ISSN 1691-5402
ISBN 978-9984-44-027-9
Environment. Technology. Resources
Proceedings of the 7th International Scientific and Practical Conference. Volume 1

EVALUATION OF THE LATVIAN FLAX GENETIC RESOURCES AND PERSPECTIVE OF THEIR UTILISATION

LATVIJAS LINU ĢENĒTISKO RESURSU NOVĒRTĒŠANA UN TO IZMANTOŠANAS PERSPEKTĪVA

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Abstract: *Flax* (Linum usitatissimum L.) *is one of the oldest fibre and oil crop in Europe, including Latvia. In the middle of the last century growing areas of this crop was reduced dramatically. Nowadays flax attracted a great interest again as a fibre and oil processor, as well as a crop for diversification of agriculture and, in the same time, as a crop for producing high quality fibre for industry, high quantity oil for biofuel and high quality oil for feeding, food, and pharmacy (source of α-linolenic acid, linoleic acid and vitamins). We evaluated all available flax accessions of the Latvian origin and number of their hybrid lines. Agronomically important qualitative and quantitative traits, such as total plant height, technical plant height, number of seed vessels, logging resistance, vegetation period, yield of straws and seeds, 1000 seeds weight, bast fibre, number of seeds in a seed vessel, oil content and rust resistance gene* L *alleles* L2 *and* L9 *were recorded. Results of the field trials of two last years were summarized. Local accessions are useful as a source for breeding to adaptation of flax varieties to the local Latvian conditions. With use of molecular methods flax rust resistance allele* L2 *and* L9 *were found in eleven accessions.*

Keywords: *fibre, flax, oil content, rust resistance.*

Introduction

Flax (*Linum usitatissimum* L.) belongs to the family *Linaceae* and is divided in two groups: oil-seed flax grown for production of oil, and fibre flax. Flax seeds, which contain up to 40% of oil, are the very riche source of polyunsaturated fatty acids (about 14% of linoleic acid and more then 60% of α-linolenic acid), vitamins, proteins, muciloginous substances and antioxidants, such as lignans, α-tocopherol [1]. This is the reason of flax oil use in medicine and modern pharmacology. Linseeds are used as well as source of industrial oil in the production of paints, varnishes, inks and linoleum. In they turn, fibre flax can be used in textile industry, as engineering and building material, energy resource.

Last years in Latvia flax sowing areas decreased for different reasons from more than 2000 ha in 2005 to the less than 600 ha in 2008 [2]. However, future of flax growing in Latvia is dependent from the development of new ideas in agriculture sector. Effectiveness of flax production is based on two essential elements: modern comprehensive technologies for the crop growing and harvesting, and close links between the production of raw materials and industrial processing to prepare a product for wider marketing. Important part of whole process is the new plant genotypes with favourable set of quantitative and qualitative traits.

Flax breeding in Latvia started in 1923. After World War II, flax growing was not considered as an important task for the region, and, therefore, the flax area in the country was gradually reduced. In 1970, flax breeding in Latvia was cancelled [3]. Fibre flax breeding was started in Latvia again since 1992 [4], oil flax growing and breeding has started there in 1993 [3].

Presently, no local flax varieties suitable for the Latvian weather conditions are registred for commercial growing. The drawback of the best foreign varieties is too long vegetation period. Therefore, repatriation and investigation of the Latvian flax genetic resources become a very actual task [3]. For the In Latvian flax breeding program important task is to obtain high yielding, middle early varieties, with good resistance to logging and to flax diseases, especially to leaf rust.

Flax resistance to microscopic fungi *Melampsora lini,* causal agent of rust, is one of the important characters, which determine breeding material quality. Flax rust occurs worldwide and can cause severe losses in seed yields and fibre quality. There are at least 34 genes conferring resistance to rust, splited in seven groups, namely K, L, M, N, P, D, and Q [5-8]. Several molecular markers can be used to test presence of particular allele in flax accessions.

The aim of this study was evolution of Latvian flax genetic resources for identification among them useful accessions for both fiber and oil breeding in Latvia. Determination of rust resistance gene alleles in Latvian breeding material was done for the first time.

Material and Methods

Old accessions of the Latvian origion repatriated from the N. I. Vavilov Institute of Plant Industry (Russia), the Flax Research Institute (Russia) and the Institute of Plant Genetics and Crop Plant Research (Germany) and best flax breeding lines of the Agriculture Science Centre of Latgale (Latvia) were evaluated in field experiments (random block design, two replications) and in laboratory experiments in 2007-2008. Accessions were compared with the standard fibre flax variety ‘Vega 2’ and standard oil flax variety ‘Lirina’.

Agriculturally important traits, such as flax total plant height, technical plant height, number of seed vessels, logging resistance, vegetation period, yield of straws and seeds, 1000 seeds weight, bast fibre, number of seeds in a seed vessel, as well as oil content, were determined.

