Development of Mid-Oleic and Low Linolenic Canola-Quality Cultivars for the Southeastern U.S.A.

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ABSTRACT

Research has demonstrated that canola-quality cultivars of oilseed rape, *Brassica napus*, (L.) can be produced profitably in the southeastern USA as a fall-planted winter crop. Although the lack of local markets has made commercialization difficult, strong regional markets currently exist for both canola oil and meal. Canola oil is considered highly desirable among health conscience Americans primarily due to its low saturated fat content. Oils with increased levels of oleic acid in combination with reduced linoleic and linolenic acid show higher thermal stability, lower levels of oxidation products, and improved shelf life without extensive hydrogenation. Breeding efforts were initiated in 1993 to develop cultivars specifically adapted to the Southeastern U.S.A. that produce oils with increased oleic acid and reduced linolenic acid content. The breeding program combined germplasm with low linolenic traits derived by mutagenesis with germplasm from derived from inter-specific crosses between *B. napus* and *B. juncea.* A recurrent selection program was applied to this germplasm and fatty acid analysis performed at each cycle of selection. Other breeding objectives included competitive seed yield, resistance to *Phoma* blackleg, and cold tolerance. This approach has been successful in producing a number of regionally adapted advanced lines with improved fatty acid profiles, highly competitive seed yields, moderate to good resistance to *Phoma* blackleg, and improved cold tolerance. Our breeding program will soon release regionally adapted cultivars that produce oils with >70% oleic acid, <2.5% linolenic acid and total saturated fat content of <6%. These new cultivars will produce superior edible oils with improved thermal stability and extended shelf life for our food industry.

Key words: Oil quality, fatty acid profile, cultivar development, trans fatty acids.

INTRODUCTION

Canola oil is considered highly desirable among health conscious Americans primarily due to its low saturated fat content. A typical canola oil profile is 7% saturated fat, 61% oleic acid, 21% linoleic acid and 11% linolenic acid. Canola oils with increased levels of oleic acid in combination with reduced linoleic and linolenic acid show higher thermal stability, lower levels of oxidation products, and improved shelf life without extensive hydrogenation.

Recent evidence that *trans* fatty acids also increase the risk of coronary heart disease has prompted proposed changes in food labeling laws in the USA to require reporting of *trans* fats on the label. *Trans* fatty acids are formed during the process of partial hydrogenation that converts liquid vegetable oils rich in polyunsaturated fats into solid fats such as margarine. These hydrogenated products were developed to replace highly saturated animal and vegetable fats. Since alpha-linolenic acid tends to change into *trans* fatty acid when hydrogenated, *trans* fat levels can be greatly reduced by using oils low in this fatty acid.

These industry developments provide encouragement for the development and utilization of canola cultivars that produce oils with very low amounts of alpha-linolenic acid, total saturated fat contents of less than 6%, and increased levels of oleic acid. The University of Georgia has an established breeding effort underway to develop Southeastern adapted Superior Edible Oil (SEO) varieties with these oil characteristics for use by the food industry.

MATERIALS AND METHODS

Breeding efforts were initiated in 1993 to develop cultivars specifically adapted to the Southeastern U.S. that produce oils with increased oleic acid and reduced linolenic acid contents. The breeding approach combined germplasm with low linolenic traits derived by mutagenesis with germplasm derived from inter-specific crosses between *B. napus* and *B. juncea.* A recurrent selection program was applied to this germplasm with selection for desired fatty acid profiles and other agronomic traits performed at each cycle of selection. Since the value of these oil traits is uncertain, other breeding objectives included competitive seed yield, resistance to *Phoma* blackleg, and cold tolerance.

RESULTS

Our early breeding efforts placed strong emphasis on the development of the necessary fatty acid profiles. Initial fatty acid breeding goals were oleic acid contents of 72-74% and <3% linolenic acid. Half-seed fatty acid analysis was used for selection of parents and the fatty acid profiles of approximately ten thousand single plants were determined annually via gas chromatography.

