficient for fatty acid analysis.

Further significant increase in erucic acid content was found from an experiment through interspecific hybridization of brassica carinata with brassica rapa lines [13].

Variation in the fatty acid content (% palmitic, oleic, linoleic, linolenic, eicosenoic, and erucic acid as part of the overall fatty acid profile) of Brassica carinata grown at three locations during 2015-2017 were observed in North Florida [14].

Table 2. *Mean of fatty acid profile for crossing of Ethiopian mustard for oil quality traits.*

Treatment code	Treatment Name	Palmitic acid (C16: 0)	Stearic acid (C18: 0)	Oleic acid (C18: 1)	Linoleic acid (C18: 2)	Linolenic acid (C18: 3)	Erucic acid (C22: 1)
1	BC1F1Y1/2019	3.16	1.24	12.89	10.62	17.86	32.36
2	BC1F1Y2/2019	3.12	1.11	7.50	13.48	19.89	37.94
3	BC1F1Y3/ 2019	3.18	1.18	10.08	11.23	18.15	34.86
4	BC1F1Y4 /2019	3.02	0.99	11.38	13.11	19.95	32.48
5	BC1F1Y5/2019	2.87	1.05	9.50	13.50	20.06	34.60
6	BC1F1Y6/2019	2.81	1.26	10.26	12.95	18.25	34.98
7	BC1F1Y7/ 2019	2.98	1.06	8.96	12.67	20.66	37.05
8	BC1F1Y8/2019	2.80	1.38	9.89	10.55	16.45	36.13
9	BC1F1Y9/2019	2.77	1.19	8.05	13.20	18.72	38.32
10	BC1F1Y10/ 2019	2.83	1.43	11.94	10.77	15.43	32.65
11	BC1F1Y11/ 2019	2.97	1.22	9.85	12.18	17.79	35.98
12	BC1F1Y12/2019	2.83	1.36	8.85	11.23	15.10	37.21
13	BC1F1Y13/ 2019	2.81	1.22	8.13	12.53	17.63	37.97
14	BC1F1Y14/2019	3.19	1.22	12.10	12.00	18.52	31.32
15	BC1F1Y15/ 2019	2.96	1.29	11.22	10.51	16.09	32.24
16	BC1F1Y16/ 2019	3.23	1.12	10.93	12.43	19.56	33.38
17	BC1F1Y17/ 2019	3.16	1.15	8.92	13.72	19.35	35.85
18	BC1F1Y18/ 2019	2.95	1.18	7.01	12.02	19.38	39.21
19	BC1F1Y19/2019	2.77	0.91	7.18	15.92	22.24	38.54
20	BC1F1Y20/2019	2.96	1.35	10.65	12.63	15.26	34.73
21	BC1F1Y21/2019	2.73	1.19	4.61	13.62	16.95	44.80
22	BC1F1Y22/2019	3.04	0.99	4.29	15.11	20.04	45.05
23	BC1F1Y23/ 2019	2.97	1.11	7.73	11.83	18.49	38.60
24	BC1F1Y24/2019	2.91	1.18	8.28	13.61	18.21	38.00
25	BC1F1Y25/ 2019	2.60	1.08	9.94	13.72	18.66	36.47
26	BC1F1Y26/ 2019	2.90	1.24	12.46	12.71	17.07	31.63
27	BC1F1Y27/ 2019	2.61	1.19	11.59	12.84	17.46	32.32
28	BC1F1Y28/ 2019	2.36	1.08	11.13	13.52	15.65	33.56
29	BC1F1Y29/ 2019	2.66	1.21	10.61	13.26	17.15	34.80
30	BC1F1Y30/ 2019	2.96	1.32	13.44	10.63	14.83	30.49
31	BC1F1Y31/ 2019	3.50	1.05	8.34	14.39	22.71	37.40
32	BC1F1Y32/2019	3.49	1.14	8.67	11.64	19.71	36.84

