Lehr- und Forschungszentrum für Landwirtschaft
Raumberg-Gumpenstein

61. Tagung der Vereinigung der Pflanzenzüchter und Saatgutkaufleute Österreichs 2010, 127 - 129
ISBN: 978-3-902559-53-1

Results of linseed breeding in the Czech Republic

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Abstract

Flax and linseed breeding in the Czech Republic has an old tradition going back to the beginning of the last century. A lot of flax and linseed varieties have been bred during this period and registered for growing in the Czech Republic. Since the beginning of the 21st century, however, the crisis in flax growing and production resulted in the termination of all breeding activities and variety development. At present all breeding work is focused on the creation of linseed varieties with various possibilities of end use. Two companies, i.e. AGRITEC, Šumperk, and SEMPRA, Praha, work at the moment on linseed cultivar development. Linseed varieties with the following characters are selected: traditional brown and yellow seeded varieties with high (55-65%) linolenic acid content, low linolenic (<3%) brown and yellow seeded varieties, brown and yellow seeded varieties with higher oleic fatty acid content, traditional brown and yellow seeded varieties with higher SECO (secoisolariciresinol) content, low linolenic brown and yellow seeded varieties with higher SECO content, traditional as well as low linolenic brown and yellow seeded varieties with lower CG (cyanogenic glycosides) content.

Keywords

Fatty acid composition, *Linum usitatissimum*, oil

Introduction

Linum usitatissimum L., grown in two types of use, i.e. flax for fibre production and linseed for seed production, is known as a traditional source for the paint manufacturing industry. Seeds contain 35-45% of oil rich in unsaturated fatty acids (FA). Standard FA composition in commercial flax and linseed cultivars is about 6% palmitic (16:0), 2% stearic (18:0), 16-20% oleic (18:1), 13-18% linoleic (18:2) and 52-60% α-linolenic (18:3) acids. Induced mutagenesis via ethylmethanesulphonat (EMS) was used to change the traditional FA composition, i.e. decrease the linolenic and increase the oleic acid content (TEJKLOVÁ 1995). The induced changes, especially the decrease of linolenic acid content were detected with the thiobarbituric acid test (TBA) (BHATTY and ROWLAND 1990). The presence of double bonds in unsatured FA provides with TBA a colour complex, thus the intensity of coloration depends on the number of double bonds. The most intensive red colour is associated with high levels of linolenic acid content. Low linolenic seeds are detected by very light coloured or colourless spots. After rapid detection of high or low linolenic linseed types by the TBA test the results are usually confirmed by gas-liquid chromatography.

Material and methods

The main breeding aims of linseed in the Czech Republic are: (i) fat yield (seed yield x fat content in the seed), (ii) resistance to diseases (*Fusarium oxysporum* f. sp. *lini*, *Alternaria linicola*, *Colletotrichum lini*, *Rhizoctonia linicola*, *Oidium lini*), (iii) resistance to lodging, and (iv) fatty acid content.

In order to increase the utilization of linseed for different end uses we focus on alterations in the fatty acid composition, e.g. high linolenic (HLN), low linolenic (LLN), and intermediate oleic (IOL), to offer varieties with the following characters:

- HLN (55-65% C18:3), brown and yellow seeds
- LLN (<3% C18:3), brown and yellow seeds
- IOL (25-40% C18:1) and LLN (<10% C18:3), brown and yellow seeds
- HLN, brown and yellow seeds, increased content of secoisolariciresionol (SECO)
- LLN, brown and yellow seeds, increased SECO content
- HLN and LLN, brown and yellow seeds, decreased content of cyanogenic glycosides (CG)

Results

Fatty acids

Alterations in fatty acid composition have been achieved at Agritec, Šumperk, by induced mutagenesis since 1995. Mutants with reduced activity of *FAD2* and *FAD3* enzymes for desaturation of oleic acid to linoleic and linoleic to linolenic acid, respectively, were found. Genotypes with different levels of C18:1, C18:2 and C18:3 were detected. Non segregating LLN genotypes with 3% C18:3, and with about 70% C18:2 were obtained after crossing of different mutants with lower levels of C18:3. Intermediate linolenic genotypes with about 30-40% of both C18:2 and C18:3 were received after crossing of LLN genotypes with standard varieties. Genotypes with higher levels of C18:1 were obtained via induced mutagenesis or they were selected as spontaneous mutants from flax and linseed genetic resources. Genotypes with 1-2% C18:3 and up to 35% C18:1 were obtained. Recently, genotypes with even higher C18:1 levels, i.e. up

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Table 1: **Characterization of linseed varities registered in the Czech Republic and new breeding lines in the official registration trials 2009**