Acceptable fatty acid profiles were developed in accordance with project time goals, however meeting the agronomic goals of competitive seed yield, resistance to *Phoma* blackleg, and cold tolerance proved to be formidable tasks. Figure 1 summarizes our progress in developing SEO lines with competitive seed yields. Table 1 presents an extensive data set for SEO lines recently tested in our yield trials.

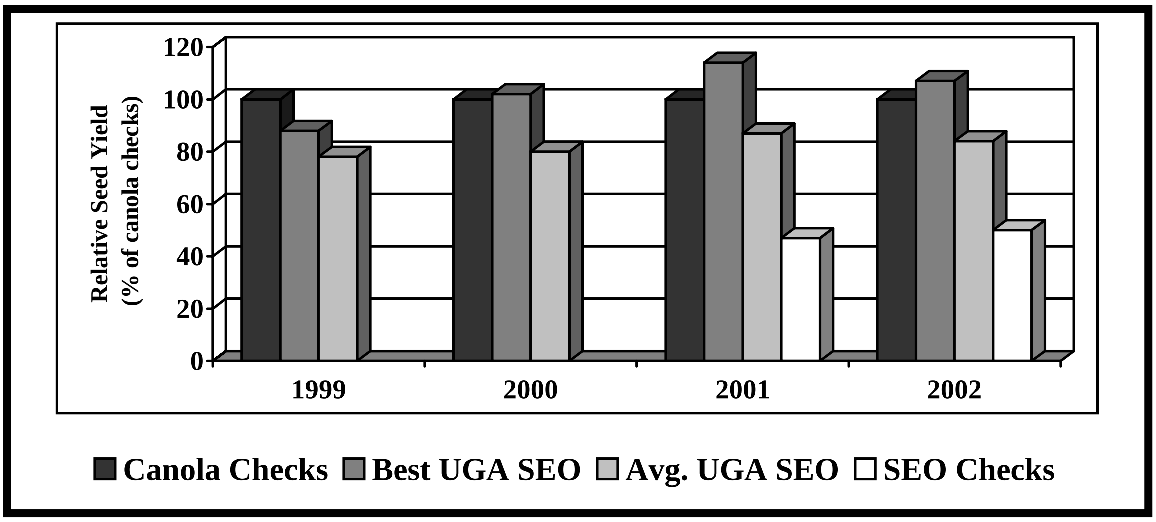

Figure 1. Summary of progress in University of Georgia specialty-oil yield trials 1999–2002.

These data indicate that we are now approaching our breeding goals and have been successful in producing a number of regionally adapted advanced lines with improved fatty acid profiles, highly competitive seed yields, moderate to good resistance to *Phoma* blackleg, and improved cold tolerance.

We have recently added an additional goal of <5% total saturated fats. Selection pressure is now being placed on SEO breeding materials to further improve the total saturated fat content of their oils. Table 2 presents the fatty acid profiles of a few selected lines with superior oil traits and total saturated fat contents ranging from 5.5 – 6.0%.

Table 1. Performance of SEO Canola Lines at Three Georgia Locations[1] in 2000-2001