The oil content in seeds was measured by the Soxhlet extraction: 10 g seeds were milled and the oil was extracted by hexane during two hours, extraction was repeated two times.

Genomic DNA was extracted from fresh leaves according to the procedure described by Fermentas Genomik DNA Purufication Kit (Fetmentas). Amplification of segments of the flax *L* locus was performed in a thermal cycler. The 50 μL reaction volume contained 1 × PCR buffer (10 mM Tris–HCl at pH 8.5, 50 mM KCl, 1.5 mM MgCl2, and 0.01% Tween-20), 250 μM of each dNTP, 25 ng of each primer, approximately 10-25 ng of genomic DNA, and 1 unit of Taq DNA polymerase (Fermentas). Following an initial 3 min denaturation step (93 °C), the reaction mixtures were subjected to 30 cycles of 1 min at 93 °C, 30 s at 55 °C, and 2 min at 72 °C. The last cycle was followed by an extension polymerization of 10 min at 72 °C.

Endonuclease digestions of PCR were performed using enzymes obtained from Fermentas fallowing the recommendations of the manufacturer. PCR products were digested with *MboI* and the DNA restriction fragments were resolved on polyacrylamide gel. Polyacrylamide gel electrophoresis was carried out in TBE buffer, on 10% polyacrylamide (39:1 polyacrylamide-bisacrylamide) gels at 100 V for 5 hours.

Results and Discussion

Some evaluated local accessions were better in several agriculturally important traits in comparison with the standard varieties. All accessions showed good logging resistance, vegetation period of accessions of the Latvian origin ranged from 66 till 90 days and were shorter or the same as for standards ‘Vega 2’ and ‘Lirina’ (87-90 days).

Flax seed yield (Fig.1) differed among years and accessions. All accessions of the Latvian origin had higher or not less seed yield than standard variety ‘Lirina’. High seed yield in both years had old Latvian local accessions ‘Blue di Riga’, ‘Riga Freis’, ‘Rigar B’. Those

accessions had also high seed yield in previous years (2004-2006) [9]. Among breeding lines rather high seed yield have two fibre flax lines: L19-6/5-97 and T11-13/3-1-94.

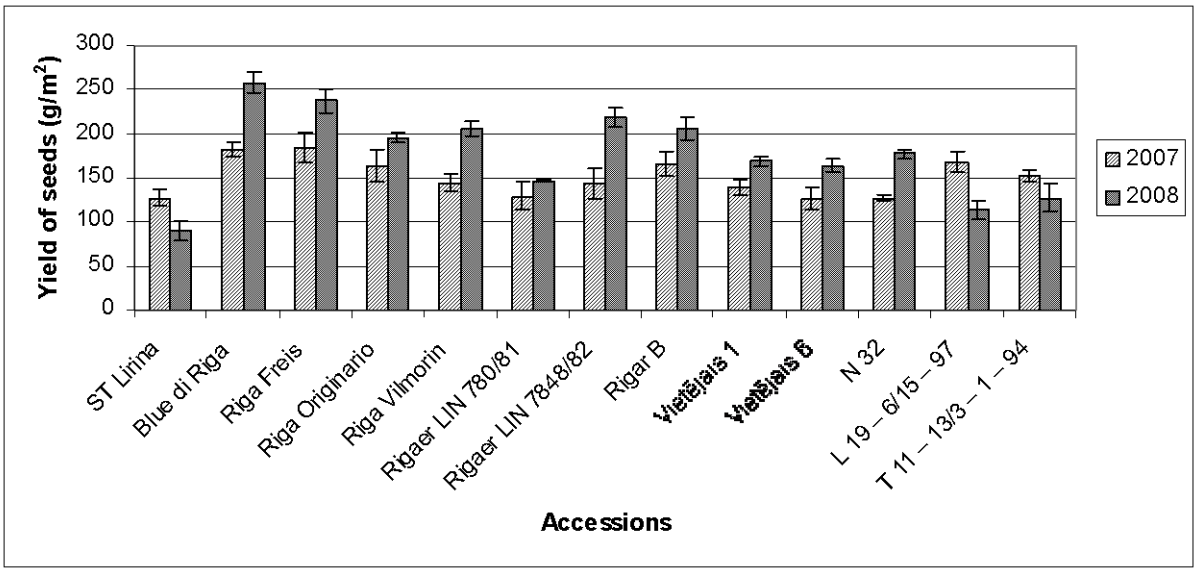

Fig. 1. **Seed yield of flax accession of the Latvian origin in 2007-2008**

1000 seeds weight did not differed significantly among two years of experiment but differed among accessions (Fig. 2). Higher weight of seeds than standard 'Lirina' had 'Rigaer LIN 7848/82'.