Genotype	YLD[1]	FAT	FYD	C16:0	C18:0	C18:1	C18:2	C18:3	MAT
Lola	2.64	43.2	999.8	6.46	2.63	14.20	71.54	3.69	131
Flanders	2.53	45.9	1016.8	4.71	3.66	17.62	15.29	56.73	129
Amon	2.48	45.0	971.6	6.20	3.66	15.51	71.26	1.86	132
Jantar	2.32	44.3	901.4	5.88	3.94	16.63	70.23	1.82	133
AGT 997/05	2.47	42.8	931.4	5.80	3.79	16.71	40.09	32.08	131
AGT 981/05	2.46	44.4	958.6	6.21	3.59	17.58	69.22	1.97	129
AGT 987/02	2.45	41.5	868.8	6.16	3.84	18.21	64.43	5.87	130
$LSD_{0.05}$	0.32	3.0	132.0	0.10	0.19	1.05	1.39	1.23	2

[1] YLD, seed yield (t·ha^{-1}); FAT, fat content (%); FYD, fat yield (kg·ha^{-1}); MAT, vegetation period from sowing to maturity (d); content of fatty acids (%): C16:0, palmitic acid; C18:0, stearic acid; C18:1, oleic acid; C18:2, linoleic acid; C18:3, linolenic acid

to 46%, were detected, however, their C18:3 level reaches 33%. This breeding effort was positively influenced by a shift in the cultivation area from flax to linseed. The first two linseed varieties of Czech origin, Jantar (Sempra) and Amon (Agritec), were released in 2006 and 2007, respectively. Before linseed cultivation was dominated by the Dutch varieties Flanders and Lola (Limagrain Advanta).

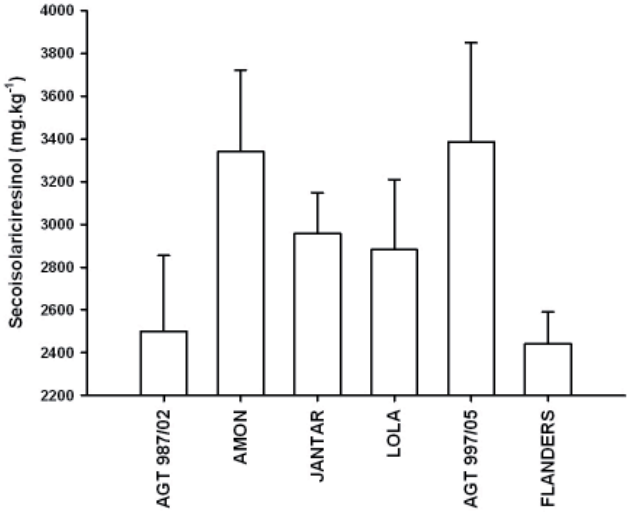

Figure 1: **Content of SECO in linseed varieties and breeding lines**

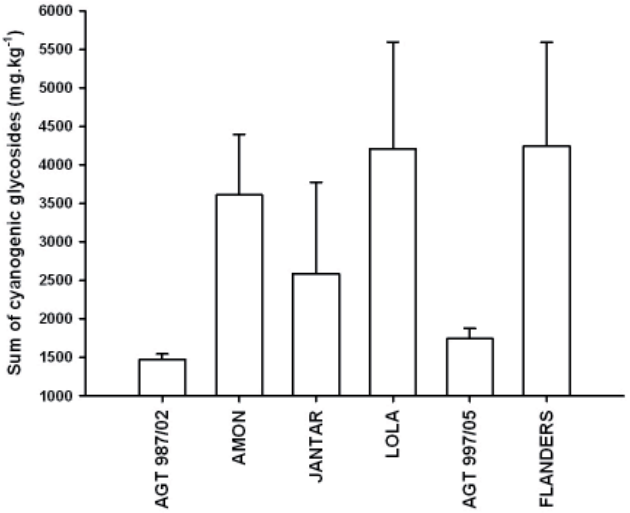

Figure 2: **Content of cyanogenic glycosides in linseed varieties and breeding lines**

In 2010 the LLN, yellow seeded Agritec line Allan received plant variety protection. The characteristics of check varieties, recently released varieties and new LLN breeding lines (AGT 997/05, AGT 987/02) are presented in *Table 1*. Linolenic acid is beneficial in human diet, however, it is unstable and reduces oil durability. Hence, a decreased amount is necessary in linseed genotypes bred for edible (cooking) oil production.

Phytoestrogens

In the Czech linseed breeding programme attention is also turned on the increase of phytoestrogens and a decrease of cyanogenic glycosides (CG). The most known phytoestrogen is secoisolariciresinol (SECO). During its enzymatic disintegration lignans are created which can have positive antioxidant influence in human organisms (TOURÉ and XU 2010). Therefore, the increase of phytoestrogens in linseed is highly desirable for the food use of linseed. In the Czech breeding programme the new breeding line AGT 997/05 demonstrated an increased SECO content comparable to variety Amon (*Figure 1*).