Variety	Yield[2]	Oil	FAP Yield Trials[3] Oleic/Linolenic	FAP Isolation[4] Oleic/linolenic	Bloom	Maturity	Plant Ht.	Winter Survival	Blackleg[5]
	kg/ha	*%*	*%*	*%*	*date*	*date*	*cm*	*%*	*% diseased*
15F7.2.A81.4	**2533**	**43.3**	69/3.9	68/3.4	03/05	05/13	122	**85**	40
Flint[C]	**2531**	40.7	67/6.0	63/8.0	03/08	05/13	124	**87**	**11**
15F7.2.A81	**2387**	**42.4**	67/3.8	67/2.7	03/04	05/11	112	**85**	32
15F7.2.3	2226	**42.4**	69/2.5	70/2.2	03/03	05/14	119	**81**	**22**
4C4.C.1	2111	40.0	66/3.2	69/2.2	03/09	05/14	117	76	38
15F7.2.A81.5	1978	**42.4**	70/2.4	71/2.6	03/06	05/13	117	**83**	**25**
Oscar[C]	1915	40.0	64/6.0	61/9.3	03/05	05/12	109	65	**16**
CL104.11.62.3	1901	41.0	68/3.6	69/2.3	03/06	05/12	114	77	35
CL106.13.4.G3.06	1896	39.0	69/2.1	72/1.4	03/09	05/14	119	74	**20**
4C4.C.5.2.04.2	1886	41.7	68/2.3	67/1.8	03/04	05/10	102	**85**	27
CL104.11.10.4.7.09	1867	41.6	69/2.4	67/1.5	03/08	05/12	114	**80**	67
CL106.13.4.G3.3	1807	39.0	67/3.5	70/1.4	03/11	05/14	109	79	**17**
4C4.C.1.2	1795	40.8	69/2.5	70/1.4	03/10	05/14	117	78	**18**
CL87.2.9.1.2.09.5	1782	40.2	68/2.9	.	03/08	05/11	112	73	40
CL87.2.9.1.2.09	1737	41.6	69/2.6	68/1.5	03/09	05/15	122	65	40
CL87.2.9.1.2.07	1703	41.2	68/3.0	68/2.8	03/08	05/12	114	75	47
4C4.C.5.2.04	1682	40.9	69/2.0	66/1.6	03/06	05/11	114	**82**	38
CL87.2.9.1.2.07.3	1564	41.1	69/2.7	70/1.4	03/09	05/12	109	72	50
Cheetah[S]	1102	41.5	69/3.5	.	03/09	05/13	107	60	82
Lynx[S]	975	**42.2**	70/3.7	.	03/08	05/11	109	60	80
Average	1869[6]	41.2	68/3.2	.	03/07	05/12	114	76	41
LSD at 10% Level	203	1.1	2/1.1	.	02	02	5	7	14
Std. Err. of Mean	86	0.6	1/0.5	.	01	01	3	3	7

1. Midville, Plains, and Tifton.
2. Yields calculated at 8.5% moisture.
3. Expressed as a percentage of the total fatty acids from open-pollinated seeds harvested from yield trials.
4. Expressed as a percentage of the total fatty acids from isolated or selfed seeds.
5. Average Blackleg rating from Griffin and Plains disease nurseries expressed as total percentage of plants killed by blackleg or with severe basal stem canker.
6. C.V. = 16.1%, and df for EMS = 171.

Bolding indicates entries equal to the best entry within a column based on Fisher's protected LSD (P = 0.10).

C = Canola quality check variety

S = Specialty oil check variety

Table 2. Fatty Acid Profiles[1] of Selected SEO Experimental Lines with Reduced Total Saturated Fat[2] Levels, Plains, Georgia 2002.

Line	18:1	18:2	18:3	Total Sats.[2]
15F7.2.A81.5.2.4	69.73	21.08	2.09	5.97
C93.248.15.4.W72.1	70.71	20.33	1.99	5.81
CGX80.95.56.4.03.4.5.1	66.27	25.21	1.66	5.48
CGX83.95.18.1.03.9.4	71.44	19.67	1.86	5.84
CGX83.95.34.3.03.5	71.20	20.09	1.47	5.99
CGX95.506.2.4.2.1.2	72.27	18.43	2.28	5.68
CGX95.508.25.6.7.5	73.57	17.01	2.16	5.82
CL87.2.9.3.1.G20	70.63	20.87	1.59	5.64

1. Expressed as a percentage of the total fatty acids from self-pollinated seeds.

2. Total saturated fats values are the Sum of 16:0, 18:0, 20:0, and 22:0.

DISCUSSION

Our breeding program will soon release regionally adapted cultivars that produce oils with >70% oleic acid, <2.5% linolenic acid, and total saturated fat content <6%. These new cultivars will produce superior edible oils with improved thermal stability, and the potential to extend shelf life and dramatically reduce *trans* fats in a wide range of food products. Additionally, efforts are now underway to introgress herbicide tolerance traits in superior advanced lines.

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