Treatment code	Treatment Name	Palmitic acid (C16: 0)	Stearic acid (C18: 0)	Oleic acid (C18: 1)	Linoleic acid (C18: 2)	Linolenic acid (C18: 3)	Erucic acid (C22: 1)
33	BC1F1Y33/2019	2.71	1.11	6.89	11.82	20.29	40.62
34	BC1F1Y34/ 2019	3.01	1.24	9.83	13.47	17.28	34.08
35	BC1F1Y35/2019						
36	BC1F1Y36/ 2019	3.13	1.21	10.39	12.81	18.98	32.97
37	BC1F1Y37/2019	2.78	1.29	9.80	11.94	17.24	35.15
38	BC1F1Y38/ 2019	2.78	1.14	9.02	11.19	19.12	36.42
39	BC1F1Y39/ 2019	3.15	1.12	10.46	12.21	18.86	35.43
40	BC1F1Y40/2019	2.88	1.26	9.54	12.04	17.50	36.24
41	BC1F1Y41/2019	3.21	1.15	11.12	14.52	19.57	34.04
42	BC1F1Y42/ 2019	2.96	1.15	10.67	13.20	19.73	34.53
43	BC1F1Y43/ 2019	3.19	1.10	10.43	14.95	21.02	35.11
44	BC1F1Y44/ 2019	2.97	1.23	10.60	13.25	16.75	34.09
45	BC1F1Y45/ 2019	2.99	1.23	10.18	10.75	16.57	35.05
46	BC1F1Y46/2019	2.86	1.19	8.05	14.25	19.04	37.61
47	RTY47/2019	2.68	1.43	9.78	11.13	14.54	35.89
48	RTY48/ 2019	2.90	1.20	11.47	11.29	17.83	32.76
49	RTY49/2019	2.84	1.00	10.81	13.19	19.65	33.53
50	RTY50/2019	2.68	1.25	9.68	9.84	16.43	35.35
51	RTY51/2019	2.92	1.41	11.72	12.09	15.90	32.32
52	RTY52/2019	3.31	1.17	11.55	11.48	18.13	33.00
53	RTY53/ 2019	2.90	1.21	10.27	13.82	18.95	33.94
54	RTY54/ 2019	3.17	0.99	4.37	14.37	20.63	42.82
55	RTY55/ 2019	3.05	1.19	10.03	13.35	17.75	35.33
56	RTY56/2019	2.92	1.36	9.58	12.60	15.24	37.00
57	RTY57/2019	2.98	1.05	7.55	15.01	20.37	39.44
58	RTY58/2019	2.55	1.27	7.85	13.65	14.19	40.62
59	RTY592019	3.02	1.24	10.66	14.51	15.50	35.35
60	RTY60/2019	2.69	1.40	12.53	12.39	12.72	33.35
61	RTY61/2019						
62	RTY62/ 2019	2.56	1.34	9.49	13.09	13.01	39.74
63	RTY63/2019	2.70	1.12	9.80	13.94	16.87	39.36
64	RTY64/2019	2.83	1.23	13.18	12.81	15.51	32.45
65	RTY65/2019	2.49	1.35	9.41	11.75	12.58	38.47
66	RTY66/2019	2.89	1.13	9.80	12.65	15.60	38.41
67	RTY67/2019	2.64	1.32	9.66	12.80	13.09	40.15
68	RTY68/2019	2.68	1.24	10.21	11.88	13.82	37.78
69	RTY69/2019	2.56	1.35	9.85	10.72	12.04	37.57
70	RTY70/2019	2.75	1.23	7.67	12.21	14.19	40.60
71	RTY71/2019	3.26	0.96	3.84	12.87	21.32	45.61
72	RTY72/2019	2.99	1.06	6.72	13.40	20.23	40.68
73	RTY73/2019	2.81	1.16	5.55	12.64	18.40	42.10
74	RTY74/2019	2.81	1.15	4.86	11.85	18.82	42.46
75	RTY75/2019	3.46	1.00	7.86	11.61	23.14	38.64
76	RTY76/2019	2.96	1.23	8.31	11.11	17.79	36.74
77	RTY77/2019	3.18	1.10	8.37	12.36	19.47	36.84
78	RTY78/2019	2.97	1.24	9.00	11.18	17.58	36.43
79	RTY79/2019	2.99	1.32	9.06	11.09	16.47	35.85
80	RTY80/2019	2.76	1.24	8.88	10.82	17.00	37.21
81	RTY81/ 2019	2.80	1.30	9.07	11.40	16.48	36.60

Yellow seed color of brassica carinata is directly correlated with high oil content and protein cont. it is possible to produce Brassica carinata using traditional plant breeding techniques with low anti-nutritional components (EA) and to assure its safety for human consumption. [15]

4. Conclusion

In the present study we evaluated linseed lines and brassica carinata lines for seed coa color and oil quality traits. To improve linseed and brassica carinata lines for oil content and oil quality traits, selection of parents for crossing was made based on traits of interest, breeding method was designed, and crossing parents and evaluation of lines was done following the breeding methodology procedures for each experiment. Finally from crossing and evaluation of lines; 122 promising lines for low linoleic acid/ high omega, 120 promising linseed lines for development yellow seed coat color, from F6 linseed lines 84 were selected for desirable trait like oil content, stand, disease resistance yield and oil quality traits, 81 lines for development of Ethiopian Mustard lines for low erucic and glucosinolate content were obtained and promoted to next breeding program.