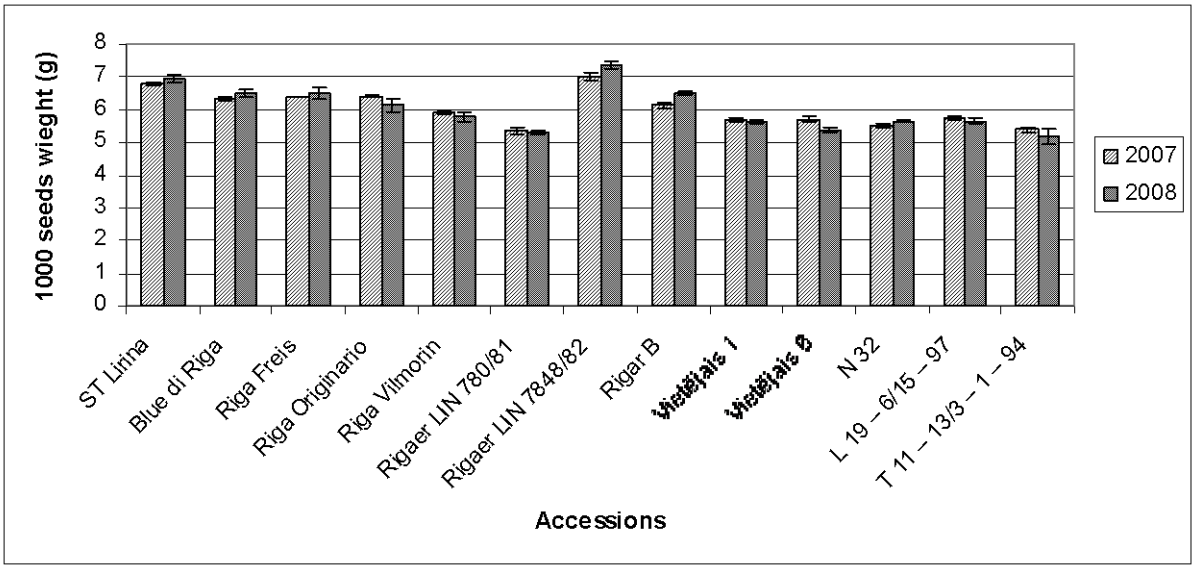

Fig. 2. **1000 seeds weight of flax accession of the Latvian origin in 2007-2008**

Oil content in seeds differed significantly among accessions (Fig. 3): it ranged 16.4-45.8%. Oil content for the local accession 'Blue di Riga' (45.8%) was similar to standard variety 'Lirina' (44.9%). Among breeding lines high oil content exhibited lines L19-6/15-97 and T11-13/3-1-94.

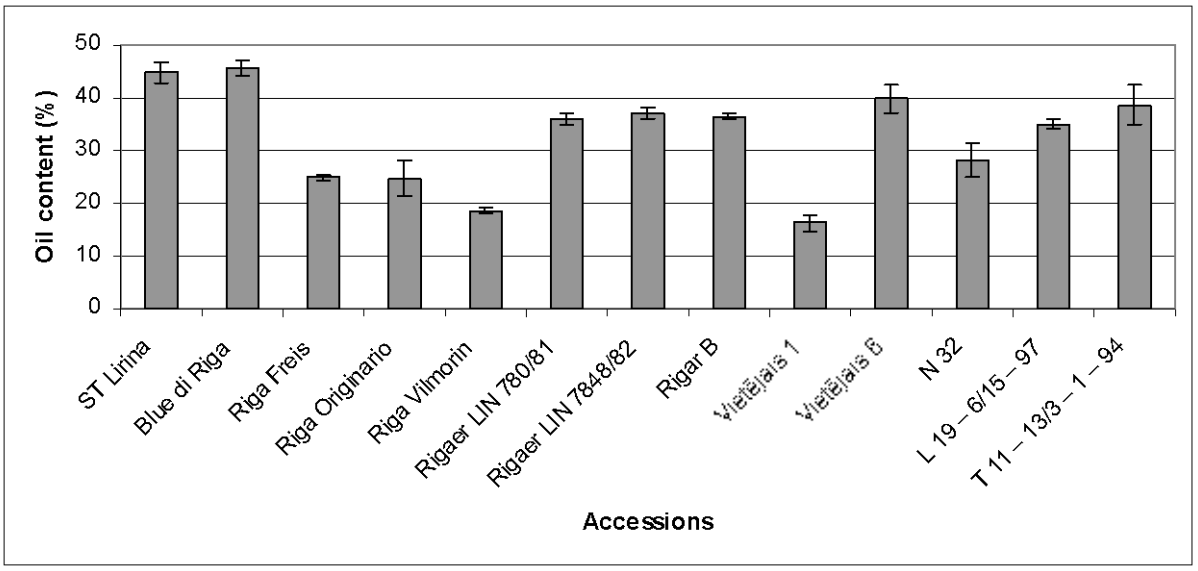

Fig. 3. **Oil content in seeds of flax accessions of the Latvian origin**

The most important traits for the fibre flax breeding are the plant technical height and bast fibre [4]. High technical height and good bast fibre content in both years showed breeding lines (Table 1).