Cyanogenic glycosides

High content of CG (linustatin, neolinustatin and linamarin) is undesirable due to their metabolic disintegration to

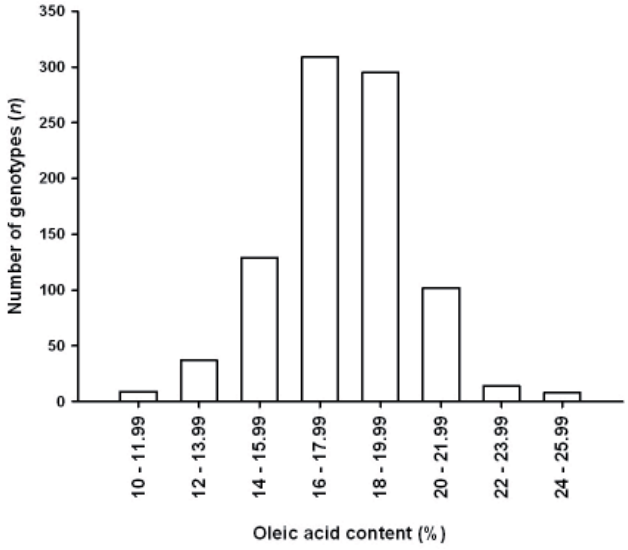

Figure 3: **Variation in oleic acid content among accessions of the Czech flax and linseed collection**

Table 2: **Fatty acid composition of 15 selected genotypes from the Czech flax and linseed collection with higher oleic acid content (location Šumperk)**

Accession number	Accession name	Fatty acid content (%) C16:0	C18:0	C18:1	C18:2	C18:3
2-583	Sziciliai olajlen	6.5	3.9	21.5	16.8	51.3
2-538	I-9	5.8	3.0	21.6	15.1	54.6
2-580	Madéfalvai kékvirágu	5.4	2.6	21.6	14.8	55.6
2-399	CI 1235	6.1	3.9	21.7	12.3	56.0
2-535	Vajžgantas	4.8	2.8	21.7	20.9	49.7
2-438	Rabat 0196-20	6.0	4.1	21.8	15.7	52.5
2-568	Omega	6.1	3.1	21.9	15.3	53.5
2-470	La Prevision	6.2	4.2	22.1	14.8	52.7
2-595	V-1-530	6.2	3.8	22.1	15.5	52.4
2-437	Rabat 01-1	5.7	3.6	22.2	14.5	53.9
2-567	Masličnyj	5.6	2.6	22.3	14.6	54.9
2-617	O/228	5.6	3.1	23.0	16.3	52.1
2-449	Rabat 03-2	6.2	3.8	23.6	16.1	50.2
2-424	CI 1235	5.9	4.3	24.0	12.7	53.1
2-380	LCSD-210	4.7	2.2	25.7	14.7	52.8

Table 3: **Fatty acid composition of 14 selected genotypes from the Czech flax and linseed collection with higher oleic acid content (location Vikyrovice)**

Accession number	Accession name	Fatty acid content (%) C16:0	C18:0	C18:1	C18:2	C18:3
2-601	Madarsky olejny	5.5	2.7	26.3	12.6	52.8
2-610	Minuano	6.0	4.6	26.3	13.4	49.6
	Liflora	4.7	3.5	26.2	13.9	51.6
2-605	Attana ZZOB	5.4	2.8	26.4	16.2	49.3
2-540	Udzan	6.3	4.1	26.6	15.7	47.3
2-617	0/228	5.9	3.2	26.6	15.8	48.5
2-399	CI 1235	6.7	5.6	27.0	12.4	48.4
2-670	P-255	5.4	3.0	27.1	14.0	50.5
2-657	Barradas Benafin	6.7	4.6	27.4	13.3	48.0
2-616	0/226	5.3	2.9	27.7	15.0	49.1
2-676	VNIIL-6	5.4	4.7	28.3	16.5	45.1
2-471	Royal	6.8	4.8	28.9	14.4	45.0
2-474	Liral Crown	6.6	5.0	28.9	14.0	45.6
2-470	La Prevision	6.3	5.5	30.0	13.9	44.3

hydrogen cyanide which is toxic for organisms. Therefore, linseed varieties with lower levels of CG are more useful for the feeding industry. *Figure 2* demonstrates the content of CG (sum of all three above mentioned CG) in registered varieties and new Agritec (AGT) breeding lines.

Oleic acid

In 2007 a screening of the Czech flax and linseed collection was started in order to find genotypes with higher contents of oleic fatty acid (C18:1). The study revealed a broad genotypic variation in the C18:1 content (*Figure 3*). Genotypes with higher contents of oleic acid were identified (*Table 2* and *3*).

Conclusion

The recently released Czech linseed varieties Jantar and Amon are comparable to the LLN standard variety Lola and, therefore, their primarily end use is in food industry. The new Agritec breeding line AGT 997/05 represents a completely new quality type given by the medium content of both linoleic and linolenic fatty acid. Based on the 2008-2010 results in the national VCU trials this line was registered for growing in 2011 in the Czech Republic under the name Raciol.

Acknowledgement

This research was financially supported by the Ministry of Eduation, Youth and Sports of the Czech Republic (ME CR, grants No. MSM 2678424601 and No.2B06087).

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