References

[1] FAO Stat (2021), http://fao.org (1st July, 2021).

[2] Gill, K. S., 1987. Flax. Indian Council of Agricultural Research, New Delhi, India. 386 p.

[3] Gan, Y., Basnyat, P., McDonald, C. L., Campbell, C. A., Liu, L., 2009. Water use and distributionprofile under pulse and oilseed crops in semiarid northern high latitude areas. Agric. Water Manage. 96, 337–348.

[4] Singer, F. A. W., F. S. Taha, S. S. Mohamed, A. Gibriel, and M. E. Nawawy. 2011. Preparation of protein/mucilage products from flaxseed. Am. J. Food Tech. 6: 260–278.

[5] Khalesi, S., C. Irwin, and M. Schubert. 2015. Flaxseed consumption may reduce blood pressure: A systematic review and Meta analysis of controlled trials. J. Nutr. 145: 758–765.

[6] Akbar, M., Mahmood, T., Anwar, M., Ali, M., Shafiq, M., and Salim, J. (2003). Linseed improvement through genetic variability, correlation and path coefficient analysis. International Journal of Agriculture and Biology 5 (3): 303-305.

[7] Getinet Alemaw. 1987. Review on breeding of Ethiopian mustard (Brassica carinata A. Braun). Proc. 7th Int. Raps. Congr., Poznan, Poland. 1987 May 11–14. pp. 593–597.

[8] Getinet Alemaw, Rakow G, Downey R K. 1996. Agronomic performance and seed quality of Ethiopian mustard in Saskatchewan. Can. J. Plant Sci. 76: 387-392.

[9] Taylor D C, Falk K C, Palmer C D, Hammerlindl J, Babic V, Mietkiewska E, Jadhav A, Marillia E F, Francis T, Hoffman T, Giblin E. M, Katavic V, Keller W. A. 2010. Brescia carinata – A new molecular farming platform for delivering bio-industrial oil feed stocks: Case studies of genetic modifications to improve very long-chain fatty acid and oil content in seeds. Biofuels Bioprod. Bioref. 4: 538-561.

[10] Abtahi, M, Mirlohi, A, Zare, S. Selection of promising lines for yield and quality traits in advanced segregating generation of linseed. J Am Oil Chem Soc. 2022; 99 (9): 759-780. https://doi.org/10.1002/aocs.12632.

[11] Jiang, J., Zhu, S., Yuan, Y. et al. Transcriptomic comparison between developing seeds of yellow- and black-seeded Brassica napus reveals that genes influence seed quality. BMC Plant Biol 19, 203 (2019). https://doi.org/10.1186/s12870-019-1821.

[12] Khedikar, Y., Clarke, W. E., Chen, L. et al. Narrow genetic base shapes population structure and linkage disequilibrium in an industrial oilseed crop, Brassica carinata A. Braun. Sci Rep 10, 12629 (2020). https://doi.org/10.1038/s41598-020-69255-w.

[13] Roslinsky V, Falk KC, Gaebelein R, Mason AS, Eynck C. Development of B. carinata with super-high erucic acid content through interspecific hybridization. Theor Appl Genet. 2021 Oct; 134 (10): 3167-3181. doi: 10.1007/s00122-021-03883-2. Epub 2021 Jul 16. PMID: 34269830; PMCID: PMC8440251.

[14] Shivendra Kumar, Ramdeo Seepaul, Michael J. Mulvaney, Blaire Colvin, Sheeja George, Jim J. Marois, Rick Bennett, Ramon Leon, David L. Wright, Ian M. Small, 2020., Brassica carinata genotypes demonstrate potential as a winter biofuel crop in South East United States, Industrial Crops and Products. 150, 0926-6690, https://doi.org/10.1016/j.indcrop.

[15] Adel Abdelrazek Abdelazim Mohdaly, Mohamed Fawzy Ramadan, Characteristics, 2022, composition and functional properties of seeds, seed cake and seed oil from different Brassica carinata genotypes, Food Bioscience, 48, 2212-4292. https://doi.org/10.1016/j.fbio