Table 1.

Average technical height and bast fibre of flax accessions of the Latvian origin in 2007-2008

Varieties and breeding lines	*Technical plant height (cm)*		*Bast fibre (%)*	
	2007	*2008*	*2007*	*2008*
ST Vega 2	66,7 ± 2,1	48,3 ± 1,9	25,1 ± 0,8	28,3 ± 0,7
Altgauzen 12*80	50,5 ± 0,9	56,5 ± 3,5	11,5 ± 0,6	28,5 ± 0,6
N32	48,2 ± 2,8	49,1 ± 0,9	20,7 ± 1,4	28,3 ± 0,6
K47–17/11–1–95	71,8 ± 2,2	56,3 ± 1,6	25,3 ± 0,6	31,8 ± 1,0
L11–11/10–97	64,9 ± 2,5	52,0 ± 1,8	22,5 ± 1,0	31,3 ± 0,7
L19–6/15–97	59,7 ± 1,8	55,1 ± 1,6	22,8 ± 0,9	29,6 ± 0,7
L2–14/6–97	58,8 ± 3,9	47,2 ± 2,3	19,8 ± 0,3	29,8 ± 0,2
S32/4–8–93	59,9 ± 2,3	46,7 ± 1,3	24,9 ± 0,4	26,9 ± 0,6
S53/8–3–93	62,1 ± 2,0	57,9 ± 2,4	27,8 ± 0,4	32,5 ± 1,0
T11–13/3–1–94	62,5 ± 5,2	50,8 ± 4,7	22,6 ± 1,3	34,0 ± 0,2
T11–6/2–15–94	59,5 ± 3,0	52,3 ± 2,5	23,4 ± 0,2	32,7 ± 0,3
T31–40–94	65,9 ± 3,9	56,5 ± 1,5	24,5 ± 1,4	27,8 ± 0,9
T36–26/4–8–94	69,7 ± 4,3	58,3 ± 0,9	26,1 ± 0,7	31,9 ± 0,4

Higher technical height than standard ‘Vega 2’ in both years had lines K47-7/11-1-95, and T36-26/4-8-94. The line T36-26/4-8-94 had also high technical height in previous years [9]. As the best fibre flax breeding lines are suggested T36-26/4-8-94 and T31-40-94, they had high technical height and bast fibre content both in 2007 and 2008. This accession also has a mid-early maturity period. Useful as breeding material is also the line S53/8-3-93, although in 2007 it had lower technical height than standard but in the same time the line had high bast fibre content and mid early maturity period.

Results of detection allele in the *L* loci are presented in the Table 2.

Table 2.

Leaf rust resistance alleles in the accessions of the Latvian origin

Varieties and hibrid lines	***Allele***
Altgauzen 16*90	*L9*
Blue di Riga	*L2;*
L 19-6/15-97	*L2*
N 116	*L9*
N 2	*L9*
N 32	*L2; L9*
Riga Freis	*L9*
Rigaer 6/5	*L9*
Rigaer LIN 780/81	*L2*
Rigar B	*L9*
Vietējais 3	*L2*
Vietējais 4	*L9*
Vietējais 6	*L2*

Flax rust resistance allele *L2* and *L9* were determinated in eleven accessions (Table 2). Seven local accessions have allele *L9* and five accessions - *L2*. Diversity within accession in resistance gene alleles (some plants have *L2* and some *L9* allele) was found for N 32. In literature as more effective is noted resistance allele *L2* [5]. Accessions 'Blue di Riga', 'Rigaer LIN 780/81' and 'Vietējais 6' are not only useful as source for high seed yield and oil content breeding, but are also a donor of rust resistance alleles. Breeding line L19-6/15-97 with *L2* resistance allele, have good seed yield, oil content and, at the same time, good technical height and bast fibre and could be useful for both seed and fibre producing.

Conclusions

The best oil flax accessions of the Latvian origin are 'Blue di Riga', 'Rigaer LIN 7848/82' and 'Rigar B' according all three criteria (seed yield, 1000 seeds weight, oil content). All of them have one of the resistance *L* allele. Those accessions we recommend as excellent source material for oil flax breeding.

Three of breeding lines (T36-26/4-8-94, K47-17/11-1-95, S53/8-3-93) had stable higher technical plant height and percentage of bast fibre than standard variety 'Vega 2' and are recommended as source for new fibre flax varieties. The breeding line L19-6/15-97 could be used for both – seed and fibre flax breeding.

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